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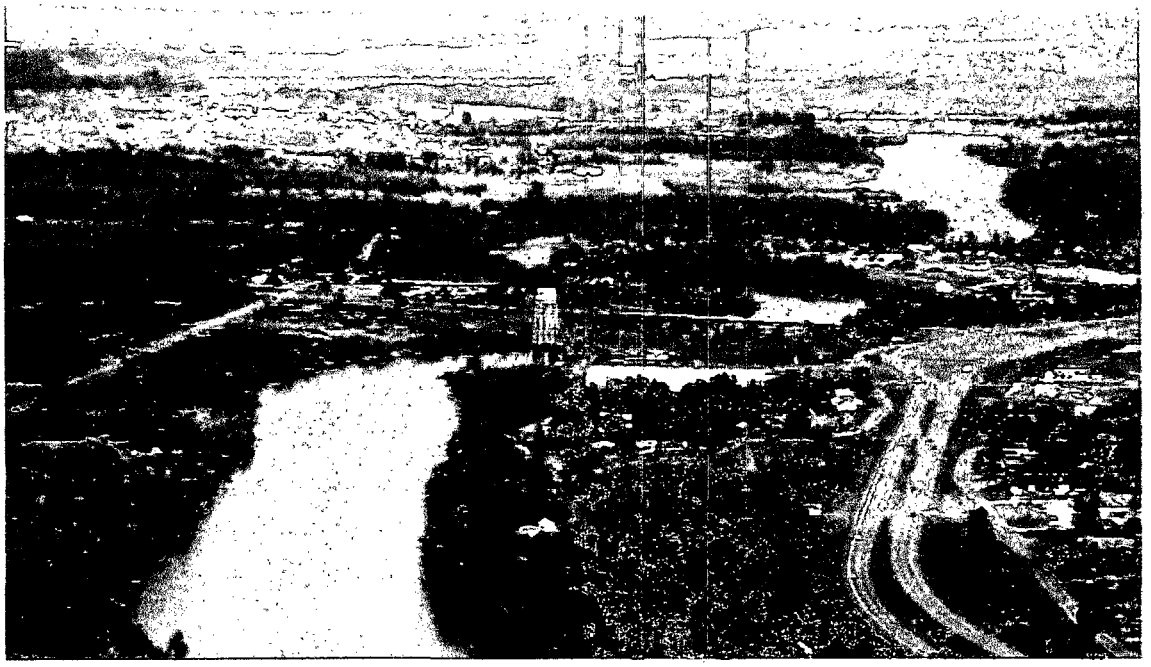
Analysis of Alternatives Report

Grasse River Study Area
Massena, New York



ALCOA

Alcoa Inc.
Massena, New York

June 12, 2002

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- Camp, Dresser & McKee Inc., Massena, New York; and
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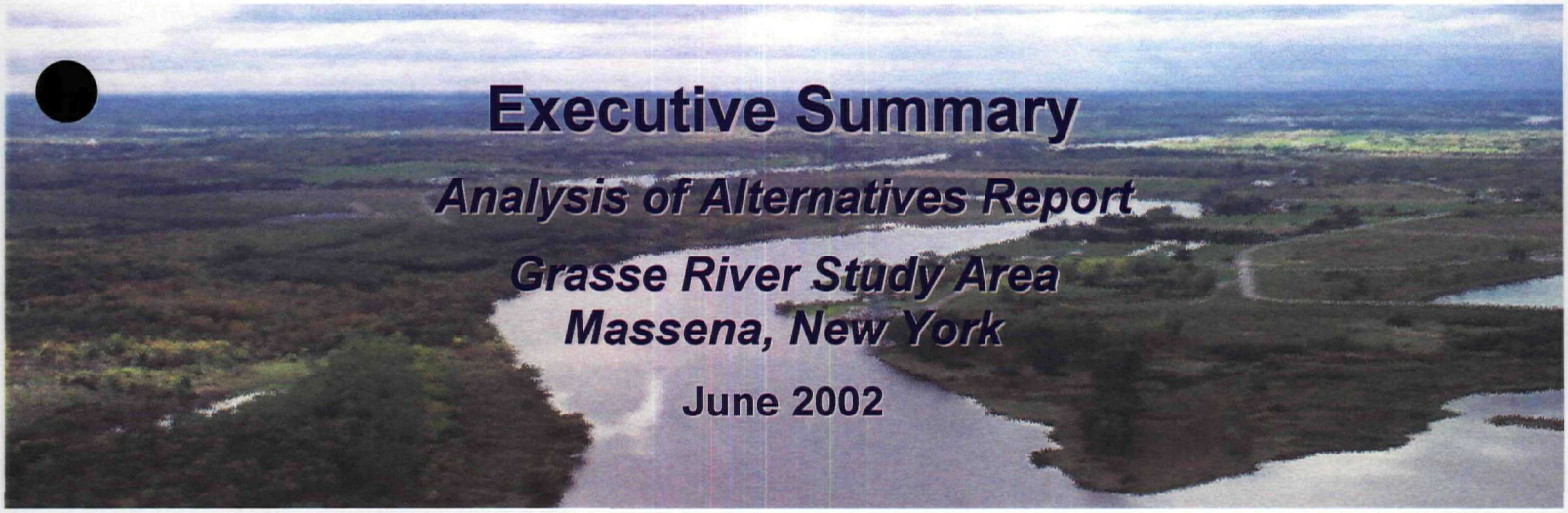
Acronyms and Abbreviations

AA	-	Analysis of Alternatives
Alcoa	-	Alcoa Inc.
ARARs	-	Applicable or Relevant and Appropriate Requirements
AWQC	-	Ambient Water Quality Criteria
BBL	-	Blasland, Bouck & Lee, Inc.
BLRA	-	Baseline Risk Assessment
BZ	-	PCB dechlorination by-products (Ballschmitter and Zell)
CCLGR	-	Comprehensive Characterization of the Lower Grasse River
CERCLA	-	Comprehensive Environmental Response, Compensation, and Liability Act
^{137}Cs	-	Cesium 137
cfs	-	cubic feet per second
cm	-	centimeters
cm/yr	-	centimeters per year
cm/d	-	centimeters per day
CMU	-	Carnegie Mellon University
CRQL	-	contract required quantitation limit
CT	-	Central Tendency
CWA	-	Clean Water Act
cy	-	cubic yards
cy/day	-	cubic yards per day
E&E	-	Ecology & Environment, Inc.
ETAB	-	Environmental Technical Advisory Board
FEMA	-	Federal Emergency Management Agency
ft/s	-	feet per second
ft^2	-	square feet
ft^2/mo	-	square feet per month
ft^3/d-ft	-	cubic foot per day per linear foot
GAC	-	granular activated carbon
GM	-	General Motors Corporation
GPS	-	Global Positioning System
grams/day	-	grams per day
GRAs	-	General Response Actions
HASP	-	Health and Safety Plan
HI	-	hazard index
HP	-	horsepower
kg/yr	-	kilograms per year
lbs/yr	-	pounds per year
L/d-m	-	liters per day per meter
L/m^2-d	-	liters per square meter per day
M	-	million
mm	-	millimeters
MDL	-	Method Detection Limit
mg/kg	-	milligrams per kilogram
mg/L	-	milligrams per liter
MGD	-	million gallons per day

MT	-	metric tons
MWWTP	-	Massena Waste Water Treatment Plant
NCP	-	National Oil and Hazardous Substances Pollution Contingency Plan
ng/L	-	nanograms per liter
NRC	-	National Research Council
NTCRA	-	Non-Time-Critical Removal Action
NTU	-	Nephelometric Turbidity Units
NYSDEC	-	New York State Department of Environmental Conservation
NYSDOH	-	New York State Department of Health
OSI	-	Ocean Surveys, Inc.
OSHA	-	Occupational Safety and Health Administration
PAHs	-	polynuclear aromatic hydrocarbons
^{210}Pb	-	Lead 210
PCBs	-	polychlorinated biphenyls
pCi/g	-	picoCuries per gram
Power Canal	-	Massena Power Canal
ppb	-	parts per billion
ppm	-	parts per million
PQL	-	Practical Quantitation Limit
prop wash	-	propeller wash
RA Update	-	Risk Assessment Update
RAOs	-	Remedial Action Objectives
RCRA	-	Resource Conservation and Recovery Act
River	-	lower Grasse River
RMC	-	Reynolds Metals Company
RME	-	Reasonable Maximum Exposure
ROB	-	run-of-bank
RSI	-	River and Sediment Investigation
RTDF	-	Remedial Technologies Development Forum
SPDES	-	State Pollution Discharge Elimination System
SPMDs	-	semi-permeable membrane devices
SRMT	-	St. Regis Mohawk Tribe
SRS	-	Supplemental Remedial Studies
SSS	-	Supplemental Sediment Sampling
TBC	-	To Be Considered
TOC	-	total organic carbon
TSCA	-	Toxic Substances Control Act
TSS	-	total suspended solids
USDOI	-	United States Department of the Interior
USACE	-	United States Army Corps of Engineers
USEPA	-	United States Environmental Protection Agency
µg	-	micrograms
µg/L	-	micrograms per liter
≥	-	greater than or equal to



Executive Summary

Analysis of Alternatives Report

Grasse River Study Area
Massena, New York

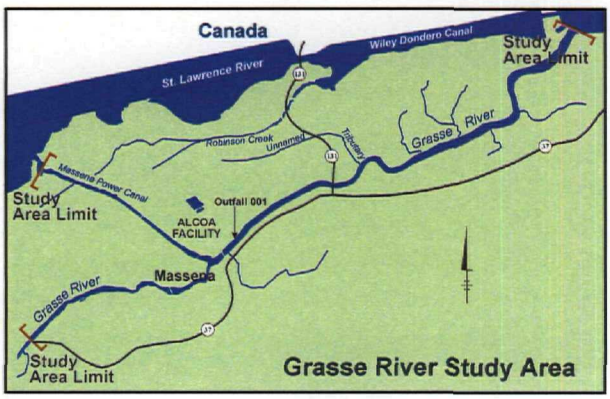
June 2002

Introduction

For more than a decade, Alcoa Inc. (formerly known as the Aluminum Company of America – Alcoa) has worked with the United States Environmental Protection Agency (USEPA), the New York State Department of Environmental Conservation (NYSDEC), and the St. Regis Mohawk Tribe (SRMT) – collectively referred to as the Agencies – to develop a comprehensive understanding of the sources, nature, and extent of various chemicals, primarily polychlorinated biphenyls (PCBs), in the Grasse River Study Area near Massena, New York. This joint interaction, along with information gathered during site-specific investigations and actions, led to the development of ten potential remedial alternatives for the Study Area. The evaluation of these ten alternatives, designed to be protective of human health and the environment, is the focus of this Analysis of Alternatives (AA) Report. Alcoa believes that the ultimate goal for the River should be to identify and implement a remedy based on site-specific information that will provide effective long-term protection from potential risks to human health and the environment while minimizing short-term impacts to the ecosystem and the community.

This Executive Summary presents an overview of the Grasse River Study Area, the key findings of the studies carried out since 1991, and the development and evaluation of the potential remedial alternatives. The information in this AA 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 more than two years of significant interaction between Alcoa and the Agencies. Alcoa has also taken steps to involve and inform the community during the development of this Report through the formation of a Community Advisory Panel and organization of public meetings and information sessions.

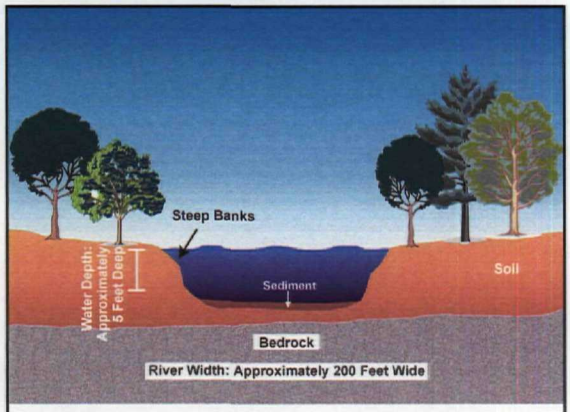
Study Area Background



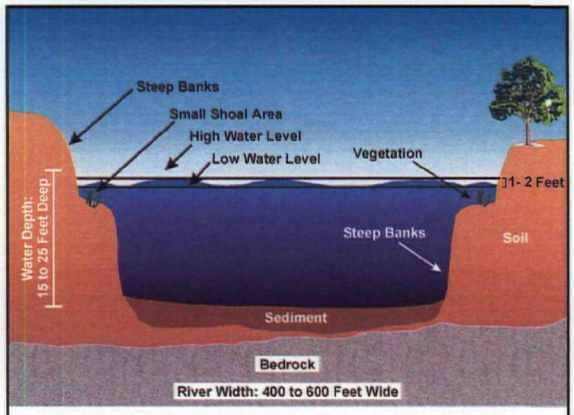
The town of Massena, located along the northern border of New York State, has been the home of several major manufacturing operations for over a century. Alcoa's 2,700-acre facility, in operation since 1903, is located at the confluence of the Massena Power Canal and the Grasse River. Historic disposal of production waste by-products in on-site lagoons and landfills – 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 response to the findings of the NYSDEC, Alcoa began implementation of land-based remedial activities at the facility in 1991. The USEPA issued an Administrative Order in 1989 (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 environmental issues.

Based on initial site studies, the boundaries of the Grasse River Study Area were established at the Route 37 Bridge in Massena and the St. Lawrence River (see map on previous page). The Study Area 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. Below the confluence with the Power Canal, the River becomes substantially deeper and the cross-sectional area increases significantly. Upstream of the Power Canal, the River is about 5 feet deep with a cross-section of 1,000 square feet, while between the Power Canal and the mouth, 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). These dramatic physical changes, due in part to dredging conducted in the lower



Typical cross section in the background reach, upstream of the lower River



Typical lower Grasse River cross section

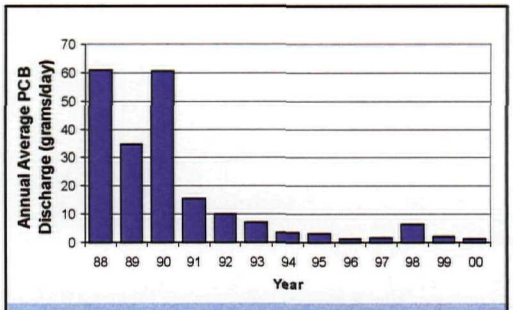
River in the early 1900s to accommodate the additional water flows from the newly-constructed Power Canal, make the lower Grasse River the functional equivalent of a reservoir. Normal water flow velocities in the area are generally so low that they can be difficult or impossible to measure with conventional equipment – during low flows it can take up to 21 days for water to travel from the area near the Alcoa facility to the River's mouth, a distance of 7 miles.

Bottom deposits in the lower Grasse River are primarily soft sediments mixed with cobbles and boulders. Most of the deposits are 0 to 5 feet deep, although there are a few isolated areas where the deposits are deeper. There are approximately 1.9 million cubic yards (cy) of sediments in the lower Grasse River covering about 405 acres; most of the sediments are underlain by bedrock or glacial till (hardpan). Currently, the average PCB concentration in surface sediments of the lower Grasse River is 18 milligrams per kilogram (mg/kg; equivalent to 18 parts per million [ppm]) between sediment probing Transects T11 and T38 (see Figure 2-15 for Transect locations) and 6 mg/kg in the downstream area. (See Section 1.2 for more on the characterization of the Study Area.)

Investigations in the Study Area

Since the USEPA issued the Administrative Order in 1989, Alcoa has conducted intensive field and laboratory investigations in the Study Area, including the collection of more than 3,500 sediment, water-column, and biota samples for PCB analysis. As a result of these thorough investigations, which included the 1995 Non-Time-Critical Removal Action (NTCRA) and the 2001 Capping Pilot Study, Alcoa has developed a comprehensive understanding of the sources of PCBs to the River, the nature and extent of PCBs in the system, and site-specific information on the efficacy of capping and dredging to address PCB-containing sediment and reduce potential risks in the lower Grasse River. In addition, 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 in improving the state of the River (see Section 1.3 for more details). These efforts to control external PCB sources are consistent with guidance in the National Research Council's (NRC's) *A Risk Management Strategy for PCB-Contaminated Sediments* (2001), which states that the first goal of any remedial approach should be to control ongoing sources.



Average annual PCB discharges from Outfall 001

Key Findings

The key findings of the studies, investigations, and actions completed at the Study Area over the last decade provide valuable insight, that when coupled with the results of the human health and ecological risk assessments (discussed below), form the basis for a conceptual site model that can be used to guide the development and evaluation of effective remedial alternatives. The findings, documented in the Comprehensive Characterization of the Lower Grasse River Report (Alcoa, April 2001) and other technical reports and summarized in Section 4.3, include:

- Plant discharges are currently an insignificant source of PCBs to the River; nevertheless, Alcoa has plans to further reduce the remaining discharges.
- Surface sediments are the dominant source of PCBs found in surface water and fish.
- Buried sediments are isolated and sequestered, and are expected to remain stable even during major 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 provide evidence that there was not any significant remobilization of sediment-bound PCBs as a result of the event (see Figures ES-1 [fish data] and ES-2 [sediment data], attached).
- 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 achieve a significant decline in PCB levels in fish and an associated decrease in potential risks.
- Remedial actions already completed have had a positive impact on the River.
- Deposition and burial are the principle means of natural recovery, while dechlorination and degradation may contribute to natural recovery.
- 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 may remobilize PCBs in the River; therefore, proper and reasonable work practices and engineering controls must be used.
- Dredging may leave residual PCBs in surface sediment, particularly in rocky areas with a bedrock bottom. These residuals may continue to affect PCB levels in the water column and biota unless dredging is combined with capping or natural recovery processes.

The 1995 NTCRA and the 2001 Capping Pilot Study provide important site-specific data regarding the effectiveness of active sediment remediation in the lower Grasse River. Brief descriptions of these programs and their results are presented below, along with a discussion of the work conducted to evaluate long-term sediment stability.

- *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-1) 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% from 518 mg/kg to 75 mg/kg. The dredging operation did, however, have negative short-term impacts on both the water column (see water-quality graph on next page, at left) and biota, and elevated concentrations of PCBs remained in residual surface sediments. After multiple dredge passes, an average of 4 inches of sediment (to a 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% 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-3 (attached). Additionally, post-NTCRA results for spottail shiner samples collected in the vicinity of Outfall 001 indicate that PCB concentrations increased by as much as six times compared to prior years (see Figure ES-1, attached).

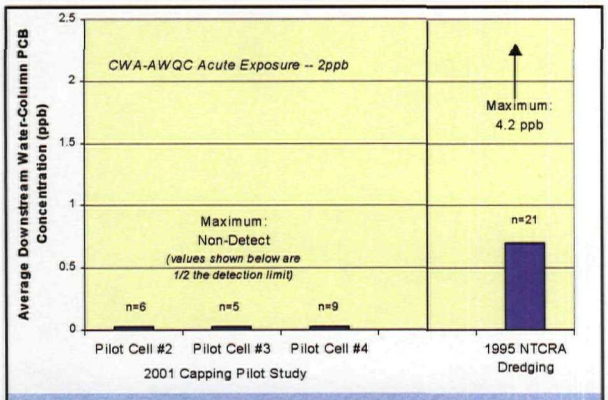
1995 NTCRA Program

These findings are consistent with the NRC's conclusion (2001) that reducing the volume of contaminated sediment does not necessarily 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 under the impacted sediments can limit dredging effectiveness. (For additional information on the NTCRA activities, see Section 2.7.1.)

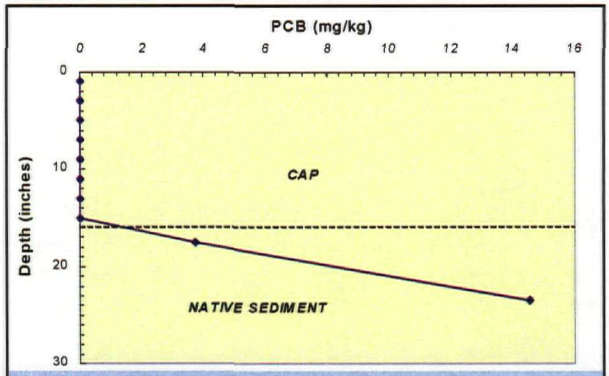
- *Capping Pilot Study*: Alcoa designed and conducted a Capping Pilot Study to evaluate the potential effectiveness of covering PCB-containing sediments with a clean cap. During the summer and fall of 2001, Alcoa tested a variety of capping materials (e.g., sand/topsoil mixture, bentonite, AquaBlok™)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

2001 Capping Pilot Study

Downstream impacts to the water column during the Capping Pilot Study were negligible (see the graph on the next page, 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, total suspended solids (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 graph on the next page, right, for typical core profile) and PCBs were typically not present in cap materials at detectable levels. 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) was successfully placed. Finally, preliminary data collected two to three weeks after the pilot study indicate active recolonization of the capped area by benthic organisms. (See Section 2.7.2 for more information.)



Downstream Water-Quality Data



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

- *Sediment Stability Findings:* The lower Grasse River has a large cross-sectional area and low flow velocities due to the size of the channel in relation to the volume of water that flows through it. Alcoa completed a number of field studies to investigate and document the stability of River sediments, including measurements of TSS and PCBs during high flows; sediment geochronology; sediment PCB composition; trend monitoring of PCB levels in surface sediment, water, and fish; and sediment erodability measurements (see Section 2.6.2 for more information). These field studies, along with results of hydrodynamic and sediment transport modeling conducted for the site, indicate that even during extreme high-flow events, erosion impacts only the top few millimeters of the sediment bed (see Section 2.6.2 and Figures ES-4A and ES-4B, attached). Further, natural sedimentation rates – a measure of how quickly sediments from upstream accumulate on the River bottom – exceed the predicted erosion rates in both normal and extreme (i.e., high-flow) circumstances. 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 cap constructed with the approximate properties of the native sediments will be stable and resistant to erosion, even during stresses equivalent to a 100-year flood. Erosion during a more extreme flood event is not expected to be substantially greater, as the 1-in-500 year flood flow of 17,070 cubic feet per second (cfs) is only 13% greater than the 1-in-100 year flow of 15,080 cfs (Federal Emergency Management Agency [FEMA], May 1980).

  Further evidence of sediment stability and historic sedimentation rates was gained through the analysis of high-resolution sediment cores collected in 1997. 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. In 1997, the highest PCB concentrations were generally observed at about 60 to 90 centimeters (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.

Evaluation of Potential Risks

In 1993, the USEPA conducted a baseline human health and ecological risk assessment (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 2001 (Alcoa, September 2001 [to be revised June 2002]) in order to incorporate more recent site-specific data and assumptions, updated PCB exposure and toxicity factors, and current scientific and regulatory policy. As stated in the 2001 update, Alcoa believes that a number of the assumptions included at the request of the USEPA introduce a variety of uncertainties and likely result in

overestimates of potential risk. The key conclusions from these assessments follow. [Note that these general conclusions are not anticipated to be affected by the June 2002 revision.]

- Consumption of PCB-containing fish from the lower Grasse River is the most significant exposure pathway for both human and ecological receptors; and
- Potential risks associated with direct exposures to sediment and surface water are generally at or below USEPA's range of acceptable risk.

Since potentially significant risks are associated with exposures in the lower Grasse River, the potential remedial alternatives are designed specifically for that section of the Study Area. It is anticipated that additional monitoring will be conducted in the Power Canal to verify that historic PCB levels in fish – which were significantly lower than those in the lower Grasse River – are still accurate. (See Section 3.2 for more on the risk assessments.)

Remedial Action Objectives

Remedial Action Objectives (RAOs) are the site-specific goals used to support both the individual and comparative evaluations of the effectiveness of the potential remedial alternatives. The RAOs for the Grasse River Study Area were developed based on discussions between Alcoa and the Agencies, and are designed to address potential risks to human health and the environment. The RAOs for the Grasse River Study Area are listed below.

1. Reduce PCBs in fish to levels protective of potential human and ecological consumers.
2. Reduce or mitigate, to the extent practicable, existing and potential adverse effects and bioaccumulation of PCBs in the lower Grasse River.
3. Reduce or mitigate, to the extent practicable, the migration of PCBs from the lower Grasse River to the St. Lawrence River.
4. Protect the ecosystem of the lower Grasse River.
5. Continue to reduce or control PCB sources within the lower Grasse River system.

Development of Potential Remedial Alternatives

As a result of extensive discussions between Alcoa and the Agencies over the past two years, 17 preliminary alternatives were identified and screened based on effectiveness, implementability, and cost. Based on this preliminary screening, ten potential remedial alternatives, listed and briefly described on the next page, were developed and carried forward for detailed analysis (see Section 5). The figures referenced in the table on the next page (which are included in the main body of the AA Report) show the areas of the River targeted for remedial action as part of each potential alternative.

Potential Remedial Alternatives for the Grasse River Study Area

Alternative 1 • No Further Action • Site-wide natural recovery • No cost; no implementation period	***Alternative 2*** (see Figure 5-1) • Monitored site-wide natural recovery • Ongoing • Cost: $2.7 million
Alternative 3 (see Figure 5-3) • Cap between sediment probing Transects T11 and T38 • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Caps will cover 127 acres • Implementation time: 2 construction seasons • Cost: $30.9 million	***Alternative 4*** (see Figure 5-5) • Dredge River areas with surface sediment PCBs ≥50 ppm • Cap between sediment probing Transects T11 and T38 • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Dredging targets removal of 48,000 cubic yards • Caps will cover 127 acres • Implementation time: 3 construction seasons • Cost: $51.4 million
Alternative 5 (see Figure 5-7) • Dredge River areas with surface sediment PCBs ≥25 ppm • Cap sediments with surface PCBs ≥10 ppm • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Dredging targets removal of 101,000 cubic yards • Caps will cover 121 acres • Implementation time: 3 construction seasons • Cost: $64.9 million	***Alternative 6*** (see Figure 5-9) • Cap sediments with surface PCBs ≥5 ppm • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Caps will cover 240 acres • Implementation time: 4 construction seasons • Cost: $54.8 million
Alternative 7 (see Figure 5-11) • Dredge River areas with surface sediment PCBs ≥50 ppm • Cap sediments with surface PCBs ≥5 ppm • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Dredging targets removal of 48,000 cubic yards • Caps will cover 240 acres • Implementation time: 5 construction seasons • Cost: $75.1 million	***Alternative 8*** (see Figure 5-13) • Dredge River areas with surface sediment PCBs ≥25 ppm • Cap sediments with surface PCBs ≥5 ppm • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Dredging targets removal of 101,000 cubic yards • Caps will cover 240 acres • Implementation time: 5 construction seasons • Cost: $89.5 million
Alternative 9 (see Figure 5-15) • Dredge River areas with surface sediment PCBs ≥10 ppm • Cap sediments with surface PCBs ≥5 ppm • Engineered cap at Outfalls 001/004 • Site-wide natural recovery • Dredging targets removal of 515,000 cubic yards • Caps will cover 240 acres • Implementation time: 5 construction seasons *(assuming dredging and capping occur concurrently)* • Cost: $196.3 million	***Alternative 10*** (see Figure 5-17) • Dredge River areas with surface sediment PCBs ≥1 ppm • Site-wide natural recovery • Dredging targets removal of 1,650,000 cubic yards • Implementation time: 9 construction seasons • Cost: $525.4 million

Evaluation of Potential Remedial Alternatives

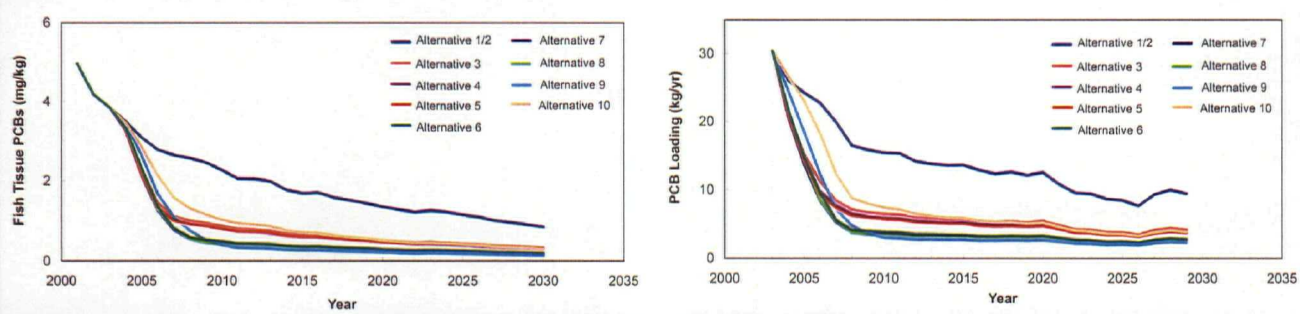
The ten potential remedial alternatives were subjected to a detailed evaluation – both individually (Section 5) and comparatively (Section 6) – against seven of the nine key decision-making criteria required by CERCLA and the NCP. The two modifying criteria, acceptance by the State (support agency) and the community, will be addressed after input received during the public comment period on the AA Report is compiled.

The individual and comparative evaluations, along with results of site-specific modeling and data analyses performed over the past decade, revealed that all ten potential remedial alternatives are implementable 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.

Long-Term Effectiveness and Permanence

Modeling was used to predict future PCB levels in fish and loading to the St. Lawrence River. PCB metrics, developed solely for the purpose of comparing the alternatives on a relative basis, include the time necessary to achieve 75% and 90% reductions in River-wide average fish PCB concentrations and an 85% reduction in PCB loading to the St. Lawrence River as a result of alternative implementation. The 30-year model projection period begins in 2001, and reductions are based on predicted PCB levels in 2003, which in the model is assumed to be the last year before the anticipated start of active remedial activities. A number of assumptions were made about how the alternatives would be implemented and how effectively they would reduce PCB levels in the River. While these are explained in detail in Appendix B, the key assumptions relevant to this discussion are: PCB releases during dredging equal 0.1% of the PCB mass removed, post-dredging PCB residual concentrations are equal to 2.5 ppm, and capping reduces surface sediment PCB concentrations by 90%. Site-specific data gathered during the NTCRA and the Capping Pilot Study indicate that these assumptions, which were used at the request of the Agencies, likely overestimate the effectiveness of dredging and may underestimate the benefits of capping. Use of the assumptions introduces a degree of uncertainty that may affect the modeled predictions of future PCB concentrations. As a result, relatively small differences in projected PCB levels may not provide meaningful distinctions in the predicted performance of the alternatives, as they could be the result of the particular assumptions used in the modeling evaluations.

All the alternatives are capable of achieving the RAOs and providing long-term protectiveness through site-wide natural recovery processes, benefits provided by completed external source control actions at the Alcoa facility, and for Alternatives 3 through 10, active remediation of PCB-containing sediment. Reductions in PCB levels in fish and PCB loading to the St. Lawrence River would require an additional period of time for Alternatives 1 and 2 relative to the other alternatives. The figures below show graphical representations of predicted reductions in fish tissue PCB levels and loading to the St. Lawrence River through 2030 associated with each alternative.



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

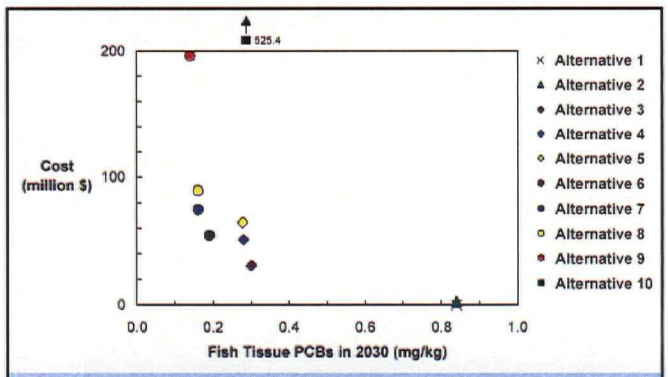
Short-Term Effectiveness

The short-term effectiveness criterion is used to assess both the impacts and risks associated with alternative implementation and construction as well as near-term improvements associated with the alternatives. Implementation of either Alternative 1 or 2 – the No Further Action and Monitored Natural Recovery alternatives – will not lead to any short-term impacts or risks. For the alternatives involving only a capping component (Alternatives 3 and 6), the results of the Capping Pilot Study indicate that there are minimal negative short-term impacts associated with the placement of a clean cap in the Study Area (see summary in the "Investigations" section above). Alternatives incorporating a dredging component (Alternatives 4, 5, 7, 8, 9, and 10) will likely lead to 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 period required for Alternative 10 (nine seasons) and the large quantity of sediment targeted for removal as part of both Alternatives 9 and 10 (515,000 and 1,650,000 cy, respectively), short-term impacts resulting from implementation of these alternatives would be the most significant among the ten alternatives. The actual timeframe for construction of the selected remedy would not be established until the remedial design phase; therefore, construction periods and duration of associated short-term impacts may be different from what is presented here.

With regard to near-term improvements, Alternatives 1 and 2 would require the longest period of time to provide near-term improvements in PCB levels in fish and loading to the St. Lawrence River relative to the other alternatives. For the alternatives that include an active remediation component, reductions in both fish tissue PCB concentrations and PCB loading to the St. Lawrence River are driven by the placement of a cap. The addition of dredging to either Alternative 3 (in Alternatives 4 and 5) or Alternative 6 (in Alternatives 7 through 9) provides only marginal additional reductions in PCB levels, even when using what Alcoa believes are optimistic assumptions regarding dredging effectiveness.

Time to Achieve Risk Reduction & Cost

The alternatives can be placed into three different groups that generally reflect the length of time necessary to achieve the PCB reduction metrics associated with the RAOs. These groups, developed in Section 6.4, are Alternatives 1 and 2, Alternatives 3 through 5 and Alternative 10, and Alternatives 6 through 9. As shown on the figure to the right, Alternatives 3, 4, 5, and 10 all achieve comparable reductions in PCB levels in fish by 2030 (from 6.3 mg/kg in 2000 to approximately 0.3 mg/kg in 2030), but Alternative 3 is by far the most cost effective – the cost of Alternative 10 is nearly 17 times the cost of Alternative 3. Similarly, implementation of Alternative 6, 7, 8, or 9 would provide comparable reductions in fish tissue PCBs by 2030 (resulting in projected PCB concentrations in fish tissue of approximately 0.15 mg/kg by 2030), but Alternative 6 would cost $20 to $141 million less than the other alternatives in that group. Alternative 6 is expected to provide a modest incremental benefit in fish tissue PCB reductions as compared to Alternative 3, but at an additional cost of $24 million ($55 million versus $31 million). The inclusion of dredging in conjunction with capping provides only minimal additional benefit in terms of absolute reductions in predicted PCB levels in fish and loading to the St. Lawrence River – even when using assumptions that likely overestimate the effectiveness of dredging and underestimate the benefit of capping. In all cases, dredging adds significant cost, but provides only incremental reductions in PCB concentrations and risks.



Cost as a Function of Predicted Fish Tissue PCB Levels in 2030

Summary

While no perfect remedy exists for the Grasse River, the most effective remedy would be one where each element directly supports reduction of identified risks to human health and the environment. Based on information gathered and assessed to date, it is clear that reduction of surface sediment PCB levels over a

large area of the lower Grasse River is necessary to achieve 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. The lessons learned during the NTCRA and the Capping Pilot Study indicate that while capping effectively reduces surface sediment PCB concentrations without any significant environmental impacts, dredging can lead to releases of PCBs during implementation and may result in residual PCB levels in sediment that are higher than current conditions. To account for the potential for elevated PCB residuals in sediments after dredging, a number of 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 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 and the Capping Pilot Study lead to the following conclusions:

- The primary differences among the alternatives are the projected rates at which PCB concentrations decline, short-term effectiveness, and cost.
- Site-wide natural recovery (Alternatives 1 and 2) is predicted to achieve a high level of reduction in fish tissue PCB concentrations compared to current levels at the lowest cost, albeit over a longer time frame than alternatives with active remediation components.
- Effectiveness of the alternatives involving active remediation is driven by placement of a cap. When combined with large-scale capping, removal of sediment from the River has a relatively small modeled influence on the achievement of PCB metrics, even when using what Alcoa believes to be optimistic assumptions regarding dredging effectiveness.
- 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.
- Short-term increases in PCB fish tissue levels and loading to the St. Lawrence River may 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 alternatives (Alternatives 3 and 6) provide an equivalent level of risk reduction to the combination alternatives (Alternatives 4, 5, 7, 8, and 9) and the dredging-only alternative (Alternative 10) at much lower cost.
- Alternative 6 is expected to provide only an incremental benefit relative to Alternative 3 – as measured by predicted fish tissue PCB concentrations in 2030 – at an additional cost of $24 million.

Based on the above information and in consideration of effectiveness, cost, and degree of disruption to the River and the community, Alcoa supports a combination of capping and monitored natural recovery as the most appropriate remedy for the site. This approach directly addresses the principal threat for the site, consistent with the NCP, which is the chronic flux of PCBs from the sediments to the water column. Alcoa recognizes that such a remedy requires a commitment to long-term monitoring and maintenance, and can make that commitment.

Alcoa believes that any large-scale remediation should be implemented in phases – both to minimize disruption to the existing ecosystem and to provide for data gathering between phases to support the need for and, if necessary, the design of subsequent activities. Such an iterative approach, as advocated in the USEPA's *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, February 2002), has been successfully used at this site and should be extended to the remediation phase of the project.

Large sediment sites such as the Grasse River Study Area are complex, and all involved in their evaluation are still learning about the most effective ways to balance the need to protect human health and the environment with the inevitable impacts of active remediation. 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.

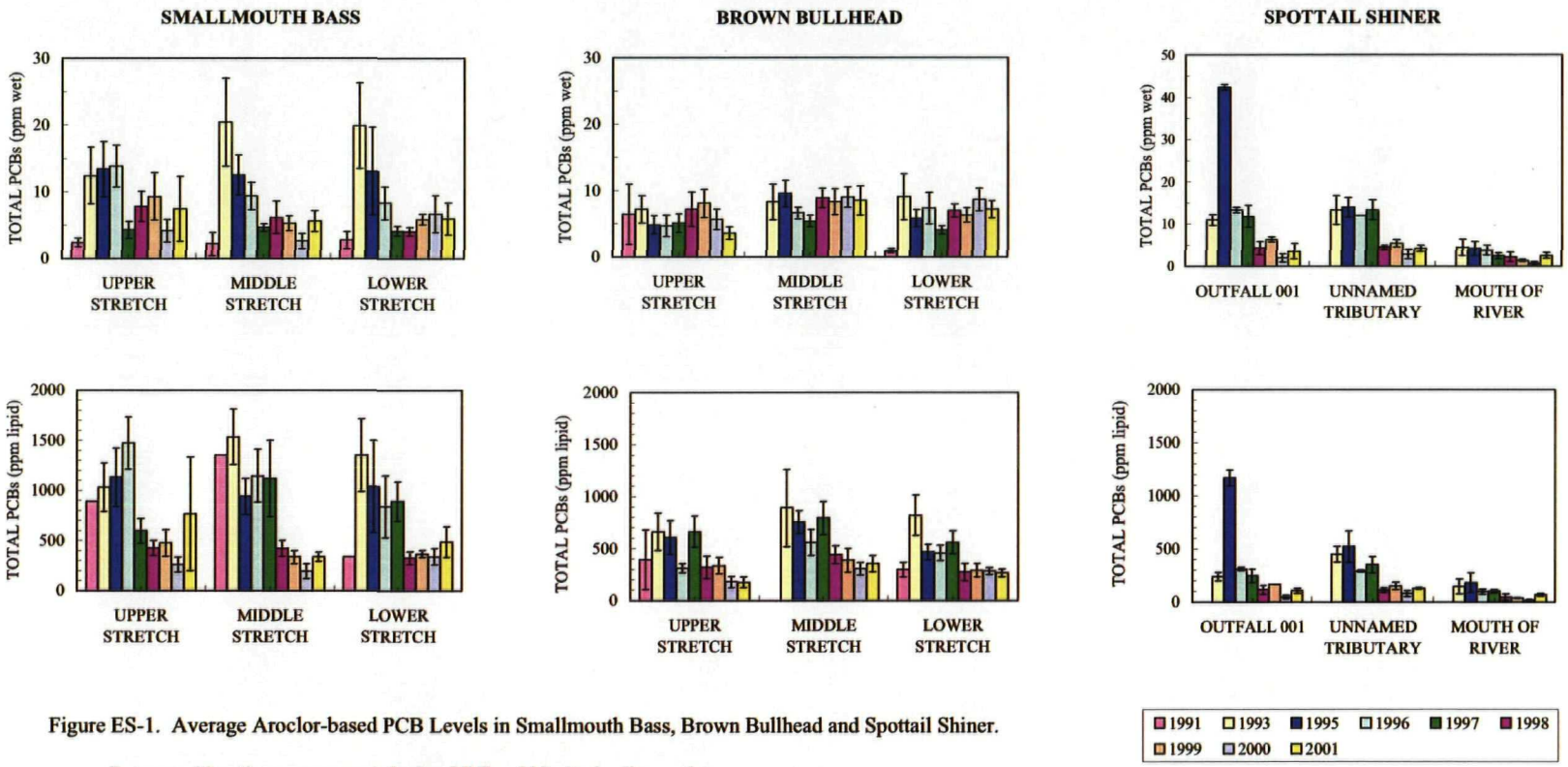


Figure ES-1. Average Aroclor-based PCB Levels in Smallmouth Bass, Brown Bullhead and Spottail Shiner.

Data are arithmetic means computed using fall Trend Monitoring Survey data.
Values are arithmetic means +/- two standard errors of the mean.
Smallmouth bass and brown bullhead values for fillet samples; spottail shiner samples analyzed as whole body composites.

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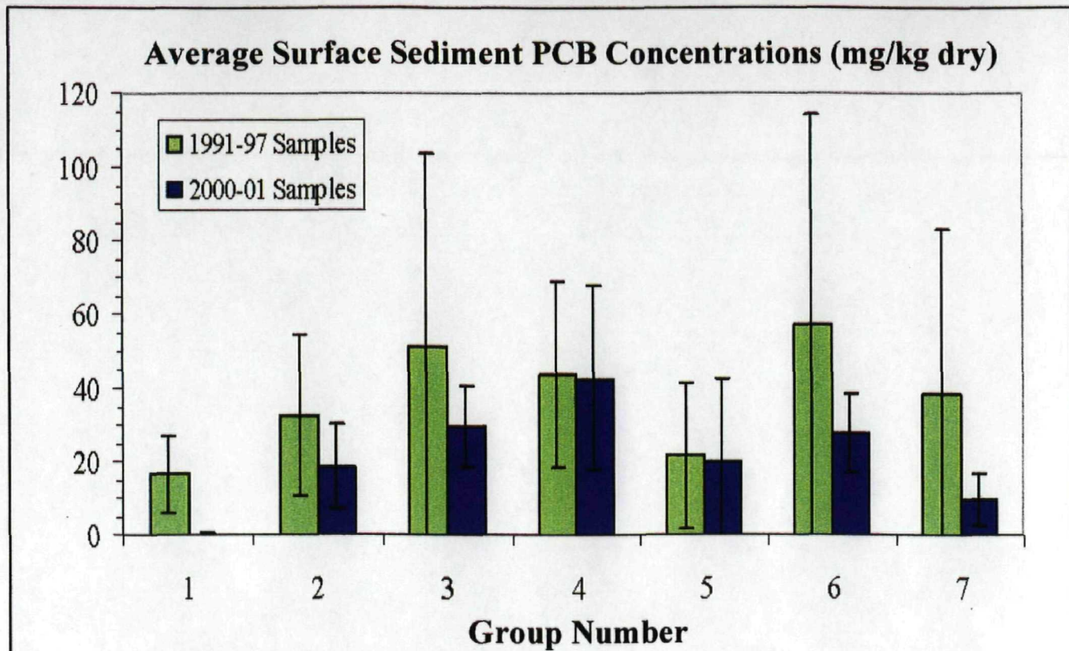
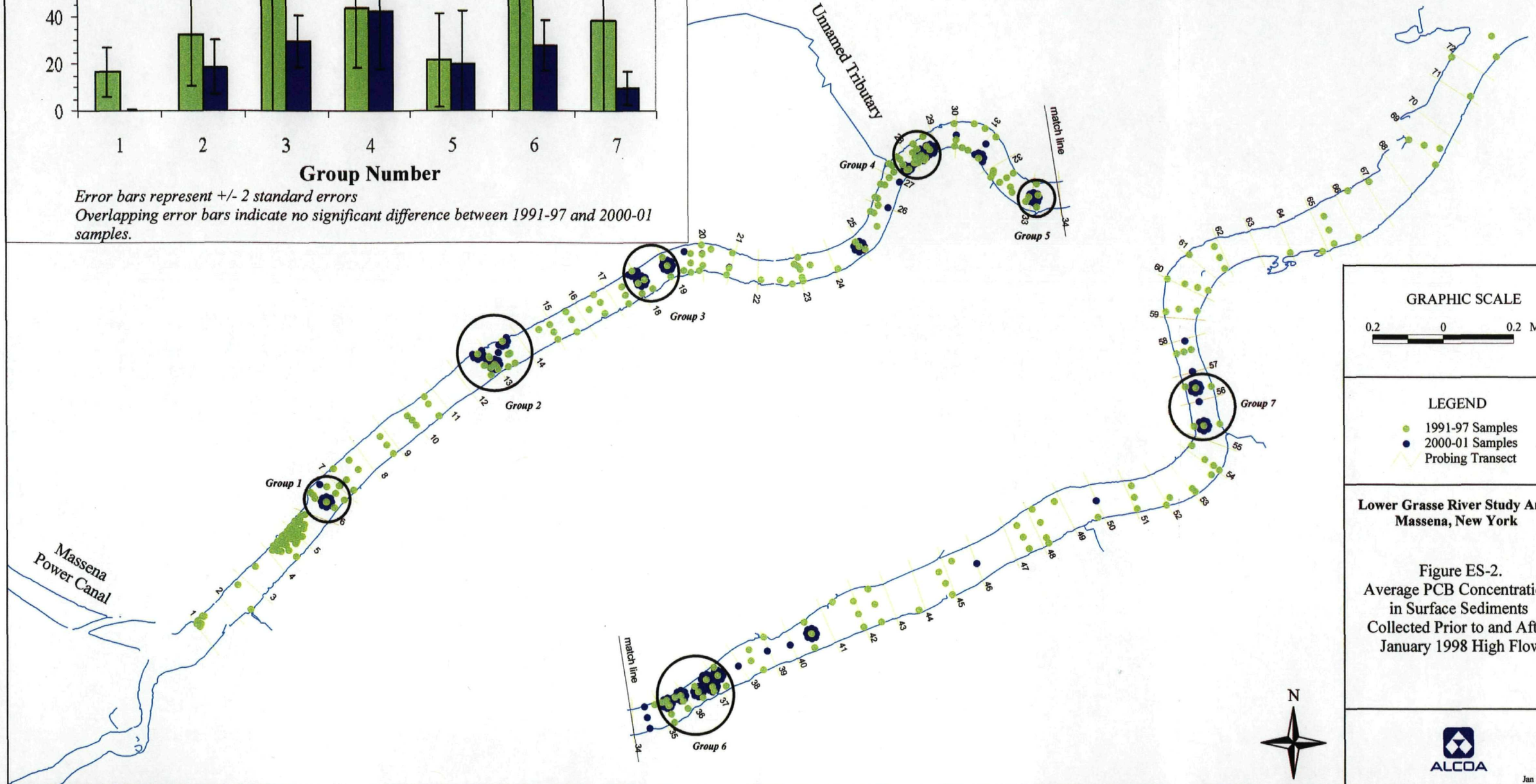


Error bars represent +/- 2 standard errors
Overlapping error bars indicate no significant difference between 1991-97 and 2000-01 samples.



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

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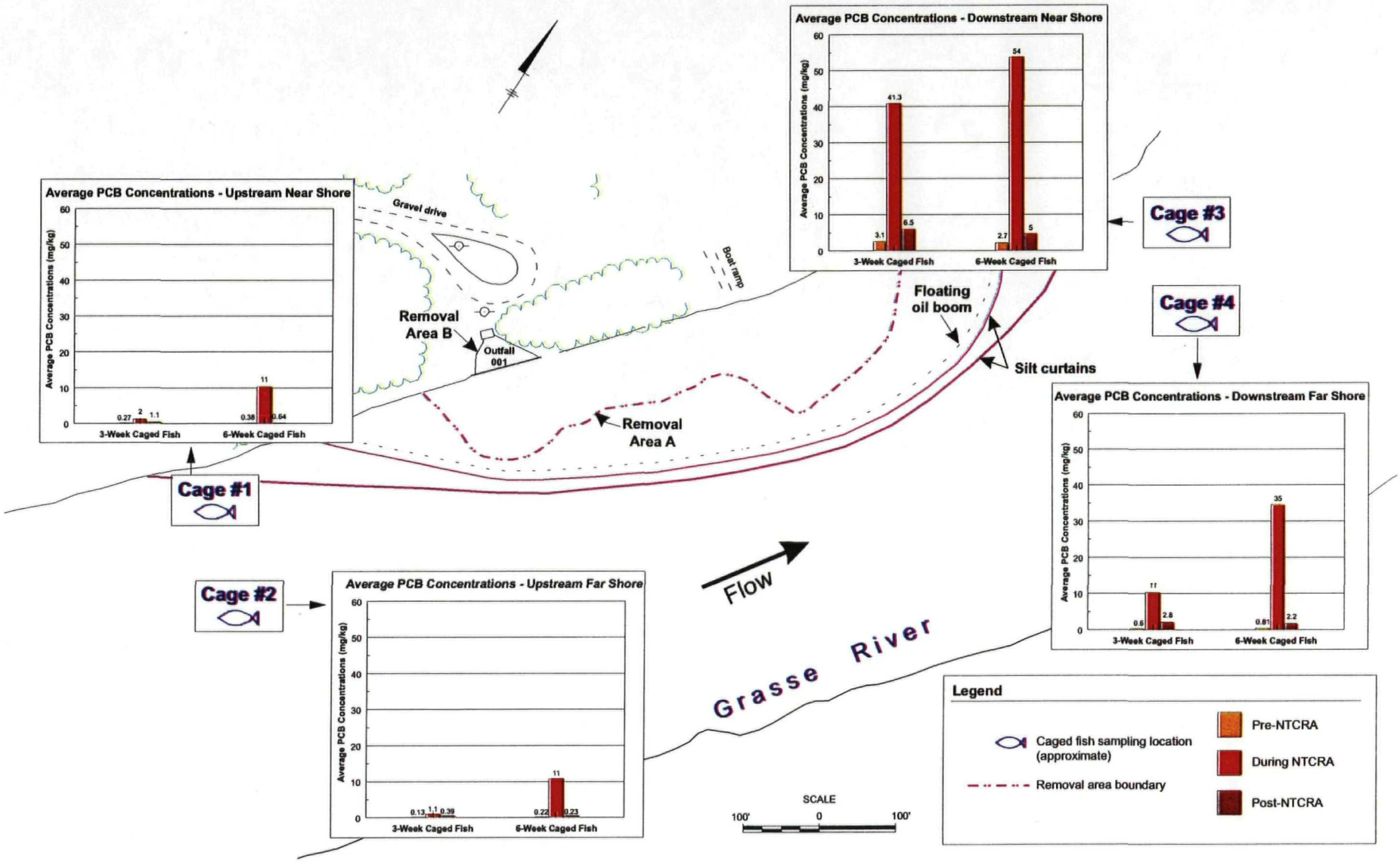
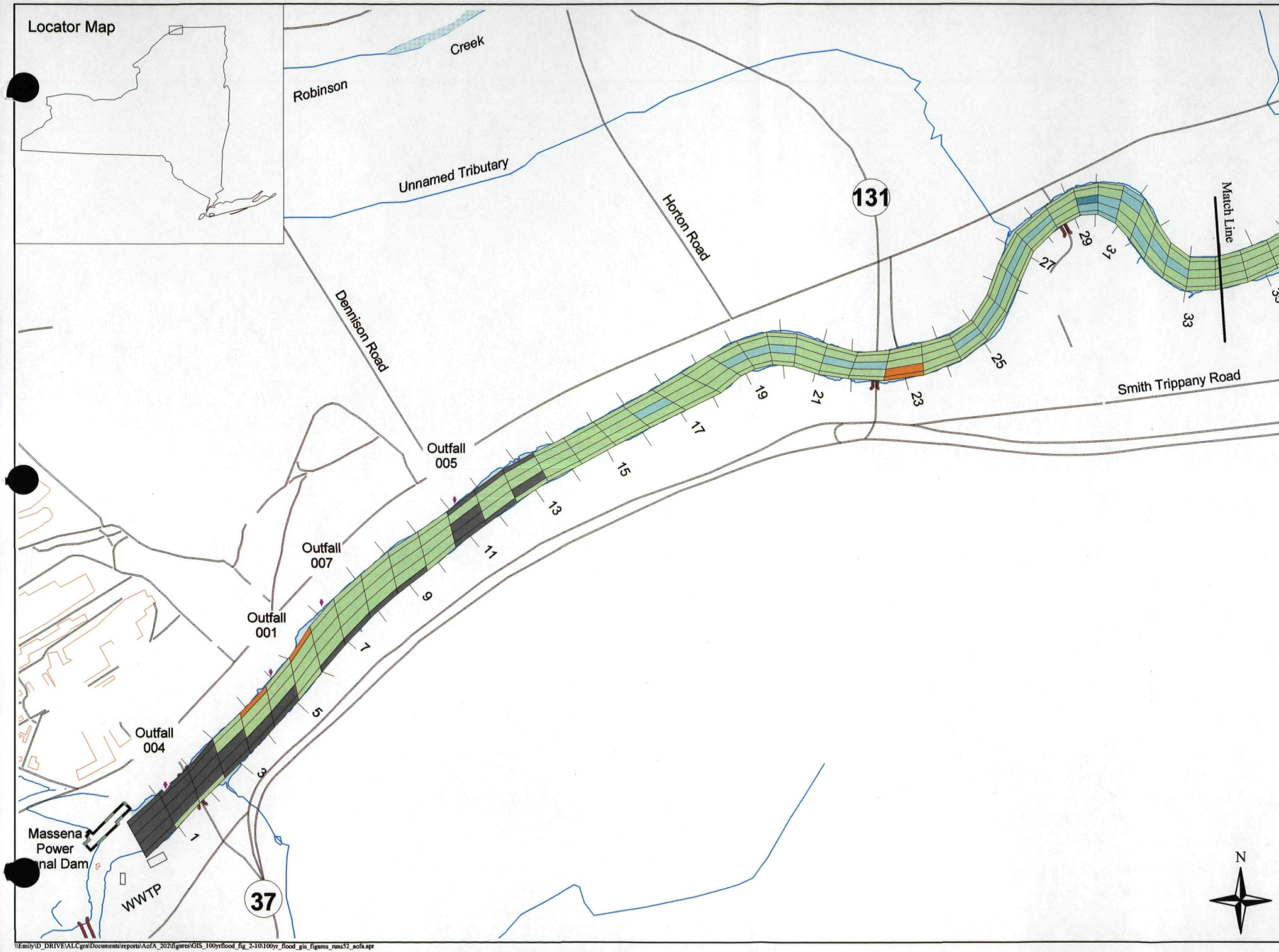


FIGURE ES-3. NTCRA Average PCB Concentrations at Caged Fish Locations



GRAPHIC SCALE

400 0 400 Feet

LEGEND

- Hard-bottom Areas
- 100 Year Flood Erosion Depths (cm)
  - Deposition
  - 0 - 0.5
  - 0.5 - 1
  - 1.0 - 1.5
- 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
- River.shp

Lower Grasse River Study Area
Massena, New York

Figure ES-4A.
Spatial Distribution of
Net Erosion in the Lower
Grasse River During a
100-Year Flood Event
(Bounding Estimates)

1 of 2

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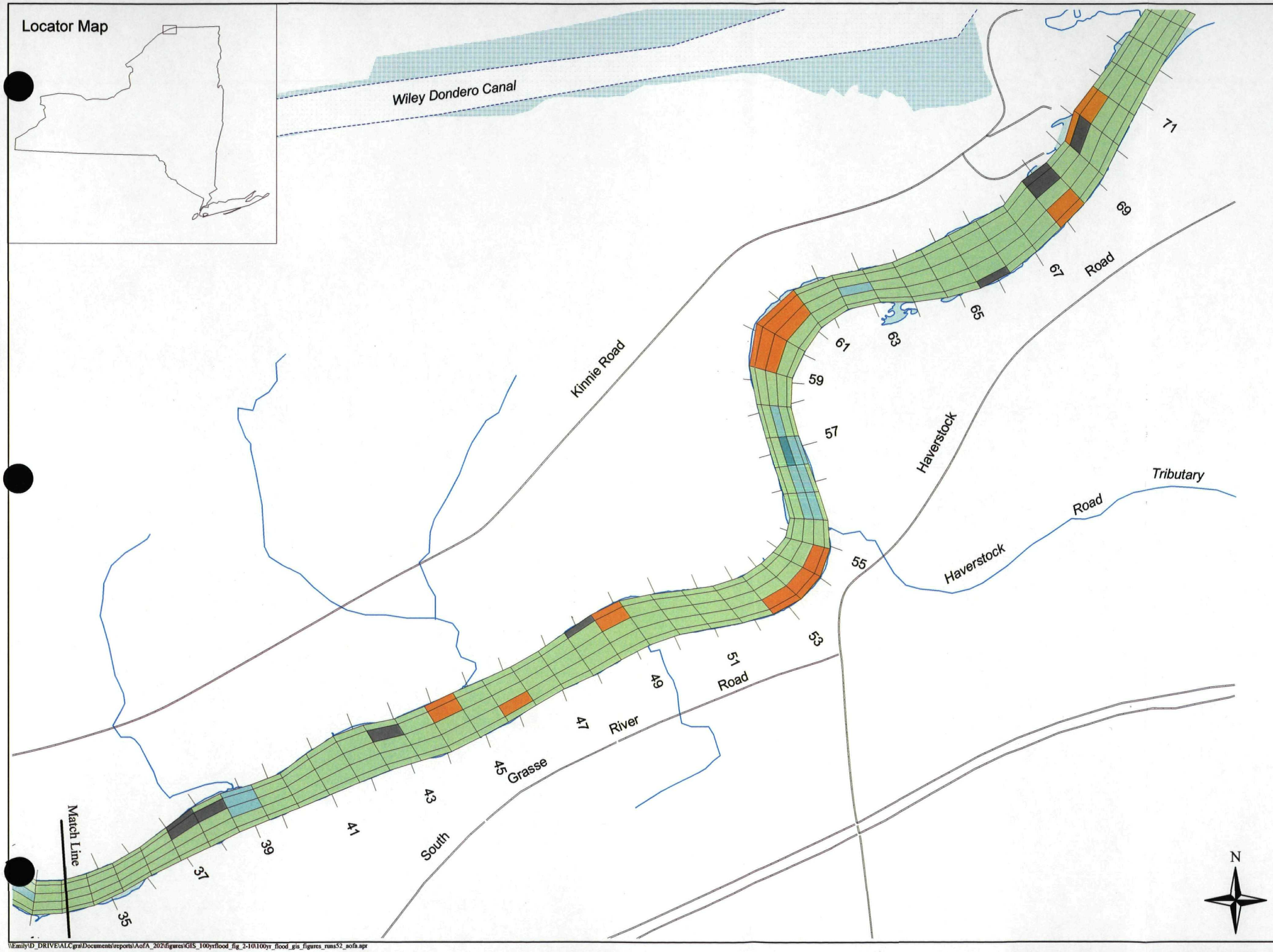

GRAPHIC SCALE

400 0 400 Feet

LEGEND

- Hard-bottom Areas
- 100 Year Flood Erosion Depths (cm)
  - Deposition
  - 0 - 0.5
  - 0.5 - 1
  - 1.0 - 1.5
- 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
- River.shp

Lower Grasse River Study Area
Massena, New York

Figure ES-4B.
Spatial Distribution of
Net Erosion in the Lower
Grasse River During a
100-Year Flood Event
(Bounding Estimates)

2 of 2

ALCOA

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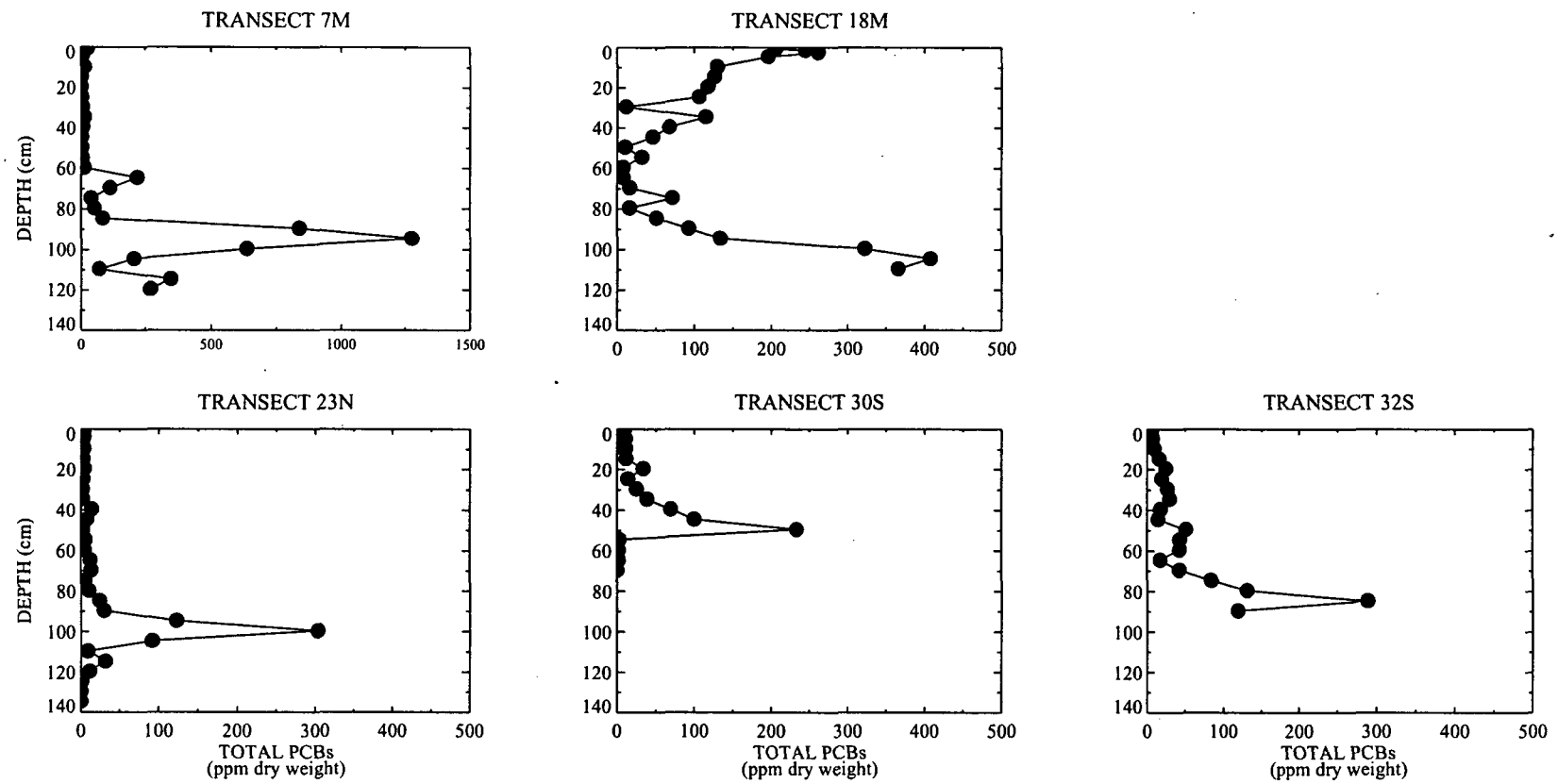

Figure ES-5. Vertical Distribution of Total PCB Levels in Sediment Cores Collected from the Lower Grasse River.

Data from 1997 SRS Sediment Core Sampling Program.

Data table: sediment_bz

1. Introduction

1.1 Overview

In accordance with the United States Environmental Protection Agency's (USEPA's) Administrative Order (Index No. II CERCLA 90229) issued to Alcoa Inc. (previously known as the Aluminum Company of America - Alcoa) on September 28, 1989 and amended on May 24, 1995, this Analysis of Alternatives (AA) Report presents the development and evaluation of ten potential remedial alternatives for the Grasse River Study Area in Massena, New York (Figure 1-1). The information presented in 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's Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final (USEPA, October 1988).

Based on numerous studies of the sediment, surface water, and biota carried out in the Grasse River over the last decade, the primary concern that potential remedial alternatives are designed to address is the potential risk associated with the consumption of fish containing elevated levels of polychlorinated biphenyls (PCBs). As such, each alternative is evaluated based on, among other criteria, its ability to achieve the objectives of reducing potential risks to human health and the environment and decreasing the transport of PCBs to the St. Lawrence River. The remedial alternatives are designed for the lower Grasse River – the reach of the River between the Massena Power Canal (Power Canal) and the St. Lawrence River – because results of the risk assessments conducted for the Study Area (see Section 3.2) indicate that the greatest concern for potential human health effects is associated with consumption of fish from this particular reach. A fish consumption advisory (eat none) is currently in effect due to elevated levels of PCBs in fish in the lower Grasse River (New York State Department of Health [NYSDOH], 2001-2002).

This report is the result of more than two years of significant interaction between Alcoa and USEPA, the New York State Department of Environmental Conservation (NYSDEC), and the St. Regis Mohawk Tribe (SRMT) (collectively referred to as the Agencies). Information and input gathered during discussions with the Agencies have been incorporated throughout this document, as appropriate.

In addition to the coordination with and direction provided by the Agencies, development of the ten potential alternatives is based on the following:

- results of Alcoa's River and Sediment Investigation (RSI) and Supplemental Remedial Studies (SRS) Programs, as provided in the final Comprehensive Characterization of the Lower Grasse River (CCLGR) Report (Alcoa, April 2001; Alcoa, April 2002b);
- results of the Non-Time-Critical Removal Action (NTCRA) dredging (Blasland, Bouck & Lee, Inc. [BBL], December 1995);
- results of the final Lower Grasse River Capping Pre-Engineering Design Studies Report (Alcoa, March 2001);
- results of the Human Health Risk Assessment Update (Alcoa, September 2001); and
- results of the Capping Pilot Study (Alcoa, April 2002a).

Alcoa has also taken steps to involve the local community in the development of potential remedial alternatives. Throughout the 1990s, Alcoa worked with local business owners and the public, held annual open house meetings, and jointly ran several public meetings with the USEPA to keep interested parties informed and involved. In 2001, Alcoa 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 in April

2001 including representatives from town government, the community, the SRMT, regulatory agencies, and local interest groups. Other activities conducted to date include a public meeting to discuss the capping pilot project in July 2001 and public availability sessions at the St. Lawrence Centre Mall (November 2001) and the Massena Public Library (February 2002). Additional activities will be planned in the future, to provide the public with opportunities to comment on the evaluation of the potential remedial alternatives.

The Grasse River Study Area is a unique site, and the task of developing and evaluating the potential remedial alternatives is a complex undertaking. Throughout this process, an effort was made to follow the guidance offered in *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.

The sections that follow briefly describe the extensive site-specific investigations carried out to develop a thorough understanding of the Study Area (see Figure 1-1). These investigations lay the groundwork for the in-depth analysis of the potential remedial alternatives presented in Sections 5 and 6.

1.2 Study Area

The Grasse River Study Area is located along the northern boundary of New York State in the town of Massena (population of about 15,000), 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 facility, also known as Alcoa Massena-West, is on the north shore of the lower Grasse River near Massena. Two other large manufacturing facilities, Alcoa Massena-East (formerly Reynolds Metals Company [RMC]) and the General Motors Corporation (GM), are located approximately seven miles northeast of Massena, adjacent to the St. Lawrence River. The SRMT Reservation is located along the St. Lawrence River downstream of the GM facility.

The Study Area extends from just downstream of the Route 37 Bridge in Massena to the St. Lawrence River confluence, and includes the Massena 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 Massena Power Dam at the Power Canal/Grasse River confluence. After the construction of the Power Canal, the lower Grasse River reportedly was dredged between 1914 and 1918 to handle the increased water flow associated with the operation of the Power Canal. The 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.

Dredging of the River significantly altered both its physical and ecological characteristics. The impacts of this dredging still exist today – typical velocities in the Grasse River through the Study Area are very low, and from the Power Canal to the confluence with the St. Lawrence River, the River's banks are steep, the bottom is underlain by bedrock or hard till, and there are minimal floodplains. To develop a more comprehensive picture of the characteristics of the River bottom, sediment probing was conducted throughout the Study Area. In 1998 and 2001, this probing effort was supplemented by in-depth surveys of the upper 3.5 miles of the lower Grasse River using side-scan sonar and sounding techniques. Results of the in-depth surveys and probing revealed that the River bottom materials and characteristics vary in the Study Area, and include the presence of boulders, cobbles, and rock outcrops in some areas (Ocean Surveys, Inc. [OSI], January 2002). See the OSI Reports (December 1998, August 2001, December 2001, and January 2002) for more detail.

The St. Lawrence River is a hydraulic control point that significantly affects both the water depth and flow of the lower Grasse River. 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. The low flow, coupled with the fact that the depth, and consequently the cross section, of the River increase 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 – make the lower Grasse River the functional equivalent of a reservoir and a backwater of the St. Lawrence River. When flows are low, especially during the summer months, the colder water from the St. Lawrence migrates upstream along the bottom of the lower Grasse River, leading to periods of thermal 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.

The middle of the River channel in much of the Study Area is fairly deep (15 to 25 feet). As a result, areas capable of supporting diverse and abundant vegetation and fish communities are primarily associated with the near-shore zones within 25 feet of either River bank.

As shown on Figure 1-2, 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 them. As stated previously, the minimal floodplains and relatively steep banks exhibited in the lower six miles of the Grasse River can be attributed to the channelization and dredging activities performed during the early 1900s. 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). Also depicted on Figure 1-2 are wetland areas contiguous to the Study Area as defined by the National Wetlands Inventory (United States Department of the Interior [USDOI], May 1981).

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).

1.3 Alcoa Facility – History and Source Control

The 2,700-acre Alcoa facility, in operation since 1903, is located adjacent to the lower Grasse River, and consists of three major production areas, including a Fabricating Plant, an Ingot and Extrusion Plant, and a Smelting Plant (Figure 1-3). Throughout the years, the facility's production processes generated various waste by-products (e.g., waste oil, solvents, caustics, and acids), which historically were disposed in on-site lagoons and landfills; a practice that, at the time, was common and generally accepted. The environmental effects of these disposal methods were not understood until much later. In 1985, the NYSDEC determined that select areas throughout the facility posed a potential threat to the surrounding environment. Since control of ongoing sources is a critical first step in any sediment remediation effort (USEPA, April 1998; NRC, 2001), an extensive investigation/remediation effort was initiated at the plant in 1991. This effort, conducted in accordance with two Records of Decision issued by NYSDEC in 1991 and 1992, was designed to mitigate any further off-site migration of chemical constituents, especially to the lower Grasse River. The source control actions completed between 1991 and 2001 have dramatically reduced PCB discharges from Alcoa's facility to the lower Grasse River, Robinson Creek, and the Unnamed Tributary. These efforts, which were a critical first step in improving the state of the River, included:

- Construction and use of three new stormwater/wastewater impoundments providing for additional management of stormwater runoff from the Alcoa facility;

- Remediation of several on-site lagoons, including the 60-Acre Lagoon and the Soluble Oil Lagoon, landfills, and other disposal areas containing PCBs;
- Remediation of a major portion of the Unnamed Tributary, which discharges to the lower Grasse River;
- Cleaning of several 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; and
- 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.

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

1.4 Previous Study Area 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 carried out two projects designed to evaluate the efficacy of both capping and dredging for management of PCB-containing sediments. These in-depth field investigations, activities, and the analysis of potential remedial alternatives (see Sections 5 and 6) lay the groundwork for selecting an appropriate remedial approach.

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

- *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. Results were considered in the development and analysis of potential remedial alternatives (Alcoa, April 2001).
- *RSI Program – Phase II (July 1993 – 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).
- *Non-Time-Critical Removal Action (July – September 1995):* Analysis of the RSI Program data revealed elevated levels of PCBs in an area of sediment adjacent to Alcoa's Outfall 001 (Figure 1-1). Alcoa removed, dewatered, and disposed of 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 Program (initiated in 1995, ongoing):* Surveys of PCB levels and other parameters (including water temperature, suspended solids, and organic carbon content) in sediment, surface water, fish, and semi-permeable membrane devices (SPMDs) are carried out between April and November each year to support an understanding of PCB fate and transport processes in the River. This information is critical for the development of a supportable conceptual site model which 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).

- *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).
- *Supplemental Sediment Sampling (SSS) (2000-2001)*: 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; Section 2 and Appendix B of this report).
- *Capping Pilot Study (Summer – Fall 2001):* Capping materials were placed over a 750-foot stretch of the lower Grasse River (see Figure 1-1) to evaluate several different cap designs and placement techniques and gather site-specific data on the feasibility and efficacy of capping (Alcoa, April 2002a).

1.5 Report Organization

The remainder of this AA Report is organized into six sections. A conceptual site model for the lower Grasse River system is presented in Section 2, while Section 3 discusses 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. Finally, Alcoa's recommendation for the site is presented in Section 7.

2. PCBs in the Lower Grasse River

2.1 Introduction

Identification of effective remedial alternatives to address potential risks associated with the presence of PCBs in the lower Grasse River requires an understanding of the nature and extent of PCBs, and the PCB fate and transport processes in the River, under both present day and future scenarios. To develop this understanding, Alcoa conducted a decade-long program of field and laboratory studies (see Section 1.4), coupled with the development of predictive numerical fate and transport models. This approach follows the recommendations of the recent NRC report on management of PCB-contaminated sediments (NRC, 2001). The analysis of the data and information gathered during these studies has provided an understanding of the processes that can affect PCB transport and bioaccumulation within the River, and from this, the ability to comparatively assess the effectiveness of various approaches for improving conditions in the River.

In addition to the efforts associated with the River program, Alcoa expended significant resources between 1991 and 2001 to eliminate on-site sources of PCBs to the River. These on-site remediation efforts, which were a critical first step in managing the PCB-containing sediments in the Study Area, are briefly described in Section 1.3.

The River studies focused on the collection and interpretation of the site-specific data needed to develop an overall conceptual model and a predictive numerical model. The specific program activities utilized in these efforts are summarized in Table 2-1, and include the following:

- Collection of almost 800 sediment samples to determine the nature and extent of PCB-containing sediment and the trends in PCB levels of surface sediments to which the water column and the biota are exposed;
- Collection of almost 1,000 water column samples to determine the spatial and temporal trends in PCB levels and support identification of the significant sources of the PCBs found in the water column;
- Collection of almost 1,700 fish samples 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 in the River, 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 PCB-containing sediments;
- Measurement of the erosion potential of the River sediments using both "Shaker" and SedFlume devices to support assessment of the erosion that would occur under high-flow conditions;
- 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 River 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 the sediment would be subjected during high-flow events;
- Development of a sediment transport model within the River 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 provide a means to predict the short- and long-term effectiveness of various remedial approaches;
- Implementation and extensive 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; and
- Implementation and intense monitoring of the Capping Pilot Study, a site-specific field program designed to develop an understanding of the feasibility and construction impacts associated with the use of capping as a remedial option.

An external peer review process provided oversight of these activities to ensure proper scoping of studies and interpretation of results. Periodic project review was also conducted by the Alcoa Environmental Technical Advisory Board (ETAB). This board consists of two members of the National Academy of Engineering (Drs. Raymond Loehr of the University of Texas and Perry McCarty of Stanford University); Dr. Granger Morgan, Head, Department of Engineering and Public Policy at Carnegie Mellon University (CMU); and Dr. Andrew Middleton, President of Corporate Environmental Solutions. In addition, an expert panel reviewed the laboratory capping studies. This panel consisted of Mr. Steven Liikala, Wilder Construction, Inc.; Drs. Louis Thibodeaux and Danny Reible, Louisiana State University; Dr. Gerald Matisoff, Case Western Reserve University; Dr. Wilbert Lick, the University of California at Santa Barbara; and Dr. Robert Werner, State University of New York College of Environmental Science and Forestry. Finally, field capping studies were reviewed by the expert panel mentioned above and by members of the USEPA-sponsored Remedial Technologies Development Forum (RTDF).

The results of the River studies are summarized below. More detailed information can be found in the CCLGR Report (Alcoa, April 2001), the NTCRA Documentation Report (BBL, December 1995) and the Capping Pilot Study Documentation Report (Alcoa, April 2002a).

2.2 Ongoing PCB Sources

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

2.2.1 Upstream Sources

Forty-five water column samples were collected upstream of the lower Grasse River during the SRS Program at the Main Street Bridge and Transect WC001 (see Figure 2-1). PCB concentrations were below the nominal

detection limit (20 nanograms per liter [ng/L]) in almost all samples, and averaged an estimated 3 ng/L. These estimated PCB concentrations are similar to PCB levels measured in rain collected in the Great Lakes region during the late 1980s and 1990s (1 to 8 ng/L; Eisenreich and Strachan, 1992; 1 to 12 ng/L, USEPA [undated]; 1 to 3 ng/L, Simcik et al., 2000). Low PCB levels also were measured in SPMDs deployed at the upstream location (averaging 0.12 micrograms [μg] compared to 32.8 μg downstream at Transect WC007). Sediment samples collected in the upstream Grasse River between the Route 37 Bridge and water column Transect 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 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 were below the nominal detection limit (average of 7.9 ng/L). In 1999, all water samples collected from the Massena Intake Dam on the St. Lawrence Seaway (Transect 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). Surface sediment samples collected in 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 sources within the lower River are significantly higher than 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 (water column Transect WC004), and at a transect one mile downstream of Outfall 001 (water column Transect WC007). 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 samples were 5- to 10-fold lower. Stratification is sometimes observed at Transect 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) (Figure 1-3). Two other outfalls, 002 and 005, function as emergency bypasses for storms that exceed design levels. PCB discharges from Outfall 001 have declined in response to remediation activities from about 60 grams per day (grams/day) in 1990 to about 1.7 grams/day in 1997 (Figure 2-2). In 1998, PCB discharges from Outfall 001 increased to about 6.3 grams/day, likely due to 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[1]. PCB discharges from Outfall 001 in 1999 and 2000 averaged 2.1 grams/day and 1.4 grams/day, respectively. In comparison, the PCB flux from the River sediments in the first three miles downstream of the outfalls is estimated to be about 50 grams/day.

[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.

Comparison of PCB composition[2] in SPMDs deployed in the Outfall 001 mixing basin to SPMDs deployed in the River indicate that PCBs from Outfall 001 contain a greater amount of higher chlorinated congeners than samples from the River (Alcoa, April 2001). This difference in PCB composition between Outfall 001 and the River provides further support for the conclusion that Outfall 001 is not a significant contributor to water column PCBs (Figure 2-3).

While the outfall discharges were the original source of PCBs to the River, mass balance calculations generated by the PCB fate model for the four-year calibration period (1997-2000) indicate that PCBs from Outfalls 001, 004, 005, and 007 represent less than 5% of the PCB mass discharges to the River during this period (Alcoa, April 2001). As discussed previously, the extensive external source control efforts implemented at the Alcoa facility between 1991 and 2001 have dramatically reduced PCB discharges to the lower Grasse River. Additional on-site efforts are currently planned to further reduce outfall discharges.

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

PCB discharges from the former Outfall 002 entered the Unnamed Tributary, an 8,000-foot long channel that primarily discharges surface water collected from the northern portion of the Alcoa facility directly to the lower Grasse River (see Figure 1-1). Prior to the 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.

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 below the nominal detection limit of 20 ng/L (reported range of 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).

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 ~ 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 greater levels of hexa- and hepta-chlorobiphenyls (i.e., PCB molecules containing 6 and 7 chlorine atoms, respectively) relative to those observed in the River (Figure 2-4) (Alcoa, April 2001).

Although not a plant outfall, the Massena Waste Water Treatment Plant (MWWTP) is a potential source of PCBs to the lower Grasse River. It 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 water column Transect WC004 (14.0 ng/L) and from water column

[2] PCBs are mixtures of 209 related chemical compounds (also known as congeners) that contain between 1 and 10 chlorine atoms. When evaluating the composition of these mixtures, the individual compounds typically are grouped by PCB homolog. A PCB homolog is defined as all PCB-related molecules that contain the same number of chlorine atoms. For example, all PCB molecules that contain 1 chlorine atom are considered mono-CBs, those that contain two chlorine atoms considered di-CBs, etc.

Transect 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 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 River Sediments

Deposits of sediment exist on most of the 405 acres of River bottom in the lower Grasse River. Nearly all of the sediment depths vary between 0 and 5 feet. A few isolated deep sediment deposits exist with depths up to 10 feet. Cobbles and boulders are commonly found in the sediment deposits. The sediments generally are underlain by bedrock or hard till. Results of PCB sediment sampling are shown on Figures 2-5 through 2-10, and are detailed below.

2.3.1 PCBs in Surface Sediments

PCB concentrations in surface sediments[3] are highly variable and range over several orders of magnitude, even for closely-spaced samples (Figure 2-11). The average PCB concentration in surface sediments of the lower Grasse River is about 11 mg/kg (area-weighted average using polygon analysis). Between River miles 6.3 and 3.3 (see Figure 2-1 for mile markers), surface sediment PCB concentrations average about 18 mg/kg. Downstream of River mile 3.3, the average surface sediment PCB concentration is about 6 mg/kg. Except for several samples collected between River miles 1.5 and 1.8, surface sediment PCB concentrations in the lower 3 miles generally are below 10 mg/kg, and decline to about 1 to 2 mg/kg near the mouth of the River. In general, the higher PCB levels tend to be found in areas with deeper water (i.e., closer to the middle of the channel). The significant variability in the surface sediment PCB concentrations suggests that the surface 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 2-12) which indicate that, although areas of elevated surface sediment PCB concentrations may have local effects, these areas are not the predominant source of the PCBs in the water column (Alcoa, April 2001).

2.3.2 PCBs in Buried Sediments

Sediment core data collected in 1991, 1997, 2000, and 2001 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. In 1997, the peak PCB concentration in Core 30S was measured about 50 centimeters (cm) (1.6 feet) below the sediment-water interface; peak PCB

[3] Although an extensive database exists for PCBs in lower Grasse River sediments, the data analysis is complicated by the different segmentation schemes employed during each of the surveys. For example, sediment cores collected in 1991 were divided into 0- to 3-inch, 3- to 12-inch, 12- to 24-inch and 24- to 36-inch segments (when possible). In 1993, cores were generally divided into 12-inch segments, while cores in 1995 were segmented into 0- to 1-inch, 1- to 6-inch and 6- to 12-inch slices. In 1997, sediment cores were segmented into 1-centimeter slices (to depth of core) while grab samples represented the top 3 inches of sediment. Finally, sediment cores collected in 2000 and 2001 were divided into the same depth intervals as in 1991 (0- to 3-inch, 3- to 12-inch, 12- to 24-inch and 24- to 36-inch slices). In an attempt to make use of the entire data set, samples collected within the top 3 inches of the sediment surface during the 1991, 1995, 1997, 2000 and 2001 surveys, and all 0- to 12 inch samples from the 1993 survey, were considered "surface sediments."

levels in the other four cores occurred between 85 to 105 cm (2.8 to 3.5 feet) below the sediment-water interface (Figure 2-13). Average PCB levels in sediment cores collected in 2000 and 2001 generally increase with sediment depth, with maximum PCB levels observed approximately 2 to 3 feet below the sediment-water interface (Alcoa, April 2001). PCB concentrations observed in dated fine-resolution cores tend to be highest at depths near the cesium-137 (^{137}Cs) peak, corresponding to the early 1960s time frame. The sharpness of the concentration gradients around the PCB and ^{137}Cs peaks indicates that once deposited, the sediments remained in place with little resuspension or mixing. These data are consistent with the conceptual site model of historic PCB discharges accumulating in the deeper sediments and being gradually covered over by cleaner sediments as on-site sources of PCBs to the River were controlled.

Buried sediments can act as a PCB source to the water column and fish, if mechanisms that are capable of moving these sediments (or the PCBs in them) to the surface sediments or to the water column are operational. These mechanisms include molecular diffusion, groundwater movement through the sediments to the River, sediment resuspension, bioturbation, ice scour, and propeller wash (prop wash). The significance of each of these potential transport mechanisms is evaluated in Section 2.6.

2.4 PCBs in the Water Column

PCB levels in the lower Grasse River exhibit a distinct seasonal pattern; highest levels 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 in levels over the period of record. These temporal patterns are partially explained by seasonal and year-to-year variations in River flow. However, the patterns also are evident in 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 water column Transect WC007, maximum summertime PCBs declined from 200 to 260 ng/L in 1995 to about 50 ng/L in 2001 (Figure 2-14, top panel). At water column Transect WC007A, PCB levels declined from about 300 ng/L in 1995 to about 120 ng/L in 2001 (2000 and 2001 samples collected from Route 131 Bridge located about 500 feet upstream of Transect WC007A; Figure 2-14, middle panel). Finally, PCB levels measured at water column Transect WC011 in summer 2001 are about 1.5 to 2 times lower than those observed in summer 1995 (Figure 2-14, bottom panel) (Alcoa, April 2001).

2.5 PCBs in Resident Fish

Resident fish have been collected from various stretches (see Figure 2-15) within the Grasse River over several years. Average wet tissue PCB concentrations in smallmouth bass have ranged over about a factor of ten from about 2.5 mg/kg in 1991 to about 20 mg/kg in 1993 (Figure 2-16). Between 1993 and 1997, a general, though variable, decline in average PCB levels was observed, with 1997 concentrations averaging 4 to 5 mg/kg. After 1997, no consistent trend is apparent. Average lipid-normalized PCB concentrations (expressed as mg/kg lipid) in smallmouth bass exhibit patterns that are somewhat different from those of the wet tissue concentrations (Figure 2-16). Declines in average lipid-normalized PCB levels between 1993 and 1997 are evident throughout the entire lower River. Levels in the Upper and Middle Stretches continue to decline through 2000. However, in 2001, PCB levels measured at these locations were higher than previous years and similar to levels measured in 1997 and 1998 (Upper and Middle Stretches, respectively). PCB levels measured in the Lower Stretch since 1998 are variable, but differences between years are not statistically significant.

PCB concentrations in brown bullhead exhibit less spatial and temporal variability than those observed in smallmouth bass. Average PCB concentrations in wet tissue vary by about a factor of three between 1993 and 2001 (Figure 2-16). Declines between 1993 and 1997 are evident throughout the River; however, PCB levels from 1998 and 1999 are similar to those observed in 1993. Since 1999, PCB levels measured in the Upper Stretch have declined while those from the Middle and Lower Stretches have remained relatively unchanged. Lipid-normalized PCBs in brown bullhead exhibit greater variability than wet tissue PCB levels, ranging from about 180 to 900 mg/kg lipid throughout the River (Figure 2-16). Although year-to-year variability confounds the interpretation of temporal trends in the brown bullhead, a general decline in lipid-normalized PCB levels between 1993 and 2001 is evident at all locations.

In 1993, average wet tissue PCB levels in spottail shiners collected near Outfall 001 and the Unnamed Tributary were relatively similar, averaging 11 mg/kg and 13 mg/kg, respectively, while those collected at the mouth of the River were much lower (4.5 mg/kg; Figure 2-16). In October 1995, PCB levels in spottail shiners near Outfall 001 increased to about 42 mg/kg, while levels measured near the Unnamed Tributary and the mouth of the River remained similar to the levels observed in 1993. This increase was likely a result of the NTCRA dredging operations. Since 1995, PCB levels have declined to about 3 to 4 mg/kg in the Upper and Middle Stretches. At the mouth of the River, declines in spottail shiner PCBs were observed between 1995 and 2000 (from about 4 mg/kg in 1995 to about 0.7 mg/kg in 2000). PCB levels in 2001 were higher than in previous years (about 2.5 mg/kg) and are similar to those observed in 1997. Similar trends are exhibited in the lipid-normalized PCB concentrations (Figure 2-16). Presumably, the reductions in PCB loading provided by the on-site remediation and the NTCRA activities have caused a reduction in PCB exposure within the River, and thus have resulted in the general declines observed in fish tissue PCB levels.

2.6 Phenomena Affecting PCB Fate

2.6.1 Mass Transfer from Surface Sediment Pore Water

Pore water PCBs can be transported to the water column via numerous 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, the mass transfer rates necessary to account for the PCB accumulation in the water column range from 1 to 2 centimeters per day (cm/d) in winter to 4 to 5 cm/d in summer. These lower winter values compare well 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.

2.6.2 Resuspension

As indicated in Section 1.2, the lower Grasse River was deepened in the early 1900s to accommodate water flow from the Massena 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 Outfall 004 and the River's mouth is close to 21 days. During extreme flow conditions, flow velocities still are 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 3 to 4 ft/s (Alcoa, April 2001).

Given the quiescent nature of the lower Grasse River, resuspension is not likely to be an important factor in the fate of PCBs. Nonetheless, it is a process that must be quantitatively examined because of its potential impact on sediment stability and remedy selection. A number of field studies were undertaken in this examination:

- Total suspended solids (TSS) and PCB concentration measurements during high flows;
- Sediment geochronology;
- Sediment PCB composition;
- Trend monitoring of PCB levels in surface sediment, water and fish; and
- Sediment erodibility measurements.

These field studies demonstrate that there is insufficient resuspension in the River to materially impact PCB fate (Alcoa, April 2001). The principal evidence includes the following:

- TSS concentrations remained 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 2-17).
- PCB composition was similar during low flow and high flow (Figure 2-18) and differed from the composition on the surface sediments (Figure 2-19). It more closely matched the composition estimated to exist in the pore waters of the sediment (Figure 2-20).
- 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 2-21).
- PCBs in lower PCB concentration sediments characteristic of downstream areas are less dechlorinated than PCBs in higher PCB concentration sediments found upstream. In other words, the downstream sediments could not have been derived from erosion of the upstream sediments (Figure 2-22).
- The PCB concentrations in the water column, surface 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 surface sediment and fish concentrations (Figures 2-16 and 2-23) indicates that sediments remained stable during this event and that erosional scour did not result in the remobilization of deeper higher concentration sediments.

These field observations are supported by calculations of erosion based on site-specific 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 achieved. 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 of these simulations indicated that, for a variety of bounding parameter values, the extent of sediment scour during an extreme flood did not change appreciably. Results of these simulations indicate that, on average, about 0.2 cm of erosion is predicted to occur during a 100-year flood, with about 99% of the cohesive sediments in the River experiencing less than 1 cm of erosion (Figures 2-24 and 2-25). The maximum erosion predicted during the 100-year flood was about 1.4 cm. 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). Thus, even under extreme flow conditions, little sediment resuspension is expected within the River (Alcoa, April 2001).

2.6.3 Deposition and Burial

Historic sediment deposition rates in the lower Grasse River were examined through the analysis of ^{137}Cs levels in finely-sliced sediment samples from high-resolution cores collected from the River in 1997. 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 (Figure 2-21a). Cesium peaks were not evident in 7 of the 12 cores analyzed (Figure 2-21b). However, ^{137}Cs levels in these cores are relatively constant with depth (1 to 2 picoCuries/gram [pCi/g] dry) at levels similar to the levels 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.

More recent sedimentation rates were estimated using ^{210}Pb profiles in the surface sediments of three high-resolution cores (Cores 7M, 13M, and 18M) and a one-dimensional transport model. Results of the modeling analysis indicate that contemporary sedimentation rates are on the order of 0.2 cm/yr, a rate much lower than those discerned from the ^{137}Cs profiles.

More recent sedimentation rates also were estimated through the evaluation of solids loading currently entering the Study Area from upstream. For this 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). Using this solids rating curve and the River hydrograph for 1997 and 1998, the annual solids loading to the lower Grasse River from upstream was estimated to be about 7,800 metric tons (MT). This loading could support a maximum average deposition rate of 0.4 cm/yr if all solids that enter the lower Grasse River from upstream are deposited on the River bottom. This current sedimentation rate estimate is more consistent with that discerned from the ^{210}Pb data, and lower than the average rates indicated by the ^{137}Cs data (Alcoa, April 2001). 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).

2.6.4 Bioturbation

Chironomids and oligochaetes were the predominate organisms measured during the benthic community studies performed in the lower Grasse River. Most available 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 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). Based upon these studies, some mixing in the lower Grasse River is likely to be occurring to at least a depth of about 5 cm. Biological mixing is greater in summer months than winter months, which is why higher PCB flux rates are observed in the summer.

The vertical profiles of ^{210}Pb levels in surface sediments of 3 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 2-26). ^{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 little bioturbation is occurring in surface sediments of the lower Grasse River. The depth and intensity of biological mixing in the surface 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).

It is important to note this analysis was only performed for three high-resolution cores, and that lack of information for some of the model parameters introduces uncertainty into the analysis. However, 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).

2.6.5 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 (i.e., upstream of Outfall 001); 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 severely limited by the low hydraulic conductivity of the soils (clay and till, mostly). 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 Area (i.e., upstream of Outfall 001) also is not believed to be an important pathway since: 1) there is 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 (Transects T6, T13, and T28) in the lower Grasse River during two surveys; one in fall 1998 and one in spring/summer 1999. Overall area-wide average fluxes of -0.004 L/m^2-d and 0.014 L/m^2-d were determined for the 1998 and 1999 surveys, respectively (the negative sign implying flow from the River into the sediments). The lowest and highest individual seepage velocities (ignoring porosity effects) were -0.023 cm/d and +0.025 cm/d, respectively in 1998, and -0.062 cm/d and +0.041 cm/d, respectively in 1999 (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 rule out the possibility of some locally-significant groundwater discharges through the banks of the River or through bedrock fractures where bedrock lies at or near the River bottom (Alcoa, April 2001).

2.6.6 Prop Wash and Ice Scour

The turbulence and water motion caused by boat propellers, known as prop wash, can cause resuspension of sediments, particularly in shallow waters. The United States Army Corps of Engineers (USACE) has developed methods to calculate the velocity on the River bottom caused by boat propellers. These methods were used to determine the bottom velocities caused by two boat sizes: 1) a 16-ft long, 8-ft wide boat with a 50 horsepower (HP) engine and 12-inch propeller; and 2) a 20-ft long, 8-foot wide boat with a 250 HP engine and 18-inch propeller. The USACE equations were used 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 0.3 and 1.6 millimeter (mm) of sediment for the smaller and larger boats, respectively. Full-throttle acceleration from a stationary position in 5 feet of water would resuspend 3.5 mm of sediment over a length of about 250 feet of River bottom. The modest depths of resuspension are the result of the short time the sediment bed is subjected to the high velocities, on the order of a few seconds. 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 A. In addition, placement of anchors is expected to have minimal impact due to the relatively small surface area potentially affected by this activity.

Ice scour can be important in shallow water. However, only a small percentage (estimated at 10 to 15%) of the Grasse River sediment area is in water shallower than 5 feet. For this reason, ice scour is not expected to have a significant effect on redistribution of PCB-containing sediments.

2.6.7 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 2-27). In addition, strong relationships between dechlorination end-products BZ[4] 4 (2,2'-dichlorobiphenyl) and BZ 19 (2,2',6-trichlorobiphenyl) and the total number of chlorines exist, 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%, 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% reduction in congener mass was observed. In addition, small amounts of biphenyl (equaling 2.7% 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).

2.7 Site-Specific Actions

In addition to the information gathered during investigations of various media in the lower Grasse River and the conceptual understanding of the fate and transport of PCBs supported by modeling, the results of two site-specific actions contributed to the development and evaluation of potential remedial alternatives for the Study Area. The NTCRA, conducted in 1995, provided information on the feasibility of dredging PCB-containing sediments. The 2001 Capping Pilot Study explored the short-term efficacy and feasibility of capping lower Grasse River sediments. Summaries of both projects are provided below.

2.7.1 Non-Time-Critical Removal Action

The NTCRA was conducted in 1995 (with USACE oversight) to address an estimated 3,500 in-situ cy of PCB-containing sediment located adjacent to Alcoa's Outfall 001. In cooperation with USEPA, NYSDEC, and USACE, Alcoa developed the program to remove this PCB source 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 are presented below. Additional information can be found in the draft NTCRA Documentation Report (BBL, December 1995).

Removal Activities

From July 1995 through September 1995, Alcoa conducted the removal/dewatering/disposal of approximately 2,600 in-situ cy of sediments (along with 400 cy of boulders/debris) from a 1-acre area within Areas A and B adjacent to Outfall 001 (Figure 1-1). Removal of boulders/debris was accomplished using mechanical excavation equipment. Removal of sediment from Area A was accomplished using a horizontal auger dredge, while Area B sediment removal was conducted using manual (i.e., hand-held) hydraulic dredging techniques. During all sediment removal activities, the targeted area was isolated using a triple-layer silt containment system. It should be noted that during the NTCRA, the secondary curtain was lowered to the River bottom to

[4] Each of the 209 individual PCB molecules (or congeners) is assigned a unique identification number that distinguishes it from other PCB molecules. In this case, each individual congener is identified by its BZ number, as assigned by Ballschmiter and Zell in 1980.

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 (thus limiting the dredge's ability to overcut), precluded the removal of all sediment. After all practicable efforts were taken, an average of four inches (up to 14 inches) of sediment remained within Area A. Up to six inches of sediment also remained within portions of Area B (Outfall 001).

Water Treatment Operations

Water treatment operations took place throughout the entire sediment removal process. During the water treatment operations, over 11 million gallons of filtrate were processed. Grab samples of the treatment plant effluent were collected daily and analyzed for total PCBs. In 93% of the samples collected, PCB Aroclor concentrations were not detected above the method detection limit (MDL) of 0.065 µg/L. One sample did, however, show individual Aroclor levels greater than 0.3 µg/L, an action level agreed upon by the Agencies. All samples exhibited total PCB concentrations (sum of all Aroclors) less than 1.2 µg/L.

Environmental Monitoring Results

Along with the removal and disposal operations described above, Alcoa implemented a 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) at various times before, during, and after the NTCRA.

Post-NTCRA (1995) sampling conducted within Area A (Figure 2-28) indicated that the average PCB concentration in the top foot of sediment was reduced approximately 86% from 518 mg/kg to 75 mg/kg. If only sediment cores with the 0- to 3-inch sampling interval in the NTCRA area are considered, the average PCB concentration was reduced approximately 57% 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. These data suggest that dredging cannot consistently achieve low residual surface sediment PCB concentrations in the lower Grasse River.

Eight sediment grab samples were collected from the NTCRA area in 1997 (approximately two years after dredging) as part of the SRS Program. Samples were collected from the top 3 inches of sediment. PCB (Aroclor) concentrations ranged from 4.52 to 3,480 mg/kg, with an arithmetic average of 452 mg/kg (see Figure 2-5A). Statistical information for both the 1995 and 1997 post-NTCRA data are provided in the table below.

Statistics for Post-Dredging Surface Sediment PCB Concentrations (mg/kg) Measured in the NTCRA Area

Survey	Number of Observations	Mean	Minimum	Median	Maximum	Standard Deviation
1995 (post-dredging)	10	74.8	1.1	53.0	260.0	78.1
1997 SRS	8	452.1	4.5	12.1	3,480.0	1,223.6

Notes:
1) Samples collected in 1995 represent the depth of sediments available for sampling up to a maximum of 8 inches.
2) Samples collected in 1997 represent top 3 inches of sediments.

Results of the biota monitoring activities (both caged fish and resident fish sampling) indicated the release of PCBs from the containment system that surrounded the NTCRA area. Specifically, in-situ exposure of fathead minnows during the caged fish studies (both during- and post-NTCRA study phases) demonstrated significant increases in PCB bioavailability as compared to the pre-NTCRA study (see Figure 2-29). Similarly, post-NTCRA analytical results for spottail shiner samples collected in the vicinity of the NTCRA area indicate that PCB concentrations were as much as six times higher than PCB concentrations from previous years (see Figure 2-16).

2.7.2 Capping Pilot Study

Alcoa implemented a Capping Pilot Study in the summer and fall of 2001 as a way to obtain the site-specific data needed 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 the River (covering approximately 7 acres) between sediment probing Transects T15 and T16.5 - about one mile downstream of Outfall 001 (Figure 2-30) using the cap designs and placement techniques discussed below. Additional details regarding the Capping Pilot Study are presented in the Documentation Report, Grasse River Capping Pilot Study (Alcoa, April 2002a). It should be noted that Alcoa will continue to monitor the cap in 2002.

2.7.2.1 Capping Pre-Engineering Design Studies

In 1998, Alcoa initiated a series of pre-design studies to evaluate the potential of a 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). Table 2-2 summarizes the pre-design studies.

2.7.2.2 Capping Pilot Study 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 (see Section 2.1).

The Capping Pilot Study was designed to achieve several objectives through the placement and monitoring of three different cap material types using both surface and subsurface placement techniques. To accomplish the study objective, the area was divided into four cells, with work proceeding in two phases (see Figure 2-31 and Table 2-3). The first phase was designed to evaluate a number of capping materials and application methods. 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 sediments. The intent of this formulation was to provide adsorptive capacity for the aqueous phase PCBs that might diffuse into the cap, as well as provide 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 cap by benthic organisms.

2.7.2.3 Capping Pilot Study Results

An extensive monitoring program was implemented during the study to collect the information needed to evaluate each of the pilot study objectives. Conclusions regarding each of these objectives are provided below.

Cap Placement Techniques

- Placement of dry, bulk capping material by clamshell was demonstrated to be more effective, cost efficient, and successful in achieving environmental objectives than was placement of slurried capping material using a tremie pumping system. Pneumatic broadcasting of granular bentonite was unsuccessful as a 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 is the optimal material for the site considering the combination of logistics, production rates, cap coverage, and unit costs. In addition, the sand/topsoil mix is expected to provide 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%; average 0.71%), but sufficient to significantly attenuate any 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 capping with the sand/topsoil mix.

- The uniformity of cap thickness varied from cell to cell. For the pilot cells, where application was 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%.

- Target cap thickness was not achieved on the steep side slopes, indicating the side slopes of the River in the area of the Capping Pilot Study generally can support a cap no more than a few inches thick. The best coverage 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 typically were near or below detection limits (commonly 0.06 mg/kg).

- For the pilot cells, PCBs were non-detect in 95% (153 of 161) of the cap material samples analyzed from 21 cores. When detected, PCBs were 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 sediments.

Water Quality Impacts

- Water quality impacts due to PCBs in downstream areas as well as inside and adjacent to the Test Cell were negligible.

- 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 capping.

Recolonization by Benthic Community

- Data collected two to three weeks after completion of the study indicates the presence of 17 different benthic species within the capped area.

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 listing of the Applicable, Relevant, and Appropriate Requirements (ARARs), 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 the various potential remedial alternatives. The findings of the human health and ecological risk assessments are the basis for developing RAOs and identifying GRAs. The latest information on the risk assessments is summarized in Section 3.2. A listing of the RAOs is presented in Section 3.3.

ARARs are federal and state 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). A listing of potential ARARs for the site is provided on 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 Baseline Risk Assessment

3.2.1 Human Health Risk Assessment Update (RA Update)

In September 2001, 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 (Alcoa, September 2001). As detailed in the CCLGR Report (Alcoa, April 2001) and summarized in Section 1.4, there have been numerous additional data collection efforts since the preparation of the 1993 BLRA (which was based only on RSI Phase I data), including 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), the NTCRA (BBL, December 1995), and the SRS Program (1996-2001) (Alcoa, April 2001). The Alcoa Risk Assessment (RA) update was specific to PCBs since PCBs were identified in the USEPA (April 1993) BLRA as the primary risk driver for the site. Available site-specific data suggest that other lipophilic chemicals found in sediment (e.g., PAHs) generally are co-located with PCBs, and therefore any remedy addressing PCBs should also address these compounds. As such, samples collected since the 1991/1992 RSI Phase I investigations generally have been analyzed only for PCBs. It should be noted that Alcoa has received Agency comments on the September 2001 update (USEPA, May 2002) and is currently preparing a revision to the September 2001 document. These comments have been considered and incorporated within the information presented in Section 3.2.

The Alcoa RA update also incorporated PCB exposure and toxicity factors that reflect current scientific and regulatory policy and specific conditions at the Study Area. The exposure factors included both 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 SRMT anglers, incidental ingestion of and dermal contact with sediment by recreational users and SRMT anglers, and incidental ingestion of and dermal contact with surface water by recreational users. As noted in the update, 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.

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

3.2.1.1 Lower Grasse River

The Alcoa RA update presents the evaluation of potential risks associated with consumption of fish from the lower Grasse River using recent (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 (April 1993) BLRA, it was assumed that SRMT anglers fished only in Reaches 7 and 8 (Lower Stretch) and, as such, only PCB data for the Lower Stretch were used to evaluate SRMT angler exposure. Because there are no site-specific data to indicate that SRMT anglers fish in Reaches 4 through 6, there may be uncertainties associated with this assumption that impact the estimate of potential risks to SRMT 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 SRMT anglers and recreational users to sediment using data from the most recent 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. Surface sediment data were combined for Reaches 4 through 8 to evaluate recreational exposure, and Reaches 7 and 8 to evaluate SRMT 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 it is 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.

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% of the RME values). Both scenarios include a significant degree of conservatism, as discussed in the uncertainty section below.

Summary of Carcinogenic and Non-Carcinogenic 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 SRMT 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 SRMT 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 SRMT 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 SRMT 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). A 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 SRMT anglers from Reaches 7 and 8 were 160 and 614, respectively. For SRMT 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 2001 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 less than those presented in the CT risk evaluation. A description of uncertainties is presented in the RA update, and briefly summarized below.

Fish

USEPA recommended that the RA update use a fish ingestion rate of 142 g/day for the RME scenario. There are, however, more recent SRMT-specific data that suggest lower fish consumption rates. For example, Fitzgerald et al. (1999) indicates that the frequency of fish ingestion by SRMT 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 that there is 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% of the fish consumed by anglers come from the Grasse River. In other words, the RME scenario assumed that 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 SRMT anglers fish in Reaches 7 and 8 only. Because there are no site-specific data to indicate that SRMT anglers fish in Reaches 4 through 6, there may be uncertainties associated with this assumption that impact the estimate of potential risks to SRMT anglers via fish ingestion.

Sediment

The sediment PCB data set used in the RA update included all surface 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. Recreational users, however, are most likely to be exposed to PCBs in sediment located in shallow waters close to shore, and are not likely to be exposed to PCBs in sediment from deeper waters (which have higher average PCB levels). Because the RA update included mid-channel samples, which are areas not easily contacted by a recreational user and where sediments are not likely to be resuspended to near-shore areas, the potential risks associated with incidental ingestion and dermal contact with sediment may be overestimated.

3.2.1.2 Power Canal

As mentioned previously, the Alcoa RA update did not address the Power Canal; therefore, human health risk information from the USEPA (April 1993) BLRA is summarized here. For the Power Canal (designated as Reach 3; Figure 3-1), the USEPA (April 1993) BLRA reported a potential human health 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., steep banks). If the updated assumptions used in the RA update were applied to the Power Canal, the CT 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, 2001-2002).

As shown on the table below, results of the 1991 RSI Phase I biota sampling indicate fish tissue PCB concentrations in the Power Canal are considerably less than in the lower Grasse River.

Total PCB Concentrations in 1991 Fish (mg/kg wet weight) [1]

Species	Lower Grasse River		Power Canal	
	Average	Maximum	Average	Maximum
Pumpkinseed	0.33	1.93	non-detect	non-detect
Smallmouth Bass	2.08	6.5	0.49	1.9
Brown Bullhead	4.38	21.9	0.12	0.12
Rock Bass	0.62	2.75	non-detect	non-detect

[1] Arithmetic mean PCB concentration in fillet samples.

USEPA has requested that additional monitoring be conducted in the Power Canal to assess PCB levels in fish and the water column to verify historic RSI Phase I data.

3.2.1.3 Robinson Creek

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 a HI of 1.0 for a "child recreational user" due to dermal contact with aluminum in surface water.

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

3.2.2 Ecological Risk Assessment

The 2001 RA update did not address the ecological risk portion of USEPA's (1993) BLRA. The findings of the USEPA (1993) ecological risk assessment are summarized below. Risks to potential avian (i.e., least bittern and belted kingfisher) and terrestrial (i.e., little brown bat and mink) receptors were estimated by comparing estimated exposure doses based on site sampling data to values derived from the existing literature. No site-specific studies were conducted to validate the assumptions, methods, or conclusions.

The USEPA (April 1993) BLRA identified the following potential ecological risks:

1. Potentially significant effects to the macroinvertebrate benthic community of the lower Grasse River and sensitive biota within the Power Canal;
2. Chronic reproductive effects in fish from the Power Canal and lower Grasse River and in birds foraging in the lower Grasse River;
3. Adverse chronic effects to bats foraging above the lower Grasse River; and
4. Reproductive impairment in mink.

The USEPA (April 1993) BLRA suggested that these potential ecological effects were due to PCBs, and in some instances, polynuclear aromatic hydrocarbons (PAHs) and metals.

3.2.3 Summary and Conclusions

Alcoa's RA update concludes that fish consumption 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 SRMT anglers. Risks associated with direct exposure to sediment and surface water are much lower, and exposures from these pathways are generally associated with risks or hazard indices at or below USEPA's range of acceptable risk.

The USEPA (April 1993) BLRA identified potential ecological risks to the macroinvertebrate benthic community of the lower Grasse River, birds foraging in the lower Grasse River, bats foraging above the lower Grasse River, and mink. PCBs were the primary constituent of concern with respect to ecological risks. 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). As was the case with human health risks, the principal pathways of concern with respect to ecological risks were those involving consumption of fish containing PCBs.

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.

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 2001 RA Update, applicable rules and regulations, discussions with and input from the Agencies, and other Study Area-specific goals. Study Area RAOs are as follows:

1. Reduce PCBs in fish to levels protective of potential human and ecological consumers.
2. Reduce or mitigate, to the extent practicable, existing, and potential adverse effects and bioaccumulation of PCBs in the lower Grasse River.
3. Reduce or mitigate, to the extent practicable, the migration of PCBs from the lower Grasse River to the St. Lawrence River.
4. Protect the ecosystem of the lower Grasse River.
5. Continue to reduce or control PCB sources within the lower Grasse River system.

As discussed in Section 3.2, human ingestion of fish from the lower Grasse River is the PCB exposure pathway of greatest concern within the Study Area. As such, focusing remedial efforts on reducing PCB levels in fish will reduce the potential risk associated with consumption of lower Grasse River fish as well as potential risks associated with other exposure pathways.

In 2001, Alcoa completed an extensive external source control program that has significantly reduced direct discharges of PCBs to the lower Grasse River. An additional PCB source within the River itself is the widespread diffusive flux from PCB-containing surface sediments. As discussed in Section 2.3.1, this diffusive flux has been identified as the main source of PCBs to the fish in the lower Grasse River; therefore, addressing this source is expected to have a positive effect on PCB concentrations in fish in the lower Grasse River. Further, PCB loading from the lower Grasse River to the St. Lawrence River is expected to be reduced by continuing natural recovery processes (e.g., sedimentation), ongoing effects of completed external PCB source control work at the Alcoa facility, and active remediation.

Remedial actions undertaken to reduce PCB levels in lower Grasse River fish and reduce the PCB loading to the St. Lawrence River are anticipated to mitigate potential adverse effects and bioaccumulation of PCBs in the lower Grasse River.

For alternatives involving active remediation, any potential impacts to the River and associated ecosystem would be minimized through the use of appropriate institutional and engineering controls.

3.4 Identification of ARARs and TBCs

According to USEPA guidance (USEPA, October 1988), remedial actions must comply with applicable or relevant and appropriate requirements of Federal and State 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 items "to be considered" (TBC). 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 exist for which a waiver of an ARAR may be justified. 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; and
- 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. The application of the ARARs in the evaluation of the potential remedial alternatives is discussed further in Sections 5 and 6 of this document.

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 General Response Actions (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, the 2001 Capping Pilot Study, 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. There currently is a fish consumption advisory in effect for the lower Grasse River (from the River mouth upstream to the Massena Power Canal) and a less restrictive consumption advisory for the Power Canal due to PCBs.

4. Source Control/Natural Recovery: Includes measures to reduce direct PCB sources to the River, as appropriate. As referenced in the NRC's *A Risk-Management Strategy for PCB-Contaminated Sediments* (NRC, 2001), "source control should be the first milestone in any risk-management strategy." 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 technologies such as 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., biodegradation, immobilization, and/or other potentially appropriate treatment technologies) to reduce PCB 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.

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

4. Technology Screening

4.1 Introduction

This section identifies and screens remedial technologies and process options that will be used to develop potential Study Area-specific 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 were 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). The technologies retained following this second step were 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, experience gained from other PCB sediment sites, and available information 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 and 2001 Capping Pilot Study) also were used in this evaluation.

Criterion 2: Implementability
Both the technical and administrative feasibility of implementing each process option were evaluated (USEPA, October 1988). Since 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 a comparative evaluation of process options within each remedial technology type could be made. This relative evaluation was conducted because detailed cost comparisons cannot be made between 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. 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, this option 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 1.3 and the NTCRA conducted in 1995 (see Section 2.7.1). 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, currently are being conducted at the Study Area as part of the SRS Program (1995 through 2002). 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) that already are in place at the Study Area would be revisited and modified as appropriate based on monitoring results. Access restrictions also were 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. Extensive external source reduction described in Section 1.3 will expedite the achievement of the RAOs by mitigating contribution of known sources to the River and allow 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 to occur. As these natural processes are ongoing in the River, they are retained as representative process options as well.

E. In-Place Containment

The representative process options retained under the capping technology type include sand/topsoil cap and engineered capping.

Sand/Topsoil Cap – Within the capping technology type, sand/topsoil capping (hereafter referred to as "capping") was retained as a representative process option. This technology was demonstrated during the 2001 Capping Pilot Study (Section 2.7.2) in the lower Grasse River (Alcoa, April 2002a), and has been used at a number of other sites across the country.

Engineered Cap – Engineered capping also was retained as a representative process option within the capping technology type. It is envisioned that engineered capping would be used in localized areas (such as near facility outfalls) where the added stability of an engineered cap may be required. As with the sand/topsoil cap retained above, based on USEPA (Palermo et al., September 1998) and USACE (June 1998) guidance, technical research and full-scale application of engineered capping as a remedial action at other sites, engineered capping is a viable technology for use at the Grasse River Study Area. In addition, inclusion of this process option widens the array of alternatives to be evaluated in adherence to USEPA guidance (October 1988), which suggests the evaluation of one or more containment alternatives that prevent potential exposure and reduce mobility.

Any cap type (e.g., sand/topsoil cap, engineered cap) placed within the lower Grasse River would be designed in accordance with USEPA (Palermo et al., September 1998) and USACE (June 1998) guidance documents. 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), "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; and
3. Reduction of the flux of dissolved constituents into the water column."

In preparation for the 2001 Capping Pilot Study, Alcoa conducted a series of pre-design studies to assess the efficacy of 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 will provide useful information regarding cap design considerations along with the results obtained from monitoring associated with the 2001 Capping Pilot Study (Alcoa, April 2002a).

F. Sediment Treatment

Sediment treatment technology types include both ex-situ and in-situ techniques. 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. Since 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. In general, the availability of specialized equipment and personnel involved with many ex-situ treatment technologies may be limited based on the complexities and required implementation time of the process. Difficulties have been noted in obtaining approvals as well. Furthermore, as a result of the large volume of material targeted for removal under the potential remedial alternatives, it will not be cost effective to treat sediments removed from the River. However, in consideration of the need for disposal of removed sediment for the alternatives that include sediment removal, treatment to address free water in removed sediment may become necessary to meet landfill requirements. To meet this potential requirement, stabilization/solidification will be retained as a representative process option under treatment. Stabilization/solidification was performed on sediments removed during the NTCRA prior to disposal (BBL, December 1995).

G. Sediment Removal

Hydraulic and mechanical dredging were retained as representative process options for sediment removal. Hydraulic and mechanical dredging processes were used during the NTCRA removal activities (BBL, December 1995) to remove 2,600 in-situ cy of sediment and 400 cy of boulders/debris, respectively.

Compared to mechanical dredges, hydraulic dredges have higher production rates and result in less sediment resuspension during operation. Hydraulically-dredged material can be transported over long distances and piped directly to a staging/processing area. However, a greater volume of water must be removed from the slurry and discharged and/or treated. Often, these large volumes of water require treatment and reduce the rate of sediment removal. The solids content of hydraulically-dredged slurries normally averages 5 to 10% 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. Stoppages to clean the cutterhead, pump, or pipeline may be frequent at sites where debris and other larger materials are present (EPRI and Northeast Utilities, September 1999).

Mechanical dredges have been used extensively and are widely available. They can operate in areas with limited space, and are highly maneuverable. The dredges are able to remove large debris and, at the same time, reduce the amount of water contained in removed sediment. Mechanical dredges are effective where dredged sediment must be transported by barge. However, mechanical dredges have lower production rates than hydraulic dredges, and there is the potential for more sediment resuspension and spillage during dredging and unloading (EPRI and Northeast Utilities, September 1999).

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 be highly dependent upon an evaluation of the in-River areas considered for dredging. For purposes of evaluation in this AA Report, hydraulic dredging has been carried forward as the representative sediment removal process option, although mechanical dredging may be needed to remove rocks and other debris.

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 due to the fact that it was successfully implemented during NTCRA 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 a local 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 PCB materials at concentrations greater than 50 ppm. Sediments removed from the NTCRA area were disposed in Alcoa's on-site Secure Landfill. Should disposal of sediment be necessary, use of Alcoa's on-site Secure Landfill would not require segregation of removed sediment (i.e., TSCA vs. non-TSCA), thus reducing handling, removal, transportation, and disposal costs, although construction of a new cell(s) would be required.

Off-site disposal would only be considered as a process option for alternatives where the volume of sediment to be managed is such that on-site disposal capacity may not be available.

J. Residuals Management

The only residuals potentially requiring management at this Study Area would be the water generated during sediment removal operations. For the purposes of this document, filtration and granular activated carbon (GAC) were retained as the representative process options for water treatment. Approximately 11 million gallons of water were treated during the NTCRA, from which only 0.3 kg of PCBs were removed via GAC adsorption (Thibodeaux, November 1999). This fraction represents only 0.009% of the total PCB mass actually removed from the River during these operations.

4.3 Key Findings of the Remedial Investigation Influencing Assembly of Remedial Action Alternatives

In order to develop an array of potential remedial alternatives for the Study Area that will comply with the ARARs and TBCs and achieve the RAOs, 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 and Capping Pilot Study provides 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), the Capping Pilot Study Report (Alcoa, April 2002a), and the NTCRA Documentation Report (BBL, December 1995). The major findings pertinent to the development of the potential remedial alternatives are presented below.

4.3.1 PCB Sources

1. **Plant discharges are an insignificant PCB source** (CCLGR Report, Section 3.3.2). PCB discharges from the Alcoa facility may have provided a significant historic PCB load to the River prior to the extensive on-site remediation efforts, but recent effluent data indicate that PCB loading has dramatically declined in response to those efforts. PCB loading from the plant has declined from about 60 grams/day [50 pounds per year (lbs/yr)] in 1990 to about 1.7 grams/day (1 lb/yr) in 2000. On-site remediation was completed in 2001 as described in Section 1.3. Currently, the plant discharges represent a small proportion of the PCB loading to the water column observed in the River. It should be noted that Alcoa intends to further reduce remaining discharges through additional on-site remediation efforts.

2. **The Grasse River upstream of the Study Area and the tributaries within the Study Area are insignificant PCB sources** (CCLGR Report, Section 3.3.2). 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 Massena 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.

3. **Surface sediments are the dominant source of the PCBs found in water and fish** (CCLGR Report, Sections 3.3.1 and 3.3.2). PCB-containing sediments have been identified in the lower seven miles of the Grasse River in the reach extending from the Power Canal to the mouth. The surface sediment PCB concentrations in the lower Grasse River average about 11 mg/kg. In the upper three miles of the site, surface sediment PCB concentrations average about 18 mg/kg. Proceeding downstream of River mile 3.3, surface sediment PCB concentrations trend downward, reaching about 1 to 2 mg/kg near the River mouth. The average over this reach is about 6 mg/kg. 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. **Buried sediments are isolated and sequestered** (CCLGR Report, Sections 3.3.1 through 3.3.3). Geochronology, vertical mixing analysis, composition of the benthic community, and measurements of groundwater advection suggest that deeper sediment PCBs are sequestered, meaning that little of the buried PCBs are at risk of being moved into surface sediments or the water column. This conclusion is supported by studies directed at evaluating whether deeper sediments can be disturbed by high-flow events or man-made forces (e.g., prop wash):
   - measurement of River velocities;
   - development of a hydrodynamic model to predict River velocities during high-flow events;
   - study of suspended solids and PCB levels during high-flow events;
   - measurements of the erosion potential and grain-size distribution of the sediments;
   - development of a sediment transport model to predict high-flow erosion;
   - radiochemistry analysis of finely-sliced sediment cores;
   - comparison of surface sediment PCB levels before and after an extreme high-flow event that occurred in January 1998; and
   - calculation of the bottom shear stresses that would be generated by boating activity and the resultant potential erosion.

These studies show that high-flow events are not expected to affect the deeper sediments. The absence of an adverse impact is attributed to the relatively low velocities that exist even under extreme events. Maximum velocities during a 100-year flood rarely exceed 3 ft/s. Data from other sites and site-specific data show that velocities of 3 ft/s 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 0.2 cm of erosion occurs during a 100-year flood, with about 99% 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 1.4 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. 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 effects of prop wash were evaluated following guidance developed by the USACE. Using conservative assumptions about motor size and boat operations in shallow water, Alcoa calculated that prop wash could have minor impacts in very shallow water, but overall would not disturb deeper sediments (see Section 2.6.6). Ice scour can be important in shallow water. However, because only a small percentage (estimated at 10 to 15%) of the Grasse River sediment area is in water shallower than 5 feet, ice scour will affect very little of the sediment.

5. **The sediment source is widely dispersed and effective remediation must address the surface sediments over a relatively large portion of the River bottom** (CCLGR Report, Section 3.3.1 and 3.3.2). The relatively widespread distribution of surface sediment PCBs in the lower Grasse River suggests that the PCB sediment source is diffuse, and that the widespread diffusive flux from the surface 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, most notably in the vicinity of the principal Alcoa discharge locations (Outfall 001 and the Unnamed Tributary), 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. **Remedial actions already taken have had a positive impact on the site** (CCLGR Report, Section 3.3.1). Fish and water column PCB levels have declined since the mid 1990s. This decline is likely the result of two factors: 1) the recovery from high PCB water column exposures attributable to the NTCRA activities; and 2) a downward trend in water column PCB concentrations resulting from on-site remediation efforts that have significantly reduced PCB discharges to the River over the last 10 years and ongoing natural recovery processes. The existing database is not sufficient to determine the relative contribution of these factors to the observed decline. The rate of decline may have slowed in recent years, although the natural variability in fish PCB levels also must be considered in evaluating the data.

4.3.3 Natural Recovery Mechanisms

1. **Deposition and burial are the principal means of natural recovery** (CCLGR Report, Section 3.3.3). Deposition, at an average rate of about 0.2 cm/yr, occurs because the lower Grasse River is functionally equivalent to a reservoir. River velocity decreases tremendously as water reaches the site, providing a situation conducive to the settling of solids. The drop in velocity occurs because the channel depth, and consequently the River cross-section, increases dramatically. The greater depth is the result of two construction activities: 1) the River was deepened in the early 1900s to accommodate water diverted from the St. Lawrence River to generate electrical power (a practice that ceased in the 1950s); and 2) the water surface was elevated when the level of the St. Lawrence River increased due to construction of the St. Lawrence Seaway.

2. **Dechlorination and degradation may contribute to natural recovery** (CCLGR Report, Section 3.3.4). A combination of sediment core data analyses and laboratory experimentation provide many indications that dechlorination and biodegradation 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. 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.

4.3.4 Efficacy of Capping

1. **A clean cap can be placed over and isolate the PCB-containing sediments** (Capping Pilot Study Documentation Report, Sections 6.1 and 6.2). The Capping Pilot Study 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.

2. **Capping does not remobilize sediment PCBs to a measurable extent** (Capping Pilot Study Documentation Report, Section 6.3). 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 Capping Pilot Study 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).

3. **The side slopes of the River in the area of the Capping Pilot Study generally can support a cap no more than a few inches thick** (Capping Pilot Study Documentation Report, Section 6.1). Target cap thickness was not 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.

4.3.5 Efficacy of Dredging

1. **Dredging can remove PCB mass from the River** (NTCRA Documentation Report, Sections 5.3 and 6.2). The NTCRA activities removed about 84% (2,600 cy) of the targeted sediments and greater than 90% of the PCB mass present in the targeted sediments. Because the targeted sediments were those containing the highest PCB levels in the River, the program removed more than 20% of the total PCB mass in the River.

2. **Dredging leaves PCB-containing sediments in the River** (NTCRA Documentation Report, Sections 5.3 and 6.2). The NTCRA Program activities were unable to remove all of the targeted sediments and left, on average, about 4 inches of sediments on the River bottom with an average residual PCB concentration of approximately 75 ppm. The inability to remove all of the targeted sediments can be attributed, in part, to the presence of an uneven hard bottom on which the PCB-containing sediments sit and the presence of cobbles and boulders on top of this hard bottom. These features did not allow for 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 all of the targeted sediments resulted in residual sediments that remained a source of PCBs to the system, and in some areas post-dredging PCB concentrations were higher than pre-dredging concentrations. The presence of clean underlying soft material could potentially improve residual PCB levels; however, conditions such as these typically are not present in the lower Grasse River. Results of recent 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 activities.

3. **Dredging can remobilize PCBs that are in buried sediments** (NTCRA Documentation Report, Sections 5.3 and 6.2; Table 4). Water column sampling conducted both during and after the removal operations indicated that, although the silt containment system significantly reduced the migration of suspended solids, some PCBs escaped the containment system and migrated downstream. On several occasions, PCBs were detected above the acute Federal Ambient Water Quality Criteria (AWQC) of 2 µg/L at locations immediately adjacent to the silt containment system (PCB levels up to 13.3 µg/L), and once at a location downstream of the Outfall 001 mixing zone (water column Transect WC006.5). PCB concentrations at the transect downstream of the dredging and outside of the silt curtains averaged about 0.5 µg/L during the period of hydraulic dredging. It is estimated that between 5 and 30 pounds of PCBs (0.1 to 0.3% of total mass removed) escaped from the containment system during the dredging activities.

4.4 Assembly of Potential Remedial Alternatives

GRAs/technology types and associated representative process options retained after the two-step screening process were combined to develop a range of various potential remedial alternatives for the Grasse River Study Area. An appropriate number of representative process options were included in each alternative so that the potential remedial alternative describes the complete remediation effort at the Study Area. A total of 17 potential alternatives were developed for analysis within this document. An initial screening of these 17 alternatives was accomplished through discussions between Alcoa and the Agencies. These interactive discussions considered the multitude of data collected at the Study Area and site-specific modeling to develop a range of remedial alternatives in consideration of the GRAs identified in Section 3.5 and screening process described in Section 4.1. In addition, the alternatives were developed to be consistent with the May 24, 1995 Amendment to the Administrative Order, which requires that this Analysis of Alternatives shall include analysis of dredging and an alternative(s) combining dredging with in-situ containment. The preliminary screening of

alternatives performed by Alcoa and the Agencies resulted in the identification of 10 alternatives that will undergo the detailed analysis of alternatives in Section 5. These alternatives are listed below.

1. No Further Action
2. Monitored Natural Recovery
3. Cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
4. Dredge River areas with surface sediment PCB concentrations greater than or equal to (≥) 50 ppm, cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
5. Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥10 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
6. Cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
7. Dredge River areas with surface sediment PCB concentrations ≥50 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
8. Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
9. Dredge River areas with surface sediment PCB concentrations ≥10 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
10. Dredge River areas with surface sediment PCB concentrations ≥1 ppm and site-wide monitored natural recovery

The specific areas of the River targeted for remedial action under each of these alternatives are illustrated and described in detail in Section 5.

Seven alternatives were eliminated during the preliminary screening evaluation due to similarity in scope and effectiveness of alternatives that were selected to undergo the detailed analysis presented in Section 5, concerns about remedy effectiveness, or implementation-related concerns. The alternatives eliminated during this screening evaluation follow.

1. Cap sediments with surface PCB concentrations ≥10 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
2. Cap sediments with surface PCB concentrations ≥1 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
3. Dredge River areas with surface sediment PCB concentrations ≥25 ppm and site-wide monitored natural recovery
4. Dredge River areas with surface sediment PCB concentrations ≥10 ppm and site-wide monitored natural recovery
5. Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap dredged areas, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery
6. Dredge River areas with surface sediment PCB concentrations ≥50 ppm, cap sediments with surface PCB concentrations ≥10 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery

7. Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery

Additional details regarding the evaluation of these alternatives are provided in Appendix B.

5. Detailed Evaluation of Alternatives

5.1 Introduction

This section presents the detailed analysis of the ten potential remedial alternatives assembled from the retained technologies and process options presented at the end of Section 4. Each alternative is assessed with respect to the NCP evaluation criteria described in Section 5.2. The results of this detailed evaluation are used in Section 6 to carry out a comparative analysis of alternatives for each of the evaluation criteria.

In this section, each alternative is described and then evaluated relative to seven of the nine NCP criteria. Two of the NCP criteria (state and community acceptance) will be evaluated by USEPA following comments on the Proposed Remedial Action Plan for the site. The detailed analysis is based on the results from significant data collection and analysis efforts, site-specific modeling, and site-specific remedial technology data (e.g., NTCRA dredging and Capping Pilot Study) assembled over the past decade. The findings and conclusions from these efforts are summarized in Section 2 and Appendix B of this document, the CCLGR Report (Alcoa, April 2001), the NTCRA Documentation Report (BBL, December 1995), and the Capping Pilot Study Documentation Report (Alcoa, April 2002a).

While some details on equipment, processes, etc. are provided in the alternative descriptions, it should be recognized that modifications may be required during the design and implementation phases of the project due to engineering considerations and site conditions.

The ten potential remedial alternatives identified for the Grasse River Study Area are listed in the table below. Note that the "abbreviated descriptions" will be used throughout the text for ease of reference.

Alternative Number	Description	Abbreviated Description
1	No Further Action	No Further Action
2	Monitored Natural Recovery	Monitored Natural Recovery
3	Cap[5] between sediment probing Transects T11 and T38, engineered cap[6] at Outfalls 001/004, and site-wide monitored natural recovery	Cap T11 to T38
4	Dredge River areas with surface sediment PCB concentrations ≥50 ppm[7], cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Dredge PCBs ≥50 ppm; Cap T11 to T38
5	Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥10 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm

[5] Throughout this document the term "cap" is used to indicate a 12-inch sand/topsoil cap.
[6] Throughout this document the term "engineered cap" is used to indicate an 18-inch unwashed run-of-bank (ROB) cap with an additional 6-inch layer of gravel.
[7] Target PCB concentrations identified in Alternatives 4 through 10 refer to PCB levels in the surface sediment (0 to 3 inches).

Alternative Number	Description	Abbreviated Description
6	Cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Cap PCBs ≥5 ppm
7	Dredge River areas with surface sediment PCB concentrations ≥50 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm
8	Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm
9	Dredge River areas with surface sediment PCB concentrations ≥10 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery	Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm
10	Dredge River areas with surface sediment PCB concentrations ≥1 ppm and site-wide monitored natural recovery	Dredge PCBs ≥1 ppm

As described in detail in Appendix B, model simulations were performed for a 30-year period (i.e., 2001-2030) to estimate the changes in water column and fish tissue PCB concentrations that are projected from implementation of each potential remedial alternative. To characterize the rates of decline estimated for each remedial alternative, three metrics were selected: the time needed to achieve 75% and 90% reductions in River-wide average fish PCB concentrations[8] and the time needed to achieve an 85% reduction in PCB loading to the St. Lawrence River[9]. It should be noted that these metrics are not intended as target goals for remediation, rather they were selected to provide meaningful comparison between alternatives. The 75% reduction provides an indication of the near-term rate of decline, while the 85% and 90% reductions provide a longer-term average rate of decline. These longer-term metrics were selected considering the time trend plots and the general concentrations at which these lines become asymptotic. These fish tissue and loading metrics are used in the evaluation of the long-term effectiveness and permanence provided by each potential remedy. The percent reductions are calculated based on PCB levels predicted during 2003[10], assumed to be the last year before the start of remediation activities for the modeling evaluation.

Current (2000) and projected (2003) PCB values used for comparison throughout the alternative analyses are:

Metric	Current PCB Value (2000)	Projected PCB Value (2003)
River-wide average fish tissue PCB concentration	6.3 ppm	3.8 ppm
PCB loading to the St. Lawrence River[10]	31.9 kg/yr	30.4 kg/yr

[8] River-wide average fish tissue PCB concentrations are computed in two steps. First, two species averages are computed, one for each model stretch (i.e., Upper Stretch [T1-T41] and Lower Stretch [T41 – T72]). These species averages represent the arithmetic average of PCB concentrations in smallmouth bass and brown bullhead. Second, the River-wide average is computed as the average of the two species averages, area-weighted by model stretch.

[9] Three-year moving averages of the PCB loading to the St. Lawrence River were computed (e.g., PCB loading in 2006 represent the average loading between 2005 and 2007). This was performed to reduce the year-to-year variations associated with the fluctuations in annual river flows used in the synthetic hydrograph.

[10] For PCB loading to the St. Lawrence River, the base condition represents the average PCB loading between 2001 and 2003.

Remediation activities are assumed to begin in 2004 for purposes of the modeling evaluation. As a result, the time frame upon which to assess reductions in predicted fish tissue PCB levels during and post-remediation (i.e., 2004 to 2030) is 27 years. For reductions in predicted PCB loading to the St. Lawrence River, the time frame is 25 years due to the averaging scheme employed to dampen the variations associated with the year-to-year fluctuations in River flows (see footnote 9 on previous page). In cases where the time to achieve the targeted reductions is longer than the model projection period, the results are described as greater than 27 years (for decreases in PCB concentrations in fish tissue) or greater than 25 years (for decreases in loading to the St. Lawrence River).

Model Sensitivity to Dredging Assumptions

At the request of the Agencies, assumptions for PCB releases during dredging (0.1% of the PCB mass removed) and post-dredging PCB residual (2.5 ppm) were specified in the model projections presented within Sections 5 and 6. To the extent that these conditions are not achieved, the model predictions may underestimate actual PCB levels experienced in the field and overestimate the predicted benefits of some of the alternatives that include dredging. This issue was explored by assessing the sensitivity of the model predictions to various input assumptions including the extent of PCB release during dredging and post-dredging PCB residual. Results of this evaluation are summarized below, and additional detail is provided in Appendix B.

The sensitivity analyses indicate that the extent of PCB release during dredging and post-dredging PCB residual affect the response of the River to remediation. For example, an increase in PCB release during dredging for Alternative 10 (dredge ≥ 1 ppm scenario) from 0.1% to 2.5% results in increases in average water column and fish tissue PCB concentrations of about a factor of 2.5 and 5.0, respectively, during the period of remediation. These increased PCB levels result in long-term (i.e., between 2004 and 2030) average water column and fish tissue PCB levels that are about 1.6 and 2.8 times higher, respectively, than those predicted assuming a 0.1% PCB release. Simulations of alternatives with smaller dredging components indicate these effects diminish as the magnitude of the dredging program is reduced. In all cases, these impacts are evident for the duration of the dredging program; however, the effects dissipate over time and by 2030 PCB levels are similar, regardless of the assumed PCB release.

The assumption of post-dredging sediment PCB concentration also has short- and long-term effects on projected average water column and fish tissue PCB concentrations. For the dredge ≥ 1 ppm scenario with a 10 ppm post-dredging PCB sediment concentration, average water column and fish tissue PCB levels over the modeled period are about 2.5 times higher than those predicted assuming a 2.5 ppm post-dredging residual. By 2030, predicted PCB levels are 3 to 3.5 times higher under the assumption of a 10 ppm PCB residual. Similar trends are observed for smaller dredging programs, although increases in PCB levels are not as great, indicating that the effects of this assumption diminish as the magnitude of the dredging program is reduced. In fact, little difference is observed for the dredge ≥ 25 ppm scenario.

To the extent that the assumptions regarding PCB release and post-dredging PCB-residual are conservatively low, the model predictions may underestimate actual PCB levels achievable during implementation, and thus overestimate the predicted benefits of each potential remedial alternative with a dredging component. Site-specific information indicates the presence of boulders and cobbles in portions of the River, bedrock and/or hardpan under the PCB-containing sediments, and higher PCB levels with depth; all factors that can adversely impact the ability to achieve low post-dredging PCB residuals. To account for the potential for elevated PCB residuals in sediments after dredging, it was assumed that for all alternatives except Alternative 10 (dredge ≥ 1 ppm), dredged areas are subsequently remediated by capping and, thus, the associated effects of the post-dredging PCB residual assumption are moderated. Nonetheless, these uncertainties require consideration during the evaluation of the model projections presented here, especially when attempting to distinguish between

alternatives based on relatively small differences in both projected fish tissue PCB levels and the time predicted to these certain levels.

5.2 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 alternatives provides a means to develop the comparative analysis presented in Section 6 and support the selection of the most appropriate remedial action for the Grasse River Study Area. The nine evaluation criteria are as follows:

- **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).

- **Long-Term Effectiveness and Permanence:** Evaluates the alternative for the long-term effectiveness and permanence it affords. Factors to be considered, as appropriate, include magnitude of residual risk remaining after implementation, along with 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 will be the basis of this evaluation. The RAOs include:

    1. Reduce PCBs in fish to levels protective of potential human and ecological consumers.
    2. Reduce or mitigate, to the extent practicable, existing and potential adverse effects and bioaccumulation of PCBs in the lower Grasse River.
    3. Reduce or mitigate, to the extent practicable, the migration of PCBs from the lower Grasse River to the St. Lawrence River.
    4. Protect the ecosystem of the lower Grasse River.
    5. Continue to reduce or control PCB sources within the lower Grasse River system.

- **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 selected treatment, including how treatment is used to address the principal 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 mitigative 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 during implementation.

- **Cost:** Evaluates present-worth direct and indirect capital, operating, and maintenance costs of implementing an alternative.

- **State (Support Agency) Acceptance:** Assesses the technical and administrative 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 alternatives.

Note that the last two criteria – State (Support Agency) Acceptance and Community Acceptance – will be evaluated by USEPA after public comments and input received on the Proposed Remedial Action Plan for the site are compiled.

To avoid repetition in the document, cross-references are provided between sections where the discussion related to the evaluation of a specific criterion is similar for multiple alternatives.

5.3 Detailed Evaluation of Alternatives

5.3.1 Alternative 1 – No Further Action

Description (Alternative 1 – No Further Action)
Under this alternative, no further remedial action would be undertaken in the Grasse River Study Area (see Figure 5-1) beyond activities already completed as part of the 1995 NTCRA dredging, the Alcoa facility external source control measures completed in 2001, and activities performed during the 2001 Capping Pilot Study. This alternative would take advantage of naturally-occurring sedimentation and microbially mediated dechlorination and degradation of PCBs – collectively referred to as natural recovery processes – within the lower Grasse River.

Natural sedimentation (on the order of 0.2 cm/yr) is expected to positively affect the system over the long term as it provides a continuous source of clean material to cover existing sediments. Sediment core data and laboratory studies indicate the potential for dechlorination and degradation of PCBs to contribute to the long-term decline of PCBs in the River. The benefits of these natural recovery processes would be augmented by the effects of the completed source control actions at the Alcoa facility, which have significantly decreased PCB discharges to the lower Grasse River.

Overall Protection of Human Health and the Environment (Alternative 1 – No Further Action)
Implementation of Alternative 1 is expected to result in a slow decline of fish PCB concentration and PCB loading to the St. Lawrence River, thereby reducing risks associated with exposure to PCBs. However these reductions would not be tracked through monitoring.

Compliance with ARARs (Alternative 1 – No Further Action)
Study Area-specific modeling indicates that River-wide average PCB levels in the water column would not meet certain chemical-specific ARARs, namely the Clean Water Act (CWA) - AWQC for chronic exposure to PCBs [0.014 parts per billion (ppb)], the AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), or the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) within the 30-year projection period. It is anticipated that technical impracticability waivers will be required for the latter three ARARs. These ARARs will not be attained due to site background PCB loading conditions (which have been accounted for in model projections). Since Alternative 1 does not include any active remediation, no action-specific or location-specific ARARs apply.

Long-Term Effectiveness and Permanence (Alternative 1 – No Further Action)
Long-term reductions in fish PCB levels and loading to the St. Lawrence River would occur because PCB sources to the River would be reduced through natural recovery processes. Additional protection would be provided by the external source control actions completed at Alcoa's facility (see Section 2.2.2), which have reduced PCB discharges from Outfall 001 to the River from an average of 60 grams/day in 1990 to about 1.4 grams/day in 2000 (Alcoa, April 2001). Additional source control efforts are planned for the future.

In an effort to fully evaluate this criterion, Alternative 1 is evaluated against the five RAOs established in Section 3.3. These RAOs were developed with the primary objective of providing long-term protectiveness of human health and the environment within the lower Grasse River.

RAOs #1 and #3 focus on reducing fish tissue PCB concentrations to levels protective of human and ecological consumers and mitigation of PCB loading from the lower Grasse River to the St. Lawrence River, respectively. Site-specific modeling (briefly described in Section 5.1) was performed to predict the time necessary to achieve various percent reductions in River-wide average fish PCB concentrations and PCB loading to the St. Lawrence River as a result of alternative implementation (see Appendix B for details).

As summarized in the table below, ongoing natural recovery processes are predicted to provide a 75% reduction in River-wide average fish tissue PCB concentrations (from projected 2003 levels) in about 25 years, while a 90% reduction is predicted to take more than 27 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.84 mg/kg in 2030. A reduction of 85% (from average levels projected for 2001 to 2003) in PCB loading from the Grasse River to the St. Lawrence River is anticipated to require more than 25 years.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
No Further Action	25 years	>27 years	>25 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.

Modeling projections indicate that RAOs #1 and #3 (reducing the lower Grasse River fish tissue PCB concentrations and PCB loading to the St. Lawrence River, respectively) could eventually be reached through ongoing natural recovery processes, but would take a significant amount of time (i.e., decades).

Reduction and mitigation (to the extent practicable) of existing and potential adverse effects and bioaccumulation of PCBs in the River (RAO #2) would be achieved through the expected long-term reduction in surficial sediment PCB flux resulting from the ongoing natural processes identified above.

Protection of the ecosystem (RAO #4) would be met because no intrusive remedial activities would be conducted within the River. Any effects to the ecosystem resulting from the presence of PCBs would, however, continue for a longer period of time for this alternative relative to the alternatives involving active remediation.

In consideration of the source control RAO (#5), the on-site remedial activities completed in 2001 (see Section 1.3) significantly reduced PCB inputs to the lower Grasse River. 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. Due to the effects of the natural recovery processes described above, the source control RAO would be met through implementation of this alternative, although it could take a significant amount of time (i.e., decades).

As PCB-containing sediment remains in the River, the potential for sediment erosion is relevant in the evaluation of the expected permanence of this alternative. However, erosion is not expected to be a significant mechanism for moving PCBs from buried sediments to the bioavailable surface sediments and the water column. Hydrodynamic modeling predicts that, for the lower Grasse River system as a whole, average net sedimentation rates exceed the erosion rate (on an annual basis) even when extreme River flows or storm events occur. To support an understanding of the long-term erosion potential of sediments during extreme flow events, Alcoa conducted erodability studies and collected TSS and PCB data during several high-flow events. Results indicate there is limited erosion of bottom sediments during these events. This finding is consistent with monitoring results obtained prior to and after a rare high-flow event in 1998, which approximated a 100-year flood, and indicated there were no apparent long-term impacts on PCB levels in sediment, water, or fish. It is also supported by sediment transport modeling, which indicates that most of the River bottom is aggrading and, on average, erosion in extreme events (as characterized by a 100-year flood) typically affects only the top few millimeters of sediment, with isolated areas potentially experiencing erosion up to 2 cm (Alcoa, April 2001). 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).

While it is possible that ice scour may resuspend near-shore River sediments in shallow water, only a small percentage (estimated at 10 to 15%) of Grasse River sediment is in water shallower than 5 feet. Therefore, ice scour is not expected to have a significant effect on the redistribution of PCB-containing sediments.

In summary, the potential for sediment erosion and near-shore scour of native sediments are not expected to affect either long-term effectiveness or permanence of ongoing natural recovery processes in the River. It is projected that this alternative would ultimately achieve long-term protectiveness, but would require a relatively long time period to do so because of the low sedimentation rate in the lower River.

Reduction of Toxicity, Mobility, and Volume through Treatment (Alternative 1 – No Further Action)
Since this alternative does not include active treatment, implementation would not actively remove or destroy any of the PCB-containing sediment in the lower Grasse River, and the reduction in total volume of the PCBs currently in the River would be limited to that which would occur through microbially-mediated degradation. 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 are expected to reduce the quantity and concentration of PCBs available for biological exposure. Studies conducted to date indicated that microbially mediated dechlorination is operative in the River, but is not expected to be an important near-term process.

Short-term Effectiveness (Alternative 1 – No Further Action)
There are no short-term effects associated with the implementation of this alternative. However, with respect to near-term improvements related to remedy implementation, this alternative would require the longest period of time for reduction of PCB levels in fish and PCB loading to the St. Lawrence River.

Implementability (Alternative 1 – No Further Action)
This alternative does not involve active remediation; therefore, there are no implementability issues.

Cost (Alternative 1 – No Further Action)
There is no cost associated with this alternative.

5.3.2 Alternative 2 – Monitored Natural Recovery

Description (Alternative 2 – Monitored Natural Recovery)
Under this alternative, no further remedial action would be undertaken in the Grasse River Study Area (see Figure 5-1) beyond activities already completed as part of the 1995 NTCRA dredging, the Alcoa facility external source control measures completed in 2001, and activities performed during the 2001 Capping Pilot Study. As described in Section 5.3.1, this alternative would take advantage of naturally-occurring sedimentation and microbially mediated dechlorination and degradation of PCBs – collectively referred to as natural recovery processes – within the lower Grasse River. The progression of these processes would be tracked via a monitoring program (described below).

Monitoring
A 30-year monitoring program, developed with Agency input, likely would include monitoring of the water column, sediments, and fish in the lower Grasse River. In addition, it is anticipated that a fish and water column sampling event would be conducted in the Power Canal to confirm historical data and determine if future investigation is necessary. The monitoring program would be reviewed every 5 years to assess the need to continue all program components and whether or not to add other components. It is anticipated that fish consumption advisories would remain in place until monitoring indicates the advisories are no longer necessary.

Overall Protection of Human Health and the Environment (Alternative 2 – Monitored Natural Recovery)
As with Alternative 1, implementation of this alternative would be expected to result in a slow decline of fish PCB concentrations and PCB loading to the St. Lawrence River, thereby reducing risks associated with exposure to PCBs. Further, it is anticipated that maintenance of the current fish consumption advisories until monitoring data indicate they are no longer necessary also would provide for protection of human health.

Compliance with ARARs (Alternative 2 – Monitored Natural Recovery)
Compliance with chemical-specific ARARs is as discussed under Alternative 1 (Section 5.3.1).

Considering action-specific ARARs, since this alternative includes monitoring activities, any work conducted on-site would be performed in compliance with the substantive requirements of all applicable permits.

No remedial activities would be implemented in this alternative, therefore, no location-specific ARARs would be invoked.

Long-Term Effectiveness and Permanence (Alternative 2 – Monitored Natural Recovery)
Long-term reductions in fish PCB levels and PCB loading to the St. Lawrence River would occur because PCB sources to the River would be reduced through natural recovery processes. Additional protection is provided by the external source control actions completed at Alcoa's facility (see Section 2.2.2).

In an effort to fully evaluate this criterion, this alternative is evaluated against the five RAOs established in Section 3.3. The results of this evaluation are similar to those discussed for Alternative 1 (see Section 5.3.1); however, monitoring as part of this alternative would provide necessary site data to verify that RAOs are being achieved.

As discussed in Section 5.3.1, the potential for sediment erosion and near-shore scour of native sediments is not expected to affect either long-term effectiveness or permanence of natural recovery processes occurring in the

River. It is projected that this alternative would ultimately achieve long-term protectiveness, but would require a longer time period to do so because of the low sedimentation rate in the lower River.

Reduction of Toxicity, Mobility or Volume through Treatment (Alternative 2 – Monitored Natural Recovery)
Since this alternative does not include active treatment, implementation would not actively remove or destroy any of the PCB-containing sediment in the lower Grasse River, and there would be no short-term reduction in total volume of the PCBs currently in the River. 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 are expected to reduce the quantity and concentration of PCBs available for biological exposure. Studies conducted to date indicated that microbially mediated dechlorination is operative in the River, but is not expected to be an important near-term process.

Short-Term Effectiveness (Alternative 2 – Monitored Natural Recovery)
There are no short-term effects associated with the implementation of this alternative. With respect to near-term improvements related to remedy implementation, this alternative would require the same amount of time as Alternative 1 for reduction of PCB levels in fish and PCB loading to the St. Lawrence River. Risks to workers engaged in monitoring activities would be managed through the implementation of a Health and Safety Plan (HASP) that meets the requirements of the Occupational Safety and Health Administration (OSHA) 29 CFR 1910.129.

Implementability (Alternative 2 – Monitored Natural Recovery)
There are no administrative or technical feasibility issues associated with the implementation of this alternative.

Cost (Alternative 2 – Monitored Natural Recovery)
The estimated present worth of the monitoring program planned for this alternative is approximately $2,700,000. The present worth analysis for this and all other alternatives was performed assuming that the long-term monitoring program would include annual sampling in the lower Grasse River for a period of 30 years. A discount rate of 7% was used for the present worth calculation as specified by USEPA guidance (USEPA, July 2000). The total estimated cost is provided in 2004 dollars. Details of this cost estimate are provided in Appendix C.

5.3.3 Alternative 3 - Cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Cap T11 to T38)

Description (Alternative 3 – Cap T11 to T38)
This alternative combines the placement of a cap between sediment probing Transects T11 and T38, installation of an engineered cap at Outfalls 001/004, and ongoing site-wide natural recovery processes (Figure 5-3). The section of the River between sediment probing Transect T11 and T38 was identified as a candidate for capping based on data collection and analysis that indicates these sediments contribute a significant amount (approximately 70%) of the PCB loading to the water column, as this area contains higher average sediment PCB concentrations than the remainder of the River. Since Outfalls 001/004 are upstream of sediment probing Transect T11, it is anticipated that the engineered cap would be placed in these areas first.

Engineered Cap Placement
The engineered cap would be placed over an area covering approximately 5 acres (approximately 218,000 ft^2) adjacent to Alcoa's Outfall 001 and Outfall 004. The 24-inch thick engineered cap would include 6 inches of 1-

to 1.5-inch diameter gravel placed on top of 18 inches of unwashed ROB material containing a wide variety of particle sizes. During placement, the remedial area surrounding each outfall would be cordoned off using a silt curtain to reduce downstream migration of materials. Placement of the engineered cap is estimated to occur at a rate of 420,000 square feet per month (ft^2/mo); therefore, installation would be expected to require less than one month. Placement of an engineered cap in the manner described here is also a component of Alternatives 4 through 9 and, to minimize redundancy in the text, will not be further discussed in detail in subsequent alternative descriptions.

Cap Placement

A cap would be placed over an approximately 122-acre area (approximately 5,300,000 ft^2) of the River between sediment probing Transect T11 and T38. The cap would consist of 12 inches of a 1:1 sand/topsoil mixture and cover the River bottom from bank-to-bank. Cap material would be placed along the side slopes as possible, although the results of the Capping Pilot Study indicate that a 12-inch thickness cannot be achieved on the steeper side slopes. Based upon studies conducted by the USACE (July 1993), a thinner capping design can be developed and applied to the near-shore vegetated areas which can preserve the integrity of the habitat while at the same time providing isolation of the native sediments in these areas. As such, for purposes of evaluation this alternative includes provisions for placement of a thin layer of cap material (approximately 3 inches) over the near-shore vegetated areas. Note that other approaches for capping near-shore vegetated areas may be considered during the remedial design phase.

In accordance with the design guidance set forth by the USEPA (Palermo et al., September 1998) and 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 cap thickness was determined through an 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[11] (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 A). 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. 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 B). 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.

[11] 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.

Data obtained during the Capping Pilot Study indicate that silt curtains may not be necessary to control downstream water-quality impacts related to the resuspension of PCBs during cap placement, but they have been included in this description in the event that their use is required. To allow for boat traffic and fish movement during construction, no more than one-half of the River width would be cordoned off at any time. Multiple silt curtain setups would be used to allow for continuous capping. After capping is complete at a given area, the silt curtain system, if used, would remain in place an appropriate length of time to mitigate release of materials downstream. Placement of a cap in the manner described here is also a component of Alternatives 4 through 9, and therefore will not be discussed in detail in subsequent alternative descriptions.

Actual cap placement techniques would be determined during the design phase, but for the purposes of this evaluation, it is assumed that the cap materials would be placed using two six-inch lifts. Specifically, both lifts would be placed via clamshell; the first at the water surface and the second below the water surface. Based on the estimated placement rate for capping of approximately 450,000 ft^2/mo (i.e., two crews at 225,000 ft^2/mo per crew), it would take approximately 12 months of total construction time (over multiple construction seasons) to complete installation of the cap.

Monitoring
Monitoring would be performed during all in-River work, and would consist of water column sampling to measure the effect of engineered controls, sediment and in-situ cap material sampling, and cap thickness monitoring. Following completion of capping activities, a long-term monitoring program would be conducted for a 30-year period to promote proper maintenance of the cap and determine long-term effects of alternative implementation. In addition to the activities described under Alternative 2, the long-term monitoring program would include annual events for water column, sediment, fish, and benthos monitoring; diver observation; and observation by boat for new construction within the River that may affect the integrity of the cap. Additional diver observations would be performed following high-energy events (i.e., greater than 10-year flood event). In addition, bathymetry of the capped area would be obtained every five years and cap maintenance activities would occur as necessary. It is anticipated that fish consumption advisories would remain in place until monitoring indicates they are no longer necessary.

Once installation of the engineered cap at Outfalls 001/004 is completed, cap placement between sediment probing Transects T11 and T38 would progress from upstream to downstream. Construction seasons in Massena are approximately six months long; therefore, implementation of this alternative is anticipated to require two construction seasons. For purposes of the modeling evaluation, construction is assumed to begin in 2004. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Overall Protection of Human Health and the Environment (Alternative 3 – Cap T11 to T38)
This alternative provides overall protection and risk reduction through isolation of approximately 127 acres of PCB-containing sediments by placing a "clean" sediment surface over a 2-year construction period that would reduce the diffusive flux of PCBs from surface sediments to the water column. Additional protectiveness is anticipated for the areas adjacent to Outfall 001/004 through the placement of a 24-inch thick engineered cap. Protection of human health and the environment in areas of the lower Grasse River not addressed by capping activities would be provided by the natural recovery processes described in Alternative 1. Potential short-term negative impacts on water quality, habitat, and human health are expected to be minimal, and would be addressed in the design and implementation of the alternative.

Compliance with ARARs (Alternative 3 – Cap T11 to T38)
Based on Study Area-specific modeling (Appendix B), River-wide average PCB levels in the water column are predicted to meet the CWA-AWQC for chronic exposure to PCBs (0.014 ppb) by approximately 2021. The

AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2 x 10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1 x 10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

It is expected that all applicable action-specific ARARs would be met during implementation of this alternative.

All applicable location-specific ARARs also would be met during implementation of this alternative. Precautions would be taken to comply with the Endangered Species Acts, the Historic and Historical Preservation Act, the Coastal Zone Management Act, and the Fish and Wildlife Coordination Act. Furthermore, implementation of this alternative should not invoke Freshwater Wetlands Permit requirements, as in-River activities would be conducted in a portion of the River where there are no wetlands located immediately adjacent to the shoreline. The hydrodynamic model developed for the lower Grasse River predicts that placement of the caps would not adversely affect areas outside of the existing floodplains, even during a significant high-flow event (i.e., a 100-year flood).

Long-Term Effectiveness and Permanence (Alternative 3 – Cap T11 to T38)
In addition to reductions in fish PCB levels and loading to the St. Lawrence River as a result of ongoing natural recovery processes and Alcoa's completed external source control actions, surface sediment PCB concentrations in the Study Area are expected to be significantly and quickly reduced after placement of the caps.

In an effort to fully evaluate this criterion, this alternative is evaluated against the five RAOs identified in Section 3.3.

Results of site-specific modeling indicate that this alternative would meet RAOs #1 and #3. Placement of the caps is predicted to reduce PCB flux from the sediments to the water column – the primary source of PCBs to the River – and provide a 75% reduction in River-wide average fish tissue PCB concentration in about 6 years and a 90% reduction in about 24 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.30 mg/kg in 2030. Achieving an 85% reduction in PCB loading from the Grasse River to the St. Lawrence River is anticipated to take about 19 years. Results of these modeling efforts are illustrated on Figure 5-4 and are summarized below.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Cap T11 to T38	6 years	24 years	19 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, both caps were assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 127 acres.

Reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River (RAO #2) would be achieved through implementation of this alternative by decreasing PCB availability to lower Grasse River fish, reducing PCB loading the St. Lawrence River, and reducing the PCB flux from the surface sediments through the placement of a cap and ongoing natural recovery processes.

Implementation of this alternative would achieve RAO #4 (protection of the lower Grasse River ecosystem) through the installation of silt curtains, if necessary, to contain materials within targeted areas and control any potential PCB releases to the system, and through the placement of a thin layer cap over areas identified to contain near-shore vegetation. Further, migration of fish within the remedial area should not be impacted as no more than one-half of the River would be cordoned off at one time. The capping materials should provide spawning habitat for a number of fish species and a suitable substrate for the benthic invertebrate community (Barton, 1988; Smith, 1985).

RAO #5 (source control) would be satisfied through implementation of this alternative. In addition to external source controls already completed by Alcoa (see Section 1.3), approximately 127 acres of lower Grasse River sediment – an area responsible for approximately 70% of the diffusive flux from surface sediment – would be covered with clean material. These measures would effectively address a large portion of the remaining source of PCBs to the system.

Potential long-term capping effectiveness and permanence issues and consideration of how each specifically relates to capping as a remedial alternative in the lower Grasse River are discussed below.

Cap Stability

As discussed in Alternative 1, erosion and near-shore scour are not expected to be significant mechanisms for re-mobilizing River sediments. Additional evidence to support the stability of sediments is provided by the monitoring data for fish, sediment, and water collected prior to and following a high-flow storm event January 1998. These monitoring data indicated that the high-flow event did not cause a significant resuspension of sediment or remobilization of buried PCBs, even in the absence of a cap. Further, since the cap materials and design would be chosen to mimic the physical characteristics of the native sediments, erosion and scour are not expected to jeopardize the adequacy or reliability of the caps proposed in this alternative. Also, prop wash and scour from recreational boats (see Section 2.6.6) is expected to have little impact on the stability of the caps. Placement of anchors on the caps is expected to have minimal impact, due to the relatively small surface area potentially affected by this activity.

Based on the extensive site-specific data collection efforts directed towards this issue, coupled with the results of the hydrodynamic and sediment transport modeling, the cap is expected to be stable under future conditions, including extreme flow events.

Isolation of PCBs by Capping

Over time, PCBs isolated under the cap could migrate into the cap via molecular diffusion. The rate of migration would vary among the PCB homologs, but the fastest migration rate (for monochlorobiphenyl) would be less than the estimated average sedimentation rate of about 0.2 cm/yr (Alcoa, April 2001). Furthermore, advective flux of PCBs due to groundwater passing through the deeper sediments and carrying PCBs to the surface is expected to be negligible, and the lower chlorinated biphenyls have been shown to aerobically degrade in River sediments (Alcoa, April 2001). The combination of the cap and natural sedimentation is expected to provide permanent isolation and control PCBs from migrating to the sediment-water interface (see Section 2 for more detail).

In summary, this alternative provides long-term protectiveness from potential exposure risks associated with PCBs in the lower Grasse River through placement of the caps, continued natural recovery processes, institutional controls, and monitoring. Further, based on site-specific evidence and modeling, the benefits provided by the cap are expected to be permanent. Although long-term monitoring and maintenance of the caps would be necessary, proper design and installation should reduce these maintenance requirements. In the

unlikely event that damage to the caps occurs, affected areas would be identified and addressed during routine and post-high-flow monitoring.

Reduction of Toxicity, Mobility, or Volume through Treatment (Alternative 3 – Cap T11 to T38)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. However, in addition to the reductions in mobility and toxicity described in Alternative 1, placement of capping materials would reduce the mobility of PCBs through isolation of PCBs in the native sediments in areas where the cap has been placed.

Short-Term Effectiveness (Alternative 3 – Cap T11 to T38)
The short-term effects of capping would last for two construction seasons and include disruption of areas along the River to construct access points, some possible short-term effects on water quality, the benthic and fish communities, possible disruption of/inconvenience to recreational boating traffic in the River, and potential transportation accidents. It is expected that any necessary access and staging areas would be constructed on Alcoa property, thereby minimizing any potential effect to the community. Two areas developed during the Capping Pilot Study could be used during implementation of this alternative. The application of cap materials may cause mixing or suspension of PCB-containing materials during and immediately following remedial activities, which could result in temporary exceedances of water quality corrective action triggers. However, results of the Capping Pilot Study (as described in Section 2.7.2) indicated that this is unlikely, as both resuspension of PCB-containing material and adverse effects on the water column were minimal.

While the benthic community in the targeted areas would be disrupted in the short term, implementation of this alternative is expected to provide suitable benthic substrate conditions through the placement of clean materials which approximate the characteristics of the native sediments. As a whole, adverse ecological effects should be minimal as the cap materials (i.e., 1:1 sand/topsoil mixture) would be selected to provide a substrate similar to that of the native sediment. Benthic data collected during the RSI and SRS Programs (i.e., Hester-Dendy samples) identified the presence of a diverse and abundant benthic community within the water column, indicating the potential for these organisms to settle and recolonize the capped River bottom. Further, post-capping benthic monitoring collected two to three weeks after completion of the Capping Pilot Study indicate benthic recolonization is occurring, as a total of 17 species were identified within the capping pilot area (Alcoa, April 2002a).

Efforts would be taken to reduce disruption (short-term or otherwise) of any fish spawning or migration that may occur within the River. During capping activities only one-half of the River would be blocked off at one time to allow fish movement. This set up also would minimize disruption to boating traffic in the River. The potential for navigation transportation accidents does exist (though none were observed during the pilot study), although if any accidents did occur, the barges would be transporting clean material.

Implementation of this alternative would provide significant near-term improvements as evidenced by predicted reductions in fish PCB concentrations and PCB loading to the St. Lawrence River.

During capping operations, remediation workers and the community are not expected to be exposed to PCB levels that present unacceptable health risks, and appropriate health and safety practices (OSHA 29 CFR 1910.129) would be followed through implementation of a Study Area-specific HASP.

Implementability (Alternative 3 – Cap T11 to T38)
Based upon the results of the Capping Pilot Study (Alcoa, April 2002a), design and construction of a cap in the lower Grasse River is both administratively and technically implementable, and logistical operations such as onshore processing of the capping materials, personnel requirements, silt curtain installation, and transportation of the capping materials from the staging area to the placement area are feasible. Necessary personnel for the

various tasks (i.e., crane and loader operators, Global Positioning System [GPS] engineer, monitoring crew) should be readily available. As discussed previously, one implementability issue of potential concern is the limited ability to place a cap on the steep side slopes of the River channel. During the Capping Pilot Study, attempts to place a 12-inch cap in these areas resulted in a cap thickness of only a few inches. Based on the limited areas of the River represented by the side slopes coupled with the fact that even a thin layer is expected to provide benefit, this issue is not expected to impact the overall effectiveness of the cap. Actual cap placement methods on the steep side slope areas would be determined during the remedial design phase and would consider various options including the type of cap material, placement technique, substitution of additional River bed area to achieve equivalent PCB flux reduction, or an enhanced monitoring plan for those areas.

Cost (Alternative 3 – Cap T11 to T38)
The estimated present worth of this alternative is $30,900,000. This is based on a two-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.4 Alternative 4 - Dredge River areas with surface sediment PCB concentrations ≥50 ppm, cap between sediment probing Transects T11 and T38, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Dredge PCBs ≥50 ppm; Cap T11 to T38)

Description (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
This alternative combines dredging River areas with surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 50 ppm, placement of a cap between sediment probing Transects T11 and T38, installation of an engineered cap at Outfalls 001/004, with ongoing site-wide natural recovery processes (Figure 5-5). Dredging activities would occur first, followed by construction of the engineered cap at Outfalls 001/004, then installation of the cap between sediment probing Transects T11 and T38. Dredged materials would be dewatered, stabilized, and placed in an on-site landfill cell. The cap placed between sediment probing Transects T11 and T38 would cover all areas dredged as part of this alternative. One isolated downstream area with surface sediment PCB concentrations greater than or equal to 50 ppm would be excluded from both dredging and capping (see below).

Dredging
Dredging activities would be performed using hydraulic dredging equipment. It is estimated that a total of approximately 48,000 in-situ cy of soft sediment material (in an area covering about 15 acres) would be removed. Note that the dredge volumes provided for all alternatives were estimated based on the removal of all materials to the extent practicable in those individual model grid elements that contain surface sediment PCB concentrations above the targeted concentration. Concurrent with hydraulic dredging, any boulders and debris present in the targeted area would be removed from the River to the extent feasible via mechanical means. An isolated area located downstream of sediment probing Transect T38 with surface sediment concentrations greater than or equal to 50 ppm, but less than an acre in size would not be dredged due to the significant implementation inefficiencies associated with such an effort.

It is anticipated that hydraulic dredging would occur at a rate of approximately 1,250 cubic yards per day (cy/day) using two dredges simultaneously for a total of two months of removal activity. The results of the recent OSI underwater surveys (January 2002) and other available data would be considered during the remedial design phase of this remedy.

Silt curtains would be installed around the areas targeted for dredging to mitigate PCB releases during implementation, and multiple setups would be employed to promote continuous operations. No more than one-half of the River width would be cordoned off at any time to allow for boat traffic and fish movement during dredging activities. After dredging is complete at a given area, the silt curtain system would remain in place for an appropriate length of time to mitigate potential releases of material downstream.

For purposes of this evaluation, it is assumed that dredged sediment would undergo a similar treatment process to that used during the NTCRA (see Section 2.7.1). Dredged material likely would be pumped to the staging area and dewatered and stabilized if necessary. The treated effluent then would be discharged back to the lower Grasse River. The debris, sand, rock, and dewatered sediment would be loaded, transported and disposed in Alcoa's on-site Secure Landfill. A new cell would need to be constructed to accommodate the volume of material anticipated for disposal. Alcoa's on-site Secure Landfill is permitted to accept materials with PCB concentrations greater than or equal to 50 ppm, and as such, segregation activities would not be required for the dredged materials.

Capping
Engineered capping adjacent to Outfalls 001/004 (approximately 5 acres) and capping between sediment probing Transects T11 and T38 (approximately 122 acres) from bank-to-bank. For purposes of this evaluation areas supporting near-shore aquatic vegetation would be capped with a thin layer to preserve habitat integrity; other approaches may be considered during the remedial design phase) would be placed using the same design and processes described in Alternative 3. Engineered capping would take less than one month to complete and capping would require approximately 12 months of total construction time (two construction seasons) for completion.

Implementation of this alternative is anticipated to require three construction seasons, and for the purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow construction of the on-site landfill. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Monitoring
In addition to the activities related to capping and long-term monitoring described in Alternatives 2 and 3, monitoring would be performed during dredging activities to assess the effectiveness of engineering controls and water treatment, and physical probing would be performed following dredging to assist in the determination of sediment volume removed. It is anticipated that fish consumption advisories would remain in place until long-term monitoring indicates the advisories are no longer necessary.

<u>Overall Protection of Human Health and the Environment</u> (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
This alternative provides overall protection by combining the benefits of Alternatives 2 and 3 (related to natural recovery and capping). Removal of 48,000 in-situ cy of PCB-containing sediment likely would not contribute significantly to overall protection since reductions in surface sediment exposure levels would be driven by placement of a cap over the dredged areas. Benefits of source control, reduction in PCB volume, and permanent removal associated with the dredging component of this alternative are discussed in various sections below. Potential short-term negative impacts on water quality, habitat, and human health may be reduced through proper design and implementation of the alternative.

Compliance with ARARs (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
River-wide average PCB levels in the water column are predicted to meet the chronic exposure CWA-AWQC of 0.014 ppb by approximately 2016. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

It is expected that all location- and action-specific ARARs would be met for the dredging component of this alternative. Specifically, compliance would be achieved since Alcoa's on-site landfill is permitted to hold dredged material that contains PCBs at concentrations in excess of 50 ppm and it is anticipated that the water removed from the River during hydraulic dredging would be treated and discharged back to the River considering applicable ARARs (i.e., CWA – Federal Water Pollution Control Act, NYS Pollution Discharge Elimination System, Surface Water Regulations, Fish and Wildlife Management). Compliance with ARARs in consideration of the capping component of this alternative is discussed in detail under Alternative 3.

Long-Term Effectiveness and Permanence (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
Implementation of this alternative would provide reductions in PCB concentrations in fish and PCB loading to the St. Lawrence River over time beyond those resulting from ongoing natural recovery and completed external source control actions. Site conditions would be tracked through long-term monitoring.

In an effort to fully evaluate the effectiveness of this alternative in meeting this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

RAOs #1 and #3 would be met via implementation of this alternative. Reduction of PCB flux from the sediment to the water column – the primary source of PCBs to the River – by dredging and cap placement is expected to reduce fish tissue PCB levels and PCB loading to the St. Lawrence River from the Grasse River (RAOs #1 and #3, respectively). Modeling indicates that this alternative would provide a 75% reduction in River-wide average fish tissue PCB concentration in about 5 years and a 90% reduction in about 22 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.28 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River would be achieved in about 18 years. As discussed previously, the modeling results are based on assumptions related to dredging effectiveness, including achievement of a 2.5 ppm residual PCB concentration. It should be recognized that site-specific data obtained from the NTCRA resulted in significantly higher residual PCB levels, and model results should be viewed in this context. Results of these modeling efforts are illustrated on Figure 5-6 and are summarized below.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥50 ppm; Cap T11 to T38	5 years	22 years	18 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the caps were assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 127 acres.
(4) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).

During dredging activities, model projections assume that 0.1% of the targeted PCB mass is released to the water column and a residual PCB concentration of 2.5 ppm remains in the surficial sediments (see Appendix B). Short-term increases in PCB concentrations in both fish tissue PCB concentrations and PCB loading to the St. Lawrence River likely would be observed as a result of the dredging activities (see time-trend plot, Figure 5-6). Subsequent placement of the cap would significantly reduce the residual PCB levels in the dredged areas and is responsible for a substantial percentage of the projected PCB reductions in fish tissue and loading to the St. Lawrence River.

Reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River (RAO #2) would be achieved through implementation of this alternative by decreasing PCB availability to lower Grasse River fish, reducing PCB loading the St. Lawrence River, and controlling sources to and within the system.

Protection of the lower Grasse River ecosystem (RAO #4) could be achieved through the use of engineered controls. Achievement of this RAO with regard to the capping component is discussed under Alternative 3. A silt containment system and daily monitoring would be implemented to mitigate the effects of the sediment removal activities; however, potential short-term risks are likely to increase as a result of anticipated sediment resuspension/PCB releases during dredging operations. Since the targeted sediment removal area is somewhat limited in size (approximately 15 acres, representing 4% of the total lower Grasse River surface area), removal is not expected to disrupt, to any great extent, the overall ongoing natural recovery processes in other areas of the River. Placement of a cap over the dredged areas would reduce any long-term effects which may result from dredging as it provides a layer of clean material that would isolate the residual PCB-containing sediment from the overlying water column. It also would provide a suitable habitat for fish and benthos. Implementation of this alternative likely would satisfy RAO #4.

Under this alternative, approximately 15 acres of the lower River would be dredged and approximately 127 acres (including dredged areas) would be covered with clean material. These areas are responsible for approximately 70% of the diffusive flux from surface sediment. It is anticipated that the implementation of this alternative, along with the benefits provided by ongoing natural recovery processes and the external source control actions already completed by Alcoa, would satisfy RAO #5 (source control).

The dredging component of this alternative would target the permanent removal of approximately 48,000 in-situ cy of PCB-containing sediments from the lower Grasse River. However, due to the limitations discussed in short-term effectiveness (below) it is likely that not all of the PCB-containing sediments from the targeted areas would be removed. The long-term effectiveness and permanence associated with the capping component of this alternative is described in detail under Alternative 3. As discussed previously, the cap would be designed to

address the potential for future erosion as well as PCB migration through the cap. Also, scour resulting from recreational boating (i.e., prop wash and anchor impacts) is expected to have limited impact on the cap.

This alternative provides adequacy and reliability in terms of the long-term protectiveness and permanence from any potential exposure risks associated with PCBs in the lower Grasse River through continued natural recovery processes, placement of the caps, removal of sediments with PCB concentrations greater than or equal to 50 ppm, institutional controls, and monitoring and maintenance. Monitoring would provide a means for identification and subsequent repair of damage to the cap. Alcoa's on-site Secure Landfill would provide adequate control and effective long-term management of all dredged sediment materials and maintain any potential exposure to human and environmental receptors within acceptable levels. The treated water discharged back into the River would meet reasonable discharge requirements.

In summary, this alternative provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River. This assessment is based on the assumptions related to dredging and capping effectiveness as provided in Section 5.1, and could change if these assumptions are not consistent with what is actually achievable.

Reduction of Toxicity, Mobility or Volume Through Treatment (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. Removal of approximately 48,000 in-situ cy of sediment in the River via dredging would reduce the volume of the PCB-containing sediment in the lower Grasse River, although based on experience during the NTCRA, some increase in mobility would be likely in the short term. Over the longer term, mobility of the dredged PCBs would be reduced via disposal in Alcoa's on-site Secure Landfill. Stabilization/solidification of removed sediments would further reduce PCB mobility. It should also be recognized that consistent with the findings of the NRC (2001), the reduction of PCB-containing sediment volume does not necessarily equate to a reduction in risk.

A detailed discussion of reduction of toxicity, mobility or volume for the capping component is provided under Alternative 3.

Short-Term Effectiveness (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
The short-term effects of implementation of the dredging component of this alternative would occur over a two-month implementation period and include disruption of areas along the River to construct access points, potential impacts to the water column during dredging, potential for increased bioavailability of PCBs, alteration of the benthic habitat, possible disruption of/inconvenience to recreational boating traffic in the River, and potential transportation accidents. Short-term effects associated with the capping component (lasting 12 months/2 construction seasons) are discussed in detail under Alternative 3.

To understand the potential short-term impacts of dredging, technical limitation/uncertainties associated with the removal of PCB-containing sediments must be assessed. These limitations/uncertainties, which result from a variety of factors, were experienced during the NTCRA and would therefore be anticipated to occur during future removal activities at the Study Area. Limitations of dredging effectiveness include the presence of rocks/cobbles or other debris on the River bottom, the presence of bedrock and/or hardpan under the soft sediments which precludes overdredging into clean material, mixing of PCB-containing sediment with underlying or surrounding sediment, limitations/inconsistencies of removal efficacy, and resuspension (and settlement) of sediment – all conditions that may be encountered during implementation of the dredging component of this alternative. Such factors limit the ability to accurately predict post-dredging residual PCB concentrations. Further, due to the increased potential of sediment resuspension during dredging, it is possible

that impacts to the water column will occur. During the 1995 NTCRA dredging, the corrective action trigger of 2 ppb was exceeded during removal operations (BBL, December 1995). Additionally, PCB concentrations in caged as well as native fish were observed to increase during the NTCRA dredging activities (see Figures 2-16 and 2-29).

As evidenced during the NTCRA, increased surficial PCB concentrations in some areas may result after dredging, due to the inability to remove all sediments from the target area and higher PCB levels that may exist at depth. These remaining PCB-containing sediments would act as continuing sources of PCBs to the water column and fish. For this reason, dredged areas would be covered with cap material as part of the continuous cap placed from sediment probing Transects T11 to T38. Reasonable and practical means would be undertaken to reduce concerns associated with the implementation of dredging, however, these effects cannot be entirely avoided.

In areas of the River targeted for dredging, the fish habitat and benthic community would be significantly altered or destroyed. Cap placement over the dredged area would support recovery of the benthic community and re-establishment of the habitat. As a whole, adverse ecological effects associated with implementation of this alternative should be limited due to the size of the area impacted by the dredging.

Near-term improvements in the reduction of PCB levels in fish and PCB loading to the St. Lawrence River resulting from implementation of this alternative would be similar to those observed for Alternative 3, as the capping component is similar in size under both alternatives and is responsible for the predicted reductions.

Measures would be taken to minimize disruption to boating traffic and the potential for transportation accidents (including both 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) to the extent practicable. Note that no accidents were observed during the NTCRA dredging or the Capping Pilot Study. During implementation, remediation workers and the community are not expected to be exposed to PCB levels that present unacceptable health risks, and appropriate health and safety practices (OSHA 29 CFR 1910.129) would be followed through implementation of a Study-Area specific HASP.

<u>Implementability</u> (Alternative 4 - Dredge PCBs ≥50 ppm; Cap T11 to T38)
As documented during the NTCRA activities (BBL, December 1995), the presence of steep side slopes and debris is expected to affect the practicability of removing sediment from the targeted areas. Results of recent underwater surveys performed by OSI (January 2002) indicate that a large portion of the sediment bed that would be targeted for dredging in this alternative is irregular and contains boulders, rocks, and cobbles – all of which would limit implementability and ultimate effectiveness of the dredging component. It is expected that sediment suspended during dredging would either resettle in the removal area or be transported further downstream. Based on experience gained through the NTCRA, effective removal of sediment likely would be limited to areas with greater than one foot of sediment and relatively shallow side slopes.

Dredging of sediment and construction of the caps is technically feasible and could be accomplished using construction equipment available from a number of contractors. Necessary equipment and services would be available in sufficient supply to implement this alternative. As demonstrated through the NTCRA removal operations, dredging and dewatering of sediment can be executed at the Study Area. An additional disposal cell at Alcoa's on-site Secure Landfill would have to be constructed to contain the dredged sediment and the time required for construction of this cell would need to be considered. Further details associated with the capping component of this alternative are discussed under Alternative 3.

Implementation of capping and dredging is administratively feasible, as no permits are required for in-River activities on-site. However, construction will be performed in accordance with the substantive requirements of ARARs. Personnel and technologies required to perform dredging and install the caps are expected to be available in sufficient supply.

Cost (Alternative 4 – Dredge PCBs ≥50 ppm; Cap T11 to T38)
The estimated present worth of this alternative is $51,400,000. This is based on a two-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.5 Alternative 5 - Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥10 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)

Description (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
This alternative combines dredging River areas with surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 25 ppm, placement of a cap over sediment with surface PCB concentrations greater than or equal to 10 ppm, installation of an engineered cap at Outfalls 001/004, and site-wide natural recovery processes (Figure 5-7). Dredging activities would occur first, followed by construction of the engineered cap at Outfalls 001/004, then installation of a cap over those areas with surface sediments greater than or equal to 10 ppm. The cap also would cover all dredged areas.

Dredging
Dredging would be performed as outlined under Alternative 4 using both hydraulic and mechanical dredging equipment within all areas identified to contain surface sediment PCB concentrations greater than or equal to 25 ppm. It is estimated that a total of approximately 101,000 in-situ cy of soft sediment material (in an area covering about 26 acres) would be removed. In addition, silt curtains would be installed around the area targeted for dredging to mitigate PCB releases during implementation (see Alternative 4 for more details). It is anticipated that hydraulic dredging would occur at a rate of approximately 1,250 cy/day using two dredges simultaneously for a total of four months of removal activity.

Capping
Using the same capping processes described in Alternative 3, an engineered cap would be placed adjacent to Outfalls 001/004 followed by the installation of a cap over sediment with surface PCB concentrations greater than or equal to 10 ppm. The engineered cap would be placed over approximately 5 acres and the cap would cover an area approximately 116 acres from bank-to-bank. For purposes of this evaluation, areas supporting near-shore aquatic vegetation would be capped with a thin layer to preserve habitat integrity (other approaches may be considered during the remedial design phase). To minimize potential constructability inefficiencies associated with capping surface sediments with PCB concentrations greater than or equal to 10 ppm (as these areas are not all contiguous), design of the cap could be modified to consist of a continuous cap that would extend from sediment probing Transects T11 to T38 and cover approximately 122 acres (capping of this area would provide similar reductions in water column and fish tissue PCB levels). However, for purposes of this discussion, only capping of areas with surficial PCB concentrations greater than or equal to 10 ppm is considered.

The estimated placement rate for engineered capping is 420,000 ft^2/mo and would take less than one month to complete. Construction of the sand/topsoil cap is assumed to occur at a rate of 450,000 ft^2/mo (using two crews) and take approximately 12 months. It is anticipated that installation of the engineered cap would occur concurrently with the last month of dredging activities. Capping would begin once both dredging and engineered capping are complete.

Implementation of this alternative is anticipated to require three construction seasons for purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow construction of the on-site landfill. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Monitoring
Monitoring conducted during construction and over a 30-year long-term monitoring program would be consistent with the program described under Alternative 4. It is anticipated that fish consumption advisories would remain in effect until monitoring indicates the advisories are no longer necessary.

Overall Protection of Human Health and the Environment (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
This alternative provides overall protection by combining the benefits of Alternatives 2 and 3 (related to natural recovery and capping). Removal of 101,000 in-situ cy of PCB-containing sediment likely would not contribute significantly to overall protection since reductions in surface sediment exposure levels would primarily result from the placement of a cap over the dredged areas. Benefits of source control, reduction in PCB volume, and permanent removal associated with the dredging component of this alternative are discussed in various sections below. Potential short-term negative impacts on water quality, habitat, and human health may be reduced through proper design and implementation of the alternative.

Compliance with ARARs (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
Based on modeling results, River-wide average PCB water column concentrations would meet the chronic CWA-AWQC standard for PCBs (0.014 ppb) by approximately 2021. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions which have been accounted for in model projections. As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Both dredging and capping likely would comply with action- and location-specific ARARs as described in the pertinent subsections of Alternatives 3 and 4.

Long-Term Effectiveness and Permanence (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
Dredging of sediments with surface PCB concentrations greater than or equal to 25 ppm (approximately 26 acres) followed by engineered capping at Outfalls 001/004 (total area of approximately 5 acres) and capping of areas with surface sediment concentrations greater than or equal to 10 ppm PCBs (total area of approximately 116 acres) would significantly lower PCB concentrations in surface sediment, water column, and fish. These reductions would be in addition to those resulting from ongoing natural recovery and completed external source control actions.

To fully evaluate the effectiveness of this alternative against this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

As summarized in the table below, modeling indicates that dredging and placement of the caps are predicted to provide a 75% reduction in River-wide average fish tissue PCB concentrations in about 5 years and a 90% reduction in about 22 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.29 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River would be achieved in about 18 years. As discussed previously, the modeling results are based on assumptions related to dredging effectiveness, and must be viewed in that context. Results of these modeling efforts are illustrated on Figure 5-8 and are summarized below.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm	5 years	22 years	18 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the cap was assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 121 acres.
(4) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was set equal to 2.5 ppm (see Appendix B for further details).

RAOs #2 (reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River) and #4 (protection of the lower Grasse River ecosystem) would be met for this alternative in the same manner as described under Alternative 4. Since the targeted sediment removal area is approximately 26 acres (representing 6% of the total lower Grasse River surface area), removal should not significantly disrupt ongoing natural recovery processes in other areas of the River.

Under this alternative, approximately 26 acres of the lower River would be dredged and approximately 121 acres (including dredged areas) would be capped with clean material. These areas are responsible for approximately 70% of the diffusive flux from surface sediment. Implementation of this alternative, along with the benefits provided by ongoing natural recovery processes and the completed external source control actions, would satisfy RAO #5 (source control).

Other expected long-term effects associated with dredging (i.e., resuspension, settlement, mixing, water quality impacts, etc.) are similar to those discussed in Alternative 4, although effects associated with this alternative would occur over a larger area of the River (26 acres versus 15 acres) and for a longer duration (4 months versus 2 months). The dredging component would target approximately 101,000 in-situ cy of PCB-containing sediments for permanent removal from the lower Grasse River; however, due to the limitations discussed in short-term effectiveness in Alternative 4, it is likely that not all of the PCB-containing sediments from the targeted areas would be removed. Capping the dredged areas would address the possibility that elevated post-dredging sediment PCB concentrations may remain and would improve the long-term effectiveness of this alternative. The long-term effectiveness and permanence associated with the capping component of this alternative is described in detail under Alternative 3.

As discussed under Alternative 4, this alternative provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River. This assessment is based on the assumptions related to dredging and capping effectiveness as provided in Section 5.1, and could change if these assumptions are not consistent with what is actually achievable.

Reduction of Toxicity, Mobility or Volume Through Treatment (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of this criterion as it pertains to dredging is contained under Alternative 4. The additional 53,000 cy of sediment targeted for removal under this alternative would provide additional reduction of toxicity and mobility over Alternative 4. With regard to the capping component of this alternative, a detailed discussion is provided under Alternative 3. The reductions in mobility would be slightly less since the total area capped in this alternative would be 6 acres smaller (121 acres versus 127).

Short-Term Effectiveness (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
Short-term effects and measures to be taken to minimize these effects are described in detail in Alternative 3 (capping component) and Alternative 4 (dredging component). Note however, that the dredging component of this alternative includes the removal of an additional 53,000 cy of sediment over Alternative 4, increasing projected construction time from two to four months. In addition, technical limitations and uncertainties associated with dredging are described under Alternative 4. Short-term effects related to capping would last for 12 months, or 2 construction seasons.

Near-term improvements in the reduction of PCB levels in fish and PCB loading to the St. Lawrence River resulting from implementation of this alternative would be similar to those observed for Alternative 3, as the capping component is similar in size under both alternatives and is responsible for the predicted reductions.

Implementability (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
Implementability issues for this alternative, including technical and administrative feasibility are discussed under Alternative 4 (for dredging) and Alternative 3 (for capping).

Cost (Alternative 5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm)
The estimated present worth of this alternative is $64,900,000. This is based on a three-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.6 Alternative 6 - Cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Cap PCBs ≥5 ppm)

Description (Alternative 6 - Cap PCBs ≥5 ppm)
This alternative combines the placement of a cap over areas containing surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 5 ppm, installation of an engineered cap at Outfalls 001/004, and site-wide natural recovery (Figure 5-9). The engineered cap would be placed at Outfalls 001/004 prior to the installation of the cap over areas with surficial sediment concentrations greater than or equal to 5 ppm PCBs.

Capping
Using the same processes described in Alternative 3, the engineered cap would be placed over approximately 5 acres and the cap would cover an area approximately 235 acres from bank-to-bank; for purposes of this evaluation, areas supporting near-shore aquatic vegetation would be capped with a thin layer to preserve habitat integrity (other approaches may be considered during the remedial design phase). To improve implementability, the cap design could be modified from a cap covering only areas with PCB surface sediment concentrations greater than or equal to 5 ppm to a continuous cap that would provide similar reductions in water column and

fish tissue PCB levels. This continuous cap would extend from sediment probing Transects T11 to T58 and cover approximately 247 acres. However, for purposes of this discussion, only capping of areas with surficial PCB concentrations greater than or equal to 5 ppm is considered.

The estimated placement rate for engineered capping is 420,000 ft^2/mo and would take less than one month to complete. Capping sediments with PCB levels greater than or equal to 5 ppm would take approximately 23 months at a rate of 450,000 ft^2/mo (using two crews).

Implementation of this alternative is anticipated to require four construction seasons (each construction season is six months long) and for purposes of the modeling evaluation, construction is assumed to begin in 2004. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Monitoring
Monitoring would be performed during all in-River work and following the completion of capping, consistent with the program described under Alternative 3. It is anticipated that fish consumption advisories would remain in-place until monitoring indicates the advisories are no longer necessary.

<u>Overall Protection of Human Health and the Environment</u> (Alternative 6 - Cap PCBs ≥5 ppm)
This alternative provides overall protection and risk reduction by isolating 240 acres of sediment with PCB concentrations greater than or equal to 5 ppm. Potential short-term negative impacts on water quality, habitat, and human health are expected to be minimal and would be addressed, to the extent practicable, in the design and implementation of the alternative.

<u>Compliance with ARARs</u> (Alternative 6 - Cap PCBs ≥5 ppm)
River-wide average PCB levels in the water column would be anticipated to meet the chronic exposure CWA-AWQC by approximately 2011. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

It is expected that all applicable action- and location-specific ARARs (discussed under Alternative 3), would be met during implementation of this alternative.

<u>Long-Term Effectiveness and Permanence</u> (Alternative 6 - Cap PCBs ≥5 ppm)
In addition to reductions in fish PCB levels and loading to the St. Lawrence River as a result of ongoing natural recovery processes and Alcoa's completed external source control actions, surface sediment PCB concentrations in the Study Area are expected to be significantly reduced after placement of the caps.

To fully evaluate the effectiveness of this alternative in meeting long-term effectiveness and permanence, the alternative is evaluated against the five RAOs identified in Section 3.3.

Results of site-specific modeling indicate that the reduction of PCB flux from the sediment to the water column achieved through implementation of this alternative would ultimately reduce fish tissue PCB levels and PCB loading to the St. Lawrence River from the Grasse River (RAOs #1 and #3, respectively). Placement of the 235-acre cap and the 5-acre engineered cap is predicted to provide a 75% reduction in River-wide average fish tissue PCB concentration in about 4 years and a 90% reduction in about 11 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.19 mg/kg in

2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River is predicted to take about 5 years. Results of these modeling efforts are illustrated on Figure 5-10 and are summarized below.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Cap PCBs ≥5 ppm	4 years	11 years	5 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the cap was assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 240 acres.

RAOs #2 (reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River) and #4 (protection of the lower Grasse River ecosystem) would be met through implementation of this alternative (see Alternative 3 for discussion).

In addition to the benefits provided by Alcoa's completed external source control actions, as part of this alternative, approximately 240 acres of the lower Grasse River would be covered with clean material. This area is responsible for approximately 90% of the diffusive flux from surface sediment. As such, it is anticipated that source control RAO (#5) would be satisfied through implementation of this alternative. More detail on PCB sources to the River is provided in Section 2 and Alternative 3.

This alternative provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River through placement of the caps, continued natural recovery processes, institutional controls, and monitoring. Although long-term monitoring and maintenance of the caps would be necessary, proper design and installation should reduce these maintenance requirements. Potential long-term capping issues (i.e., cap stability, cap erodability, and isolation of PCBs) are discussed in detail under Alternative 3.

<u>Reduction of Toxicity, Mobility, or Volume through Treatment</u> (Alternative 6 - Cap PCBs ≥5 ppm)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of the reduction of toxicity, mobility, or volume through treatment due to placement of a cap is provided in Alternative 3. Additional benefits in regard to reduction of mobility would be realized due to the increased areal extent of the caps (240 acres for this alternative versus 127 acres for Alternative 3).

<u>Short-Term Effectiveness</u> (Alternative 6 - Cap PCBs ≥5 ppm)
The potential short-term effects associated with construction of the caps are assessed in detail under Alternative 3. Impacts from implementation of this alternative would be greater due to the increased area targeted for capping (240 acres versus 127 acres) and the longer implementation period (4 construction seasons versus 2 construction seasons). Further, significant near-term improvements would result from implementation of this alternative through predicted reductions in fish PCB concentrations and PCB loading to the St. Lawrence River. These reductions would be more rapid than those observed for Alternative 3, but would require a longer implementation time frame and result in additional short-term impacts due to the larger target area within the River.

Implementability (Alternative 6 - Cap PCBs ≥5 ppm)
Implementability issues for this alternative are discussed in Alternative 3. Despite the increased areal extent and construction period for this alternative, construction of a cap is expected to be both technically and administratively implementable.

Cost (Alternative 6 - Cap PCBs ≥5 ppm)
The estimated present worth of this alternative is $54,800,000. This is based on a four-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.7 Alternative 7 - Dredge River areas with surface sediment PCB concentrations ≥50 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)

Description (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
This alternative combines dredging River areas with surface (0 to 3 inches) PCB sediment concentrations greater than or equal to 50 ppm (48,000 in-situ cy), placement of a cap over sediment with surface PCB concentrations greater than or equal to 5 ppm (235 acres), installation of an engineered cap at Outfalls 001/004 (5 acres), and site-wide natural recovery (Figure 5-11). The sequencing of components for this alternative would include implementation of dredging activities first, then construction of the engineered cap at Outfalls 001/004, and finally installation of the cap. The cap would cover all dredged areas. As noted in Alternative 6, the capping portion of this alternative could be modified from a cap covering only areas with surface sediments containing PCB concentrations greater than or equal to 5 ppm to an equivalent continuous cap covering approximately 247 acres from sediment probing Transects T11 to T58. However, for purposes of this discussion, capping of areas with surficial PCB concentrations greater than or equal to 5 ppm is considered.

Capping would proceed as described in Alternative 3, and activities associated with dredging and monitoring would be performed as outlined in Alternative 4. It is anticipated that fish consumption advisories would remain in place until monitoring indicates the advisories are no longer necessary. Implementation of this alternative is anticipated to require 5 construction seasons and for purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow construction of the on-site landfill. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Overall Protection of Human Health and the Environment (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
This alternative provides overall protection by combining the benefits of Alternatives 2 and 3 (related to natural recovery and capping). Removal of 48,000 in-situ cy of PCB-containing sediment likely would not contribute significantly to overall protection since reductions in surface sediment exposure levels would be attained primarily through the placement of a cap over the dredged areas. Benefits of source control, reduction in PCB volume, and permanent removal associated with the dredging component of this alternative are discussed in various sections below. Potential short-term negative impacts on water quality, habitat, and human health may be reduced to the extent practicable through proper design and implementation of the alternative.

Compliance with ARARs (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
Based on modeling results, River-wide average PCB water column concentrations would meet the chronic CWA-AWQC standard for PCBs (0.014 ppb) by approximately 2009. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to the site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Both dredging and capping likely would comply with action- and location-specific ARARs as described in the pertinent subsections Alternatives 3 and 4.

Long-Term Effectiveness and Permanence (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
Implementation of this alternative would provide a significant reduction in PCB concentrations in lower Grasse River fish and PCB loading to the St. Lawrence River over time. These reductions would be in addition to the reductions that would result from ongoing natural recovery and completed external source control measures. Site conditions would be tracked through long-term monitoring.

To fully evaluate the effectiveness of this alternative in meeting this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

As presented on the table below, modeling indicates that dredging and placement of the caps are predicted to provide a 75% reduction in River-wide average fish tissue PCB concentration in about 4 years and a 90% reduction in about 8 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.16 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River is anticipated to require about 5 years to achieve. As discussed previously, the modeling results are based on assumptions related to dredging effectiveness, and must be viewed in that context. These reductions would result in achievement of RAOs #1 and #3. Results of these modeling efforts are illustrated on Figure 5-12.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm	4 years	8 years	5 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the cap was assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 240 acres.
(4) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).

It is anticipated that RAOs #2 and #4 would be achieved through implementation of this alternative. Achievement of these RAOs with regard to the capping and dredging components are discussed in Alternatives 3 and 4, respectively.

Under this alternative, approximately 15 acres of the lower River would be dredged with subsequent covering of approximately 240 acres with clean material (including dredged areas). These areas are responsible for

approximately 90% of the diffusive flux from surface sediment. As such, it is anticipated that implementation of this alternative, along with the benefits provided by ongoing natural processes and completed external source control actions, would satisfy the source control RAO (#5).

Other expected long-term effects associated with dredging (i.e., resuspension, mixing, water quality impacts, etc.) are similar to those discussed in Alternative 4. The dredging component would target approximately 48,000 in-situ cy of PCB-containing sediments for permanent removal from the lower Grasse River; however, due to the limitations discussed in short-term effectiveness in Alternative 4, it is likely that not all of the PCB-containing sediments from the targeted areas would be removed. Capping the dredged areas likely would address the possibility that post-dredging sediment concentrations in some areas may increase over current levels and greatly improve the long-term effectiveness of this alternative. The long-term effectiveness and permanence associated with the capping component of this alternative is described in detail under Alternative 3, although effects associated with this alternative would occur over a larger area of the River (240 acres versus 127 acres) and for a longer period of time (23 months versus 12 months).

In summary, for the reasons discussed above and under Alternatives 3 and 4, this alternative provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River.

Reduction of Toxicity, Mobility or Volume Through Treatment (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of this criterion as it pertains to dredging is contained in Alternative 4. With regard to the capping component of this alternative, a detailed discussion is provided in Alternative 3, although this alternative provides for placement of a cap over 240 acres (approximately two times the size of the cap in Alternative 3) and therefore reduces the mobility of PCBs in sediments over a larger area.

Short-Term Effectiveness (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
The short-term effects of implementation of this alternative and measures to be taken to minimize these effects to the extent practicable are described in Alternative 3 (capping component) and Alternative 4 (dredging component). While this alternative includes the same removal volume as Alternative 4, a cap would be installed over 240 acres in 23 months (approximately double the cap area and duration under Alternative 3).

Near-term improvements in the reduction of PCB levels in fish and PCB loading to the St. Lawrence River resulting from implementation of this alternative would be similar to those resulting from implementation of Alternative 6, as the capping component is similar in size for both alternatives and is responsible for the predicted reductions.

Implementability (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
Implementability issues for this alternative, including technical and administrative feasibility are similar to those discussed under Alternative 4 (for dredging) and Alternative 3 (for capping).

Cost (Alternative 7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm)
The estimated present worth of this alternative is $75,100,000. This is based on a five-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.8 Alternative 8 - Dredge River areas with surface sediment PCB concentrations ≥25 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)

Description (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
This alternative combines dredging River areas with surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 25 ppm (101,000 in-situ cy), placement of a cap over sediment with surface PCB concentrations greater than or equal to 5 ppm (235 acres), installation of an engineered cap at Outfalls 001/004 (5 acres), and site-wide natural recovery (Figure 5-13). The sequencing of components for this alternative would include implementation of dredging activities first, then construction of the engineered cap at Outfalls 001/004, and finally installation of the cap. The cap would cover all dredged areas. As noted in Alternative 6, this alternative could be modified from a cap covering only areas with surface sediments containing PCB concentrations greater than or equal to 5 ppm to an equivalent continuous cap covering approximately 247 acres from sediment probing Transects T11 to T58. However, for purposes of this discussion, capping areas with surficial PCB concentrations greater than or equal to 5 ppm is considered.

Capping would proceed as described in Alternative 3, and activities associated with dredging and monitoring would be performed as outlined in Alternative 4. It is anticipated that fish consumption advisories would remain in place until monitoring indicates the advisories are no longer necessary. Implementation of this alternative is anticipated to require 5 construction seasons and for purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow construction of the on-site landfill. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Overall Protection of Human Health and the Environment (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
This alternative provides overall protection by combining the benefits of Alternatives 2 and 3 (related to natural recovery and capping). Removal of 101,000 in-situ cy of PCB-containing sediment likely would not contribute significantly to overall protection since reductions in surface sediment exposure levels would be attained primarily through the placement of a cap over the dredged areas. Benefits of source control, reduction in PCB volume, and permanent removal associated with the dredging component of this alternative are discussed in various sections below. Potential short-term negative impacts on water quality, habitat, and human health may be reduced to the extent practicable through proper design and implementation of the alternative.

Compliance with ARARs (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
Based on modeling results, River-wide average PCB water column concentrations would meet the chronic CWA-AWQC standard for PCBs by approximately 2009. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Both dredging and capping likely would comply with action- and location-specific ARARs as described in the pertinent subsections of Alternatives 3 and 4.

Long-Term Effectiveness and Permanence (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
Implementation of Alternative 8 would provide a significant reduction in PCB concentrations in lower Grasse River fish and PCB loading to the St. Lawrence River over time. These reductions would be in addition to the

reductions expected to result from ongoing natural recovery and completed external source control measures. Site conditions would be tracked through long-term monitoring.

To fully evaluate the effectiveness of this alternative in meeting this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

As presented on the table below, modeling indicates that dredging and placement of the caps are predicted to provide a 75% reduction in River-wide average fish tissue PCB concentration in about 4 years and a 90% reduction in about 8 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.16 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River is anticipated to require about 5 years to achieve. These reductions would result in achievement of RAOs #1 and #3. As discussed previously, the modeling results are based on assumptions related to dredging effectiveness, and must be viewed in that context. Results of these modeling efforts are illustrated on Figure 5-14.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm	4 years	8 years	5 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the cap was assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 240 acres.
(4) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).

It is anticipated that RAOs #2 and #4 would be achieved through implementation of this alternative. Achievement of these RAOs with regard to capping and dredging components are discussed in Alternatives 3 and 4, respectively.

Under this alternative, approximately 26 acres of the lower River would be dredged with subsequent covering of approximately 240 acres with clean material (including dredged areas). These areas are responsible for approximately 90% of the diffusive flux from surface sediment. As such, it is anticipated that the source control RAO (#5) would be satisfied through implementation of this alternative, along with the benefits afforded by ongoing natural processes and the completed external source control measures.

Other expected long-term effects associated with dredging (i.e., resuspension, mixing, water quality impacts, etc.) are similar to those discussed in Alternative 4, however the effects associated with this alternative would occur over a larger portion of the River (26 acres versus 15 acres) and for a longer duration (4 months versus 2 months). The dredging component would target approximately 101,000 in-situ cy of PCB-containing sediments for permanent removal from the lower Grasse River; however, due to the limitations discussed in short-term effectiveness in Alternative 4, it is likely that not all of the PCB-containing sediments from the targeted areas would be removed. Capping the dredged areas likely would address the possibility that post-dredging sediment concentrations in some areas may increase over current levels and greatly improve the long-term effectiveness of this alternative. The long-term effectiveness and permanence associated with the capping component of this alternative is described in detail under Alternative 3, although effects associated with this alternative would

occur over a larger area of the River (240 acres versus 127 acres) and for a longer period of time (23 months versus 12 months).

In summary, for the reasons discussed above and under Alternatives 3 and 4, this alternative provides long-term protectiveness and permanence from potential exposure risks associated with PCBs in the lower Grasse River.

Reduction of Toxicity, Mobility or Volume Through Treatment (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of this criterion as it pertains to dredging is contained in Alternative 4, however this alternative includes dredging 101,000 in-situ cy (approximately double the removal volume under Alternative 4). With regard to the capping component, a detailed discussion is provided in Alternative 3, although this alternative provides for placement of a cap over 240 acres (approximately two times the size of the cap in Alternative 3) and therefore reduces the mobility of PCBs in sediments over a larger area.

Short-Term Effectiveness (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
The short-term effects of implementation of this alternative, and measures to be taken to minimize these effects to the extent practicable are described in Alternative 3 (capping component) and Alternative 4 (dredging component). Note, however, that this alternative includes the removal of 101,000 in-situ cy over approximately 26 acres in 4 months with the installation of a cap over 240 acres in 23 months versus the smaller removal volume, smaller capping area, and shorter duration described under the previous alternatives.

Near-term improvements in the reduction of PCB levels in fish and PCB loading to the St. Lawrence River that result from implementation of this alternative would be similar to those observed during implementation of Alternative 6, as the capping component is similar in both alternatives.

Implementability (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
Implementability issues for this alternative, including technical and administrative feasibility, are similar to those discussed under Alternative 4 (for dredging) and Alternative 3 (for capping).

Cost (Alternative 8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm)
The estimated present worth of this alternative is $89,500,000. This is based on a five-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.9 Alternative 9 - Dredge River areas with surface sediment PCB concentrations ≥10 ppm, cap sediments with surface PCB concentrations ≥5 ppm, engineered cap at Outfalls 001/004, and site-wide monitored natural recovery (Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)

Description (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
This alternative combines dredging River areas with surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 10 ppm (515,000 in-situ cy), placement of a cap over sediment with surface PCB concentrations greater than or equal to 5 ppm (235 acres), installation of an engineered cap at Outfalls 001/004 (5 acres), and site-wide natural recovery (Figure 5-15). The cap would cover all dredged areas. If this alternative were implemented in the River, the capping portion could be modified to an equivalent continuous

cap covering approximately 247 acres from sediment probing Transects T11 to T58 as described in Alternative 6. However, for purposes of this discussion, capping of areas with surficial PCB concentrations greater than or equal to 5 ppm is considered.

Capping would proceed as described in Alternative 3, and activities associated with dredging and monitoring would be performed as outlined in Alternative 4 with dredging proceeding at a rate of 1,300 cy/day (using two dredges). It is anticipated that fish consumption advisories would remain in place until monitoring indicates the advisories are no longer necessary. Implementation of this alternative is anticipated to require 5 construction seasons, and for purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow permitting, design, and construction of additional cells at the on-site landfill. Dredging activities would start first, beginning at the farthest upstream location, and the engineered cap would be placed during the final month of the first construction season. Starting in the second season, dredging and capping would take place concurrently in an upstream to downstream manner until both activities are complete. To mitigate any effects that removal activities may have on the surrounding areas, it is expected that dredging activities would occur a minimum of approximately one mile downstream of the capping areas. Note that the actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

<u>Overall Protection of Human Health and the Environment</u> (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
This alternative provides overall protection by combining the benefits of Alternatives 2 and 3 (related to natural recovery and capping). Removal of 515,000 in-situ cy of PCB-containing sediment likely would not contribute significantly to overall protection since reductions in surface sediment exposure levels would be attained primarily through the placement of a cap over the dredged areas. Benefits of source control, reduction in PCB volume, and permanent removal associated with the dredging component of this alternative are discussed in various sections below. Potential short-term negative impacts on water quality, habitat, and human health may be reduced to the extent practicable through proper design and implementation of the alternative.

<u>Compliance with ARARs</u> (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
Based on modeling results, River-wide average PCB water column concentrations would meet the chronic CWA-AWQC standard for PCBs by approximately 2010. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Both dredging and capping likely would comply with action- and location-specific ARARs as described in the pertinent subsections of Alternatives 3 and 4.

<u>Long-Term Effectiveness and Permanence</u> (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
Implementation of this alternative would provide a significant reduction in PCB concentrations in lower Grasse River fish and PCB loading to the St. Lawrence River over time. These reductions would be in addition to those resulting from ongoing natural recovery and completed external source control measures. Site conditions would be tracked through long-term monitoring.

To fully evaluate the effectiveness of this alternative in meeting this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

As presented on the table below, modeling indicates that dredging and subsequent capping are predicted to provide a 75% reduction in River-wide average fish tissue PCB concentrations in about 5 years and a 90% reduction in about 8 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of about 0.14 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River is anticipated to require about 6 years to achieve. These reductions would result in achievement of RAOs #1 and #3. Results of these modeling efforts are illustrated on Figure 5-16. As discussed previously, the modeling results are based on assumptions related to dredging effectiveness, and must be viewed in that context. It should be noted that, as discussed in Section 5.1, due to the size of the dredging component in this alternative, model predictions are more sensitive to variations in the assumptions made regarding dredging effectiveness.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥ 10 ppm; Cap PCBs ≥ 5 ppm	5 years	8 years	6 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, the cap was assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details) over the entire 240 acres.
(4) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).

RAOs #2 (reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River) and #4 (protection of the lower Grasse River ecosystem) likely would not be met for this alternative. The capping component of the alternative would meet these RAOs (as discussed under Alternative 3), but the extensive dredging activities associated with implementation of this alternative would not. The sediment removal area targets approximately 30% of the total lower Grasse River surface area (approximately 121 acres) with dredging estimated to occur over 3 construction seasons. As a result of the extent of dredging, removal activities performed under this alternative likely would cause impacts to other areas of the River due to the PCB releases and expected post-dredging PCB residual sediments. These releases (assumed to be 0.1% of the PCB mass removed) would disrupt habitats downstream of the active work area and remain a potential source to the ecosystem during the 3 construction seasons required to complete dredging, thus increasing the potential exposure of biota to PCBs in the River. It should also be noted that assumptions regarding the effectiveness of dredging likely underestimate potential releases during dredging and post-dredging residual PCB concentrations; therefore the predicted effects of dredging could be significantly greater.

Under this alternative, approximately 121 acres of the lower River would be dredged and approximately 240 acres (including dredged areas) would be covered with clean material. These areas are responsible for approximately 90% of the diffusive flux from surface sediment. As such, it is anticipated that the source control RAO (#5) would be satisfied through implementation of this alternative, along with the benefits afforded by ongoing natural processes and the completed external source control activities. It should be noted that while the capping portion of this alternative would isolate the residual sediments in the large area targeted for dredging, the removal activities would contribute PCB sources to the River for 3 construction seasons through releases during dredging and exposed PCB-containing residual sediments prior to capping.

Other expected long-term effects associated with dredging (i.e., resuspension, mixing, water-quality impacts, etc.) are similar to those discussed in Alternative 4, however, such effects would occur over a larger portion of the River (120 acres versus 15 acres) and for a longer duration (17 months versus 2 months). The dredging component would target approximately 515,000 in-situ cy of PCB-containing sediments for permanent removal from the lower Grasse River; however, due to the limitations discussed in short-term effectiveness in Alternative 4, it is likely that not all of the PCB-containing sediments from the targeted areas would be removed. Capping the dredged areas likely would address the possibility that post-dredging sediment concentrations in some areas may increase over current levels and greatly improve the long-term effectiveness of this alternative. The long-term effectiveness and permanence associated with the capping component of this alternative is described in detail under Alternative 3, although these effects would occur over a larger area of the River (240 acres versus 127 acres) and for a longer duration (23 months versus 12 months).

In summary, for the reasons discussed above and under Alternative 4, this alternative provides limited adequacy and reliability in terms of long-term protectiveness from any potential exposure risks associated with PCBs in the lower Grasse River.

Reduction of Toxicity, Mobility or Volume Through Treatment (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)

Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of this criterion as it pertains to dredging is contained in Alternative 4. It should be recognized, however, that this alternative involves the removal of an additional 467,000 cy of sediment (in comparison to Alternative 4). According to the NRC, removal of PCB-containing sediment does not necessarily equate to risk reduction (NRC, 2001). With regard to the capping component of this alternative, a detailed discussion is provided in Alternative 3, although this alternative provides for placement of a cap over 240 acres (approximately two times the size of the cap in Alternative 3) and, therefore, reduces the mobility of a greater volume of sediments.

Short-Term Effectiveness (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)

The short-term effects of implementation of this alternative, their potential results, and measures taken to minimize these effects to the extent practicable are described in Alternative 3 (capping component) and Alternative 4 (dredging component). Note, however, that the dredging component of this alternative includes the removal of 515,000 in-situ cy over approximately 121 acres in 17 months. Since the dredging component under this alternative is 10 times larger than the volume targeted under Alternative 4, the short-term effects resulting from implementation of this alternative are expected to be significantly greater. Specifically, the short-term effects for dredging under this alternative would occur over 3 construction seasons, and include increased impacts to the water column during dredging, potential for increased bioavailability of PCBs, destruction/alteration of the benthic and fish communities, possible disruption of/inconvenience to recreational boating traffic in the River, and potential transportation accidents. Since dredging would require 3 construction seasons to complete, the short-term effects described here would become longer-term effects. Further, the short-term effects associated with capping would be greater than those for Alternative 3 as this alternative includes the installation of a cap over 240 acres in 23 months versus smaller capping areas and shorter durations described under the previous alternatives.

Near-term improvements in the reduction of PCB levels in fish and loading to the St. Lawrence River resulting from implementation of this alternative would be similar to those observed for Alternative 6, as the capping component is similar in size under both alternatives and is responsible for the predicted reductions.

Implementability (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
Implementability issues for this alternative, including technical and administrative feasibility, are similar to those discussed under Alternative 4 (for dredging) and Alternative 3 (for capping). However, the implementability issues associated with the dredging component of this alternative would be greater due to the significantly greater removal volume and area targeted under this alternative (i.e., 10 times larger and 12 times longer than the dredging program outlined under Alternative 4). As a result, there would be increased potential for accidents due to increased hauling time (estimated 32,500 truckloads of PCB-containing material to the landfill), greater inconvenience/disruption to the local community, and generally a longer time period for in-River construction.

Cost (Alternative 9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm)
The estimated present worth of this alternative is $196,300,000. This is based on a 5-year construction period followed by a 30-year post-construction monitoring and maintenance period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

5.3.10 Alternative 10 - Dredge River areas with surface sediment PCB concentrations ≥1 ppm and site-wide monitored natural recovery (Dredge PCBs ≥1 ppm)

Description (Alternative 10 - Dredge PCBs ≥1 ppm)
This alternative involves dredging River areas with surface (0 to 3 inches) sediment PCB concentrations greater than or equal to 1 ppm (Figure 5-17). It is estimated that a total of approximately 1,650,000 in-situ cy of soft sediment would be targeted for removal. Activities associated with dredging are outlined in Alternative 4. It is anticipated that hydraulic dredging would occur at a rate of approximately 1,300 cy/day using two dredges for a total of 53 months of removal activity. Note that these areas would not be covered subsequent to dredging. Implementation of the alternative is anticipated to require 9 construction seasons and for purposes of the modeling evaluation, construction is assumed to begin in 2004. At least one construction season would be required prior to the start of dredging to allow permitting, design, and construction of additional cells at the on-site landfill to hold the significant volume of material targeted for dredging. The actual construction schedule will be established during the remedial design phase, and may be altered from the schedule projected herein.

Monitoring
Monitoring conducted during construction would be consistent with the program for the dredging component as described under Alternative 4. The 30-year long-term monitoring program would consist of annual water column, sediment, biota, and benthic monitoring, a 5-year review of the program, and a fish and water column sampling event in the Power Canal. It is anticipated that fish consumption advisories would remain in-place until monitoring results indicate the advisories are no longer necessary.

Overall Protection of Human Health and the Environment (Alternative 10 - Dredge PCBs ≥1 ppm)
This alternative would provide limited overall protection as the removal of approximately 1,650,000 in-situ cy of PCB-containing sediments without subsequent capping likely would result in some portion of dredged areas containing elevated residual surface PCB concentrations. For those areas not targeted for dredging (13% of the lower Grasse River surface area) and for those areas dredged (after the 9 years necessary for implementation), overall protection under this alternative would be accomplished by natural recovery as described in Alternative 2. Benefits of source control, reduction in PCB volume in the River, and permanent removal associated with this alternative are discussed in various sections below. Negative impacts associated with this alternative's 9-

year implementation period on water quality, habitat, and human health would be mitigated, to the extent practicable, through proper design and implementation of the alternative.

Compliance with ARARs (Alternative 10 - Dredge PCBs ≥1 ppm)
Based on modeling results, River-wide average PCB water column concentrations would meet the chronic CWA-AWQC standard for PCBs by approximately 2021. The AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) will not be met within the 30-year projection period due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Dredging likely would comply with action- and location-specific ARARs as described in the pertinent subsection of Alternative 4.

Long-Term Effectiveness and Permanence (Alternative 10 - Dredge PCBs ≥1 ppm)
Implementation of this alternative would provide reduction in PCB concentrations in lower Grasse River fish and PCB loading to the St. Lawrence River over time if the assumptions used regarding dredging effectiveness are actually achieved during implementation. These reductions would be achieved through the removal of PCB-containing sediment over a large area of the River, ongoing natural recovery within the River once active remedial activities are complete, and the completed external source control measures. Site conditions would be tracked through long-term monitoring.

To fully evaluate the effectiveness of this alternative in meeting this criterion, the alternative is evaluated against the five RAOs identified in Section 3.3.

As presented on the table below, modeling indicates that a 75% reduction in River-wide average fish tissue PCB concentrations is achieved in about 8 years and a 90% reduction in about 23 years. Based on modeling results, this alternative is projected to achieve a River-wide average fish tissue PCB concentration of 0.28 mg/kg in 2030. A reduction of 85% in PCB loading from the Grasse River to the St. Lawrence River is achieved in about 18 years. These reductions would result in achievement of RAOs #1 and #3. Results of these modeling efforts are illustrated on Figure 5-18. As discussed previously, the modeling results are based on assumptions to dredging effectiveness, and must be viewed in that context. As stated under Alternative 9, it should be noted that, due to the size of the dredging component in this alternative, model predictions are more sensitive to variations in the assumptions made regarding dredging effectiveness.

Alternative	River-Wide Average Fish Tissue PCB Levels		PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted Time to Achieve 85% Reduction
Dredge PCBs ≥1 ppm	8 years	23 years	18 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, PCB releases during dredging were assumed to equal 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).

Implementation of this alternative is expected to result in PCBs remaining available to lower Grasse River fish over a large area of the River through residual sediments. As indicated under Alternative 9, these residual sediments would be a source to, and within, the system. Further, modeling inputs assume that the residual PCB

levels would be 2.5 ppm, however site-specific information indicates that this level of residual is not consistently achievable and may in fact be much higher. The effects of dredging this large area would create a much higher level of sensitivity with respect to modeling results (detailed discussion provided in Appendix B). As such, reduction and mitigation of the potential adverse effects and bioaccumulation of PCBs to the River (RAO #2) would likely not be achieved through implementation of this alternative.

In consideration of RAO #4, protection of the lower Grasse River ecosystem during implementation of this alternative may be achieved through the use of engineered controls as discussed in Alternative 4. However, it should be noted that the targeted sediment removal area covers approximately 87% of the total lower Grasse River surface area (352 acres) and therefore remedial activities performed under this alternative may affect other areas of the River including habitats downstream/adjacent to the dredging activities through PCB releases. These releases (assumed to be 0.1% of the PCB mass removed) would disrupt habitats downstream of the active work area and remain a potential source to the ecosystem, thus increasing the PCB exposure potential in the River. It should also be noted that assumptions regarding the effectiveness of dredging are conservative. If dredging is less effective than indicated by the model, greater effects to the River would be observed during dredging operations. Achievement of this RAO would likely not be satisfied through implementation of Alternative 10.

Under this alternative, approximately 352 acres of the lower River would be dredged, however, residual PCBs would remain as a source within the system. Since no cap would be placed over the dredged areas, these residual sediments would result in the source control RAO (#5) not being fully satisfied through implementation of this alternative.

Other expected long-term effects associated with dredging (i.e., resuspension, mixing, water-quality impacts, etc.) are similar to those discussed in Alternative 4, although effects associated with this alternative would occur over a significantly larger area of the River (352 acres versus 15 acres) and for a substantially longer duration (53 months versus 2 months). The dredging component would target approximately 1,650,000 in-situ cy of PCB-containing sediments for permanent removal from the lower Grasse River; however, due to the limitations discussed in short-term effectiveness in Alternative 4, not all of the PCB-containing sediments from the targeted areas would be removed.

In summary, for the reasons discussed above and under Alternative 4 (dredging component), this alternative would provide less adequacy and reliability than the other alternatives in terms of the long-term protectiveness from any potential exposure risks associated with PCBs in the lower Grasse River especially in consideration of the PCB releases and residual sediments remaining following dredging.

<u>Reduction of Toxicity, Mobility or Volume Through Treatment</u> (Alternative 10 - Dredge PCBs ≥1 ppm)
Since this alternative does not include a treatment component, reduction in toxicity, mobility, or volume through treatment would not occur. A discussion of this criterion as it pertains to dredging is contained in Alternative 4. It should be noted however, that this alternative involves the removal of an additional 1,602,000 cy of sediment (in comparison with Alternative 4). Note that an increase in mobility over the short-term (9 construction seasons) is likely and the disposal volume would be substantially greater.

<u>Short-Term Effectiveness</u> (Alternative 10 - Dredge PCBs ≥1 ppm)
The short-term effects of this alternative would persist for a 9-year implementation period. Further, the long-term effectiveness of this remedy can be impacted by short-term impacts if they are substantial. Some of these short-term impacts would include disruption/destruction of areas along the River to construct access points (including construction of access areas not located on the Alcoa property), sustained impacts to the water column, the significantly increased potential for increased bioavailability of PCBs, significant

destruction/alteration of the benthic and fish community, disruption of/inconvenience to recreational boating traffic in the River, and increased potential for transportation accidents. The effects associated with dredging, their potential results, and measures to be taken to minimize these effects to the extent practicable are described in further detail in Alternative 4. Note however, that this alternative includes the removal of an additional 1,602,000 cy compared to Alternative 4 and would take 51 months longer to implement. The inability to predict residual PCB surface concentrations and uncertainty associated with predictions of short-term (and long-term) effectiveness could result in a significant impact to the overall River system.

The near-term improvements in the reduction of PCB levels in fish and PCB loading to the St. Lawrence River resulting from implementation of this alternative would be similar to those observed for Alternative 3; however, these would be offset by the other short-term effects described above. The time necessary to complete implementation of this alternative is approximately 5 times longer than the time required for Alternative 3, thereby delaying the time to achieve similar near-term improvements in the River.

Implementability (Alternative 10 - Dredge PCBs ≥1 ppm)
Implementability issues, including technical and administrative feasibility, for dredging are provided in Alternative 4. Note that implementation of this alternative would require removal of a much greater volume of material which results in a considerably longer implementation period than that required for Alternative 4 (i.e., 35 times larger and 27 times longer). As such, the implementability issues identified under Alternative 4 would be significantly magnified. There would be increased hauling time for transport and disposal and thus an increase in potential accidents (estimated 105,000 truckloads of PCB-containing material to the landfill), greater inconvenience/disruption to the local community, and a very long time period for in-River construction.

Cost (Alternative 10 - Dredge PCBs ≥1 ppm)
The estimated present worth of this alternative is $525,400,000. This is based on a 9-year construction period followed by a 30-year post-construction monitoring period using a 7% discount rate for the present worth calculation (USEPA, July 2000). The total estimated cost is provided in 2004 dollars, and all capital cost expenditures are assumed to occur in 2004. Details of this cost estimate are provided in Appendix C.

6. Comparative Analysis and Summary

6.1 Introduction

In Section 5, the ten potential remedial alternatives developed for the lower Grasse River were considered individually in detail against seven NCP evaluation criteria. The results of the detailed evaluation are used in this section to conduct a comparative analysis to identify the advantages and disadvantages of each alternative relative to the others. The list of potential alternatives is provided in a summary table within Section 5.1, along with the alternative number and corresponding abbreviated descriptions that will be used throughout this section.

6.2 Overall Protection of Human Health and the Environment

As described in Section 3.2, protection of human health and the environment would be primarily achieved through reducing PCB levels in fish and other biota by addressing the diffusive flux of PCBs from surface sediments, which currently is the primary source of PCBs to the lower Grasse River. Although the level of protectiveness and time frames vary, all of the proposed alternatives are projected to reduce PCB levels in fish over time and therefore offer some protection of human health and the environment. It is anticipated that all of the alternatives would require maintenance of the current fish consumption advisories until monitoring indicates the advisories are no longer necessary.

Each alternative provides protection through site-wide ongoing natural recovery processes coupled with the reduction of PCB discharges to the River through the completion of land-based source control efforts (see Section 1.3). The natural recovery processes would result in long-term reduction of surficial sediment PCB concentrations and subsequent reductions in fish PCB levels and loading to the St. Lawrence River. Alternatives 1 and 2 rely solely on these processes.

The placement of a cap over targeted areas would provide a "clean" layer of sediment that would isolate PCB-containing sediment, thus effectively reducing PCB flux to the water column. Seven of the 10 proposed alternatives (Alternatives 3 through 9) include a capping component. Alternatives 3, 4, and 5 include capping approximately 127 acres (Alternative 5 includes capping approximately 121 acres), which is projected to result in an approximate 70% reduction in the flux of PCBs from the sediments to the surface water. Alternatives 6 through 9 include capping approximately 240 acres, which is projected to provide an approximate 90% reduction in PCB flux from sediments to surface water.

Alternatives 4, 5, 7, 8, and 9 also include dredging various volumes (between 48,000 and 515,000 in-situ cy) of sediment prior to cap placement. The removal of sediment in these alternatives would not likely contribute significantly to overall reductions, as capping is a more effective means of reducing surface sediment PCB concentrations. The extensive modeling and monitoring work conducted on the River, taken together as weight of evidence, support the conclusion that both the native sediments and a cap constructed from similar materials are expected to be stable over the long term.

Dredging River areas containing surface sediment PCB concentrations greater than or equal to 1 ppm (Alternative 10) without capping would provide limited protection, as it is likely that some portion of the dredged areas would contain elevated residual surface PCB concentrations.

6.3 Compliance with ARARs

This criterion is used to assess whether the alternative attains the identified chemical-, action-, and location-specific ARARs (presented in detail on Tables 3-1 through 3-3).

Considering chemical-specific ARARs, none of the alternatives evaluated are capable of achieving the AWQC for navigable waterways (0.001 ppb), the New York State standard for the protection of wildlife (1.2×10^{-4} ppb), and the New York State Surface Water Quality Standard for PCBs (1×10^{-6} ppb) within the 30-year projection period, due to site background PCB loading conditions (which have been accounted for in model projections). As such, it is anticipated that technical impracticability waivers will be required for these three ARARs.

Based on modeling results, the chronic exposure CWA-AWQC (0.014 ppb) would not be achieved for Alternatives 1 and 2 (which depend only on natural recovery processes) until after the 30-year model projection period. All the remaining alternatives would meet the chronic exposure CWA-AWQC in varying time frames within the model projection period. As described in Section 5, Alternatives 3 through 5 and 10 are projected to attain this ARAR in 2021, while Alternatives 6 through 9 are projected to attain this ARAR by 2011.

It is anticipated that all applicable action- and location-specific ARARs would be met during implementation of all alternatives.

6.4 Long-Term Effectiveness and Permanence

This criterion is used to evaluate the long-term effectiveness and permanence afforded by each alternative considering factors such as magnitude of risk remaining following alternative implementation and adequacy of control measures. The potential success of each alternative in meeting the RAOs identified in Section 3.3 is the basis for this assessment.

RAOs #1 and #3: Reduce PCBs in fish to levels protective of potential human and ecological consumers, and reduce or mitigate, to the extent practicable, the migration of PCBs from the lower Grasse River to the St. Lawrence River.

In order to quantitatively compare each alternative's ability to meet these RAOs, site-specific modeling (described in detail in Appendix B and Section 5) was performed to predict PCB levels in fish and loading to the St. Lawrence River. Metrics were selected solely for purposes of alternative comparison on a relative basis, and include the time necessary to achieve 75% and 90% reductions in River-wide average fish PCB concentrations and an 85% reduction in PCB loading to the St. Lawrence River. The table below summarizes these predictions for the proposed alternatives, as well as predicted River-wide average fish PCB levels in 2030. Time-trend plots for all alternatives for both metrics over a 30-year projection period are contained on Figures 6-1 and 6-2.

Modeling assumptions associated with dredging effectiveness (i.e., PCB releases during dredging equal 0.1% of the PCB mass removed and post-dredging PCB residuals equal to 2.5 ppm) impact the modeling projections presented below. Alcoa believes these assumptions underestimate residual PCB levels that would result from implementation, as the levels measured at other dredging sites and during implementation of the NTCRA generally were higher. In addition, conditions exist in the River (presence of cobbles and boulders, hardpan and bedrock bottom) that limit the effectiveness of dredging (NRC, 2001). If these assumptions are not appropriate, the projected time to reach the various percent reductions for alternatives that include dredging (Alternatives 4, 5, 7, 8, 9, and 10) would be greater than presented in the table below. Further, while capping is assumed to reduce surface sediment PCB concentrations by 90%, results of the Capping Pilot Study indicate that placement

of a cap effectively in isolates PCBs in the underlying sediments and, therefore, could provide a greater benefit than predicted by the model. These uncertainties require consideration during the evaluation of the model. In consideration of these factors, it is important to recognize that there is a degree of uncertainty associated with these model predictions, especially when attempting to distinguish among alternatives based on relatively small differences in predicted PCB levels and corresponding times to achieve percent reductions.

Alternative	River-Wide Average Fish Tissue PCB Levels			PCB Loading to St. Lawrence River
	Predicted Time to Achieve 75% Reduction	Predicted Time to Achieve 90% Reduction	Predicted PCB Concentration in 2030 (mg/kg)	Predicted Time to Achieve 85% Reduction
1 - No Further Action	25 years	>27 years	0.84	>25 years
2 - Monitored Natural Recovery	25 years	>27 years	0.84	>25 years
3 - Cap T11 to T38	6 years	24 years	0.30	19 years
4 - Dredge PCBs ≥50 ppm; Cap T11 to T38	5 years	22 years	0.28	18 years
5 - Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm	5 years	22 years	0.29	18 years
6 - Cap PCBs ≥5 ppm	4 years	11 years	0.19	5 years
7 - Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm	4 years	8 years	0.16	5 years
8 - Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm	4 years	8 years	0.16	5 years
9 - Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm	5 years	8 years	0.14	6 years
10 - Dredge PCBs ≥1 ppm	8 years	23 years	0.28	18 years

(1) Percent reductions presented for fish tissue PCBs are in relation to year 2003 projected PCB levels.
(2) Percent reductions presented for PCB loading to the St. Lawrence River are in relation to average projected PCB levels between 2001 and 2003.
(3) For purposes of these predictions, all caps were assumed to be 90% effective in reducing PCB surface concentrations (see Appendix B for further details).
(4) For purposes of these predictions, PCB releases during dredging were assumed equal to 0.1% of the PCB mass removed and the post-dredging PCB residual was assumed equal to 2.5 ppm (see Appendix B for further details).
(5) In cases where the time to achieve the targeted reductions is longer than the model projection period, the results are described as greater than 27 years (for decreases in PCB concentrations in fish tissue) or greater than 25 years (for decreases in loading to the St. Lawrence River).

Based on the results of the modeling work, the alternatives can be grouped into three general categories:

- Alternatives 1 and 2 would take approximately 25 years to reach a 75% reduction in PCB levels in fish, but do not reach the 90% fish reduction, or 85% St. Lawrence River loading reduction within the model projection period;
- Alternatives 3 through 5 show a rapid short-term reduction in PCB levels in fish, and reach the 90% fish and 85% St. Lawrence River loading reductions in approximately 18 to 24 years – Alternative 10 achieves this endpoint in the same time frame, however short-term reductions are less rapid; and

- Alternatives 6 through 9 show a rapid short-term reduction in PCB levels in fish, and reach the 90% fish and 85% St. Lawrence River loading reductions in approximately 8 to 11 years.

Based upon Alcoa's evaluation of the information presented throughout this document, a comparison of the different remedial components for each of the alternatives relative to the model projections provided above leads to the following observations:

- Natural recovery alone (Alternatives 1 and 2) provides for significant reductions in fish PCB concentrations over time, but the rate of recovery is slower relative to the other alternatives;
- Capping can accelerate the rate of decline for both PCB levels in fish and PCB loading to the St. Lawrence River relative to natural recovery, and the alternatives with a larger cap area (Alternatives 6 through 9) have a faster rate of reduction than those that include a smaller cap area (Alternatives 3 through 5);
- Considering alternatives that combine dredging and capping (Alternatives 4, 5, 7, 8, and 9), protectiveness and effectiveness are driven by placement of a cap over the dredged areas to reduce surface PCB levels; the addition of dredging does not result in meaningful differences in the rate of reduction for PCB levels in fish or PCB loading to the St. Lawrence River regardless of the volume dredged (even when low residual PCB concentrations, that may not be achievable during implementation, are assumed);
- Based on the uncertainties associated with residual PCB concentrations, it is believed that dredging alone (Alternative 10) is less effective than a combination of dredging and capping (Alternatives 4, 5, 7, 8, and 9) or capping alone (Alternatives 3 and 6);
- Uncertainties associated with model projections need to be considered, especially when attempting to distinguish between alternatives based on relatively small differences in predicted PCB levels; and
- Considering each alternative's relative ability to achieve these RAOs and the uncertainties related to dredging effectiveness based on site-specific conditions, the alternatives with capping alone (Alternatives 3 and 6) provide the greatest degree of long-term effectiveness.

RAO #2: Reduce or mitigate, to the extent practicable, existing, and potential adverse effects and bioaccumulation of PCBs in the lower Grasse River.

This evaluation is similar to that for RAOs #1 and #3, as achievement of this objective would be reflected in reductions in PCB levels in biota and the water column (as evidenced by the PCB loading to the St. Lawrence River). It should be noted that reductions in PCB levels in fish and PCB loading to the St. Lawrence River would require an additional period of time for Alternatives 1 and 2 relative to the other alternatives. If resuspension of PCBs during dredging is more extensive than assumed in the modeling projections, the large dredging alternatives (Alternatives 9 and 10) could result in short-term and possibly longer-term increases in PCB availability. Additionally, considering the dredging-only alternative (Alternative 10), if some portion of the dredged areas contained elevated residual PCB levels in the surface sediments after dredging, a longer period of time relative to the other alternatives would be required to achieve this RAO. This would occur through post-remediation natural recovery processes.

RAO #4: Protect the ecosystem of the lower Grasse River.

This RAO would be satisfied through implementation of Alternatives 1 and 2, as neither contains any active in-River remediation. Implementation of Alternatives 3 through 8 also is expected to satisfy this RAO, although short-term impacts may be encountered during implementation for some of these alternatives (as discussed below in Section 6.6). For Alternatives 6 through 9, the extent of the River to be addressed is large enough that implementation of the work in phases may be beneficial to protect the ecosystem.

Under Alternatives 9 and 10, the extent of the area targeted for dredging covers approximately 121 acres (30% of the total lower Grasse River surface area) and approximately 352 acres (87% of the total lower Grasse River surface area) requiring 3 and 9 construction seasons for dredging, respectively. These alternatives could significantly affect other areas of the River (including the disruption of habitats through PCB releases during dredging), leading to significant short-term ecological risks over long implementation periods and, as such may not meet this RAO.

RAO #5: Continue to reduce or control PCB sources within the lower Grasse River system.

This RAO is expected to be met through Alcoa's completed efforts related to control of external PCB sources to the River (described in Section 1.3), coupled with reduction in PCB flux from surface sediments. Alternatives 1 and 2 achieve reduction of PCB flux through natural recovery, and Alternatives 3 through 9 achieve this reduction via cap placement and natural recovery processes. Capping either between sediment probing Transects T11 and T38 or surface sediment with PCB concentrations greater than or equal to 10 ppm (Alternatives 3 through 5) would target areas responsible for approximately 70% of the diffusive flux, and capping surface sediment with PCB concentrations greater than or equal to 5 ppm (Alternatives 6 through 9) would target areas responsible for approximately 90% of the diffusive flux. It should be noted that while the capping portion of Alternative 9 would isolate the residual sediments in the large area targeted for dredging, under this alternative, potential effects associated with dredging activities would occur over 3 construction seasons. The degree to which the dredging-only alternative (Alternative 10) achieves this RAO is dependent on the residual PCB concentrations and PCB resuspension during dredging. If higher values than were assumed in the modeling efforts are observed for these parameters, Alternative 10 may not achieve this RAO.

Long-Term Stability of Sediments and Permanence

Additional issues related to long-term capping effectiveness and permanence include understanding cap stability, as well as the ability of the cap to isolate PCB-laden sediments from the water column and biota. As discussed in detail within Section 2, a significant amount of information relevant to this issue has been developed, including: fish, sediment, and water column monitoring performed prior to, and following, a significant high-flow event; extensive hydrodynamic and sediment transport modeling incorporating laboratory measurements and site-specific field measurements; 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 even under high-flow conditions.

Effects of prop wash, scour from recreational boats, placement of anchors on the cap, and ice scour (see Section 2.6.6) also 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 less than the estimated average sedimentation rate of about 0.2 cm/yr (Alcoa, April 2001). 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 2.6.5).

Dredging would target the permanent removal of PCB-containing sediments from the lower Grasse River. However, it is important to note that due to the limitations discussed under short-term effectiveness and implementability (below), it is likely that not all of the PCB-containing sediments from the targeted areas would be removed.

6.5 Reduction of Toxicity, Mobility, or Volume Through Treatment

Under this criterion, the degree to which each alternative reduces the toxicity, mobility, or volume through treatment is evaluated. Note that none of the alternatives contain treatment as a principal element of the remedy, however, Alternatives 4, 5, 7, 8, 9, and 10 include treatment (via stabilization/solidification) of dredged sediments, thereby reducing the mobility of PCBs within these removed sediments.

In addition, 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, but the rate at which this occurs is slow. Placement of a cap (Alternatives 3 through 9) also would further reduce the mobility of PCBs through PCB isolation in the native sediments.

Implementation of alternatives with a dredging component (Alternatives 4, 5, 7, 8, 9, and 10) would reduce the volume of PCB-containing sediment in the lower Grasse River through permanent removal of this material; however, reduction of PCB-containing sediment volume does not necessarily equate to a reduction in risk (NRC, 2001).

It should be noted that the alternatives that include a dredging component could result in a greater mobility for targeted sediments over the short term, depending on the degree of resuspension and the residual PCB concentrations observed. The magnitude of this concern is related to the size of the dredging program. Thus, the larger dredging programs (i.e., removal of 515,000 and 1,650,000 cy in Alternatives 9 and 10, respectively) have the greatest potential to increase the mobility of PCBs in the sediments.

6.6 Short-Term Effectiveness

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 includes consideration of the effectiveness of mitigative measures and time until protection is achieved through consideration of near-term improvements resulting from remedy implementation.

Alternatives 1 and 2 do not involve active remediation, so there would be no short-term risks to workers, the environment, or the community associated with these alternatives. With respect to near-term improvements related to remedy implementation, these alternatives would require the longest period of time for reduction of PCB levels in fish and PCB loading to the St. Lawrence River. For the remaining alternatives, Alternative 3 (Cap T11-T38) would have the least short-term impact based on the duration for implementation, the lack of environmental impacts observed during the Capping Pilot Study, and the size of the area subject to active remediation. Possible impacts would include disruption to recreational boating, transportation accidents, and short-term impacts on the ecosystem. Alternative 6 (Cap ≥5 ppm) would be similar to Alternative 3, but ranked lower in short-term effectiveness because of the longer duration and the larger area of the River subject to active remediation. Both Alternatives 3 and 6 provide for significant near-term improvements as measured by reductions in PCB levels in fish and PCB loading to the St. Lawrence River. Alternative 6 provides a more rapid reduction, but requires a longer implementation time frame and incurs additional short-term impacts related to the other elements of the short-term effectiveness criterion due to the significantly larger area of the River that would be impacted through implementation.

Alternatives 4 and 5 (Dredge ≥50 ppm, Cap T11-T38; and Dredge ≥25 ppm, Cap ≥10 ppm, respectively) would rank next in terms of short-term effectiveness, as the areas to be actively remediated are similar to Alternative 3

(Cap T11-T38), but the incorporation of a dredging component would result in additional short-term impacts. Short-term impacts associated with dredging include disruption to recreational boating, potential release of PCBs during transport to the disposal area, potential impacts on PCB levels in the water column and fish, and more substantial impacts to the ecosystem. Potential short-term environmental impacts of dredging can result from technical limitations associated with site-specific conditions such as the presence of rocks/cobbles/debris on the River bottom and the presence of bedrock/hardpan under the soft sediments, which precludes overdredging into clean material. These factors can result in a great deal of variability in removal efficiency and resuspension of PCBs, which can affect both fish and the water column as was observed during the NTCRA. Engineering control measures such as silt curtains can be employed to reduce the migration of resuspended sediment to other areas of the River. With respect to near-term improvements related to remedy implementation, Alternatives 4 and 5 would be similar to Alternative 3 for this element of the short-term effectiveness criterion.

Alternatives 7 and 8 (Dredge ≥50 ppm, Cap ≥5 ppm; and Dredge ≥25 ppm, Cap ≥5 ppm, respectively) would have similar short-term effectiveness as Alternatives 4 and 5, but would rank lower because of the larger areas subject to active remediation and the longer duration of the projects. With respect to near-term improvements related to remedy implementation, Alternatives 7 and 8 would be similar to Alternative 6 for this element of the short-term effectiveness criterion.

Alternatives 9 and 10 (Dredge ≥10 ppm, Cap ≥5 ppm; and Dredge ≥1 ppm, respectively) would provide the least degree of short-term effectiveness, as they would impact large areas of the River for an extended period of time. The magnitude of the potential short-term impacts associated with dredging would increase greatly for these alternatives in all areas (environmental impacts, community impacts, and worker safety) because of the size of the removal programs (5 and 16 times larger than the next greatest dredging alternative). With respect to near-term improvements related to remedy implementation, the model predictions (based on assumptions related to dredging effectiveness) indicate that Alternative 9 would be similar to Alternative 6, while Alternative 10 is similar to Alternative 3.

6.7 Implementability

The ease or difficulty of implementing the alternative by considering technical feasibility, administrative feasibility, and availability of services and materials required during implementation is evaluated using this criterion. In general, all potential alternatives are considered to be implementable within the lower Grasse River. Implementation of both capping and dredging is administratively feasible as no permits are required for in-River activities, and construction would be performed in accordance with the substantive requirements of ARARs.

Based on site-specific experience, the design and placement of a cap (Alternatives 3 through 9) is expected to be technically feasible over the long term. One potential implementability issue associated with capping is the ability to place a cap on the steep side slopes of the River channel. However, based on the limited area of the River represented by the side slopes, the limited amount of native sediments typically found on the side slopes, and the fact that even a thin layer of cap material is expected to provide benefit, this issue is not expected to significantly impact the overall effectiveness of the cap. Capping of side slope areas will be evaluated further during the remedial design phase.

Dredging of various sediment volumes is considered as part of Alternatives 4, 5, 7, 8, 9, and 10. As documented during the NTCRA activities (BBL, December 1995), some operational problems with the dredge were encountered during the removal operations. The presence of steep side slopes and debris is expected to reduce

the practicability and/or efficiency of removing sediment from the targeted areas. Results of recent underwater surveys performed by OSI (January 2002) indicate that a large portion of the targeted sediment bed contains irregular surfaces with boulders, rocks, and cobbles – all of which would limit implementability and ultimate effectiveness of the dredging component. These limitations would be present for all dredging alternatives, but would be amplified for the large dredging components in Alternatives 9 and 10 (i.e., dredging 515,000 cy and 1,650,000 cy, respectively). The results of the recent OSI underwater surveys (January 2002) and other available data will be considered during the remedial design phase of any remedy that includes dredging.

6.8 Cost

This final criterion is used to evaluate the total present worth cost for implementation of each alternative based on the alternative descriptions provided in Section 5. Estimated present worth costs for each of the alternatives are provided below.

Alternative		Estimated Cost
1 -	No Further Action	$0
2 -	Monitored Natural Recovery	$2,700,000
3 -	Cap T11 to T38	$30,900,000
4 -	Dredge PCBs ≥50 ppm; Cap T11 to T38	$51,400,000
5 -	Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm	$64,900,000
6 -	Cap PCBs ≥5 ppm	$54,800,000
7 -	Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm	$75,100,000
8 -	Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm	$89,500,000
9 -	Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm	$196,300,000
10 -	Dredge PCBs ≥1 ppm	$525,400,000

Specific details of these cost estimates are provided in Appendix C.

In view of the overall objective for the site of reducing PCB levels in fish and other biota, costs for each of the alternatives versus the projected average River-wide fish tissue PCB concentrations in the year 2030 are shown in Figure 6-3. As discussed previously, projected fish tissue concentrations must be viewed in light of the uncertainties discussed in Section 5.1.

As shown in Figure 6-3, the alternatives can be grouped into three general categories relative to the projected fish tissue concentrations in 2030. Alternatives 1 and 2 (No Further Action and Monitored Natural Recovery) are projected to achieve an average 2030 fish tissue PCB concentration of about 0.85 mg/kg at a cost of $0 and $2.7 million (M), respectively. Alternatives 3, 4, 5, and 10 (Cap T11-T38; Dredge ≥50 ppm, Cap T11-T38; Dredge ≥25 ppm, Cap ≥10 ppm; and Dredge ≥1 ppm, respectively) are projected to achieve an average 2030 fish tissue PCB concentration of about 0.3 mg/kg at costs that range between $31M and $525M. For this grouping of alternatives, Alternative 3 is the most cost effective, at $20M less than Alternative 4, $34M less than Alternative 5, and $494M less than Alternative 10, while providing an equivalent level of risk reduction.

Alternatives 6, 7, 8, and 9 (Cap ≥5 ppm; Dredge ≥50 ppm, Cap ≥5 ppm; Dredge ≥25 ppm, Cap ≥5 ppm; and Dredge ≥10 ppm, Cap ≥5 ppm, respectively) are projected to achieve an average 2030 fish tissue PCB concentration of about 0.15 mg/kg at costs that range between $55M and $196M. For this grouping of alternatives, Alternative 6 is the most cost effective, at $20M less than Alternative 7, $35M less than Alternative 8, and $141M less than Alternative 9, while providing an equivalent level of risk reduction.

In comparing cost effectiveness between the alternative groupings described above, the following observations can be made:

- Monitored Natural Recovery (Alternative 2) is expected to result in a significant reduction in fish tissue PCB concentrations over time relative to present day values, with River-wide average concentrations projected to decline from 6.3 mg/kg (2000 data) to 0.85 mg/kg in 2030, at a cost of $2.7M;
- Alternative 3 (Cap T11-T38) is expected to provide additional reductions in fish tissue PCB concentrations relative to Monitored Natural Recovery (Alternative 2), with River-wide average concentrations projected to decline from 6.3 mg/kg (2000 data) to about 0.3 mg/kg in 2030, at an added cost of about $28M;
- Alternatives 4, 5, and 10, all achieve essentially the same level of risk reduction by 2030 as Alternative 3 at much higher cost;
- Alternative 6 (Cap ≥5 ppm) is expected to provide a modest incremental benefit relative to Alternative 3 as measured by 2030 average fish tissue PCB concentrations, (with a 2030 projected fish tissue level of about 0.18 mg/kg compared to 0.3 mg/kg for Alternative 3) at a cost $24M greater than Alternative 3. As discussed in the long-term effectiveness comparative analysis (Section 6.4), Alternative 6 would achieve a faster rate of reduction than Alternative 3; and
- For the grouping of alternatives that achieve a similar 2030 average fish tissue PCB concentration to Alternative 6 (Alternatives 7, 8, and 9), all achieve essentially the same level of risk reduction at much higher cost.

6.9 Summary

All of the proposed alternatives are expected to reduce risk and, as such, offer some protection of human health and the environment, although the level of protection and time to achieve the same degree of risk reduction varies between alternatives. Each alternative includes site-wide natural recovery processes and the benefits of significant reductions in external PCB sources resulting from Alcoa's extensive land-based remediation efforts. Exposure via consumption of PCB-containing fish is the primary risk driver in the lower River, with surface sediments being the dominant PCB source to the fish. It is anticipated that all of the alternatives would require maintenance of the current fish consumption advisories until monitoring indicates the advisories are no longer necessary.

In consideration of the results of the comparative analysis of alternatives, Alcoa concludes the following:

1. The primary differences among the alternatives are the projected rates at which PCB concentrations decline, short-term effectiveness, and cost.
2. Site-wide natural recovery (Alternatives 1 and 2) is predicted to achieve a high level of reduction in fish tissue PCB concentrations compared to current levels at the lowest cost, albeit over a longer time frame than alternatives with active remediation components.
3. Effectiveness of the alternatives involving active remediation is driven by placement of a cap. When combined with large-scale capping, removal of sediment from the River has a relatively small

modeled influence on the achievement of PCB metrics, even when using what Alcoa believes to be optimistic assumptions associated with dredging effectiveness.

4. Dredging in targeted areas can remove mass from the River, but the volume of sediment removed from the River has little bearing on risk reduction.
5. Short-term impacts to the River in the form of increases in fish tissue PCBs and PCB loading to the St. Lawrence River likely would be observed during dredging activities, with the magnitude and duration of these impacts increasing with the extent of the dredging program.
6. A cap has the ability to achieve rapid risk reduction, can be implemented with minimal short-term effects and overall impacts to the ecosystem, and is expected to remain stable in this system.
7. The capping-only alternatives (Alternatives 3 and 6) provide an equivalent level of risk reduction to the combination alternatives (Alternatives 4, 5, 7, 8, and 9) and the dredging-only alternative (Alternative 10) at much lower cost.
8. Alternative 6 (Cap ≥5 ppm) is expected to provide only a modest incremental benefit relative to Alternative 3 (Cap T11-T38) as measured by projected 2030 River-wide average fish tissue PCB concentrations at an additional cost of $24M.
9. For any remedy affecting a significant area of the River system, both remedy effectiveness and consideration of protection of the ecosystem support a phased approach to implementation.

No perfect remedy exists for the River, and under all potential remedial scenarios some residual PCBs will remain. All remedial approaches will take time to implement and time for fish PCB concentrations and PCB loading to the St. Lawrence River to show significant reductions. Alcoa believes that a remedy should be implemented where each element of the remedy directly supports reduction of risk to human health and the environment and takes into consideration the site-specific characteristics of the lower Grasse River.

7. Alcoa's Recommendations

Based on the above information and in consideration of effectiveness, cost, and degree of disruption to the River and the community, Alcoa supports a combination of capping and monitored natural recovery as the most appropriate remedy for the site. This approach directly addresses the principal threat for the site, consistent with the NCP, which is the chronic flux of PCBs from the sediments to the water column. Alcoa recognizes that such a remedy requires a commitment to long-term monitoring and maintenance and can make that commitment.

Alcoa believes that any large-scale remediation should be implemented in phases – both to minimize disruption to the existing ecosystem and to provide for data gathering between phases to support the need for and, if necessary, the design of subsequent activities. Such an iterative approach, as advocated in the USEPA *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (USEPA, February 2002), has been successfully used at this site and should be extended to the remediation phase of the project.

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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	79	1995-2001	500
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	9	1995-2001	1,450
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	5	1995, 1997, 2000, 2001	650
Shaker Studies	2	1998, 2000	60[2]
Sediment cores (high resolution)	1	1997	130
Habitat Survey	1	1997	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.

Table 2-2

Grasse River Study Area
Massena, NY
Analysis of Alternatives Report

Capping Pre-Engineering Design Studies Summary

Pre-Engineering Design Studies	Approach
PCB Transport Modeling	Application of one-dimensional (1-D) chemical transport model of the sediment bed and overlying cap. Model simulates sedimentation, advection, molecular diffusion, chemical dispersion, sorption, and bioturbation.
Radioactive Lead Modeling	Modeling the vertical distribution of radioactive lead in high-resolution sediment core samples.
Hydrodynamic and Sediment Transport Modeling	Development and application of hydrodynamic and sediment transport models.
Molecular Diffusive Transport Evaluation	Tests conducted in series of small tanks containing Grasse River sediment capped with various materials. Water circulated through tanks and analyzed for PCBs.
Capping Material Adsorption Study	Batch adsorption experiments performed to simulate conditions of dissolved phase PCBs contacting the capping material.
Cap Settling Study	Settling tests conducted in columns containing Grasse River sediment at bottom and ~10 ft. of River water above. Characteristics evaluated included settling rate, effect of differential settling, extent of mixing of capping materials with sediment, impact of cap placement on suspended solids in water column, and potential for cap consolidation.
Cap Consolidation Study	Capped sediment cores generated during Cap Settling Study were incubated and measured to identify extent of consolidation.
Cap Stability Tests	Performed laboratory erosion tests on capping materials (shaker tests and Sedflume tests).
Groundwater Seepage Study	A groundwater seepage study was conducted that included developing model-based estimates of groundwater discharge to the River and field measurements of groundwater seepage.
Sediment-Water Interface Photography	Use of specialized photographic techniques to visually identify color redox potential discontinuity (RPD) layer, indicating depth of sediment mixing.
Ecological Survey	Study consisted of performing benthic macroinvertebrate survey to identify the structure (abundance and diversity) and condition (biomass density and tolerance) of the benthic community.
Sediment Bed Elevation Measurement Study	Use of 2 ft. x 2 ft. grates equipped with rods in corners placed in sediment by divers.
Geophysical Survey	Performed bathymetric survey, side-scan sonar, sub-bottom profiling, and sediment-water interface photography.
Cohesive Properties Test	Incubation of capped sediment in core tubes in River with subsequent testing for erosion potential.
Literature search, consultation with experts	Performed as appropriate.
Potential Cap Material Testing	Identification of potential borrow pits, laboratory analysis for comprehensive list of analytes.

Note:
1. These studies are discussed in further detail in the Lower Grasse River Capping Pre-Engineering Design Studies Report (Alcoa, March 2001).

Table 2-3

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Summary of 2001 Capping Pilot Study Parameters

Area	Lift Identification	Cap Material	Minimum Lift Thickness (feet)	Application Technique
Test Cell #1				
Subcell #1A	Lift 1	1:1 sand/topsoil	1.0	Surface via clamshell
Subcell #1B1[1]	Lift 1	1:1 sand/topsoil	0.5	Surface via clamshell
	Lift 2	1:1 sand/topsoil	0.5	Subsurface via clamshell
Subcell #1B2	Lift 1	1:1 sand/topsoil	1.0	Subsurface via clamshell
Subcell #1C2	Lift 1	1:1 sand/topsoil	1.0	Subsurface via tremie
Subcell #1D	Lift 1	AquaBlok™	0.25 – 0.33[2]	Surface via clamshell
	Lift 2	1:1 sand/topsoil	0.5	Surface via clamshell
Pilot Cell #2	Lift 1	1:1 sand/topsoil	0.5	Surface via clamshell
	Lift 2	1:1 sand/topsoil	0.5	Subsurface via clamshell
Pilot Cell #3	Lift 1	1:1 sand/topsoil	1.0	Clamshell at mid depth
Pilot Cell #4	Lift 1	1:1 sand/topsoil	1.0	Surface via clamshell
	Lift 2	1:1 sand/topsoil	1.0	Subsurface via clamshell

Notes:

1. The northern portion (~ 50 feet x ~ 95 feet) of Subcell #1C2 was initially covered with bentonite using a pneumatic broadcasting method. The same area was subsequently capped with one 12-inch lift of sand/topsoil using a clamshell bucket (subsurface).
2. Hydrated thickness target of 3-4 inches was to be achieved through placement of minimum 2 inches of dry material.

Table 3-1

Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

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 U.S.C. §§ 1251-1387; 40 CFR § 129.105(a)(4)	ARAR	The ambient water quality criterion for navigable waters is 0.001 µg/L total PCBs.	Applicable to Grasse River surface water.
Clean Water Act	33 U.S.C. § 1314(a); 63 Fed. Reg. 68354 (December 10, 1998)	ARAR	Criteria continuous concentration (chronic) for PCBs is 0.014 µg/L in freshwater.	Relevant and appropriate water quality criterion to protect against chronic effects in aquatic life.
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 (pp. 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 Environmental Conservation Law (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) 1×10^{-6} µg/L for protection of health of human consumers of fish; and (b) 1.2×10^{-4} µg/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.

Table 3-2

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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 U.S.C. § 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.	ARAR for remediation alternatives that include dredging/filling.
	Section 404(c) of the Clean Water Act, 33 U.S.C. § 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, which include wetlands. Includes special policies, practices, and procedures to be followed by the U.S. Army Corps of Engineers 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 the such activities must comply with substantive requirements of these regulations.	ARAR for remedial alternatives that include discharges of dredged or fill materials into U.S. waters.
Solid Waste Disposal Act, as amended - Regulated Levels for Toxic Characteristic Leaching Procedure (TCLP) Constituents	40 CFR Part 261	ARAR	Specify TCLP constituent levels for identifying wastes that exhibit toxicity characteristics.	Provisions of this Part, or equivalent authorized New York State regulations, may be applicable to determine whether sediments removed from the Grasse River contain hazardous waste(s).
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 apply to remedial alternatives that include dredging of sediments from the Grasse River that are hazardous wastes.

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)				
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 EPA 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.
Solid Waste Disposal Act, as amended - Standards for Owners and Operators of Hazardous Waste, Treatment and Storage Facilities	40 CFR Parts 264 and 265 removed	ARAR	Includes 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 the 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.
Toxic Substances Control Act (TSCA)	40 CFR Part 761	ARAR	Provides regulations for storage, handling, and disposal of sediment containing PCBs greater than 50 ppm.	Applicable to remedial alternatives which include removal and management of sediment with greater than 50 ppm PCBs.
USDOT Placarding and Handling	49 CFR Part 171	ARAR	Transportation and handling requirements for materials containing PCBs.	Would apply to remedial alternatives which include transport of materials containing PCBs on public roadways.

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)				
Rivers and Harbors Act	33 U.S.C. § 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.). U.S. Army Corps of Engineers 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.	Would apply to remedial activities that include dredging and/or capping.
Clean Air Act	42 U.S.C. §§ 7401-7671q; 40 CFR Parts 50, 51 and 52; National Primary and Secondary Ambient Air Quality Standards (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		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.
USEPA Superfund Remedial Design and Remedial Action Guidance	OSWER Directive No. 9355.0-4A, June 1986	TBC	Guidance document developed to assist agencies and parties who plan, administer, and manage remedial design and remedial action at Superfund sites.	Would be consulted during 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.	Potential ARAR for 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.	Potential ARAR for dredging alternatives that include transport of dredged sediments for disposal.

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)				
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 ppm 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.	ARAR for the transportation of dredged sediments with greater than 50 ppm 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	These regulations establish 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 ppm PCB materials.
Land Disposal Restrictions	New York State ECL Article 27, Title 9; 6 NYCRR Part 376	ARAR	This Part identifies hazardous wastes that are restricted from land disposal and defines those circumstances under which an otherwise prohibited waste may be land disposed.	May apply 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.	Would apply to remedial activities that include dredging and/or capping.

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)				
New York State Pollution Discharge Elimination System (SPDES)	6 NYCRR Parts 750 – 758	ARAR	These regulations detail 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.	ARAR for remedial alternatives which would 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	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.	ARAR for remedial alternatives which would include discharge of water back into the River.
Air Pollution Control Law	New York State ECL, Article 19, Title 3. Promulgated pursuant to the Federal Clean Air Act, 42 U.S.C. § 7401	ARAR	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.	ARAR for remedial activities which 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	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.	ARAR for remedial alternatives which would 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)				
NYSDEC Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants, 2000.		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.
NYSDEC Technical and Operational Guidance Series (TOGS)	1.2.1 Drafting Strategy for Surface Waters	TBC	Provides guidance for writing permits for discharges of wastewater from industrial SPDES permit facilities and for writing requirements equivalent to SPDES permits for discharges from remediation sites.	Would be consulted, as appropriate, in connection with wastewater treatment performed in connection with remedial activities.
	1.3.1 Waste Assimilative Capacity Analysis & Allocation for Setting Water Quality Based Effluent Limits	TBC	Provides guidance to water quality Control engineers in determining whether Discharges to water bodies have a reasonable potential to violate water quality standards and guidance values.	Would be consulted, as appropriate, in connection with remedial activities that include discharge of water to the Grasse River.
	1.3.2 Toxicity Testing in the SPDES Permit Program	TBC	Describes the criteria for deciding when toxicity testing will be required in a permit and the procedures which should be followed when including toxicity testing requirements in a permit.	Would be consulted, as appropriate, in connection with wastewater treatment performed in connection with remedial activities.
	1.3.7 Analytical Detectability & Quantitation Guidelines for Selected Environmental Parameters	TBC	Provides method detection limits and practical quantitation limits for pollutants in distilled water.	Would be consulted, as appropriate, in connection with wastewater treatment performed in connection with remedial activities.
NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites		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 remedial activities.

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Grasse River Study Area
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Location-Specific ARARs and TBCs

Regulation	Citation	ARAR or TBC	Description	Rationale
			FEDERAL ARARs AND TBCs	
Coastal Zone Management Act (CZMA)	16 USC §§ 1451- 1465; 15 CFR Parts 923 and 930	ARAR	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 National Oceanographic and Atmospheric Administration (NOAA).	The Grasse River is within the New York State Coastal Zone.
Endangered Species Act	16 USC §§ 1531- 1544; 50 CFR Part 17, Subpart I; 50 CFR Part 402	ARAR	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.'"
Fish and Wildlife Coordination Act	16 USC § 662	ARAR	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, by any department or agency of the United States, such department or agency first shall consult with the United States Fish and Wildlife Service, Department of the Interior, and with the head of the agency exercising administration over the wildlife resources of the particular State in which the impoundment, diversion, or other control facility is to be constructed, with a view to the conservation of wildlife resources by preventing loss of and damage to such resources.	Substantive requirements of the Fish and Wildlife Coordination Act are ARARs for dredging and capping remedies, although on -site CERCLA response actions are exempt from the consultation requirements of the Fish and Wildlife Coordination Act.

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 and Historical Preservation Act	16 USC §§ 470 – 470x-6; 36 CFR Part 800	ARAR	Response actions must take into account effect on properties on or eligible for inclusion on the National Registry of Historic Places.	Per September 20, 2001 letter from Mark D. Craig, NYSDEC, and a December 18, 2001 letter from Ruth L. Pierpont, New York State Office of Parks, Recreation and Historic Preservation, significant archeological sites exist on or in the vicinity of this site.
Statement of Procedures on Floodplain Management and Wetlands Protections	40 CFR Part 6, Appendix A	ARAR	Sets forth EPA 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. 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 affect floodplains or identified wetland areas (e.g., access roads).
EPA Office of Solid Waste and Emergency Response - Policy on Floodplains and Wetland Assessments for CERCLA Actions, August 1985		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 ARARs 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.	Per a September 20, 2001 letter from Mark D. Craig, NYSDEC, New York threatened species (bald eagle, lake sturgeon and blandings turtle) inhabit the area during certain times of the year. In accordance with CERCLA Section 121(e), a permit is not required for on-site CERCLA response actions. Nevertheless, if EPA determines that response actions may destroy or degrade the habitat of a New York State-listed endangered or threatened species, or cause a "taking" of any endangered or threatened species, EPA will consult with NYSDEC with respect to substantive requirements that NYSDEC would consider in determining whether to issue a permit in such a case.

Table 4-1

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
A. No Further Action			
	----	No further active remedial activities performed beyond completion of the previously undertaken NTCRA and Capping Pilot Study activities on-site and source control activities completed in 2001.	Implementable.
B. Monitoring			
	Site-Wide Monitoring	Period 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.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
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 SRS 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.
E. In-Place Containment			
I. Capping	Engineered Capping	Placement of a cap typically comprised of layered materials (e.g., clean sediment, sand, gravel, cobbles, geotextile) placed over in-situ sediment to isolate constituents from biota and mitigate chemical flux.	Potentially implementable.
	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 implemented during Grasse River Capping Pilot Study (2001).

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
E. In-Place Containment (cont'd)			
I. Capping (cont'd)	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, similar to that tested during the Grasse River Capping Pilot Study. 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; successfully implemented during Grasse River Capping Pilot Study (2001).
II. Hydraulic Modification	----	Construction/demolition of dams or similar structures to alter the rate of sedimentation in portions of the River.	No substantive control structures to utilize; lower Grasse River currently backwater of St. Lawrence River. Not likely effective.
F. Sediment Treatment			
I. Biodegradation, In-Situ	Enhanced	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.
II. Immobilization	In-Situ Stabilization/Solidification	Chemically immobilize materials by injecting and mixing a stabilization/solidification agent into the in-situ sediment.	In-situ process not yet sufficiently developed for sediment. Would increase volume of sediment in River.
	Ex-Situ Stabilization/Solidification	Dredged 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. Solidification will increase the sediment volume.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
II. Immobilization (cont'd)	Maectite (Sevenson Environmental Services)	Process converts leachable materials into mineral crystal species within the soil matrix.	Process has not been demonstrated at full-scale with sediment.
III. Extraction, In-Situ	Vacuum	Create vacuum in soil through a well; chemical constituents drawn in and extracted.	Not feasible for submerged sediment.
	Steam	Inject steam into soil, so that chemical constituents volatilize and are removed via extraction wells.	Not feasible for submerged sediment.
	Liquid	Solvents introduced in soil via injection wells, extraction wells recover solvent and extracted chemical constituents.	Not feasible for submerged sediment.
	Thermal Wells	PCB-containing soil is heated; vacuum applied to well; removes vapor phase PCBs.	Not feasible for submerged sediment.
IV. Extraction, Ex-Situ	SOLVENT EXTRACTION		
	Basic Extractive 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.	Process has not been developed at full-scale for sediment. Process has been used at pilot-scale to treat PCB-containing sediments. Process may have difficulty with fine-grained sediment and high moisture content.
	Low Energy Extraction Process (META LEEP℠)	Acetone, kerosene and other solvents are used to extract organic and inorganic chemical constituents from solids.	Not technically feasible; the process has not been proven at full-scale for sediment.
	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.	Not technically feasible; the process has not been proven at full-scale for sediment.
	Accurex Solvent Wash	A proprietary Fluorocarbon-113 and methanol solvent used to extract PCBs from solids.	Process is still being developed; no full-scale operations.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
IV. Extraction, Ex-Situ (cont'd)	SOLVENT EXTRACTION (cont'd)		
	Methanol Extraction	Methanol used as a solvent to extract PCBs and other organics from solids.	Process has not been developed or proven at full-scale.
	Terra Kleen Solvent Extraction	Solvent used to extract PCBs and other organics from sediments. The solvent is separated from the materials and reused.	Process has not been demonstrated at full-scale with sediment.
	Biotherm (former Carver-Greenfield) Process	Oil-soluble organic constituents extracted from sludge, soil, and sediment using a food-grade carrier oil.	Process has not been demonstrated at full-scale with sediment.
	SOIL WASHING		
	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 has not been demonstrated at full-scale; has been implemented at pilot-scale for sediment from NY/NJ Harbor with low concentration chemical constituents. Plans for a larger scale unit have been developed. Limited effectiveness for PCBs.
	Surbec-ART Environmental Inc.	Uses physical separation (soil washing) to remove oversize fractions, recovered clean sand, organic and inorganic fractions are treated with stabilization.	Process has not been demonstrated at full-scale; has been used to treat PCBs and PAHs in sediment at bench- and pilot-scale.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
IV. Extraction, Ex-Situ (cont'd)	THERMAL DESORPTION		
	Low Temperature Extraction (DAVES)	A low-temperature vapor extraction system utilizing a fluidized bed to remove PCBs from sediment.	Not technically feasible; process has not been demonstrated at full-scale with sediment. May require stabilization of treated solids for metals and result in emission of the more volatile inorganic constituents.
	X*TRAX™	Solids heated in the presence of nitrogen, followed by PCB extraction.	Potentially implementable; process has been demonstrated at full-scale with sediment at the Resolve Superfund Site in Dartmouth, Massachusetts. May require stabilization of treated solids for metals and result in emissions of the more volatile inorganic constituents.
	Ecotechniek Thermal Treatment System (ETTS)	Thermal extraction of chemical constituents accomplished using a two-stage heating unit and an off-gas treatment unit.	Process has not been demonstrated full-scale on sediment. Process has been demonstrated at full-scale on soil in Europe. Reportedly can be used for PCBs.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
V. Destruction, In-Situ	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.	Process has not been demonstrated full-scale on sediment. Technology currently being tested on PCB-containing sludge at Alcoa's facility. Also proposed for testing at a site in Commencement Bay, WA and the Portland Harbor Superfund Site.
	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.	Not feasible for in-situ sediment. No large scale in-situ sediment projects have been implemented to date. Difficulties experienced with off-gas emissions while treating wet sediment (ex-situ) from the New Bedford Harbor Superfund Site.
VI. Destruction, Ex-Situ	ULTRAVIOLET (UV) DESTRUCTION		
	UV/Ozone/Ultrasonics	Ultrasonics used to extract PCBs from solids. PCBs destroyed by subsequent UV/ozone treatment.	Process still being developed.
	UV/Hydrogen/Ultrasonics	Ultrasonics used to extract PCBs from solids. PCBs destroyed by subsequent UV/hydrogen treatment.	Process reportedly is no longer being pursued by developer.
	Ozonation	Ozone used to decompose PCBs in conjunction with UV radiation.	Destruction efficiency is reported to be too low for sediment matrix.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
VI. Destruction, Ex-Situ (cont'd)	ULTRAVIOLET (UV) DESTRUCTION (cont'd)		
	Radiant Energy	UV light energy, combined with a reducing agent, used to dechlorinate PCBs.	Process has not been proven to be technically feasible.
	THERMAL DESTRUCTION		
	Incineration	Sediment thermally treated in a fluidized bed, rotary kiln, or infrared incinerator, all of which would require TSCA permitting.	Potentially implementable.
	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.	Process pilot tested on Fox River PCB-containing sediments.
	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.	Not technically feasible; the high moisture content in sediment confounds the treatment process. Target chemical groups are SVOCs and pesticides. Limited performance data are available for pyrolytic systems treating hazardous wastes containing PCBs, dioxins, and other organics.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
VI. Destruction, Ex-Situ (cont'd)	THERMAL DESTRUCTION (cont'd)		
	Westinghouse Plasma Corp. – Harbor Sediment Treatment (formerly Plasma Arc)	PCBs thermally destroyed at very high temperatures.	Process has not been demonstrated at full-scale for PCBs. Technology tested in a very limited manner for NY/NJ Harbor sediments. Requires a significant level of energy and emission controls as the water is transformed into steam and treated as a vapor phase waste stream.
	Cement Lock (IGT)	Process uses a thermochemical manufacturing, which converts dredged sediments, mixed with specific modifiers into materials that can be used as a cement base.	Process has not been demonstrated at full-scale. Technology has been tested at the bench- and pilot-scale for sediment from the NY/NJ Harbor area.
	LOW TEMPERATURE THERMAL DESTRUCTION		
	Wet Air Oxidation	A proprietary process that uses special catalysts and relatively low temperature and high pressure to decompose PCBs.	Destruction efficiency is reported to be low for sediments.
	Supercritical Water Oxidation	Temperature and pressure of supercritical water dissolve materials that are oxidized into carbon dioxide, water, and salts.	Not implementable at the Study Area due to sediment particle size.
	DECHLORINATION		
	Base-Catalyzed Dechlorination (BCD)	Chlorine is stripped off PCB molecules using sodium bicarbonate in a rotary reactor.	Process has not been demonstrated at full-scale with sediment.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
F. Sediment Treatment (cont'd)			
VI. Destruction, Ex-Situ (cont'd)	DECHLORINATION (cont'd)		
	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).	Process has not been demonstrated at full-scale with sediment. Process had significant mechanical difficulties when tested on sediment from the New Bedford Harbor Superfund Site. The issues were focused on the thermal reduction mill (i.e., thermal desorption unit). The dechlorination of the off-gas from the thermal desorption process was, however, generally effective.
	Sodium-Based Reactions (NaPEG)	PCBs broken down into oxygenated organics, sodium chloride (salt), and biodegradable glycols.	Not technically feasible; water destroys the reagent or interferes with its actions; thus, the process would require excessive drying of sediment.
G. Sediment Removal			
I. Dredging	Mechanical	Remove bottom sediment by directly applying mechanical force to dislodge and excavate materials (e.g., clamshell).	Implementable.
	Hydraulic	Removal and transportation of bottom sediment in a liquid slurry form using hydraulic pumps (e.g., horizontal auger, Soli-Flo's Eddy Pump®, cutterhead dredge).	Implementable; already performed at the Study Area using a horizontal auger.
	Pneumatic	Removal of bottom sediment by compressed air (e.g., PNEUMA pump).	Potentially implementable.

Table 4-1
(cont'd)

Grasse River Study Area
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
G. Sediment Removal (cont'd)			
II. Excavation (in-the-dry)	Mechanical	Temporary structures (e.g., cofferdams) 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.
	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.
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.
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.
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 performed at the Study Area.
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; new cells would need to be designed and constructed.	Implementable; already performed at the Study Area.
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 ppm PCBs) in existing off-site permitted solid waste landfill.	Potentially implementable.

Table 4-1
(cont'd)

Grasse River Study Area
Massena, New York
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Preliminary Screening of Potential PCB-Containing Sediment Remedial Technologies[1]

General Response Action/ Remedial Technology	Process Option	Description	Preliminary Assessment
J. Residuals Management			
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.
	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.

Note:

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.

Table 4-2

Grasse River Study Area
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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							
	---	RAOs would eventually be met through ongoing naturally occurring processes (including sedimentation, dechlorination, degradation).	None.	Reliable.	Readily implementable.	Readily implementable with no permits/equipment required.	Negligible.
B. Monitoring							
	Site-Wide Monitoring	Periodic visual observations and/or field sampling to monitor Study Area conditions. RAOs would eventually be met through ongoing naturally occurring processes, but site data indicate this could take a significant period of time to achieve site wide.	Minimal.	Reliable means to track Study Area conditions; 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. RAOs would eventually be met through ongoing naturally occurring processes, but site data indicate this could take a significant period of time to achieve site wide.	None.	Reliable.	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. RAOs would eventually be met through ongoing naturally occurring processes, but site data indicate this could take a significant period of time to achieve site wide.	None.	Reliable; applied at this and numerous other aquatic sites.	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. RAOs would eventually be met through naturally occurring processes, but site data indicate that this could take a significant period of time to achieve site wide.	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 isolation primarily through natural deposition/mixing. This option can be used in combination with other process options 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.	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
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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	Engineered 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. outfall areas) and would need to be used in combination with other process options to achieve RAOs.	Potential effects could be reduced by use of engineering controls to mitigate release of sediment/cap material resuspended during construction of cap. Short-term effects on benthic community expected during placement.	USACE has demonstrated engineered 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.	Implementable.	Expected to be implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Moderate.
	AquaBlok™	Based on available information, application of AquaBlok™ should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs.	Results of 2001 Capping Pilot Study indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement. May require placement of additional materials over AquaBlok™ to provide adequate substrate for benthic recolonization.	Concerns raised about viability of bentonite as a substrate for benthos. Material has been placed as part of 2001 Grasse River Capping Pilot Study. Longer-term monitoring results pending.	Implementable. Placed during 2001 Grasse River Capping Pilot Study.	Expected to be 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	
E. In-Place Containment (cont'd)							
I. Capping (cont'd)	Sand/Topsoil Cap	Based on available information, application of a sand/topsoil cap should be effective in reducing PCB flux to the water column and downstream PCB loading to achieve RAOs.	Results of 2001 Capping Pilot Study indicate that implementation effects on water quality are minimal. Short-term effects on benthic community expected during placement.	USACE has demonstrated capping of PCB-containing sediments at a number of sites nationwide. Material has been placed as part of 2001 Grasse River Capping Pilot Study. Longer-term monitoring results pending.	Implementable. Placed during 2001 Grasse River Capping Pilot Study.	Expected to be implementable. Permits not required under CERCLA, although substantive requirements should be met. Equipment, materials and personnel are commercially available.	Low to Moderate.
F. Sediment Treatment							
I. Immobilization	Ex-Situ 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 NTCRA.	Implementable; utilized during the NTCRA.	Implementable.	Moderate.
II. Extraction, Ex-Situ	X* TRAX™	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.	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
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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 (cont'd)							
III. Destruction, Ex-Situ	Incineration	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 products of incomplete combustion (PICs) and unburned PCBs during incineration are of concern. Risk of release and potential exposures increased due to additional material transport, handling, and processing.	Incineration of PCB-containing materials has been demonstrated at several sites in the U.S.	Implementable. Low moisture content materials preferable.	Full-scale units and technical assistance/support currently are available for mobile incineration. Public resistance to incineration may be encountered. Permits may be required for off-site incineration.	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 and the results of the NTCRA, 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. Well suited for removal of boulders/debris.	Implementable. River bottom conditions, such as presence of boulders/debris and 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
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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	
G. Sediment Removal (cont'd)							
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 NTCRA, 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, 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.	Implemented at Study Area during NTCRA. Removed approximately 2,600 in-situ cubic yards of sediment via hydraulic dredging during the NTCRA. 0 to 14 inches of residual material remained following dredging to the extent practicable.	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.	Permits not required under CERCLA, although substantive requirements should be met.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
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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	
G. Sediment Removal (cont'd)							
I. Dredging (cont'd)	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 and the results of the NTCRA, 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 similarly to hydraulic dredging. 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.	Not widely used, especially for environmental dredging. Post-dredging residuals and releases during dredging are difficult to predict.	Implementable. Generally requires 7 feet of water 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 know to exist at the site.	Requires specialty equipment which is available on a limited basis.	High.

Table 4-2
(cont'd)

Grasse River Study Area
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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	
G. Sediment Removal (cont'd)							
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 dredging combined with other process options to achieve RAOs.	Risks to workers are greater due to the need to work within a cofferdammed area below water surface elevation outside the cofferdam. 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 overtapping 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 NTCRA.	Implementable.	Implementable.	Moderate.

Table 4-2
(cont'd)

Grasse River Study Area
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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	
H. Sediment Dewatering (cont'd)							
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. 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.
III. 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.
IV. 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, MI. and Cumberland Bay in Plattsburgh, NY. A site-specific study would be required to assess treatment effectiveness.	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
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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	
H. Sediment Dewatering (cont'd)							
V. 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 (including removal, dewatering, disposal, residuals management) that would be expected to eventually 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 NTCRA materials.	Implementable. Requires construction of an additional landfill cells on-site. On-site landfill is currently permitted for two more cells. Space exists at the Alcoa facility for additional disposal area, although siting/design work would need to be conducted.	Implementable.	Low to 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.	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 ppm 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. Residuals Management							
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 accicents 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 could 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 Alcoa's NTCRA, 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 NTCRA.	Implementable.	Implementable.	Low to Moderate.

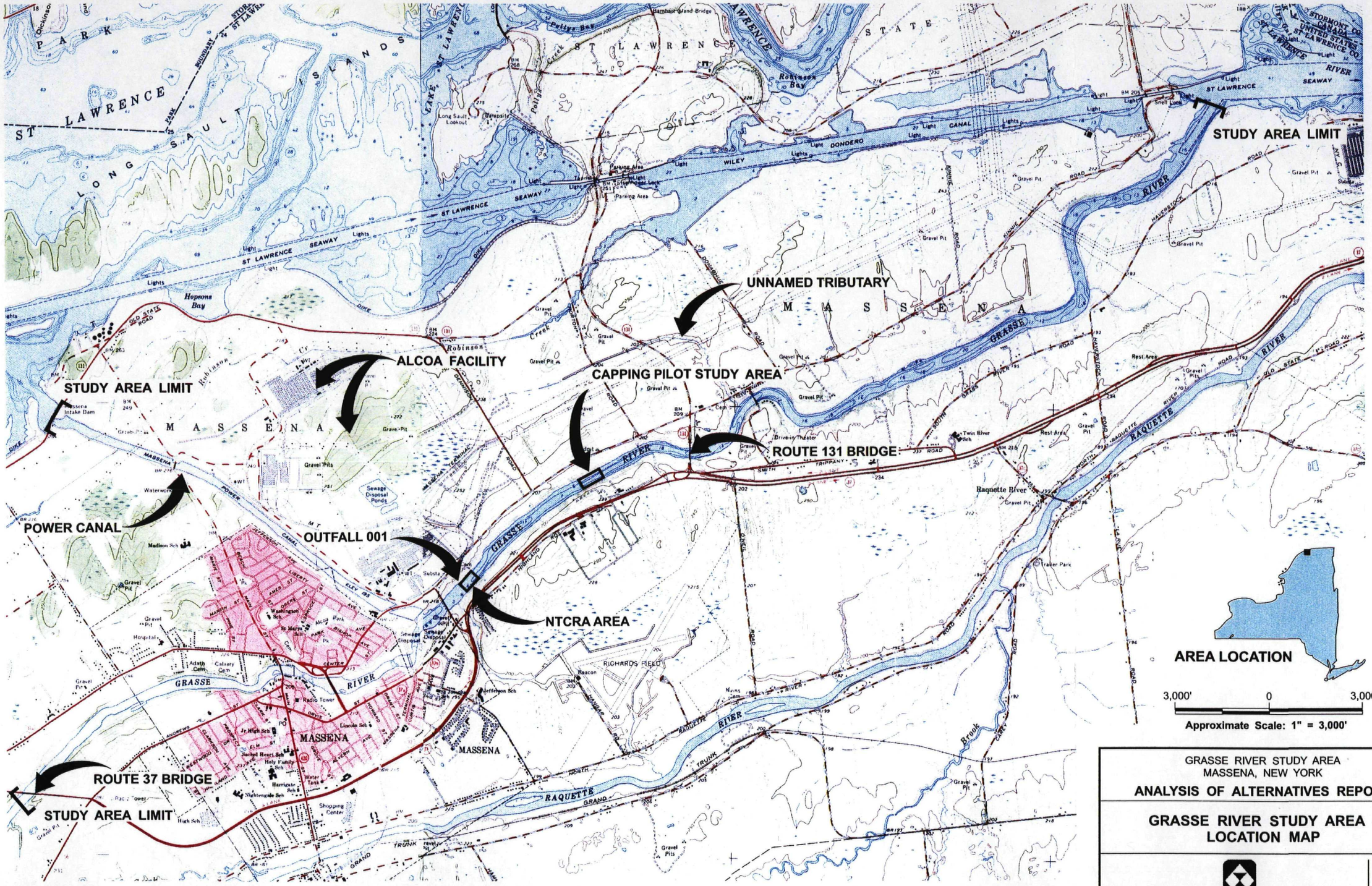
Notes:
1. Costs are relative to other process options within each general response action.

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	Engineered Capping Sand/Topsoil Cap
F) Sediment Treatment Immobilization	Stabilization/Solidification, Ex-situ
G) Sediment Removal Dredging	Hydraulic Dredging Mechanical Removal
H) Sediment Dewatering Filtration	Plate and Frame Filter Press
I) Sediment Disposal On-Site Disposal	Local Landfill
J) Residuals Management Water Treatment	Filtration Granular Activated Carbon



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

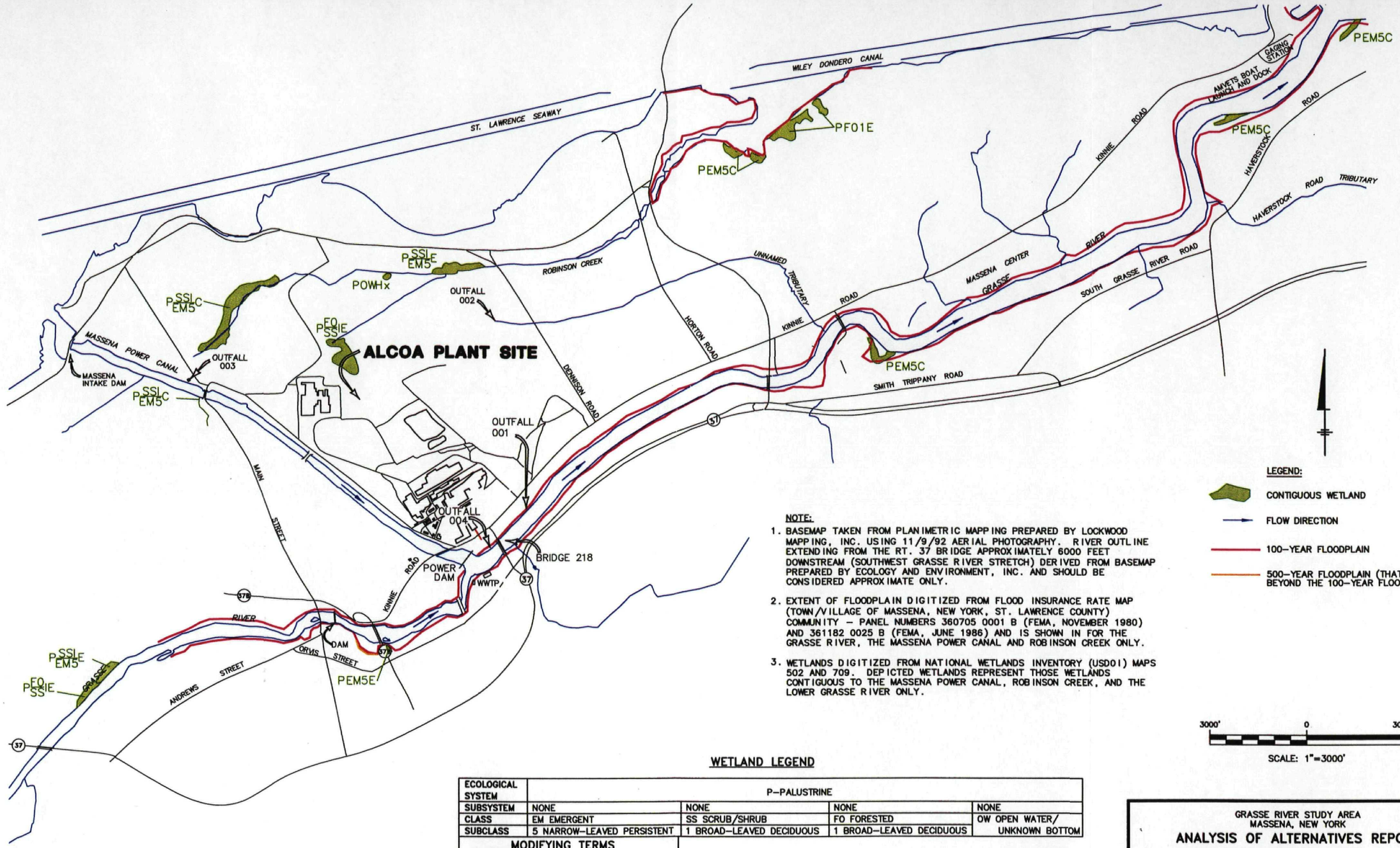
GRASSE RIVER STUDY AREA - LOCATION MAP

ALCOA

FIGURE 1-1

05/28/02 SYR-D54-DJH LBR MRC
10442005/10442n02.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)

NOTE:

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 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

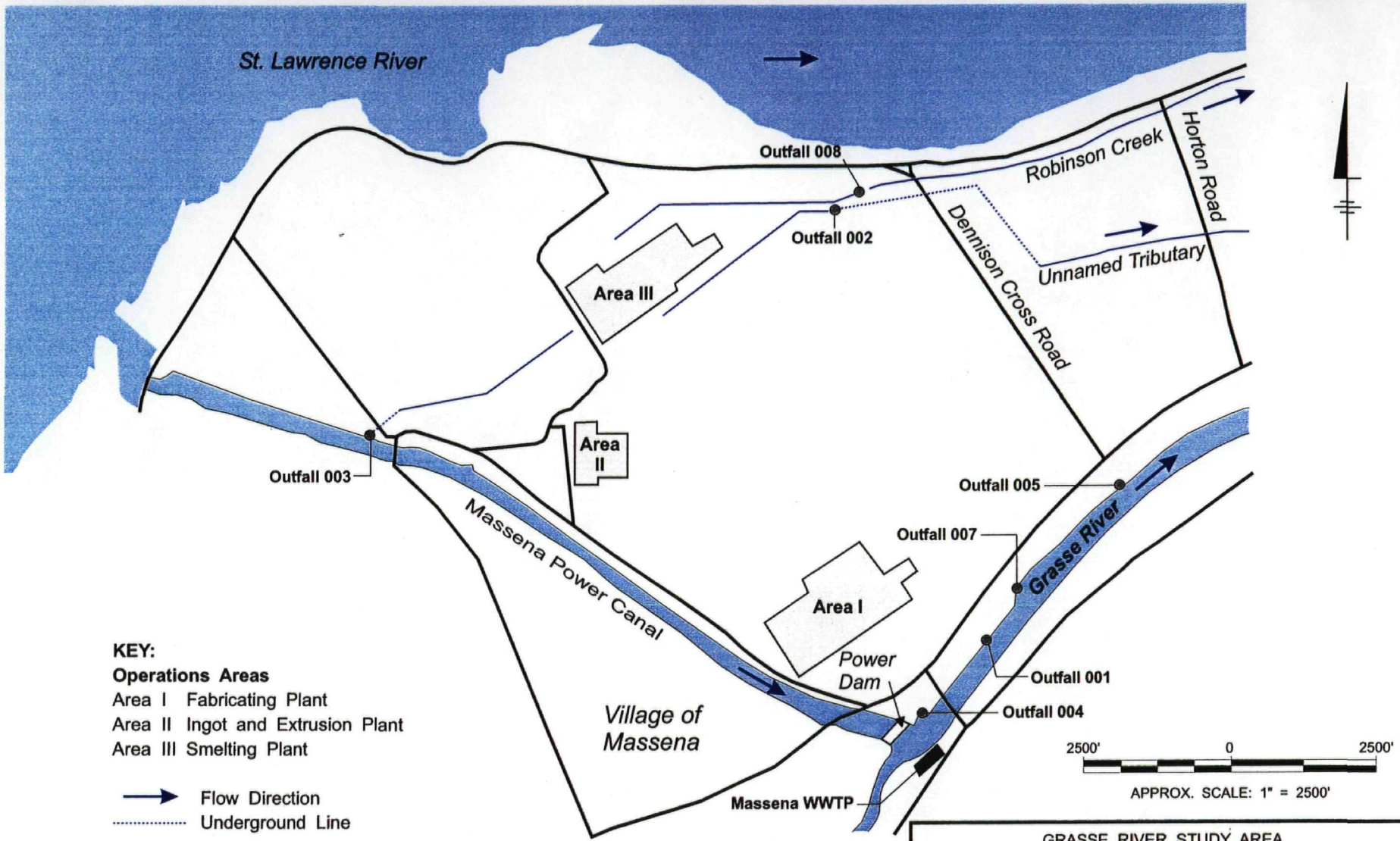
ANALYSIS OF ALTERNATIVES REPORT

100/500-YEAR FLOODPLAIN AND CONTIGUOUS WETLAND AREAS

ALCOA

FIGURE **1-2**

X:10436X01
L: PILOT
P: STD-PL/BL
05/23/02 SYR-54-RLP CBM LAS
10451001/10451B02.DWG



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

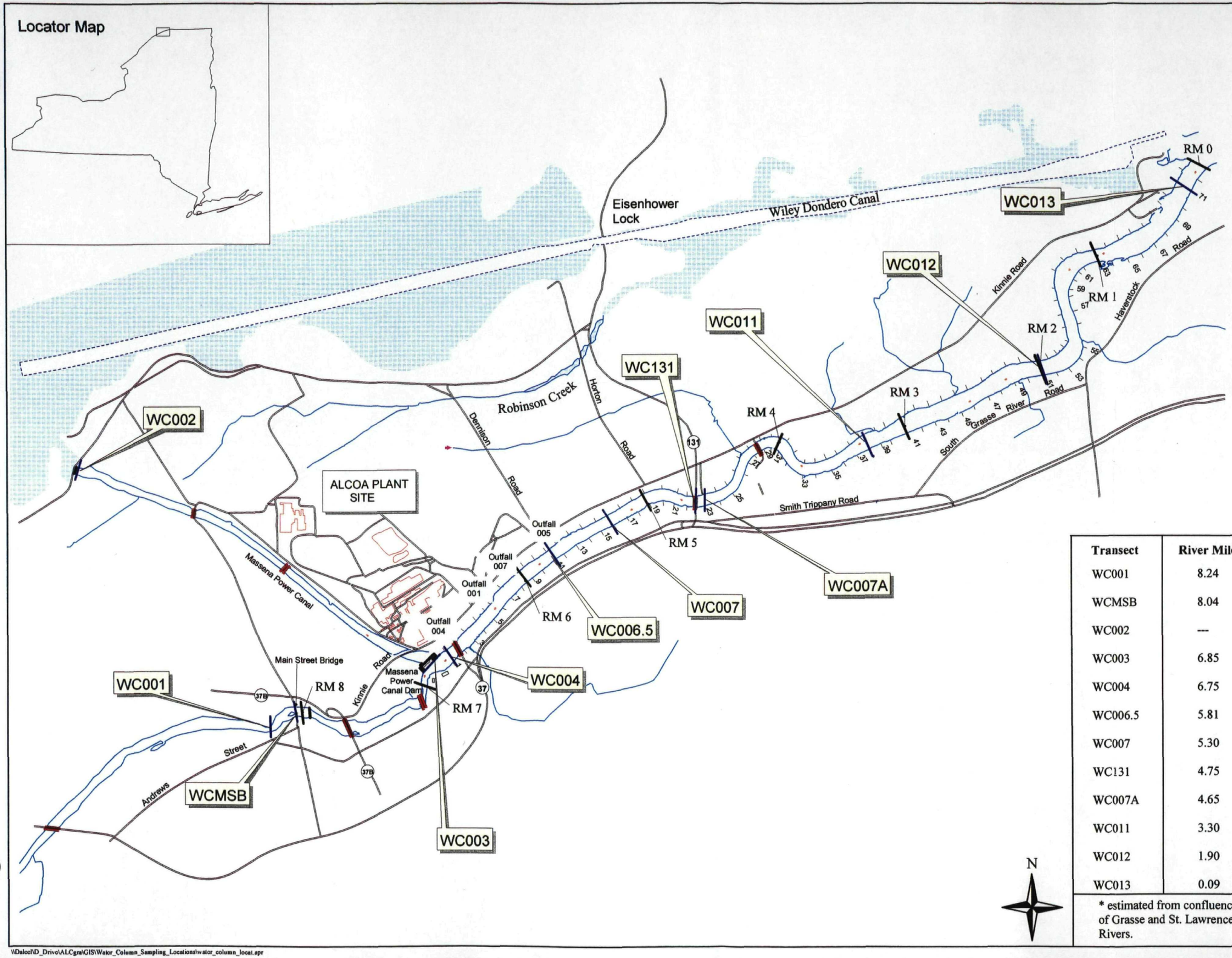
ANALYSIS OF ALTERNATIVES REPORT

LOCATION OF ALCOA PRODUCTION FACILITIES AND OUTFALLS

ALCOA

FIGURE
1-3

05/28/02 SYR-D54-DJH LAS
10442005/10442G01.CDR



GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- Water Column Sampling Locations
- River Mile
- 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

Transect	River Mile*
WC001	8.24
WCMSB	8.04
WC002	---
WC003	6.85
WC004	6.75
WC006.5	5.81
WC007	5.30
WC131	4.75
WC007A	4.65
WC011	3.30
WC012	1.90
WC013	0.09

* estimated from confluence of Grasse and St. Lawrence Rivers.

Lower Grasse River Study Area
Massena, New York

Figure 2-1.
Water Column Sampling Locations

ALCOA

Feb 2001

\\Daloel\D_Drive\ALCgra\GIS\Water_Column_Sampling_Locations\water_column_locat.apr

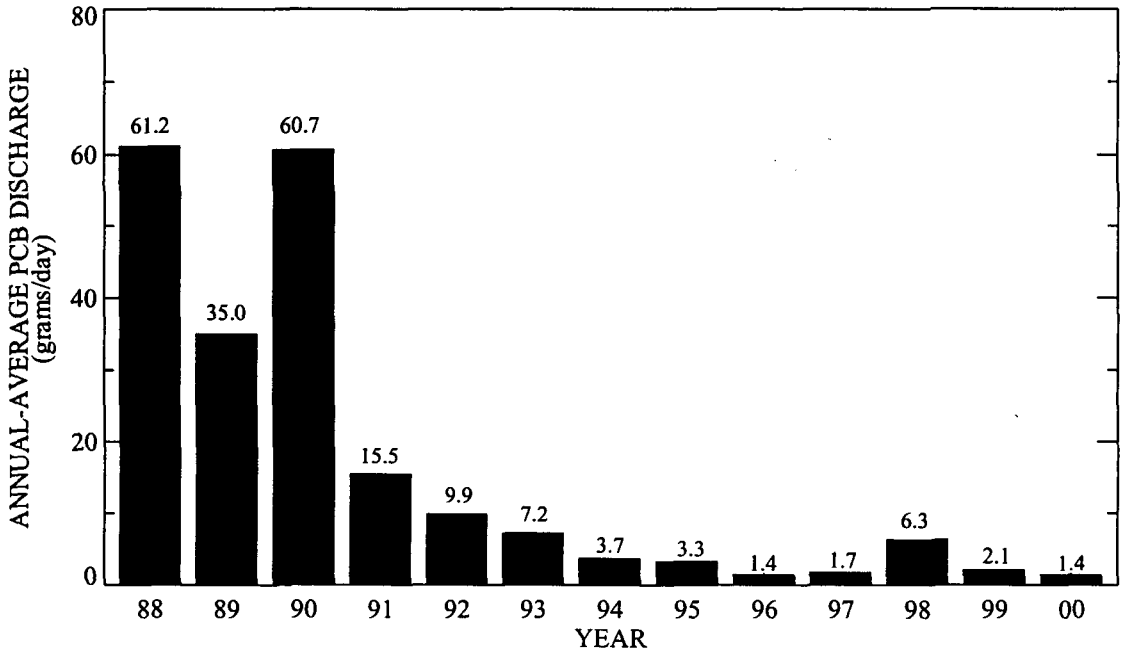


Figure 2-2. Average Annual PCB Discharges from Outfall 001.

Averages computed using SPDES monitoring data.

PCBs reported below the detection limit set equal to zero.

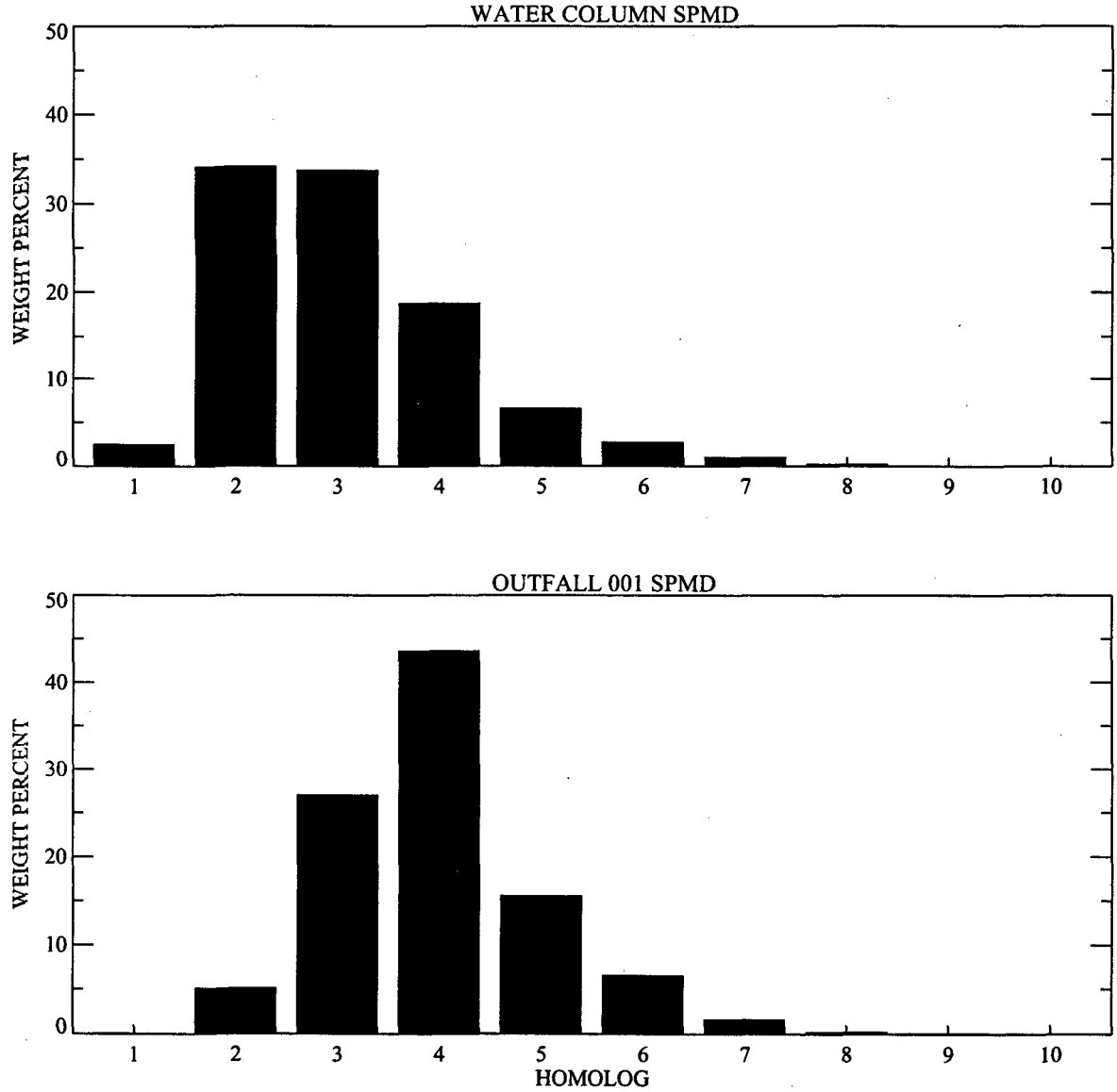


Figure 2-3. Average PCB Homolog Distributions in SPMDs from the Grasse River and Outfall 001.

Water column 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).

Outfall 001 SPMD values represent average of data collected from Outfall 001 mixing basin during dry-weather conditions (summer 1997).

Data table: water_bz

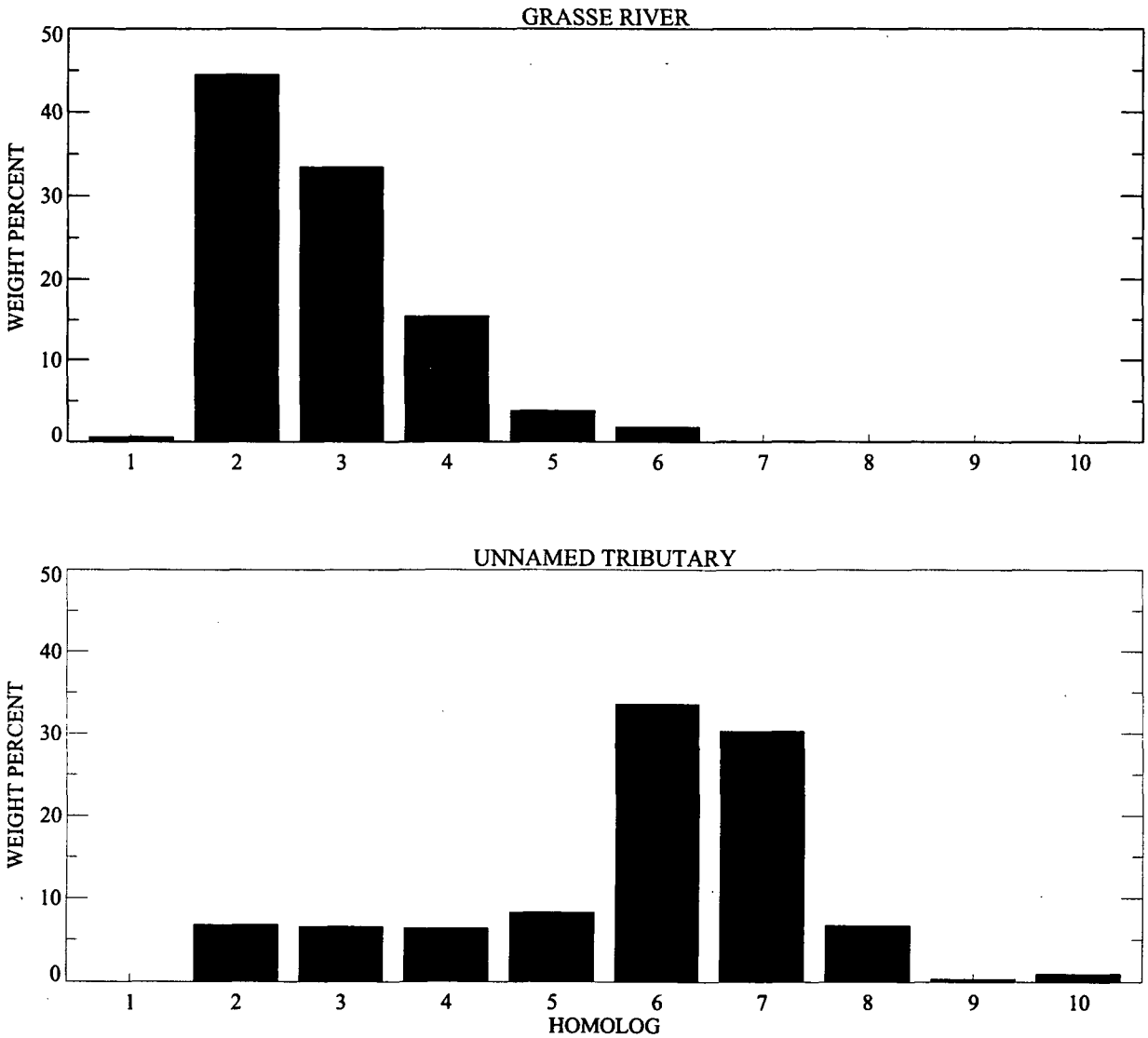
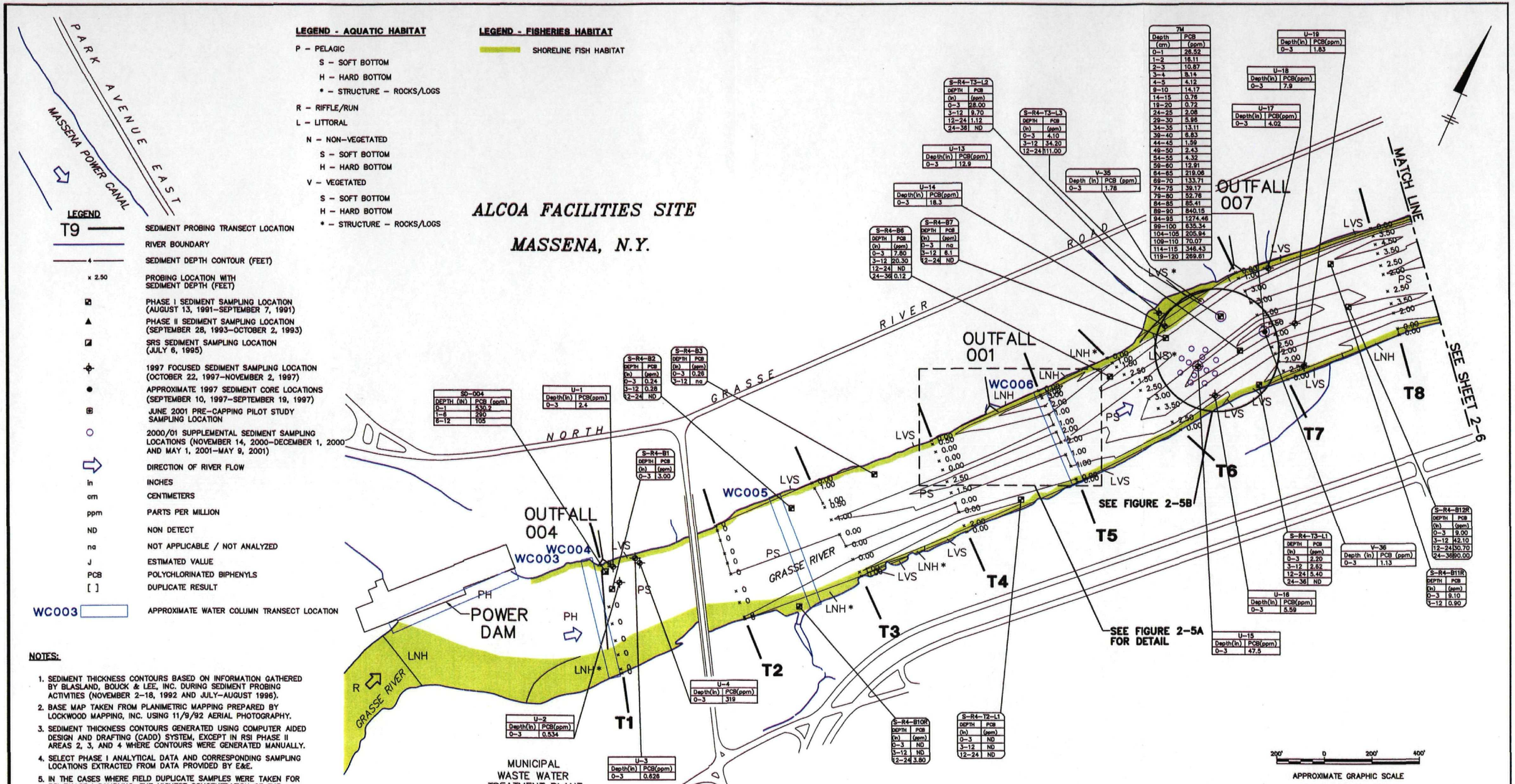


Figure 2-4. Average PCB Homolog Distributions in Water Samples Collected from the Grasse River and the Unnamed Tributary.

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



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-5

X: 10442X00.DWG, 10442X02.DWG, 10442X03.DWG, 10442X07.TIF
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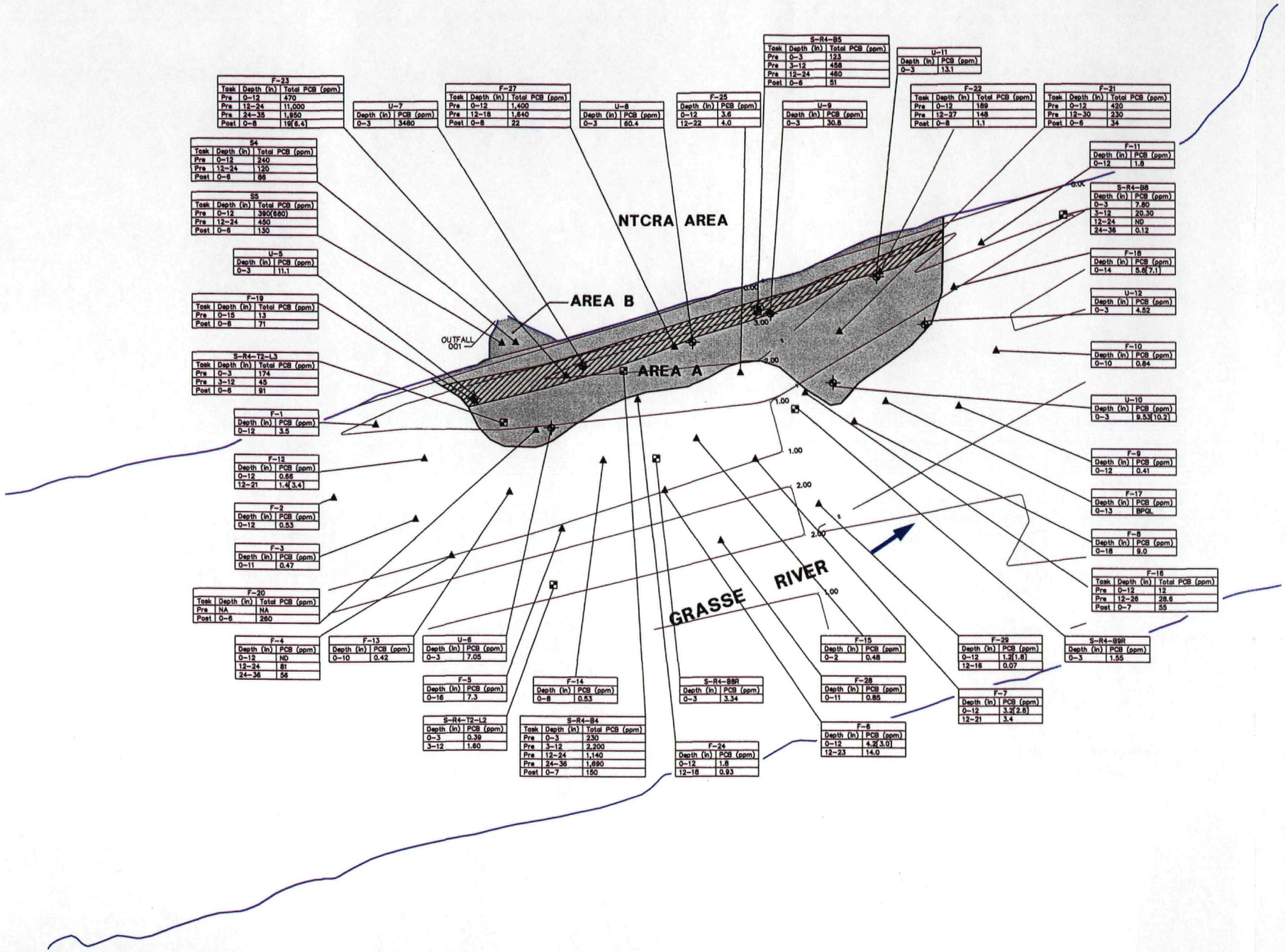
P: PAGESET: DL
5/28/02 SYR-54-DCC JER LAS
10442005/10442C01.DWG



X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C25.DWG

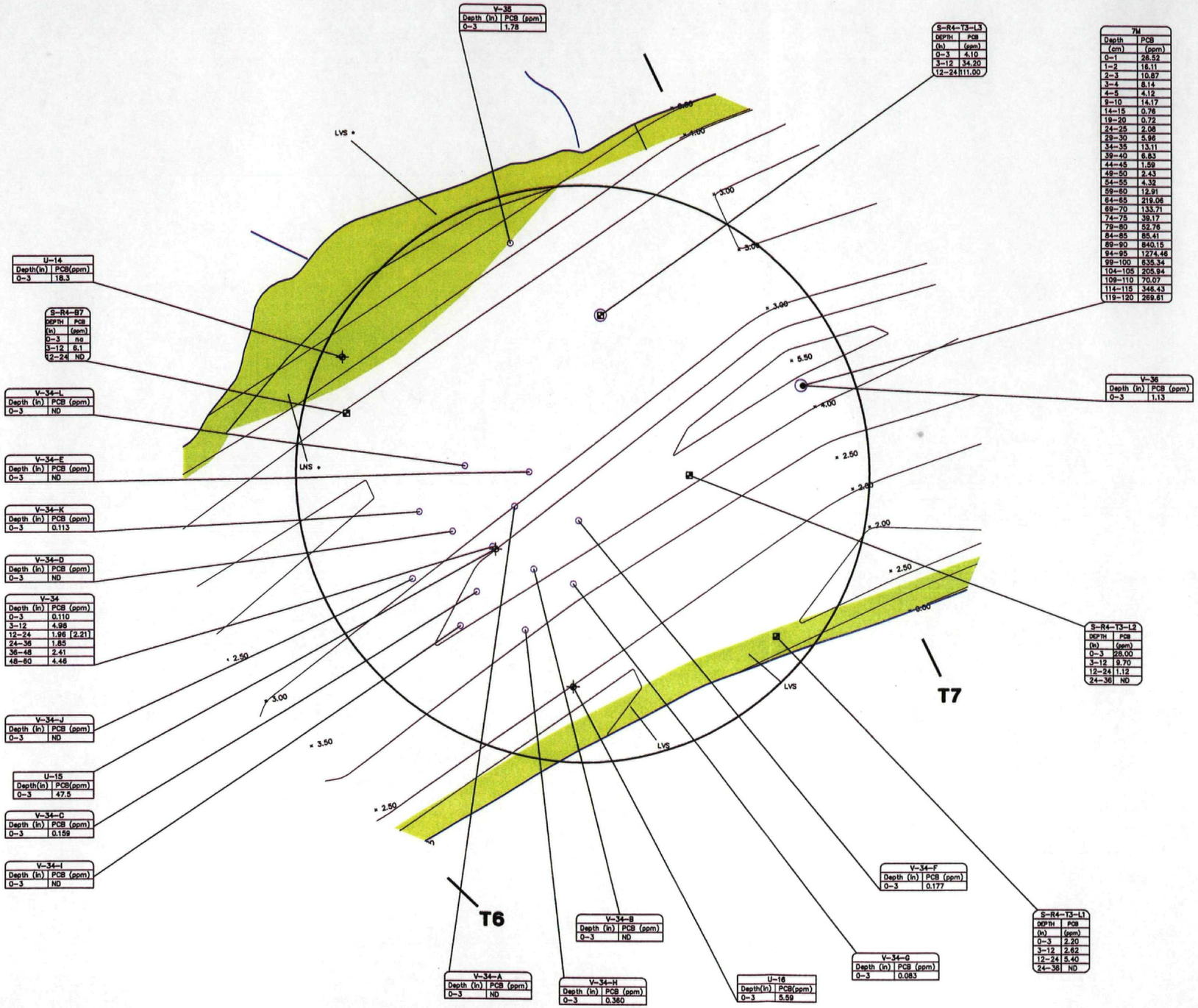
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-5A



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL

N – NON-VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM

V – VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-5B

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
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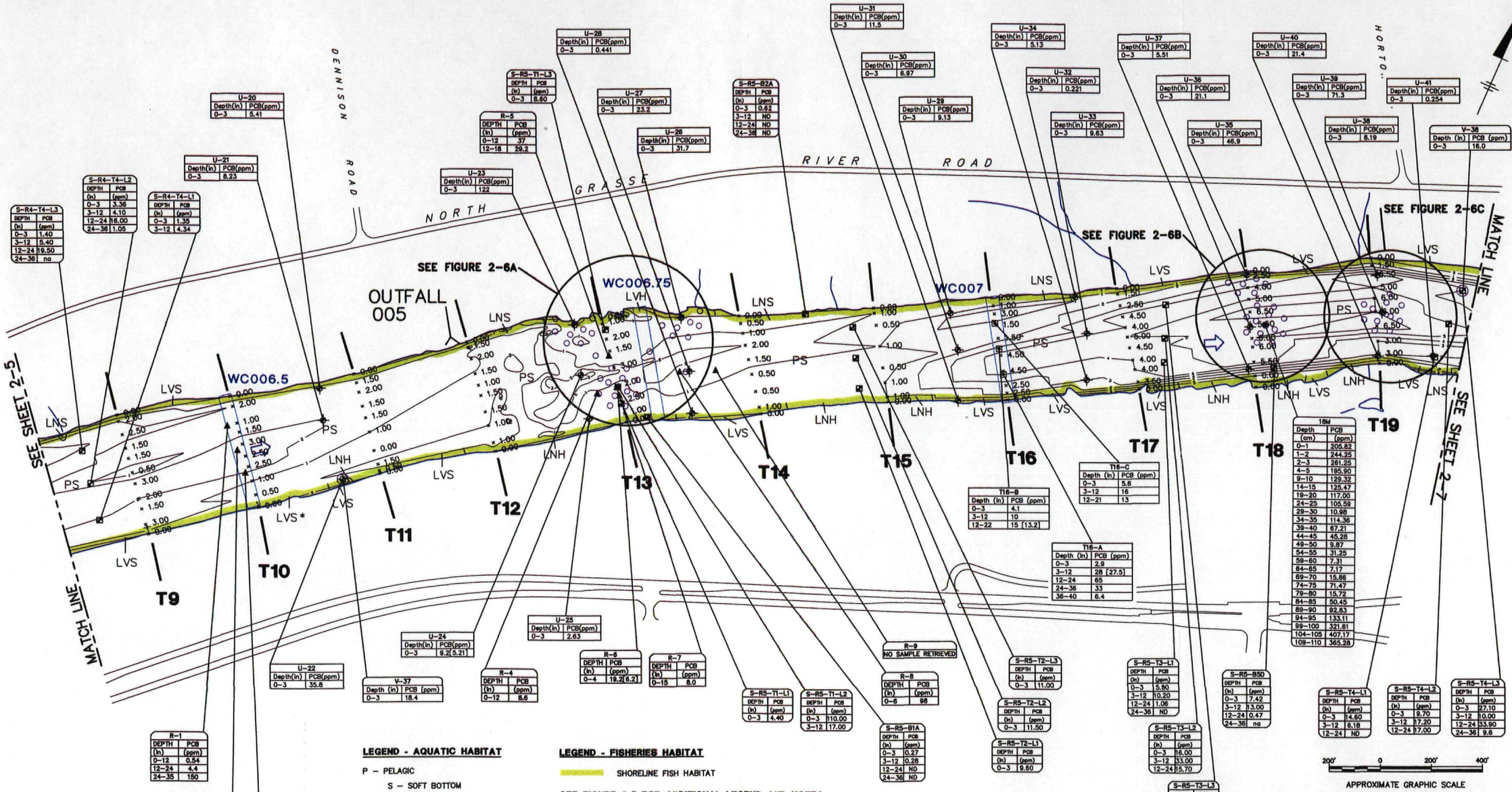
P: PAGESET: DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C23.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-6

X: 10442X00, 10442X02, 10442X03.DWG, 10442X07.TIF
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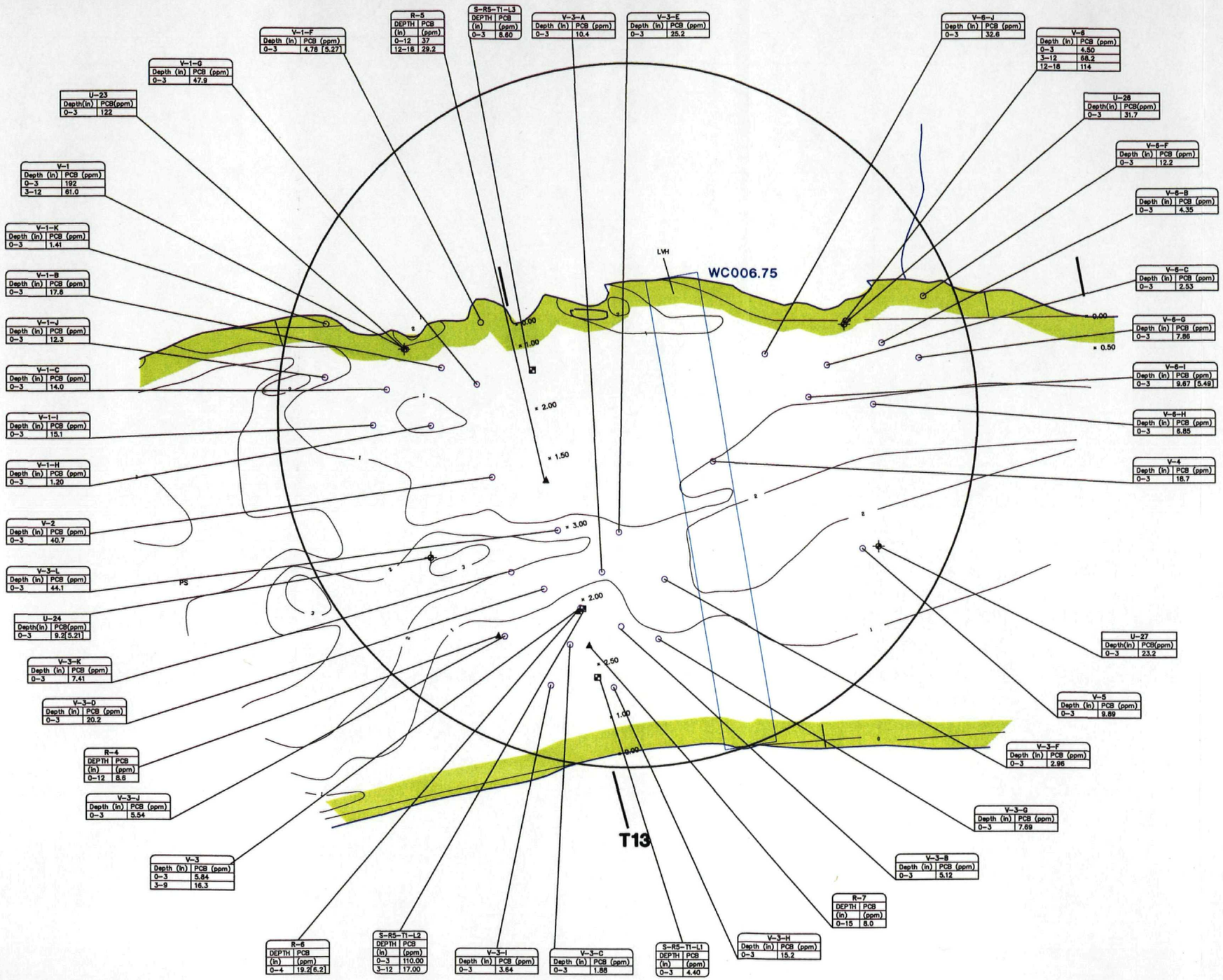
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C02.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-6A

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
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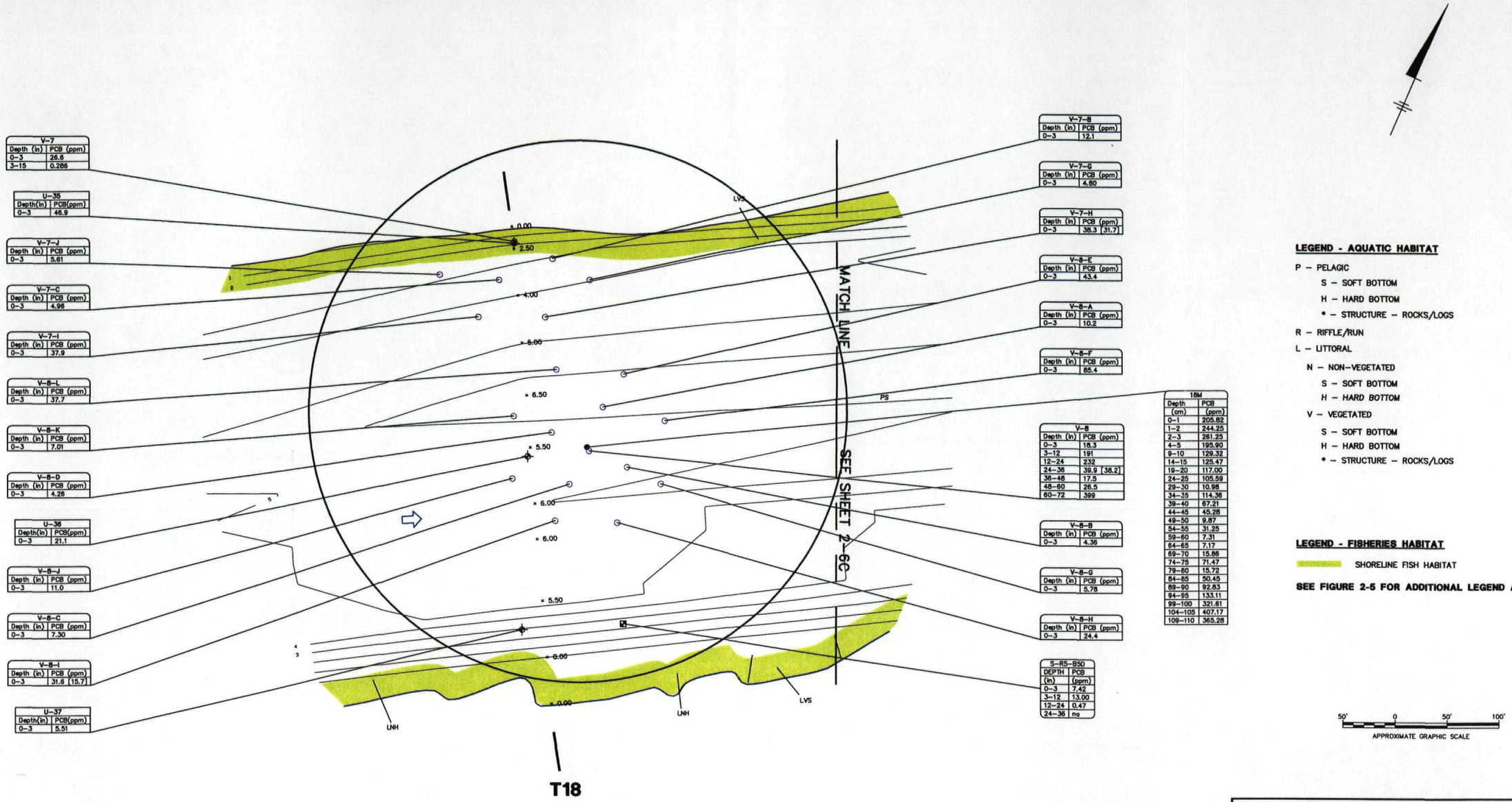

V-7	
Depth (in)	PCB (ppm)
0-3	26.6
3-15	0.286

U-35	
Depth(in)	PCB(ppm)
0-3	46.9

V-7-J	
Depth (in)	PCB (ppm)
0-3	5.61

V-7-C	
Depth (in)	PCB (ppm)
0-3	4.96

V-7-I	
Depth (in)	PCB (ppm)
0-3	37.9

V-8-L	
Depth (in)	PCB (ppm)
0-3	37.7

V-8-K	
Depth (in)	PCB (ppm)
0-3	7.01

V-8-D	
Depth (in)	PCB (ppm)
0-3	4.26

U-36	
Depth(in)	PCB(ppm)
0-3	21.1

V-8-J	
Depth (in)	PCB (ppm)
0-3	11.0

V-8-C	
Depth (in)	PCB (ppm)
0-3	7.30

V-8-I	
Depth (in)	PCB (ppm)
0-3	31.6 [15.7]

U-37	
Depth(in)	PCB(ppm)
0-3	5.51

V-7-B	
Depth (in)	PCB (ppm)
0-3	12.1

V-7-G	
Depth (in)	PCB (ppm)
0-3	4.80

V-7-H	
Depth (in)	PCB (ppm)
0-3	38.3 [31.7]

V-8-E	
Depth (in)	PCB (ppm)
0-3	43.4

V-8-A	
Depth (in)	PCB (ppm)
0-3	10.2

V-8-F	
Depth (in)	PCB (ppm)
0-3	85.4

V-8	
Depth (in)	PCB (ppm)
0-3	18.3
3-12	191
12-24	232
24-36	39.9 [38.2]
36-48	17.5
48-60	26.5
60-72	399

V-8-B	
Depth (in)	PCB (ppm)
0-3	4.36

V-8-G	
Depth (in)	PCB (ppm)
0-3	5.78

V-8-H	
Depth (in)	PCB (ppm)
0-3	24.4

S-R5-B50	
DEPTH (in)	PCB (ppm)
0-3	7.42
3-12	13.00
12-24	0.47
24-36	ns

18M	
Depth (cm)	PCB (ppm)
0-1	205.82
1-2	244.25
2-3	261.25
4-5	195.90
9-10	129.32
14-15	125.47
19-20	117.00
24-25	105.59
29-30	10.98
34-35	114.36
39-40	67.21
44-45	45.28
49-50	9.87
54-55	31.25
59-60	7.31
64-65	7.17
69-70	15.86
74-75	71.47
79-80	15.72
84-85	50.45
89-90	92.83
94-95	133.11
99-100	321.61
104-105	407.17
109-110	365.28

LEGEND - AQUATIC HABITAT

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  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-6B

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
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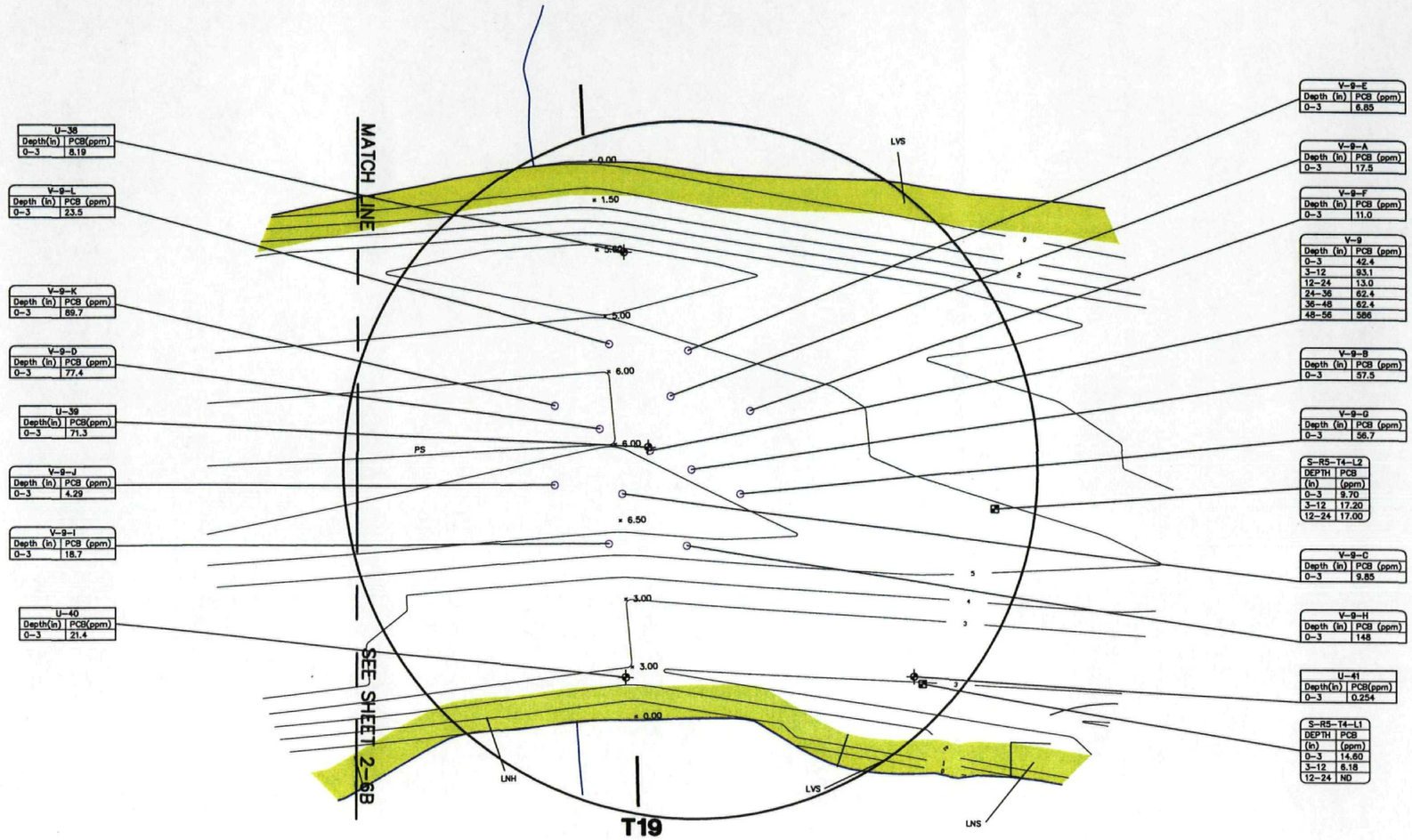
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C20.DWG



LEGEND - AQUATIC HABITAT

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- H – HARD BOTTOM
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- H – HARD BOTTOM

V – VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-6C

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
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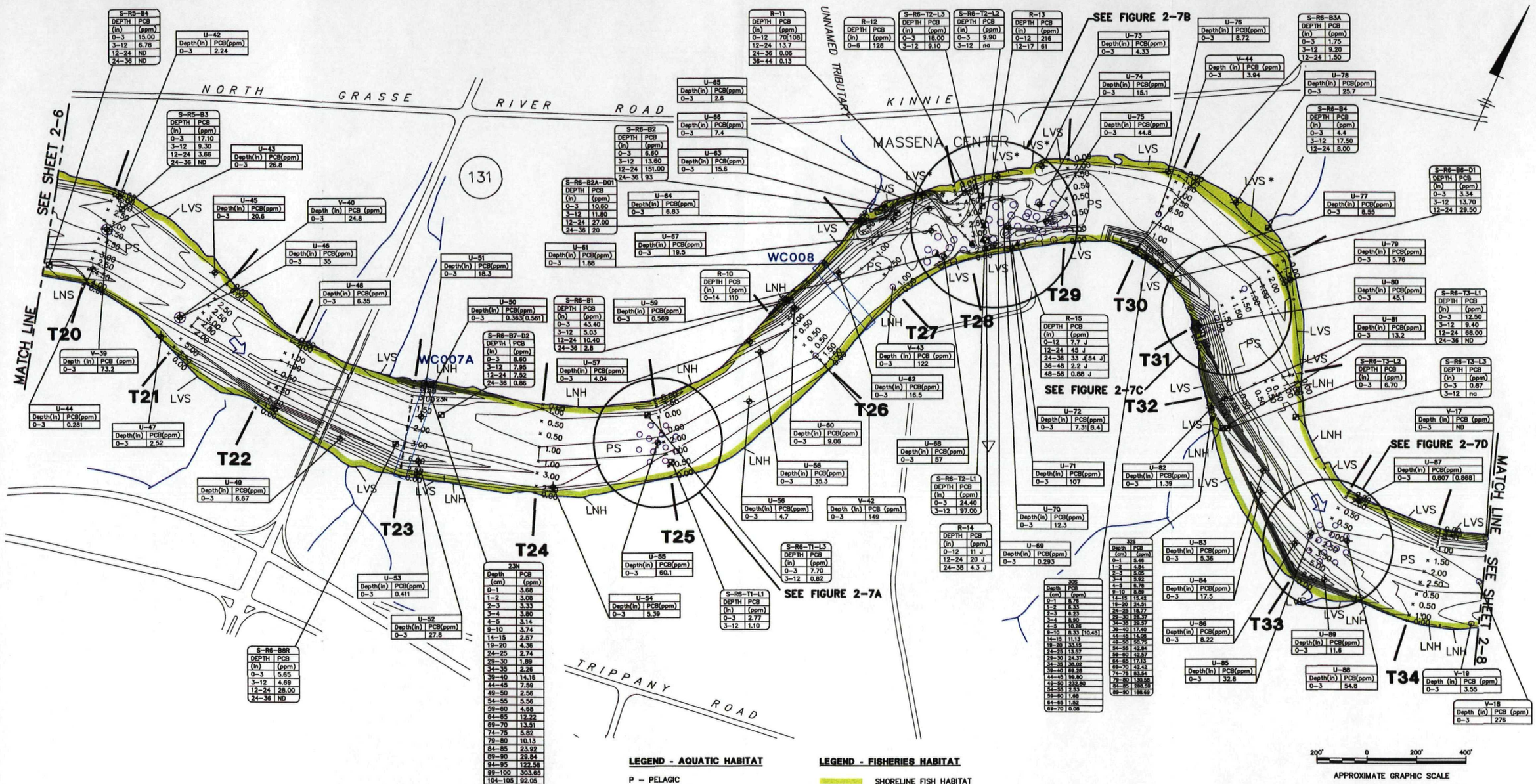
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C21.DWG



S-R5-B4	
DEPTH (in)	PCB (ppm)
0-3	15.00
3-12	6.78
12-24	ND
24-36	ND

U-42	
Depth(in)	PCB(ppm)
0-3	2.24

S-R5-B3	
DEPTH (in)	PCB (ppm)
0-3	17.10
3-12	9.30
12-24	3.66
24-36	ND

U-43	
Depth(in)	PCB(ppm)
0-3	26.8

U-45	
Depth(in)	PCB(ppm)
0-3	20.6

V-40	
Depth (in)	PCB (ppm)
0-3	24.8

U-46	
Depth(in)	PCB(ppm)
0-3	35

U-48	
Depth(in)	PCB(ppm)
0-3	6.35

V-39	
Depth (in)	PCB (ppm)
0-3	73.2

U-44	
Depth(in)	PCB(ppm)
0-3	0.281

U-47	
Depth(in)	PCB(ppm)
0-3	2.52

U-49	
Depth(in)	PCB(ppm)
0-3	6.67

U-53	
Depth(in)	PCB(ppm)
0-3	0.411

U-52	
Depth(in)	PCB(ppm)
0-3	27.8

S-R6-B8R	
DEPTH (in)	PCB (ppm)
0-3	5.65
3-12	4.69
12-24	28.00
24-36	ND

23N	
Depth (cm)	PCB (ppm)
0-1	3.68
1-2	3.08
2-3	3.33
3-4	3.80
4-5	3.14
9-10	3.74
14-15	2.57
19-20	4.36
24-25	2.74
29-30	1.89
34-35	2.26
39-40	14.16
44-45	7.58
49-50	2.56
54-55	5.56
59-60	4.68
64-65	12.22
69-70	13.51
74-75	5.82
79-80	10.13
84-85	23.92
89-90	29.84
94-95	122.58
99-100	303.65
104-105	92.05
109-110	8.93
114-115	31.85
119-120	11.36
124-125	1.11
129-130	0.26
134-135	0.20

U-51	
Depth(in)	PCB(ppm)
0-3	18.3

U-50	
Depth(in)	PCB(ppm)
0-3	0.363 [0.561]

S-R6-B7-D2	
DEPTH (in)	PCB (ppm)
0-3	8.60
3-12	7.95
12-24	7.52
24-36	0.86

U-57	
Depth(in)	PCB(ppm)
0-3	4.04

U-55	
Depth(in)	PCB(ppm)
0-3	60.1

U-54	
Depth(in)	PCB(ppm)
0-3	5.39

S-R6-B2	
DEPTH (in)	PCB (ppm)
0-3	6.60
3-12	13.60
12-24	151.00
24-36	93

S-R6-B2A-D01	
DEPTH (in)	PCB (ppm)
0-3	10.60
3-12	11.80
12-24	27.00
24-36	20

U-61	
Depth(in)	PCB(ppm)
0-3	1.88

U-65	
Depth(in)	PCB(ppm)
0-3	2.6

U-66	
Depth(in)	PCB(ppm)
0-3	7.4

U-63	
Depth(in)	PCB(ppm)
0-3	15.6

U-64	
Depth(in)	PCB(ppm)
0-3	6.83

U-67	
Depth(in)	PCB(ppm)
0-3	19.5

S-R6-B1	
DEPTH (in)	PCB (ppm)
0-3	43.40
3-12	5.03
12-24	10.40
24-36	2.8

U-59	
Depth(in)	PCB(ppm)
0-3	0.569

R-10	
DEPTH (in)	PCB (ppm)
0-14	110

R-11	
DEPTH (in)	PCB (ppm)
0-12	70[108]
12-24	13.7
24-36	0.06
36-44	0.13

R-12	
DEPTH (in)	PCB (ppm)
0-6	128

S-R6-T2-L3	
DEPTH (in)	PCB (ppm)
0-3	18.00
3-12	9.10

S-R6-T2-L2	
DEPTH (in)	PCB (ppm)
0-3	9.90
3-12	na

R-13	
DEPTH (in)	PCB (ppm)
0-12	216
12-17	61

U-73	
Depth(in)	PCB(ppm)
0-3	4.33

U-74	
Depth(in)	PCB(ppm)
0-3	15.1

U-75	
Depth(in)	PCB(ppm)
0-3	44.8

U-76	
Depth(in)	PCB(ppm)
0-3	8.72

V-44	
Depth (in)	PCB (ppm)
0-3	3.94

S-R6-B3A	
DEPTH (in)	PCB (ppm)
0-3	1.75
3-12	9.20
12-24	1.50

U-78	
Depth(in)	PCB(ppm)
0-3	25.7

S-R6-B4	
DEPTH (in)	PCB (ppm)
0-3	4.4
3-12	17.50
12-24	8.00

S-R6-B6-D1	
DEPTH (in)	PCB (ppm)
0-3	3.34
3-12	13.70
12-24	29.50

U-77	
Depth(in)	PCB(ppm)
0-3	8.55

U-79	
Depth(in)	PCB(ppm)
0-3	5.76

U-80	
Depth(in)	PCB(ppm)
0-3	45.1

U-81	
Depth(in)	PCB(ppm)
0-3	13.2

S-R6-T3-L1	
DEPTH (in)	PCB (ppm)
0-3	12.50
3-12	9.40
12-24	68.00
24-36	ND

S-R6-T3-L2	
DEPTH (in)	PCB (ppm)
0-3	6.70

S-R6-T3-L3	
DEPTH (in)	PCB (ppm)
0-3	0.87
3-12	na

V-17	
Depth (in)	PCB (ppm)
0-3	ND

U-87	
Depth(in)	PCB(ppm)
0-3	0.807 [0.868]

U-83	
Depth(in)	PCB(ppm)
0-3	5.36

U-84	
Depth(in)	PCB(ppm)
0-3	17.5

U-86	
Depth(in)	PCB(ppm)
0-3	8.22

U-85	
Depth(in)	PCB(ppm)
0-3	32.8

U-89	
Depth(in)	PCB(ppm)
0-3	11.8

U-88	
Depth(in)	PCB(ppm)
0-3	54.8

V-19	
Depth (in)	PCB (ppm)
0-3	3.55

V-18	
Depth (in)	PCB (ppm)
0-3	276

R-15	
DEPTH (in)	PCB (ppm)
0-12	7.7 J
12-24	45 J
24-36	33 J [54 J]
36-48	2.2 J
48-58	0.88 J

U-72	
Depth(in)	PCB(ppm)
0-3	7.3 [8.4]

U-71	
Depth(in)	PCB(ppm)
0-3	107

U-70	
Depth(in)	PCB(ppm)
0-3	12.3

U-69	
Depth(in)	PCB(ppm)
0-3	0.293

30S	
Depth (cm)	PCB (ppm)
0-1	8.78
1-2	8.33
2-3	8.23
3-4	8.50
4-5	10.28
9-10	8.33 [10.43]
14-15	11.13
19-20	33.15
24-25	13.57
29-30	24.37
34-35	38.02
39-40	69.28
44-45	99.80
49-50	232.60
54-55	2.53
59-60	1.66
64-65	1.52
69-70	0.06

32S	
Depth (cm)	PCB (ppm)
0-1	5.46
1-2	4.84
2-3	5.05
3-4	5.92
4-5	6.76
9-10	8.69
14-15	15.42
19-20	24.31
24-25	18.77
29-30	28.37
34-35	29.57
39-40	17.40
44-45	14.06
49-50	50.75
54-55	42.84
59-60	42.57
64-65	17.13
69-70	42.42
74-75	83.54
79-80	130.56
84-85	288.59
89-90	188.69

S-R6-T2-L1	
DEPTH (in)	PCB (ppm)
0-3	24.40
3-12	97.00

R-14	
DEPTH (in)	PCB (ppm)
0-12	11 J
12-24	20 J
24-38	4.3 J

U-62	
Depth(in)	PCB(ppm)
0-3	16.5

V-43	
Depth (in)	PCB (ppm)
0-3	122

U-60	
Depth(in)	PCB(ppm)
0-3	9.06

U-68	
Depth(in)	PCB(ppm)
0-3	57

U-56	
Depth(in)	PCB(ppm)
0-3	35.3

U-56	
Depth(in)	PCB(ppm)
0-3	4.7

V-42	
Depth (in)	PCB (ppm)
0-3	149

S-R6-T1-L3	
DEPTH (in)	PCB (ppm)
0-3	7.70
3-12	0.82

S-R6-T1-L1	
DEPTH (in)	PCB (ppm)
0-3	2.77
3-12	1.10

LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

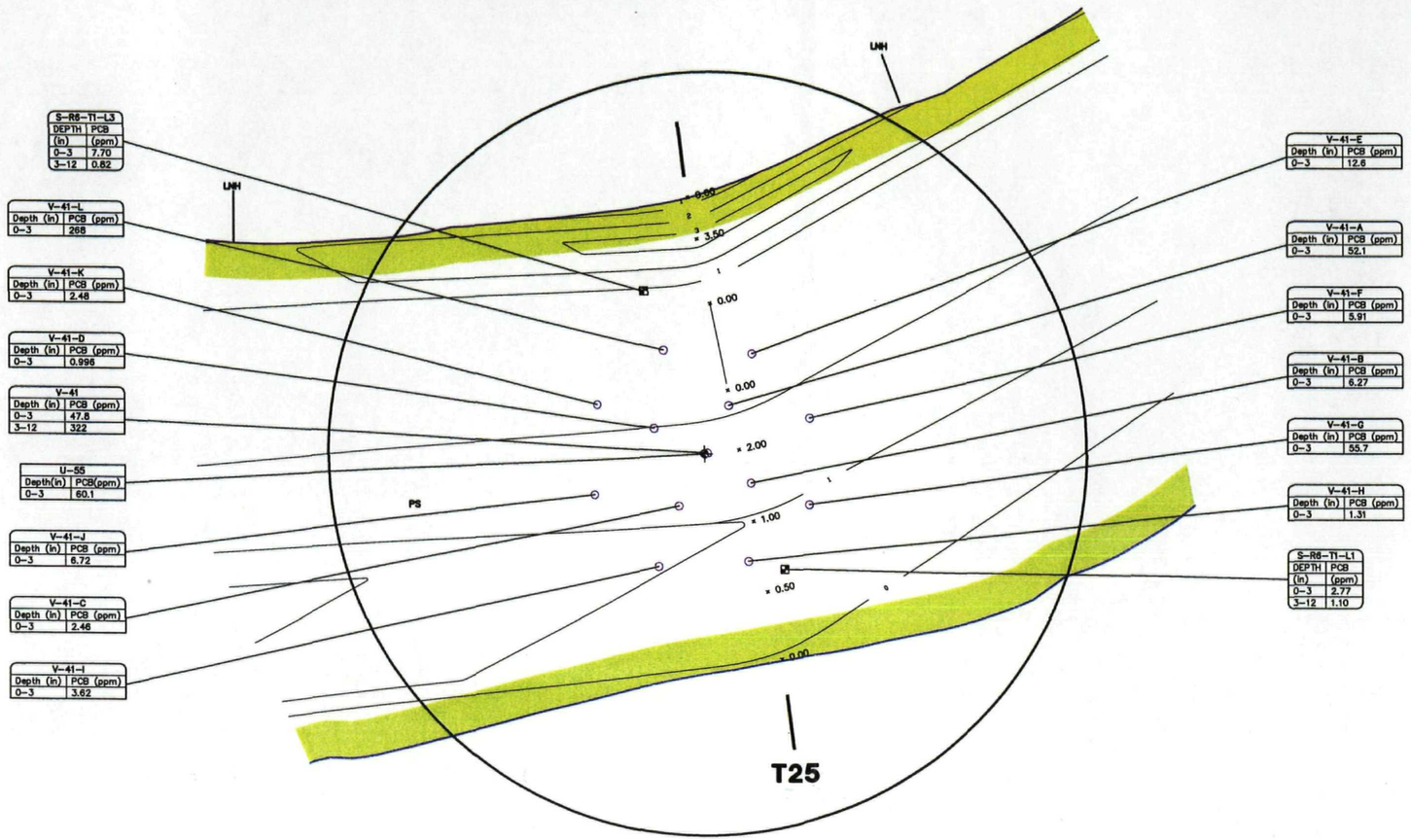
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-7

X: 10442X00, 10442X02, 10442X03.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/PLT-DL
5/28/02 SYR-54-DCC KMO LAS
10442005/10442C03.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

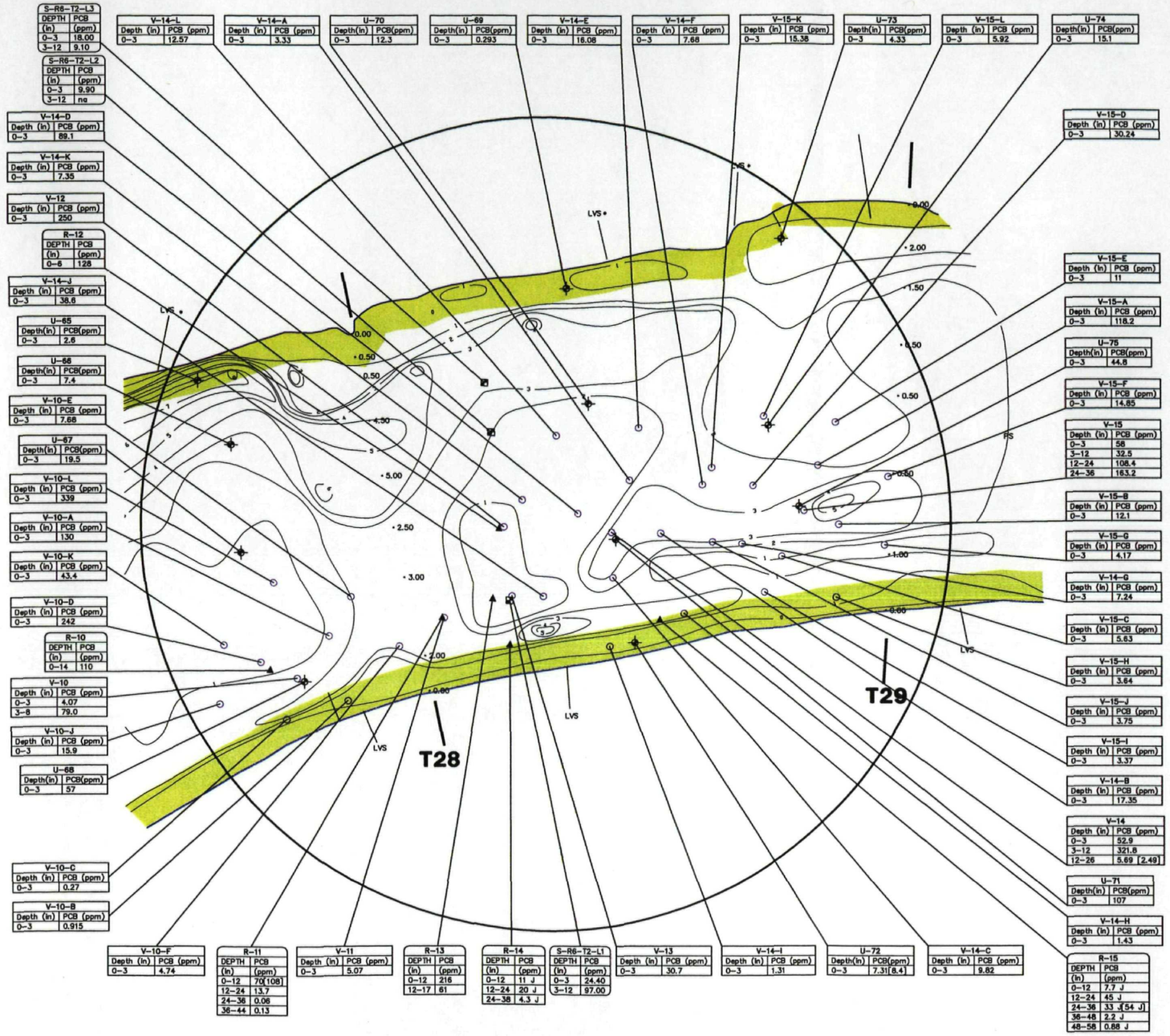
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-7A

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C17.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

NOTES:

1. LOCATION OF SAMPLE V-10-E IS APPROXIMATE.

50' 0 50' 100'

APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

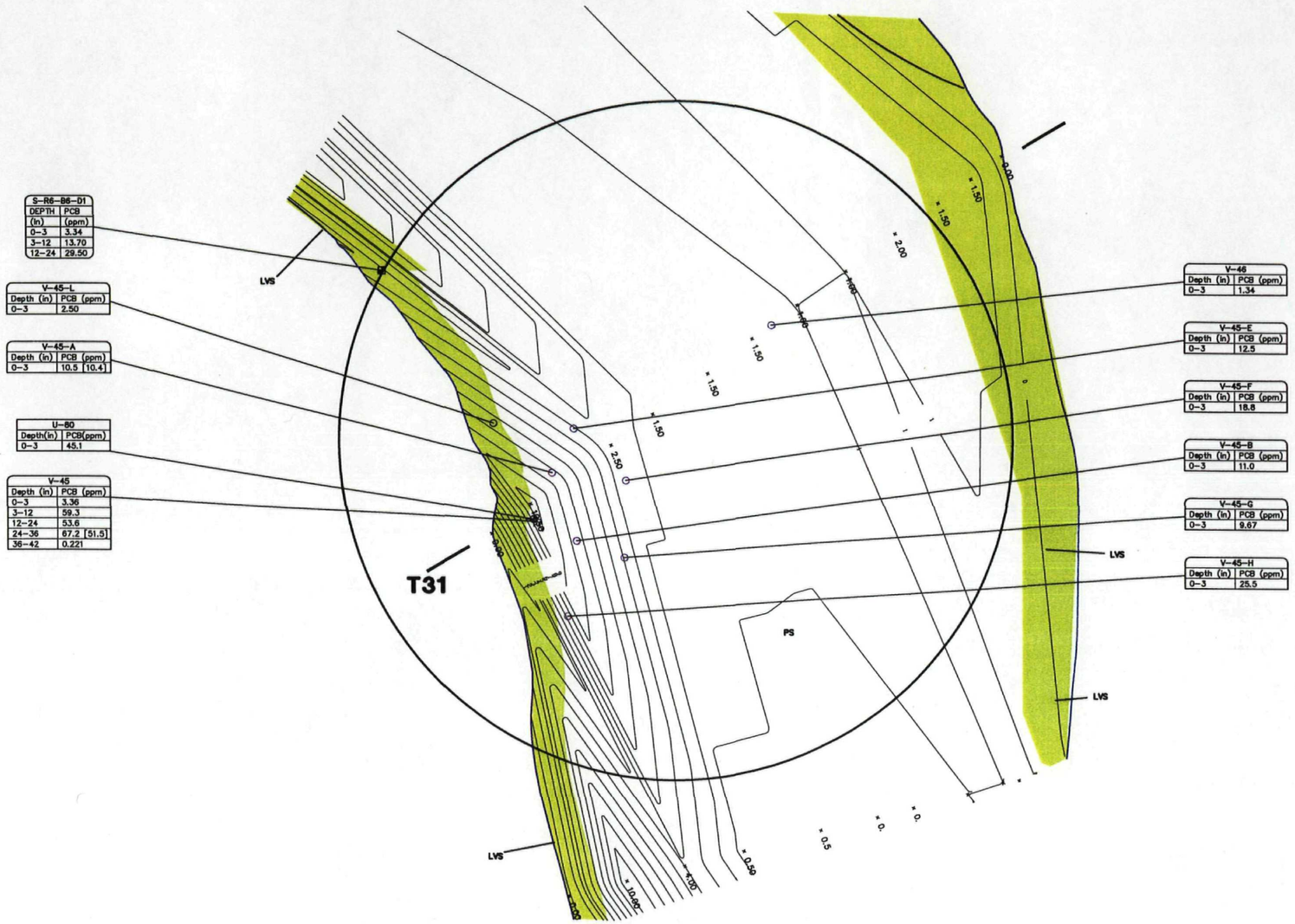
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-7B

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C08.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL

N – NON-VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM

V – VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

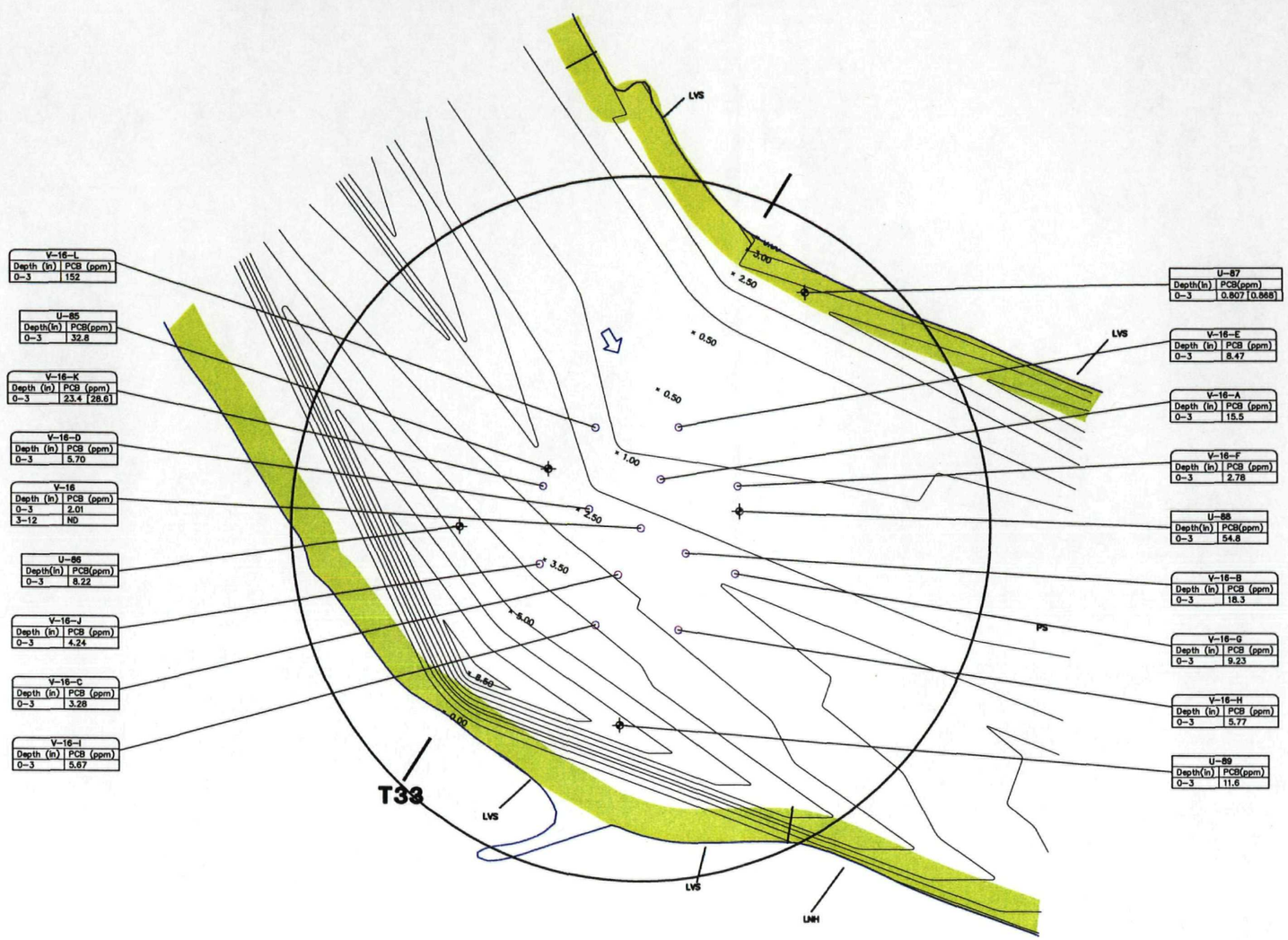
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-7C

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C16.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL

N – NON-VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM

V – VEGETATED
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

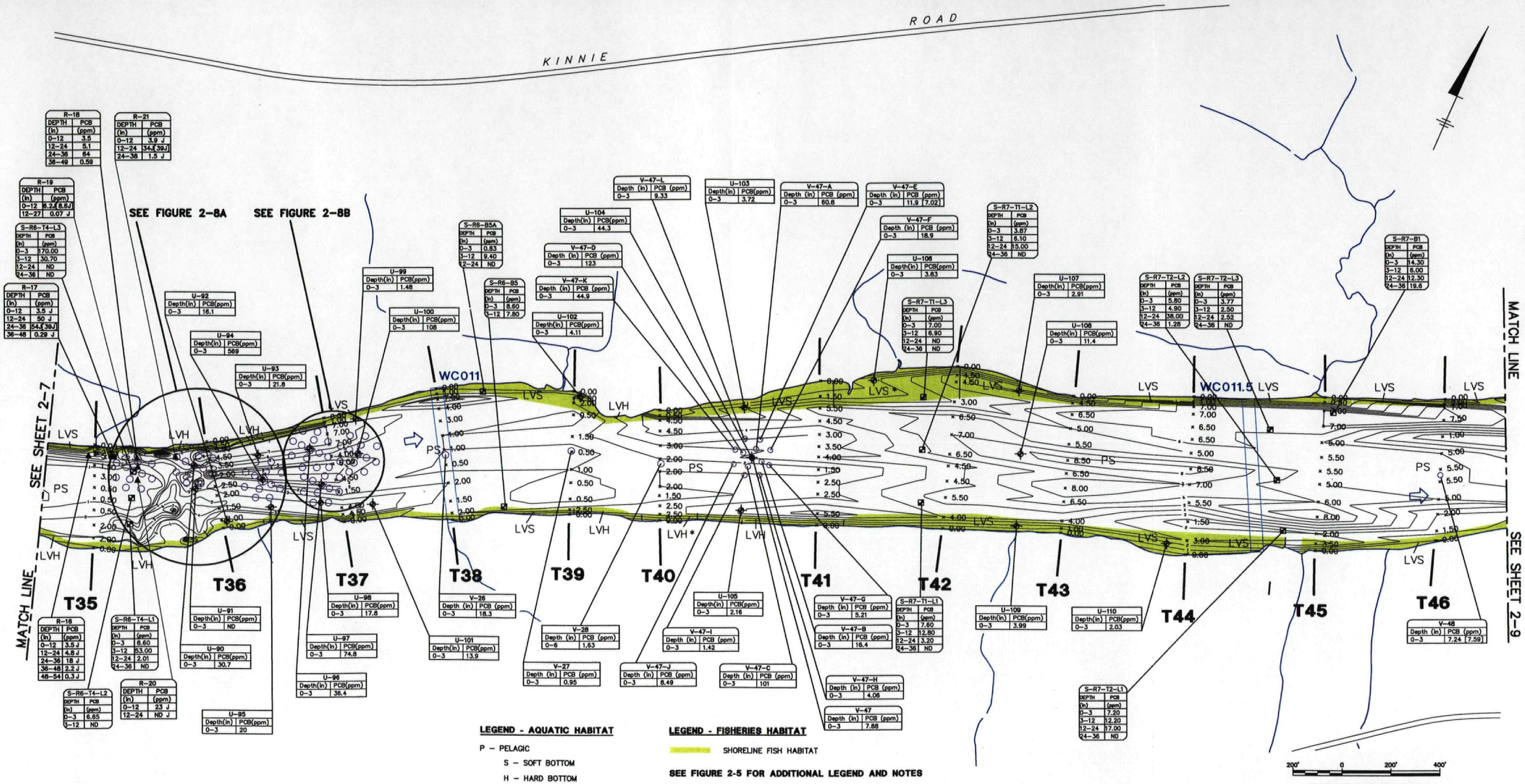
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-7D

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C15.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

X: 10442X00, 10442X02, 10442X03.DWG 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C04.DWG

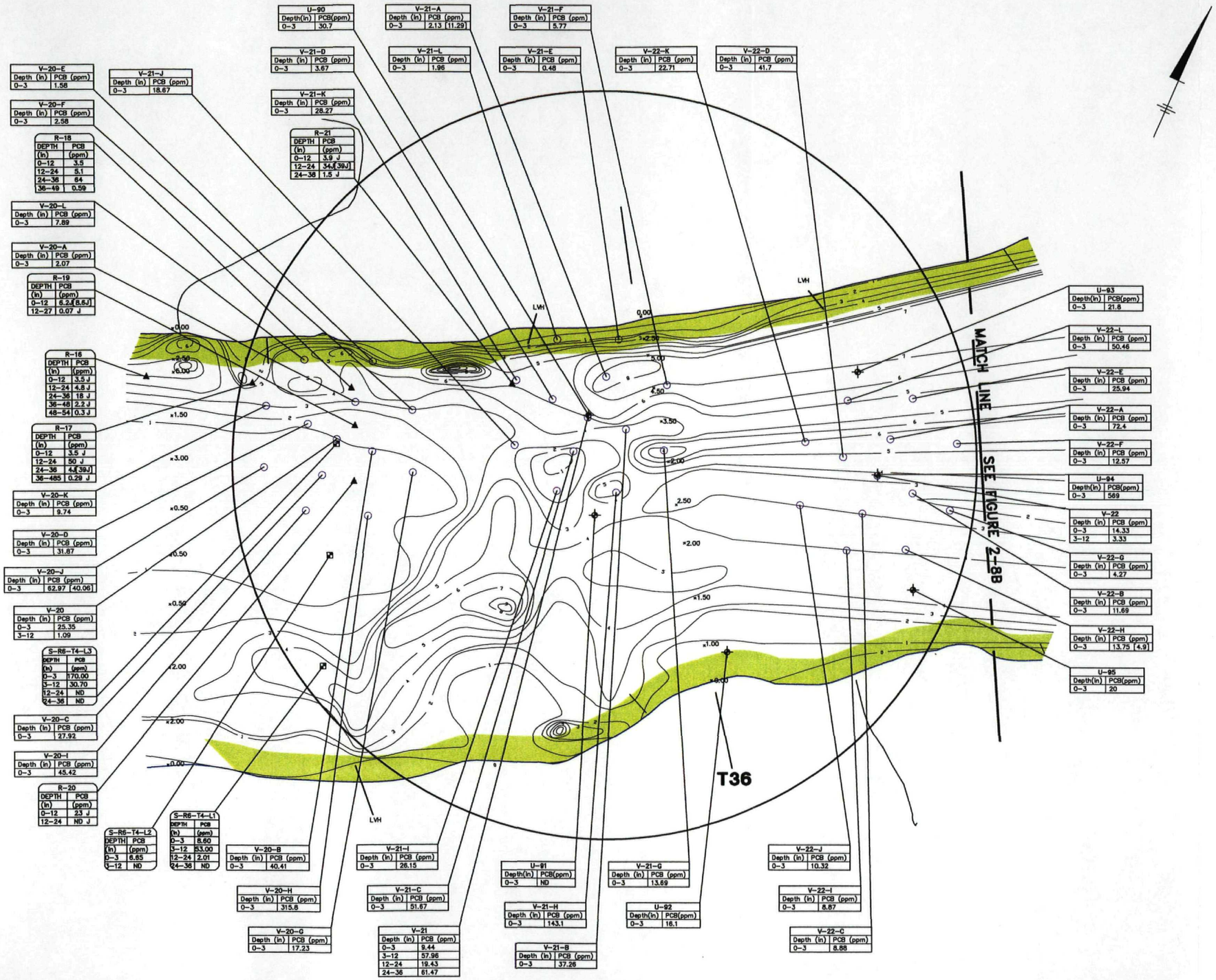
GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE **2-8**



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

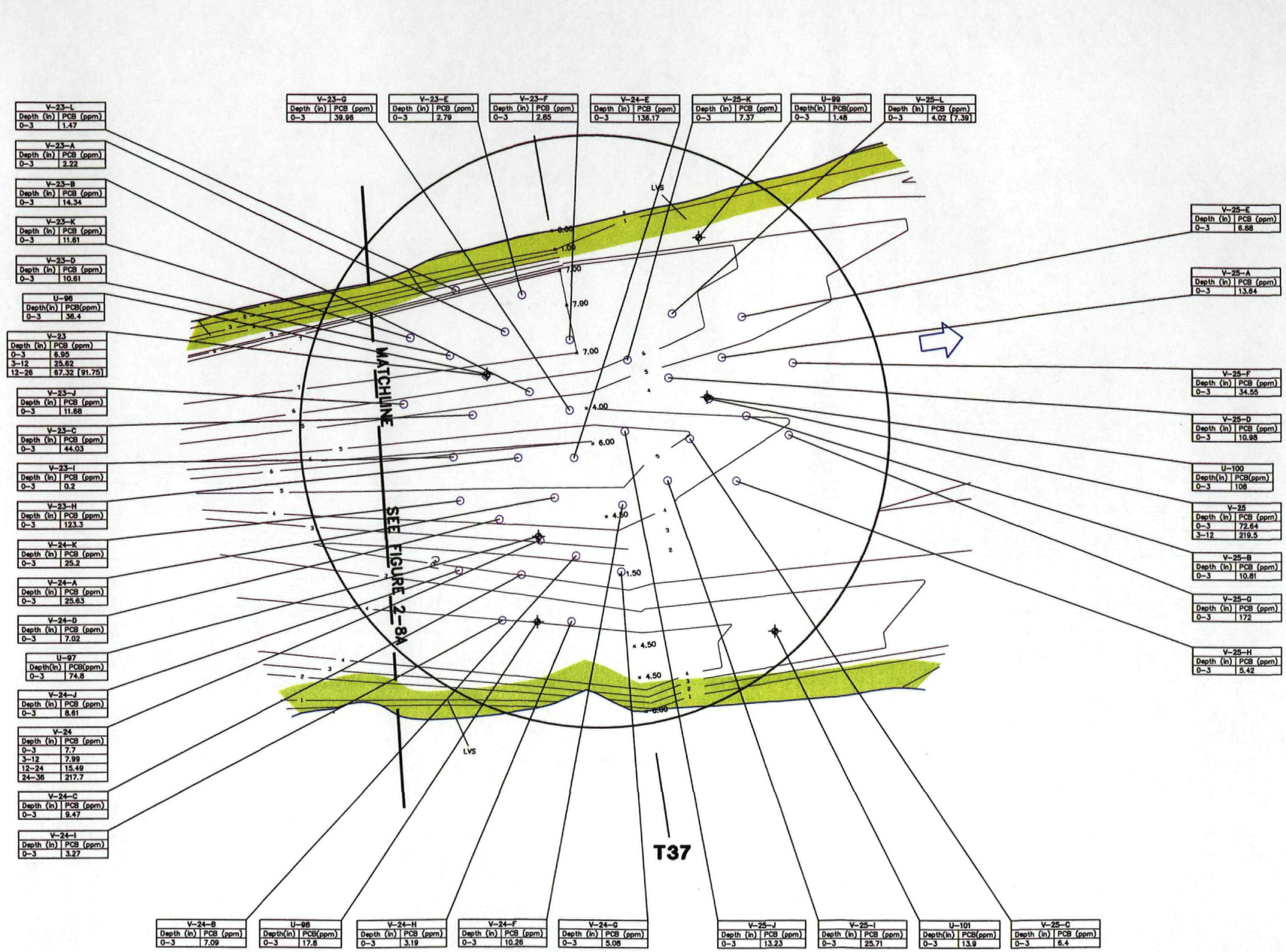
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-8A

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF,
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C09.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

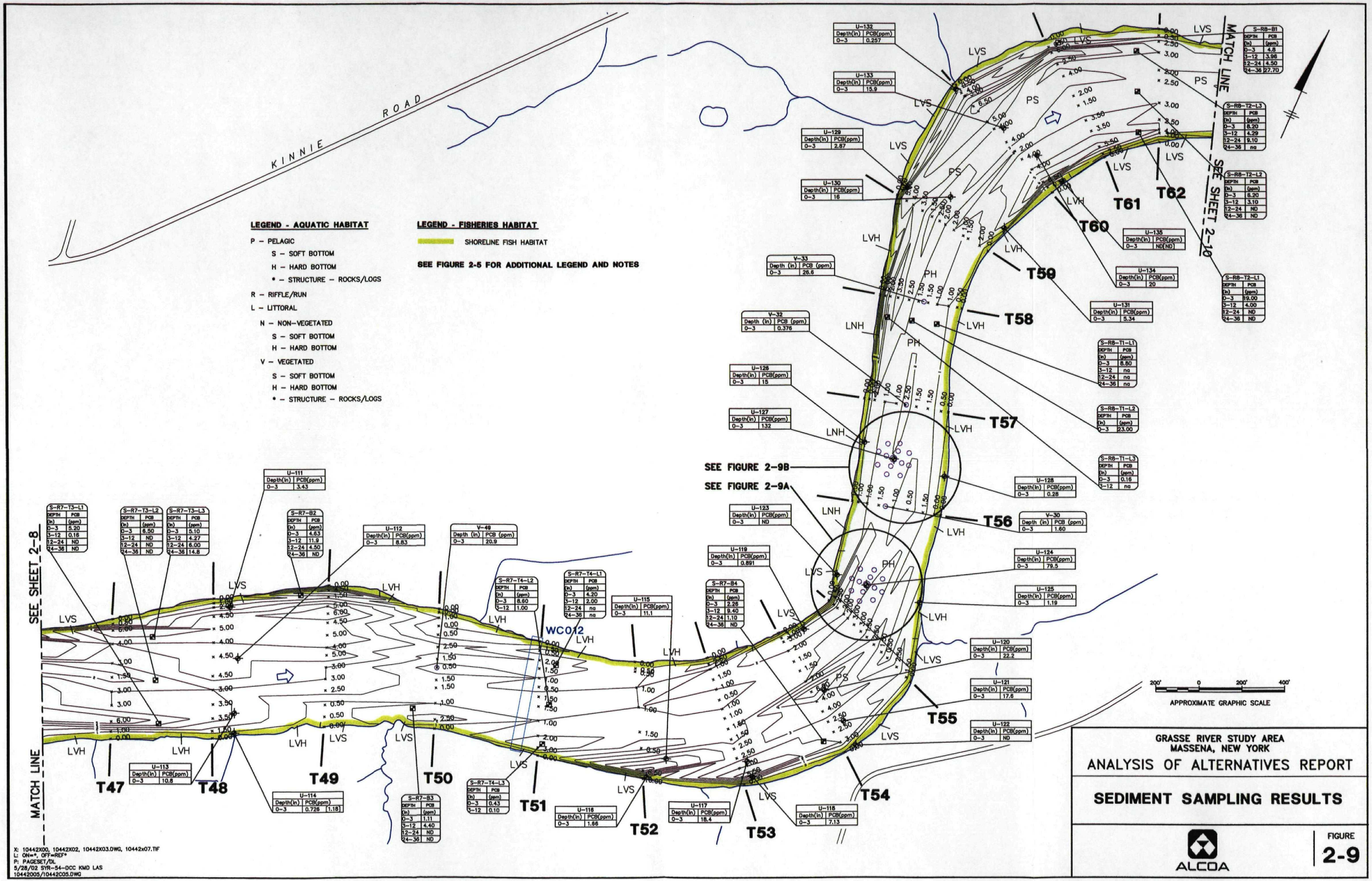
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-8B

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C10.DWG



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

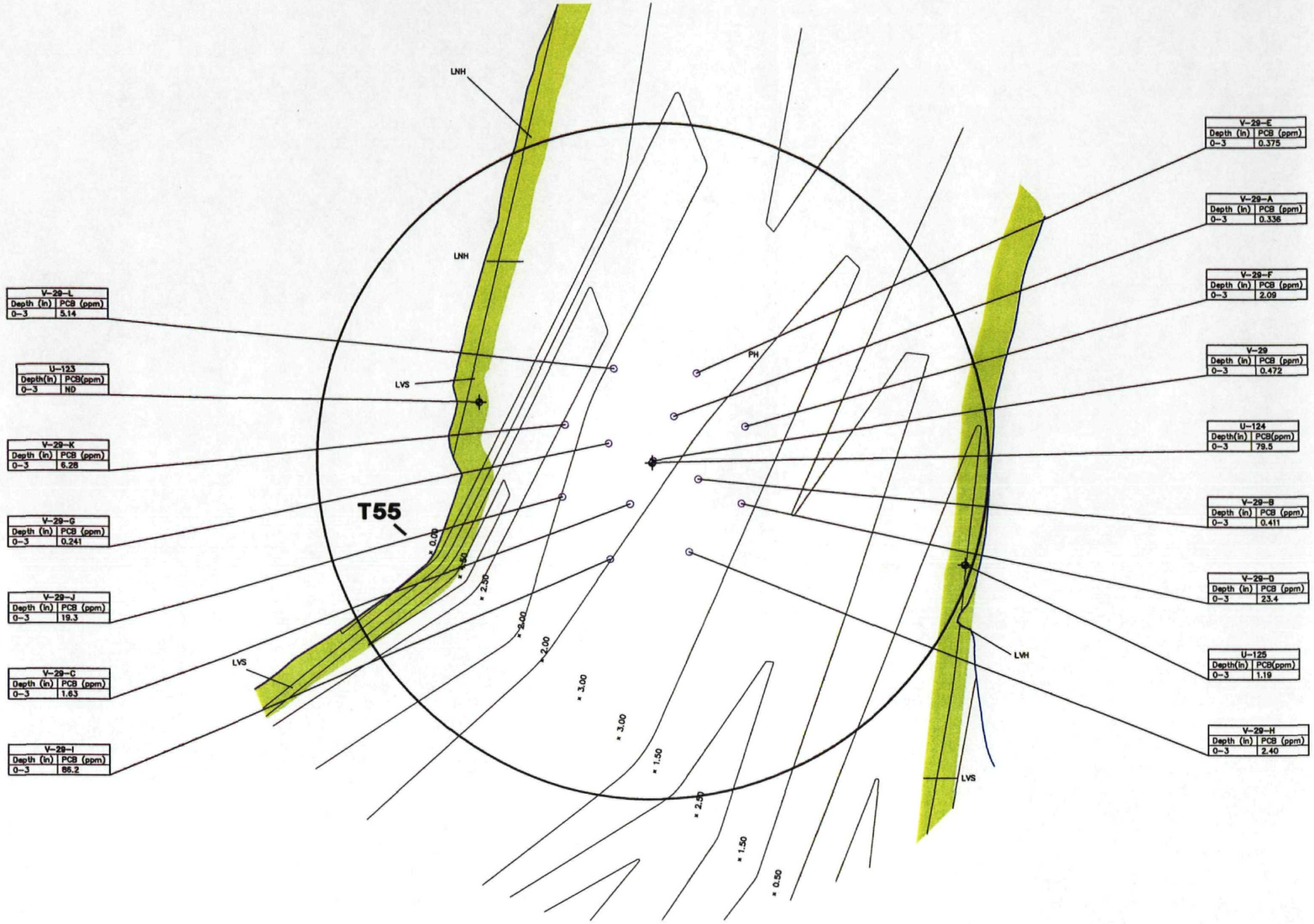
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-9

X: 10442X00, 10442X02, 10442X03.DWG, 10442x07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C05.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

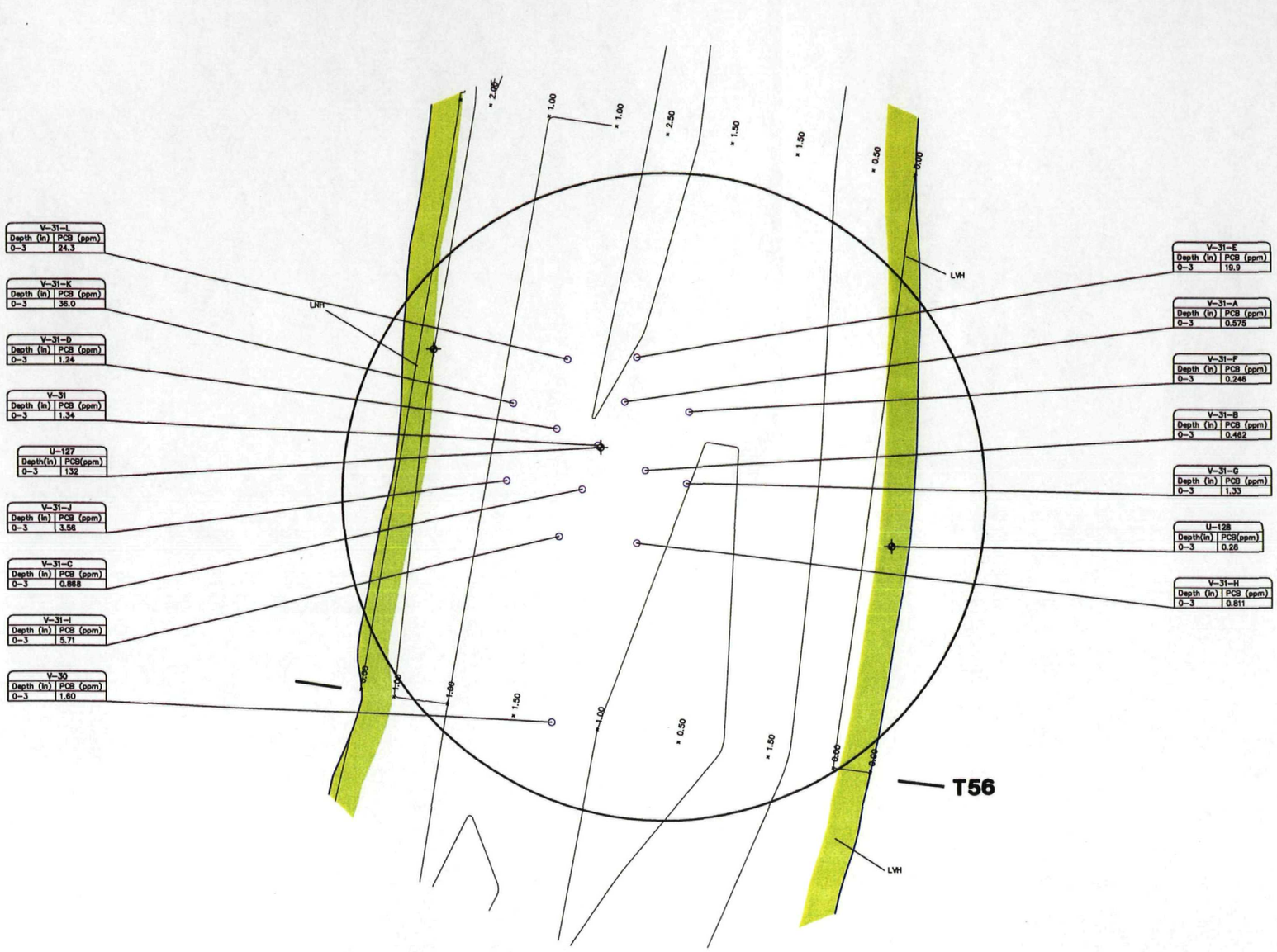
ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE 2-9A

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C14.DWG



LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES

50' 0 50' 100'
APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE
2-9B

X: 10442X00, 10442X04, 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/DL
5/28/02 SYR-S4-DCC KMD LAS
10442005/10442C13.DWG

LEGEND - AQUATIC HABITAT

P – PELAGIC
- S – SOFT BOTTOM
- H – HARD BOTTOM
- * – STRUCTURE – ROCKS/LOGS

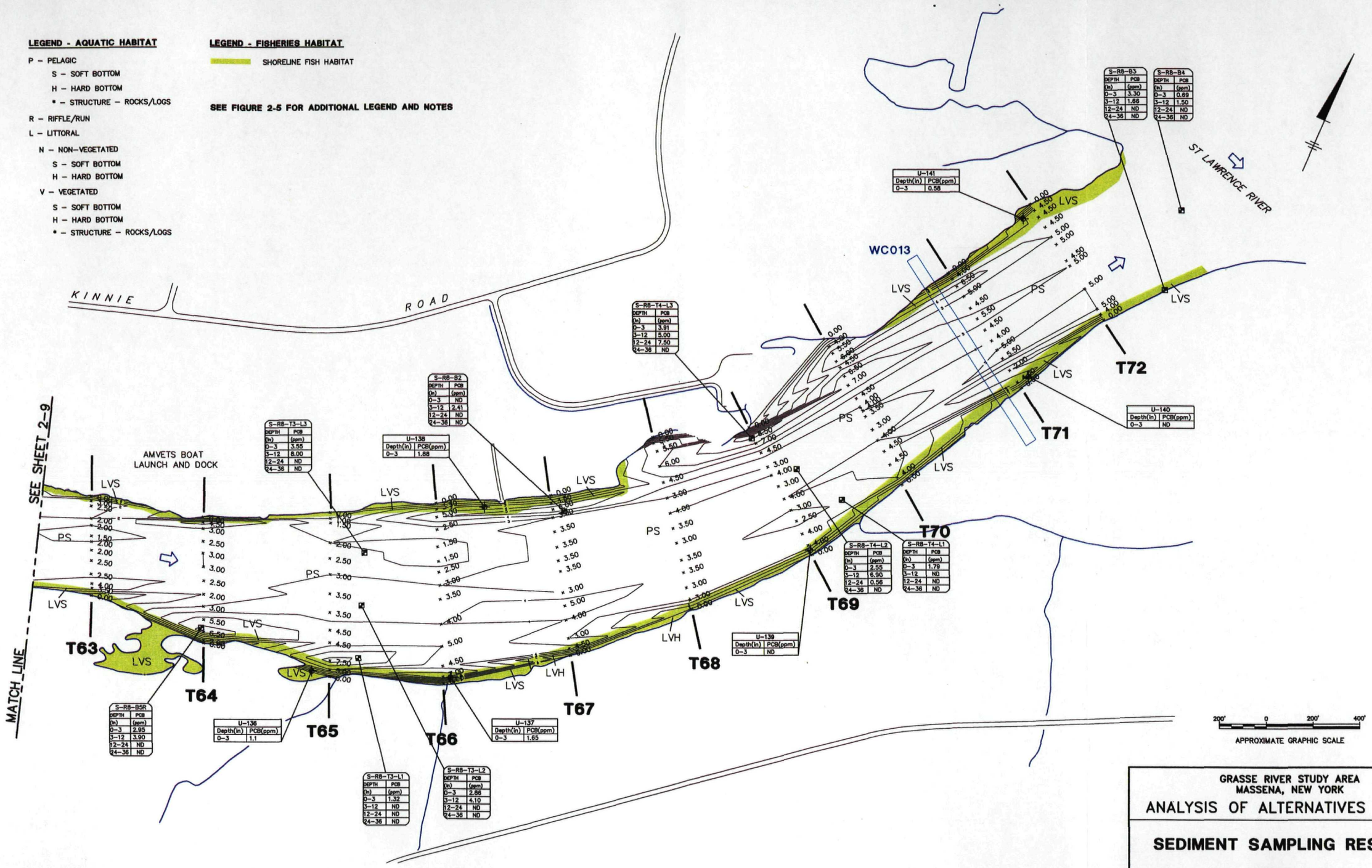
R – RIFFLE/RUN

L – LITTORAL
- N – NON-VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
- V – VEGETATED
  - S – SOFT BOTTOM
  - H – HARD BOTTOM
  - * – STRUCTURE – ROCKS/LOGS

LEGEND - FISHERIES HABITAT

SHORELINE FISH HABITAT

SEE FIGURE 2-5 FOR ADDITIONAL LEGEND AND NOTES



GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

SEDIMENT SAMPLING RESULTS

ALCOA

FIGURE **2-10**

X: 10442X00, 10442X02, 10442X03.DWG, 10442X07.TIF
L: ON=*, OFF=REF
P: PAGESET/DL
5/28/02 SYR-54-DCC KMD LAS
10442005/10442C06.DWG

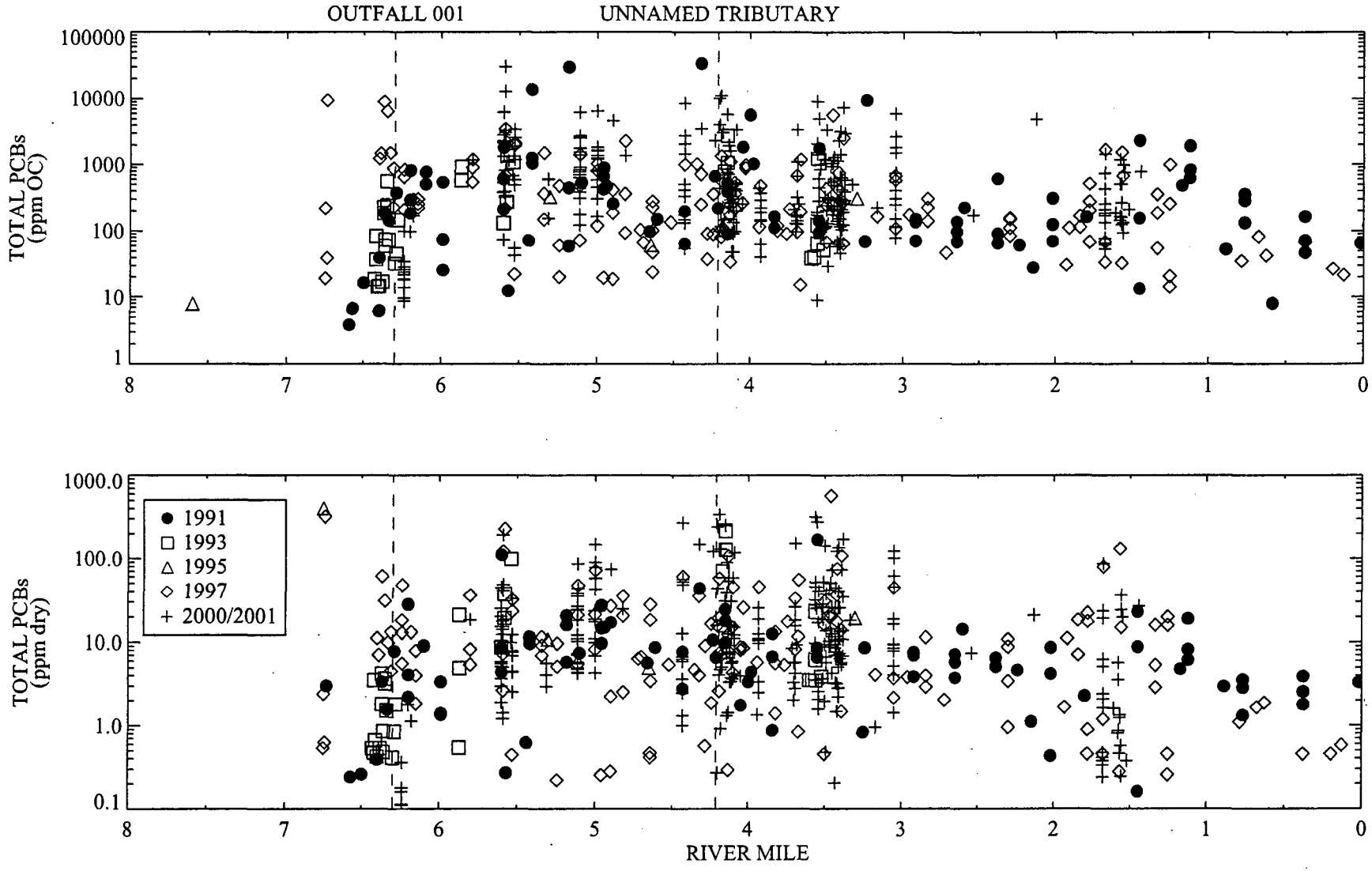


Figure 2-11. Total PCB Concentrations in Surface Sediments of the Lower Grasse River.

Data tables: sediment_aro and sediment_bz

DN - \\Daleel\D_Drive\ALCgra\Analysis\Sediment\sedspat_incl2001.pro
Tue Feb 05 15:18:36 2002

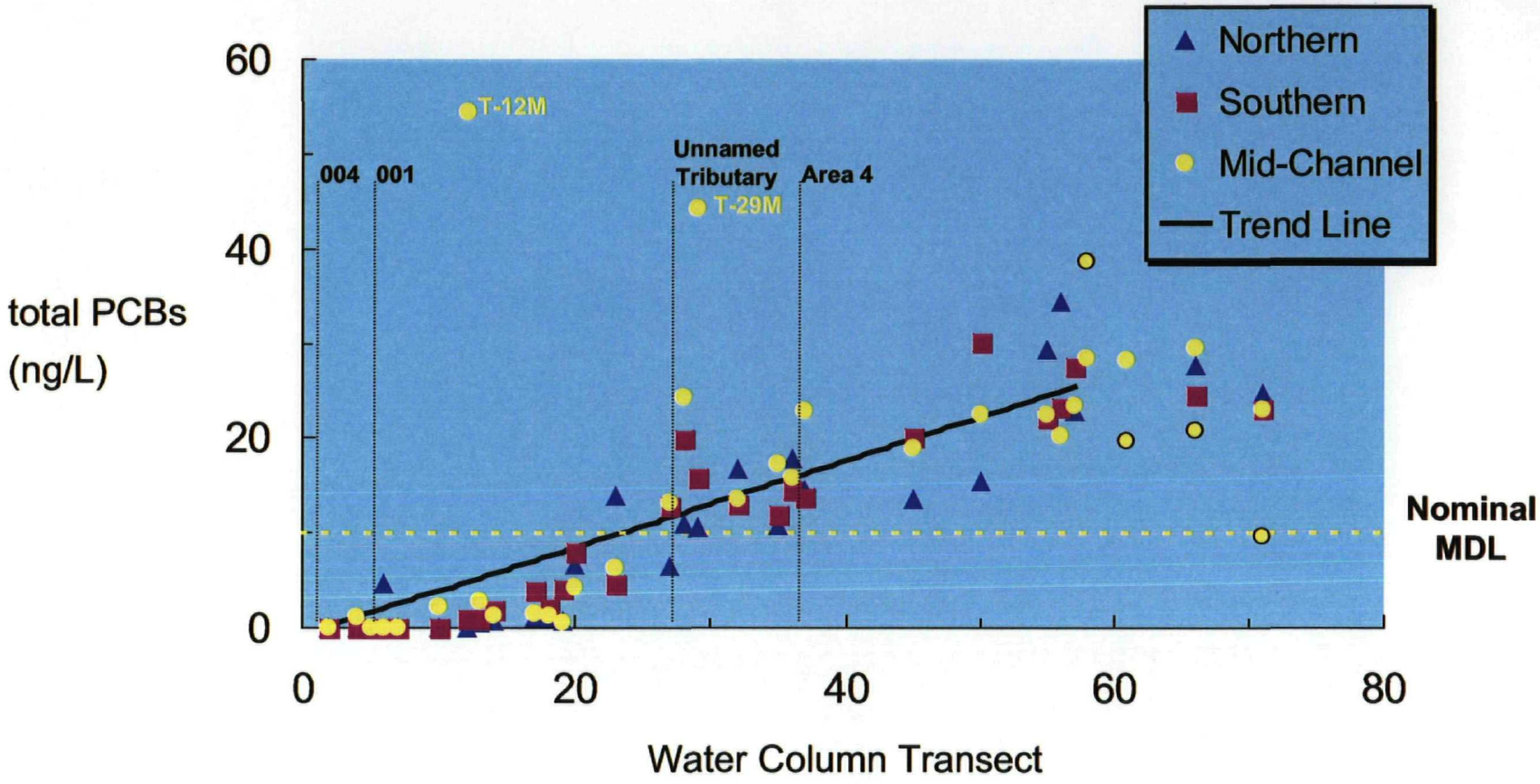


Figure 2-12. Water Column PCBs Measured During 2000 Float Survey.

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

JQ - \\Jimq\D_Drive\ALCgra\Reports\AA_0102\Figures\float_summary_rev.ppt
2/5/02 15:22

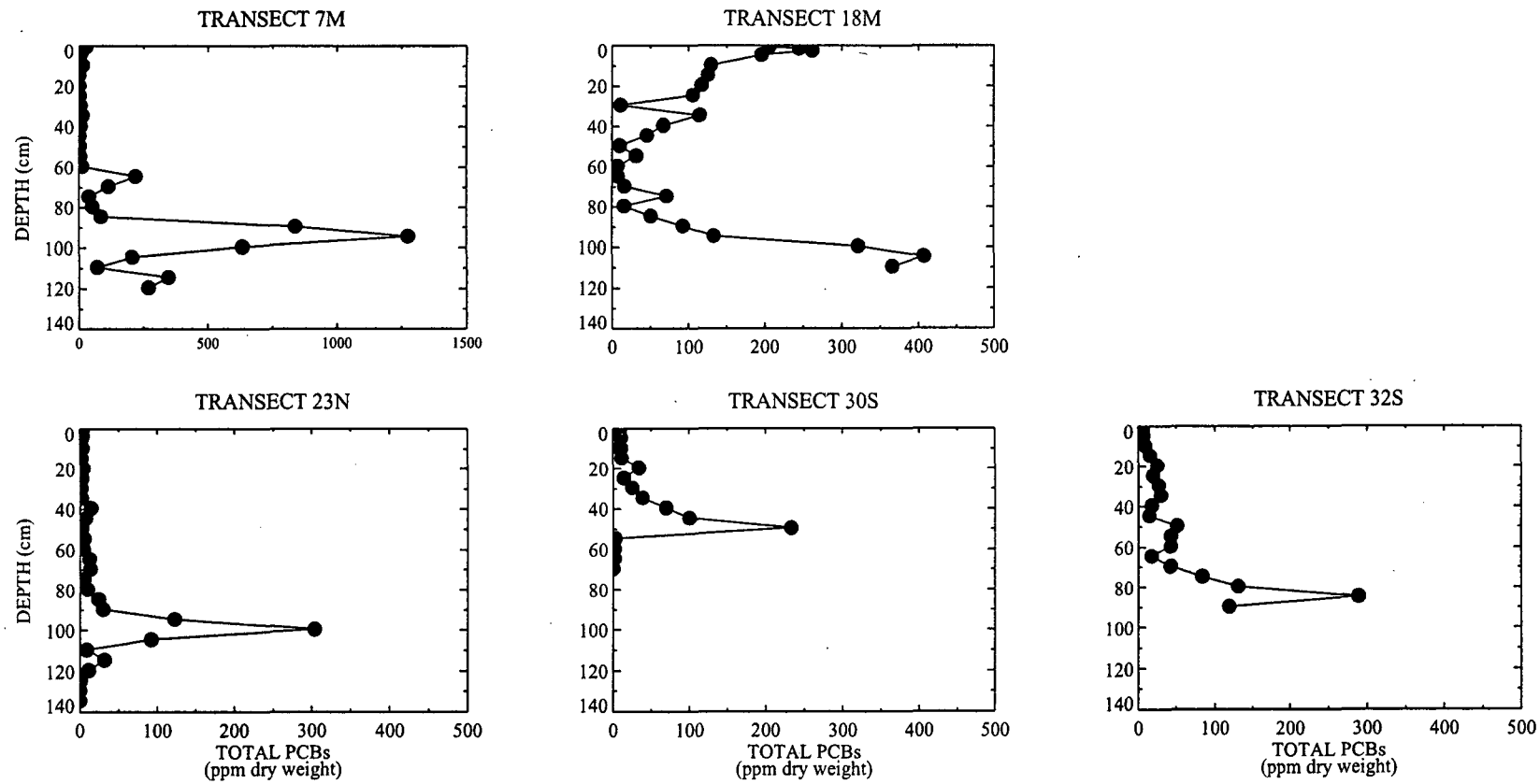


Figure 2-13. Vertical Distribution of Total PCB Levels in Sediment Cores Collected from the Lower Grasse River.

Data from 1997 SRS Sediment Core Sampling Program.

Data table: sediment_bz

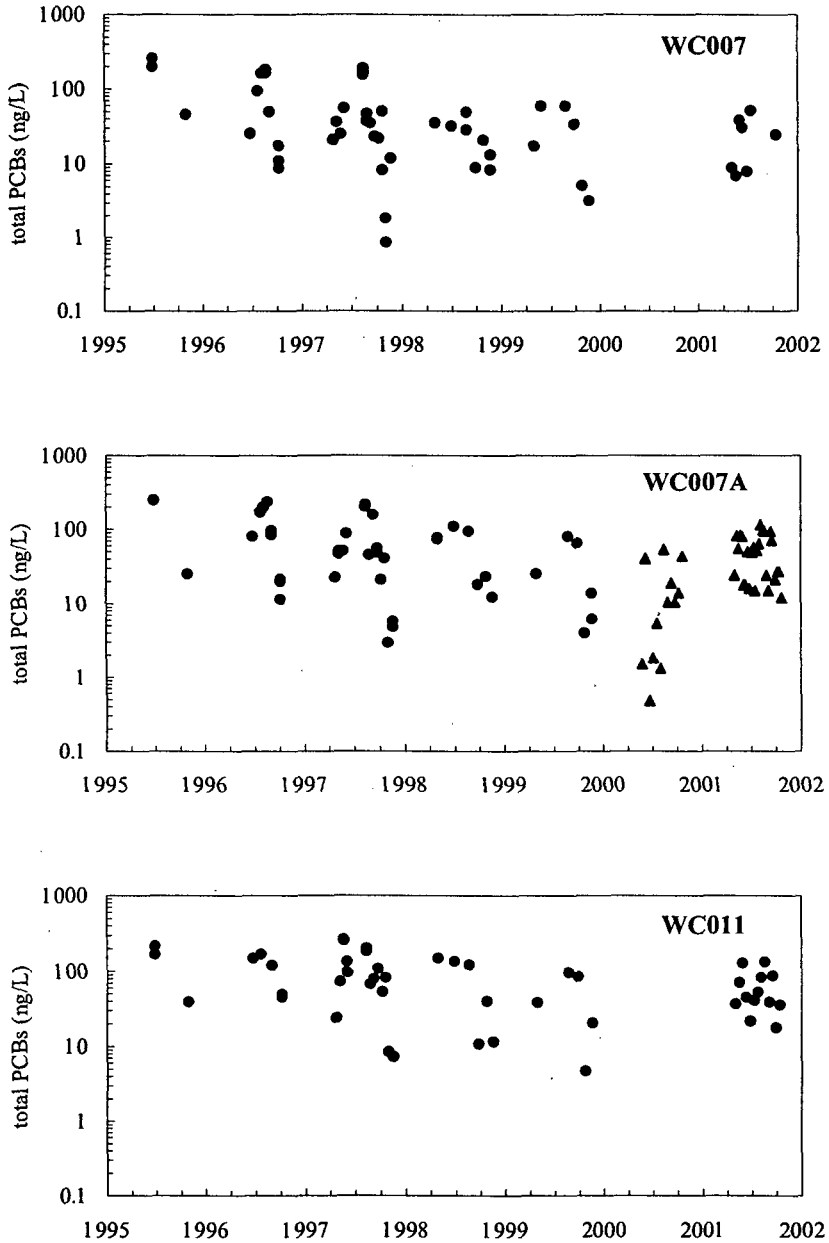
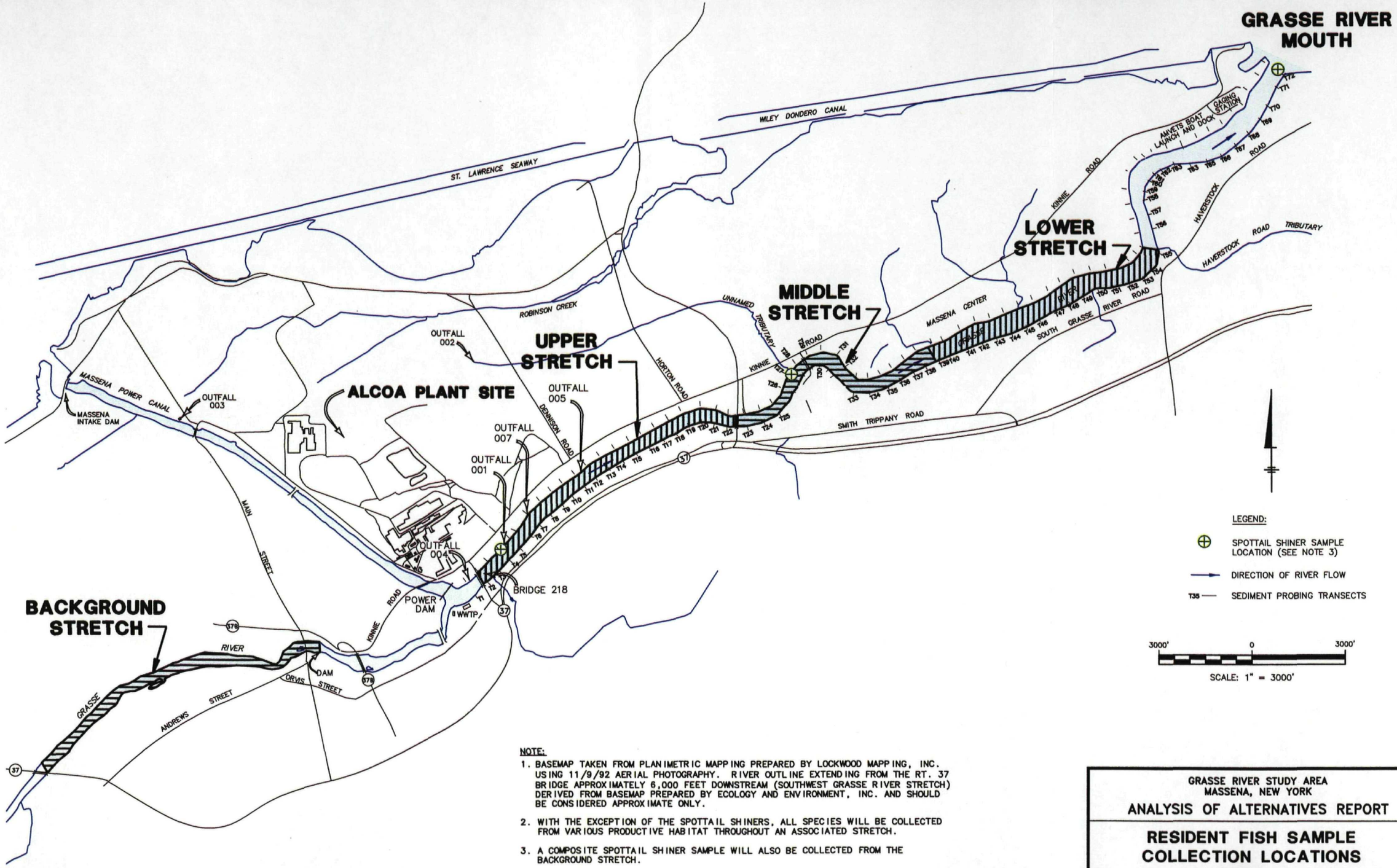


Figure 2-14. Water Column PCB Concentrations Measured in the Lower Grasse River During Non-Stratified Periods.

Triangles represent surface samples collected from Route 131 Bridge in 2000 and 2001.
Data for 2001 represent surface samples collected at 0.2 times the total water depth.
Data excluded due to elevated flows (> 2,000 cfs): 1996 Round 2, 1998 Round 1 and 2001 Round 22.
Data tables: water_bz, water_peak and water_iupac



NOTE:

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 WILL BE COLLECTED FROM VARIOUS PRODUCTIVE HABITAT THROUGHOUT AN ASSOCIATED STRETCH.
3. A COMPOSITE SPOTTAIL SHINER SAMPLE WILL ALSO BE COLLECTED FROM THE BACKGROUND STRETCH.

X: 10442X01
L: ON = *, OFF = REF,RSI*, ITEOP*,*DIM
P: STD/BL
5/28/02 SYR-54-YCC SDL JER
10442005/10442R05.DWG

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

RESIDENT FISH SAMPLE COLLECTION LOCATIONS

ALCOA

FIGURE 2-15

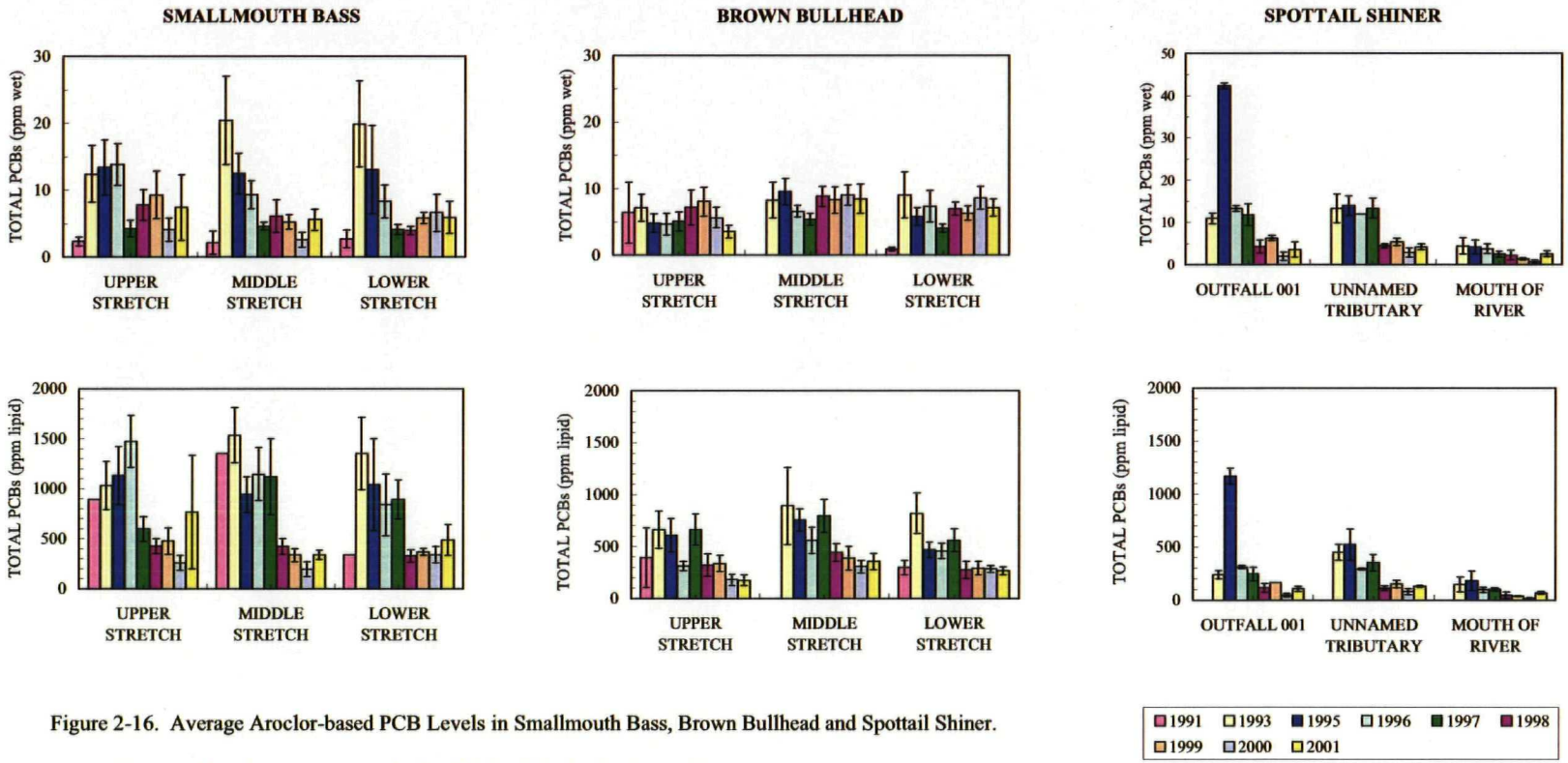


Figure 2-16. Average Aroclor-based PCB Levels in Smallmouth Bass, Brown Bullhead and Spottail Shiner.

Data are arithmetic means computed using fall Trend Monitoring Survey data.
Values are arithmetic means +/- two standard errors of the mean.
Smallmouth bass and brown bullhead values for fillet samples; spottail shiner samples analyzed as whole body composites.

EC - \\Emily\D_DRIVE\ALCgra\Documents\reports\AofA_202\main_report\figures\resfish_barplot_temporal_FIG2_9.xls AroStats
2/11/02 6:01 PM

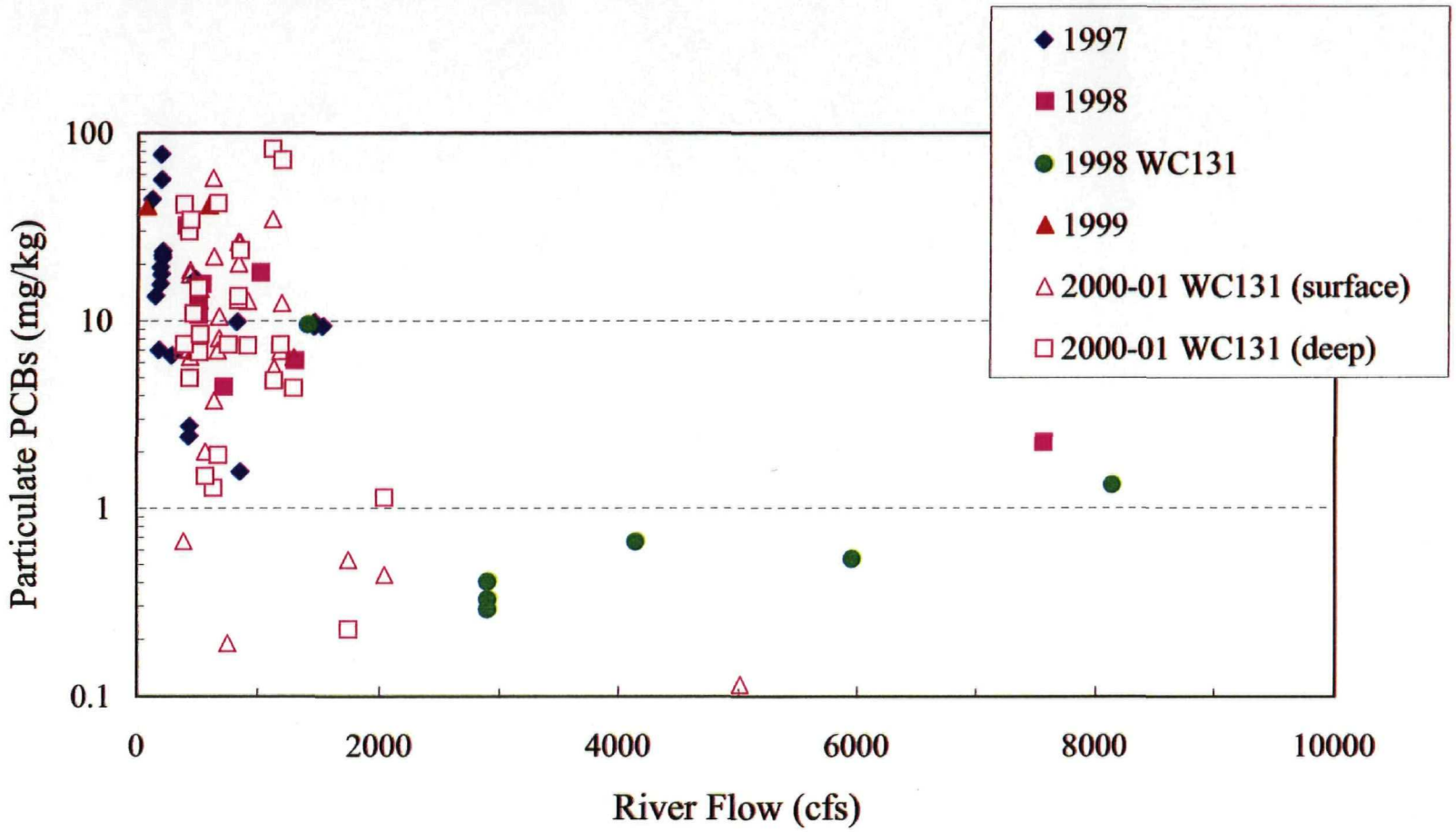


Figure 2-17. Comparison of Computed Particulate PCB Concentrations in Unfiltered Water Column Samples from Several SRS Surveys.

Water samples collected from WC007A and Route 131 Bridge.

Data collected during 2001 Capping Pilot Study (7/23-10/9) not included.

Data tables: water_bz and water_iupac

JimQ - D:\ALCgra\Reports\AA_0102\Figures\wc_flow.xls Cp_Flow
2/11/02 6:07 PM

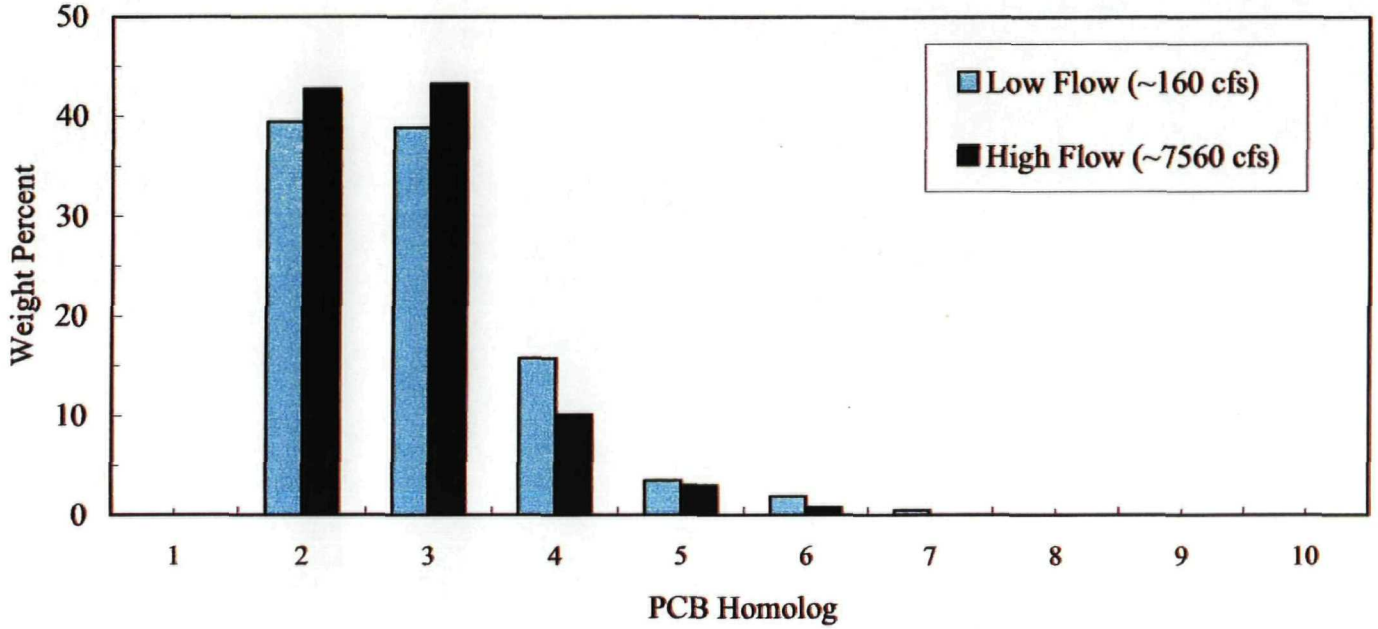


Figure 2-18. Comparison of PCB Homolog Distributions in Unfiltered Water Samples Collected During Low and High Flow Conditions.

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

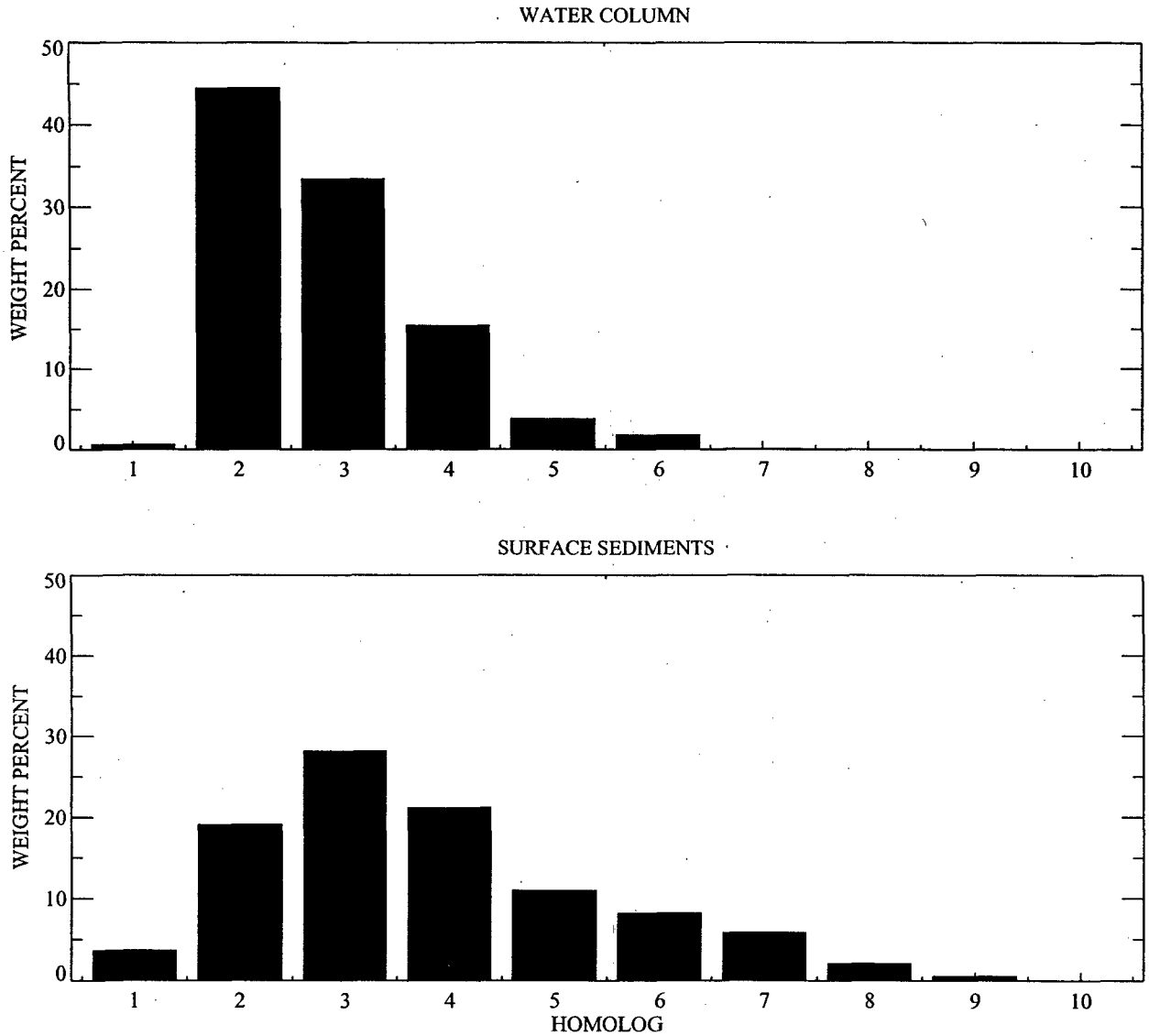


Figure 2-19. Average PCB Homolog Distributions in Water Column and Surface Sediment Samples Collected from the Lower Grasse River.

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

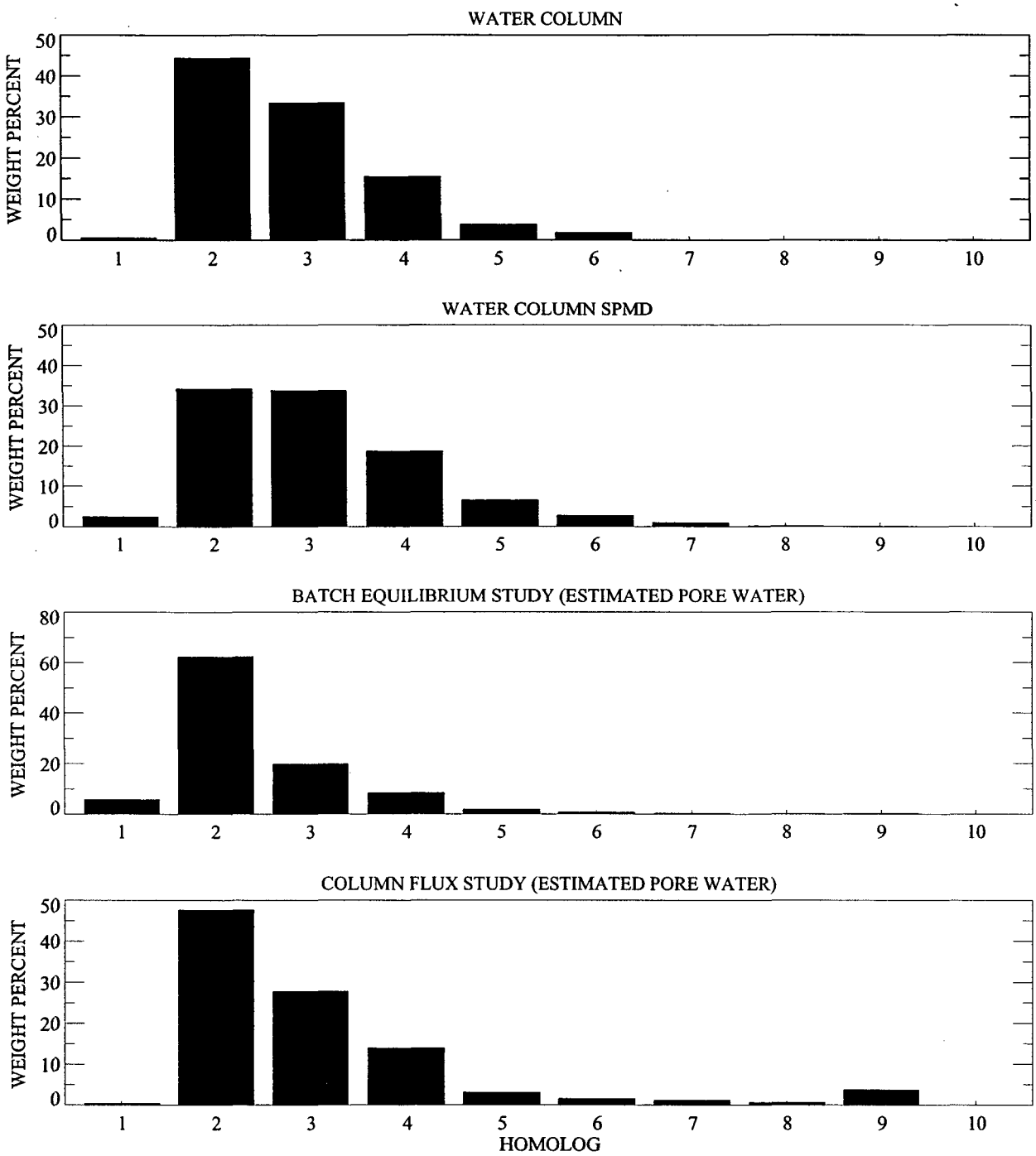


Figure 2-20. PCB Homolog Distributions in Grasse River Water and SPMD Samples and Water Samples from CMU Lab Studies.

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

JimQ - C:\D_Drive\ALCgra\Reports\AA_0102\Figures\wc_cmu_hom.pro
Wed May 22 16:01:45 2002

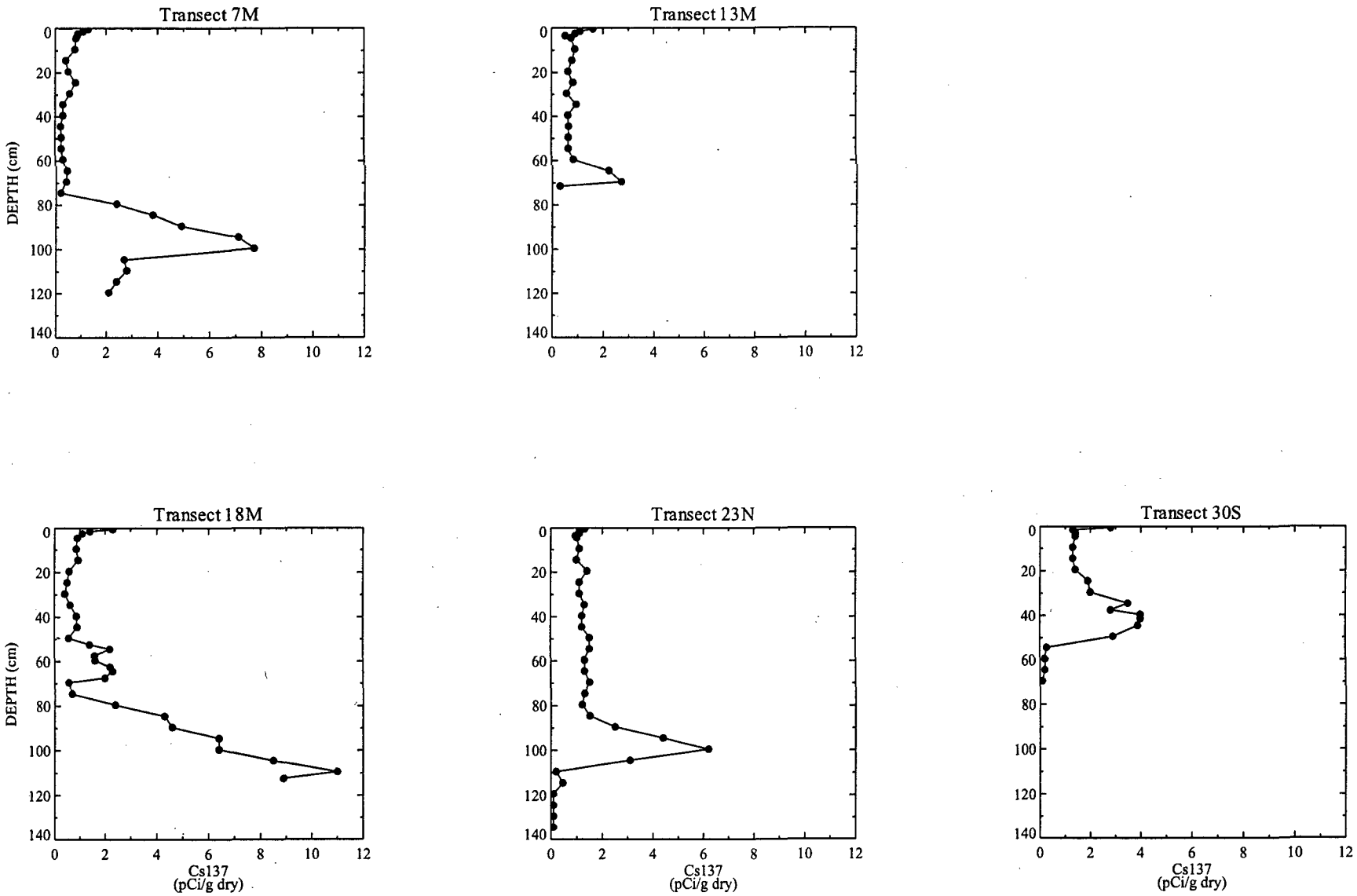


Figure 2-21 a. Vertical Distribution of Cesium Levels in Sediment Cores Collected from the Lower Grasse River.

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

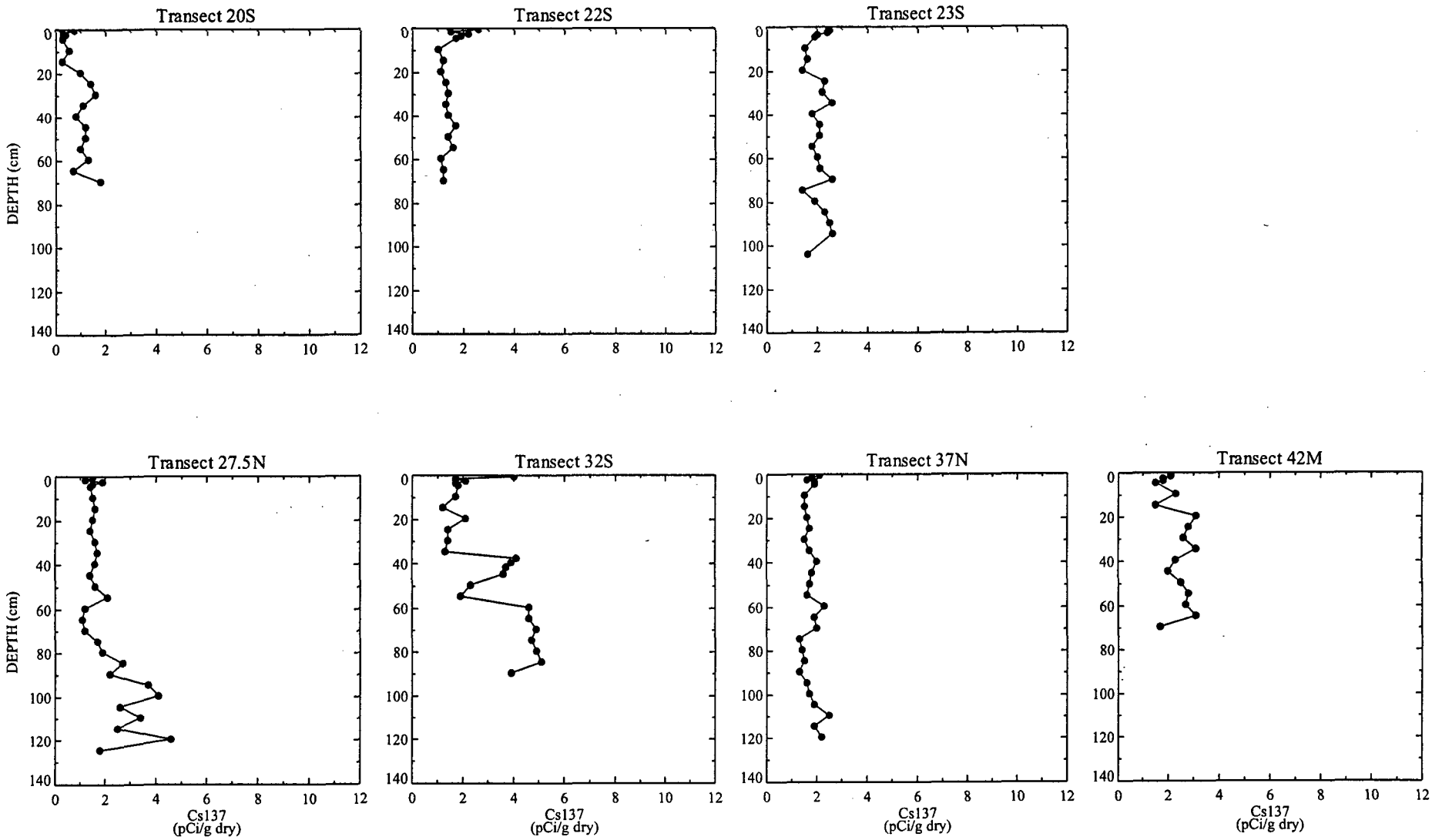


Figure 2-21 b. Vertical Distribution of Cesium Levels in Sediment Cores Collected from the Lower Grasse River.

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 13:31:17 2002

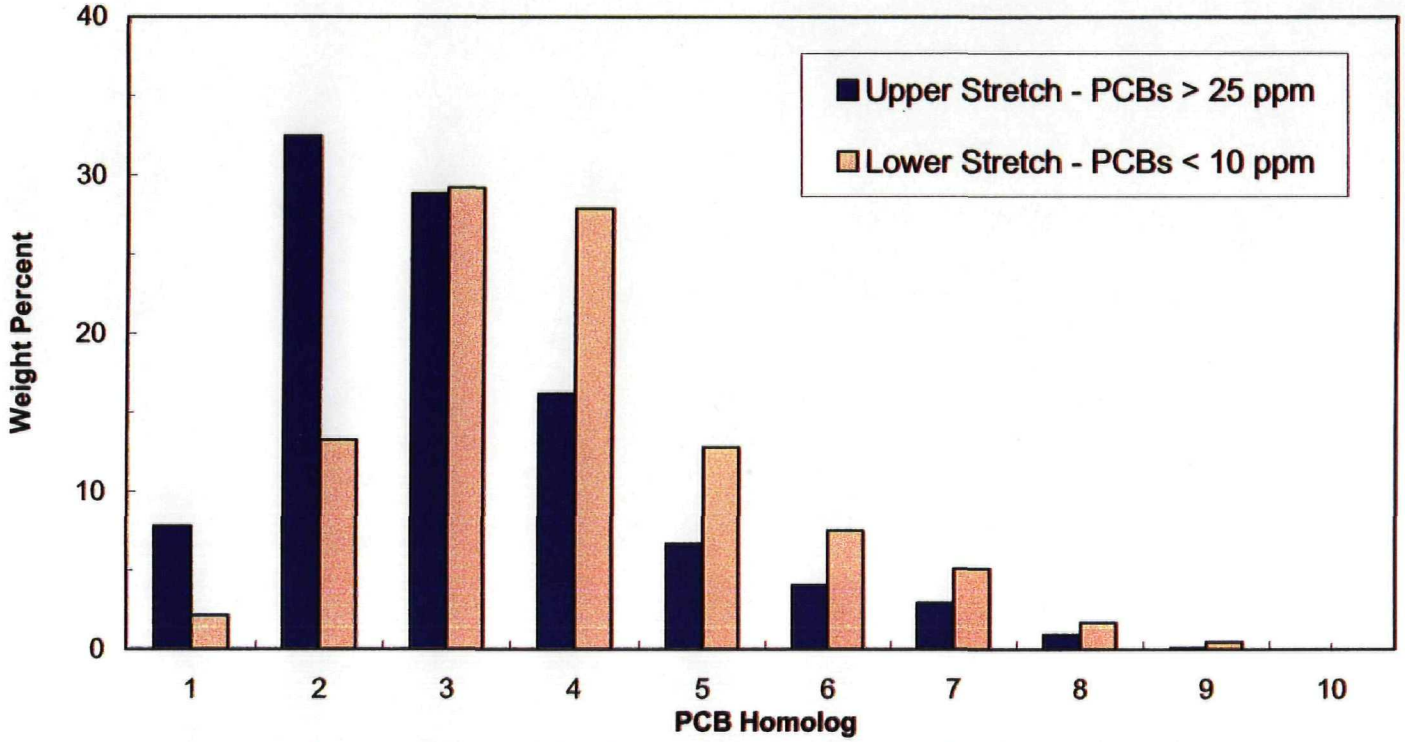
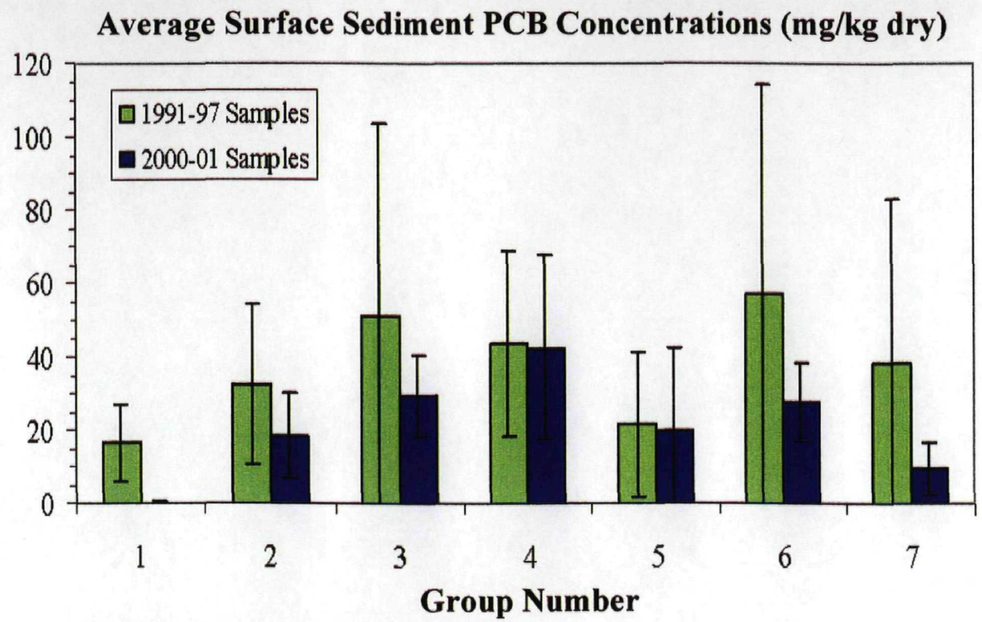
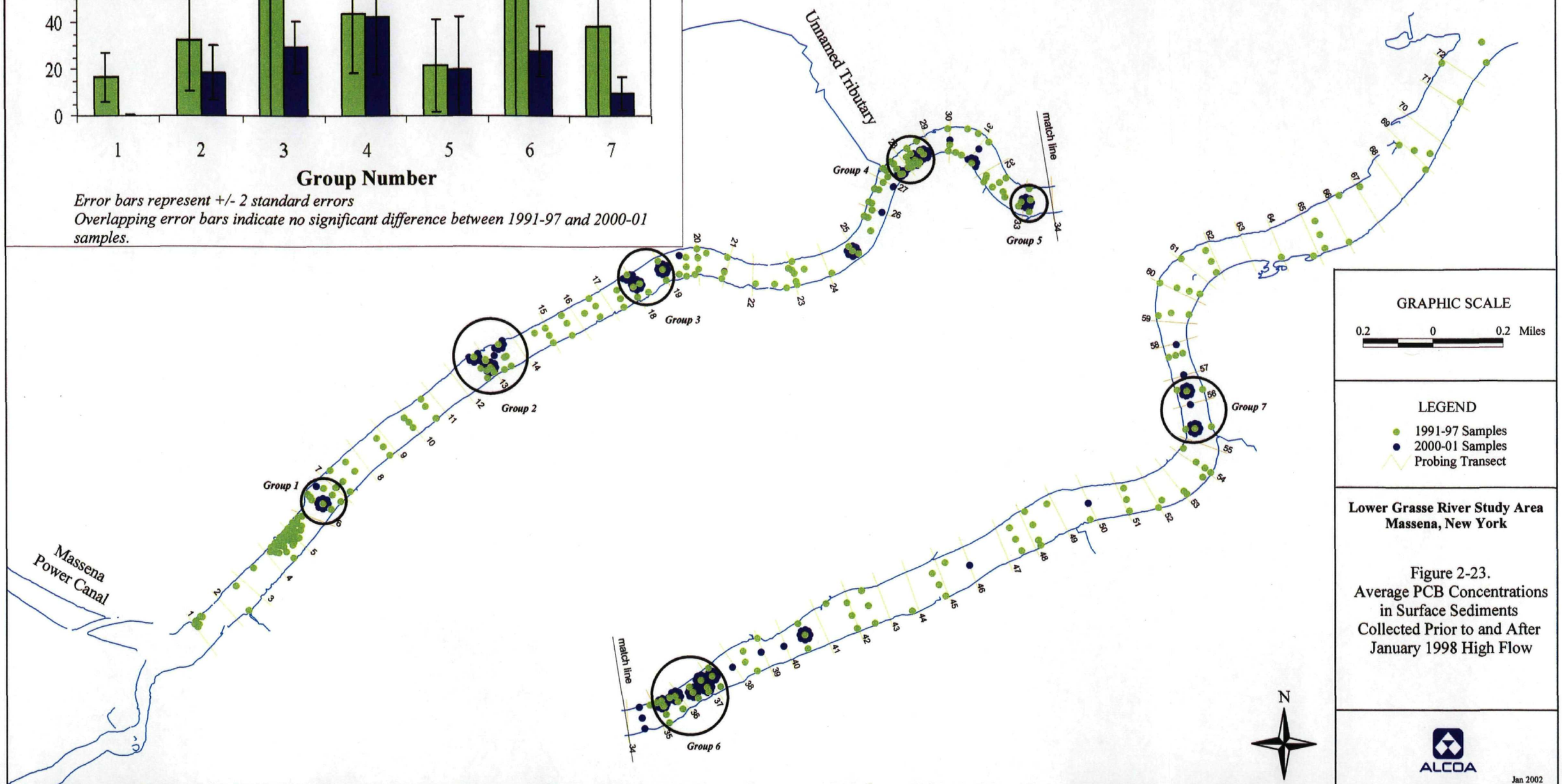


Figure 2-22. Comparison of PCB Composition of Surface Sediments from Upper and Lower Stretches of the Grasse River.

Data from samples collected in 1997, 2000 and 2001.
Upper Stretch values represent samples with PCBs > 25 ppm collected between River miles 6.3 and 3.3.
Lower Stretch values represent samples with PCBs < 10 ppm collected between River mile 3.3 and mouth.
Samples collected near Outfalls 001 and 004 not included in analysis.



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



Lower Grasse River Study Area
Massena, New York

Figure 2-23.
Average PCB Concentrations in Surface Sediments Collected Prior to and After January 1998 High Flow

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

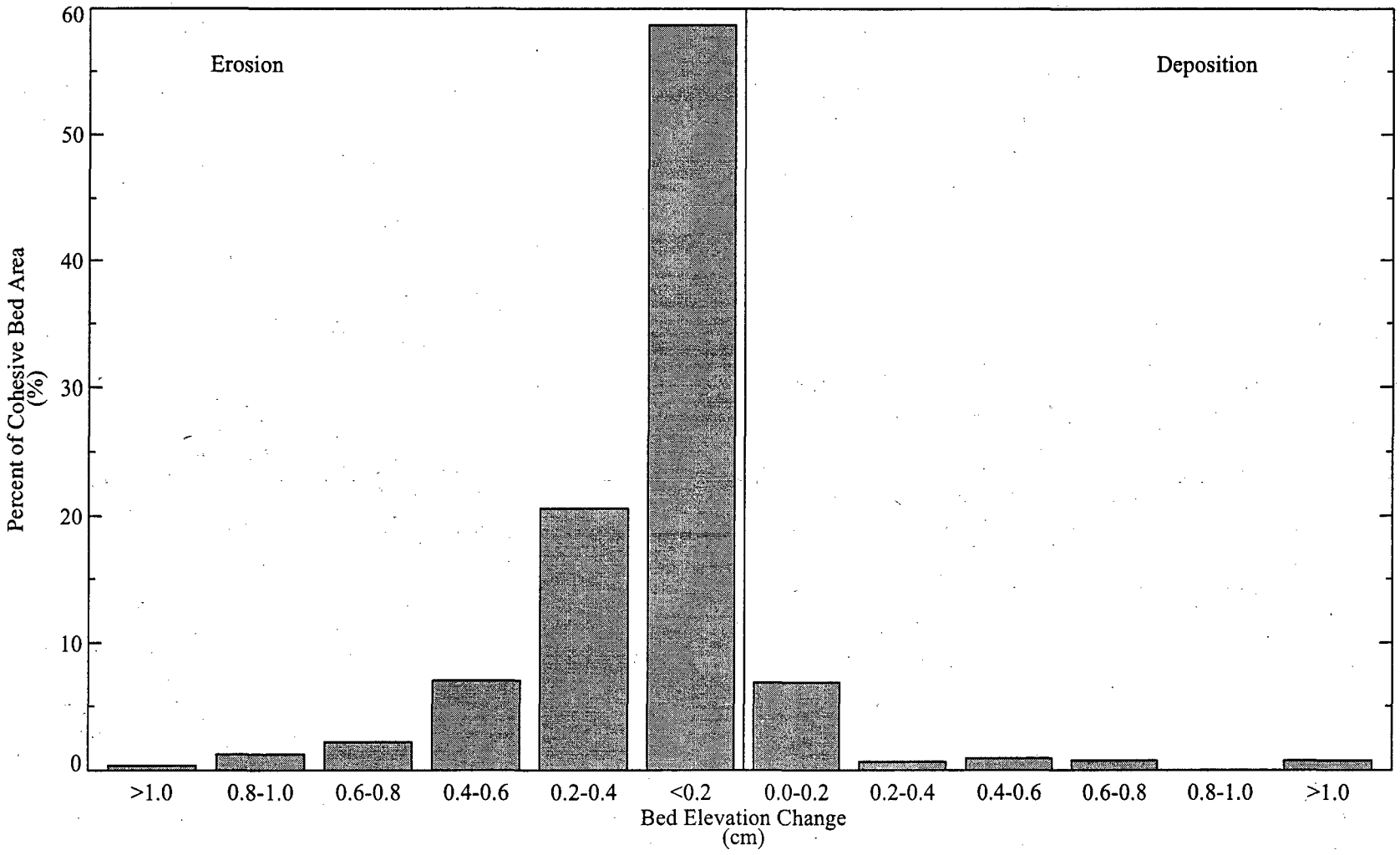
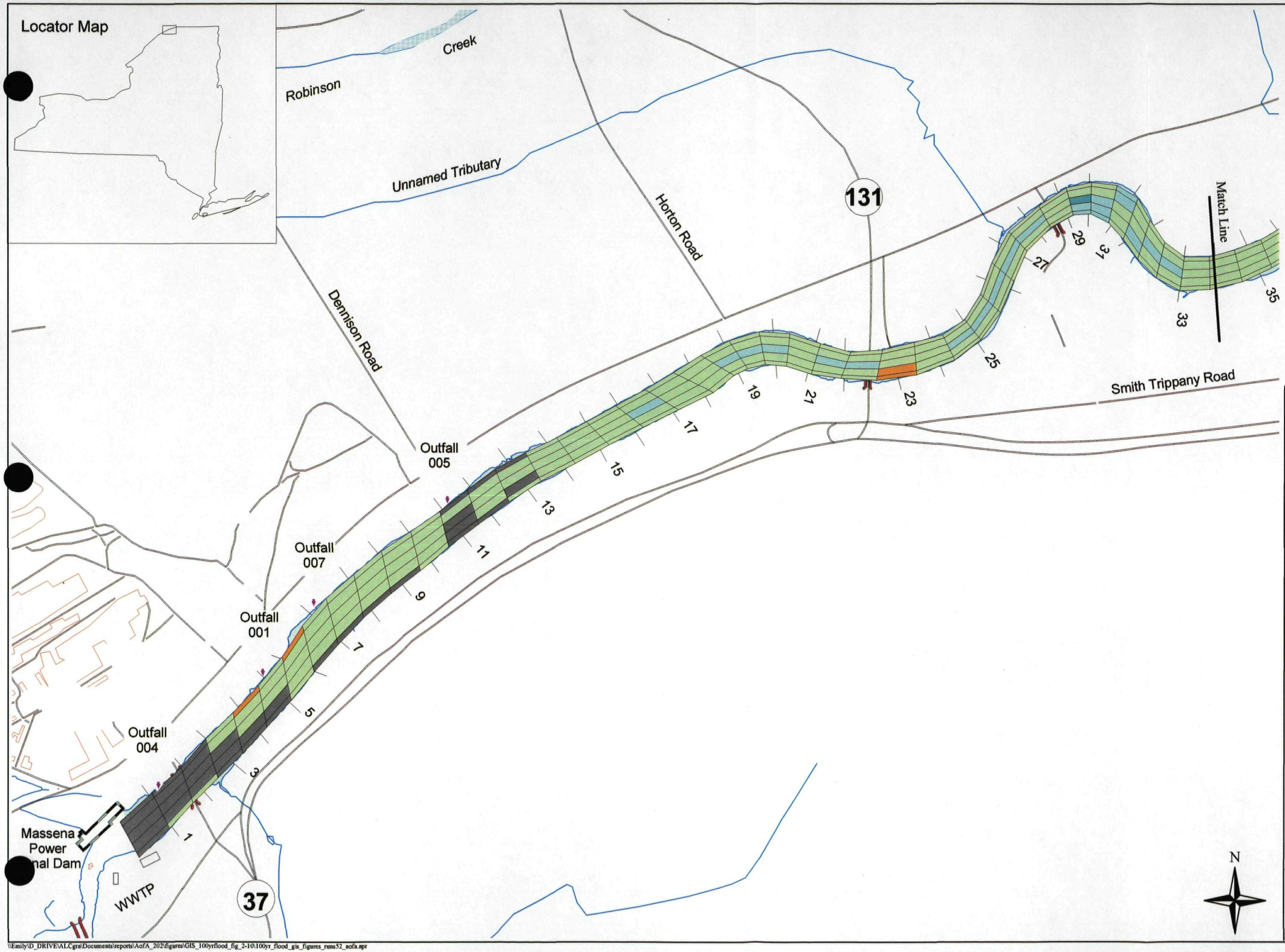


Figure 2-24. Predicted Distribution of Cohesive Bed Elevation Changes in the Lower Grasse River at the end of the 100-yr Flood.
Modeled period: Jan 6-16, 1998. Net bed elevation change predicted by the sediment transport model.

DN - D:\ALCgra\Analysis\Sediment\Flood_Elev_100yf\flood_elev_100yr.pro
Wed Jun 05 10:24:13 2002



GRAPHIC SCALE

400 0 400 Feet

LEGEND

- Hard-bottom Areas
- 100 Year Flood Erosion Depths (cm)
- Deposition
- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 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
- River.shp

Lower Grasse River Study Area
Massena, New York

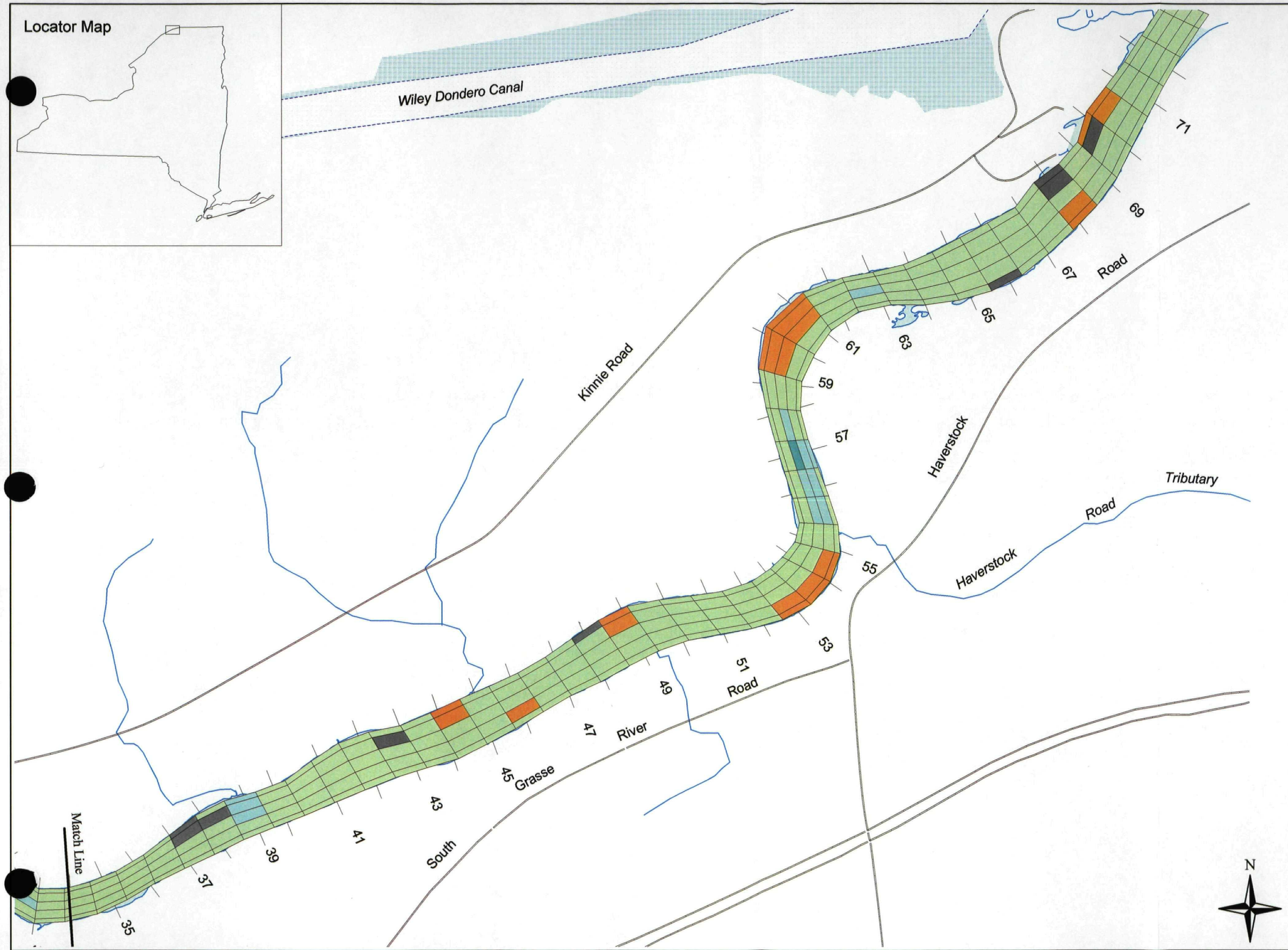
Figure 2-25A.
Spatial Distribution of
Net Erosion in the Lower
Grasse River During a
100-Year Flood Event
(Bounding Estimates)

1 of 2

ALCOA

Mar 2001

\\Emily\D_DRIVE\ALCgra\Documents\reports\AofA_202\figures\GIS_100yrflood_fig_2-10\100yr_flood_gis_figures_runs52_aofa.apr



GRAPHIC SCALE

400 0 400 Feet

LEGEND

- Hard-bottom Areas
- 100 Year Flood Erosion Depths (cm)
  - Deposition
  - 0 - 0.5
  - 0.5 - 1
  - 1.0 - 1.5
- 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
- River.shp

Lower Grasse River Study Area
Massena, New York

Figure 2-25B.
Spatial Distribution of
Net Erosion in the Lower
Grasse River During a
100-Year Flood Event
(Bounding Estimates)

2 of 2

ALCOA

Mar 2001

\\Emily\D_DRIVE\ALCgra\Documents\reports\AofA_202\figures\GIS_100yrflood_fig_2-10\100yr_flood_gis_figures_runs52_aofa.apr

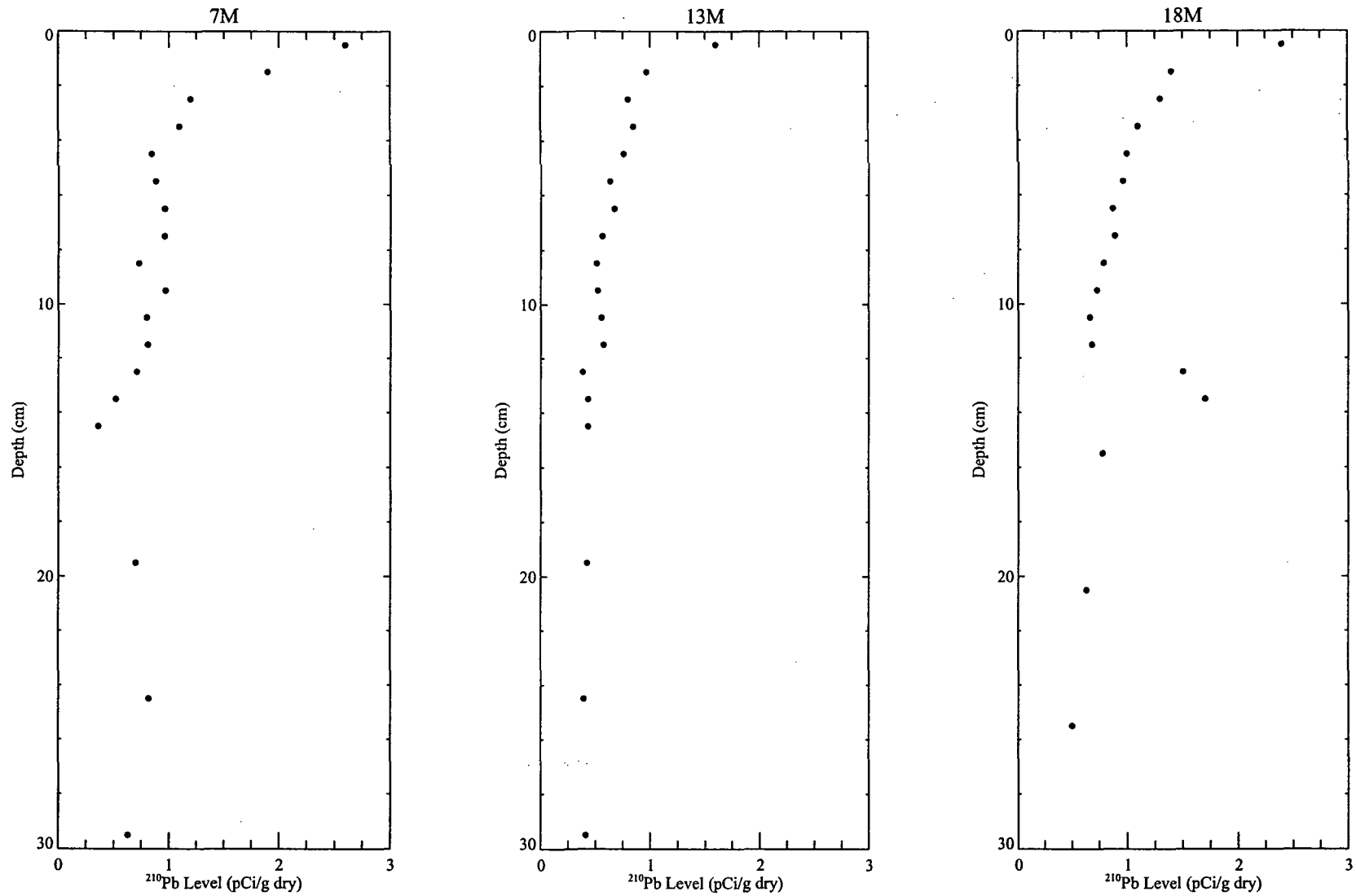


Figure 2-26. ^{210}Pb Concentrations in Lower Grasse River Sediment

Data collected during 1997 SRS Sediment Survey Program.
Circles represent measured ^{210}Pb levels.
Data table: sediment_bz

EC - D:\ALCgra\Documents\reports\AofA_202\main_report\figures\parameter_profiles_fig2_26.pro
Wed May 22 11:39:40 2002

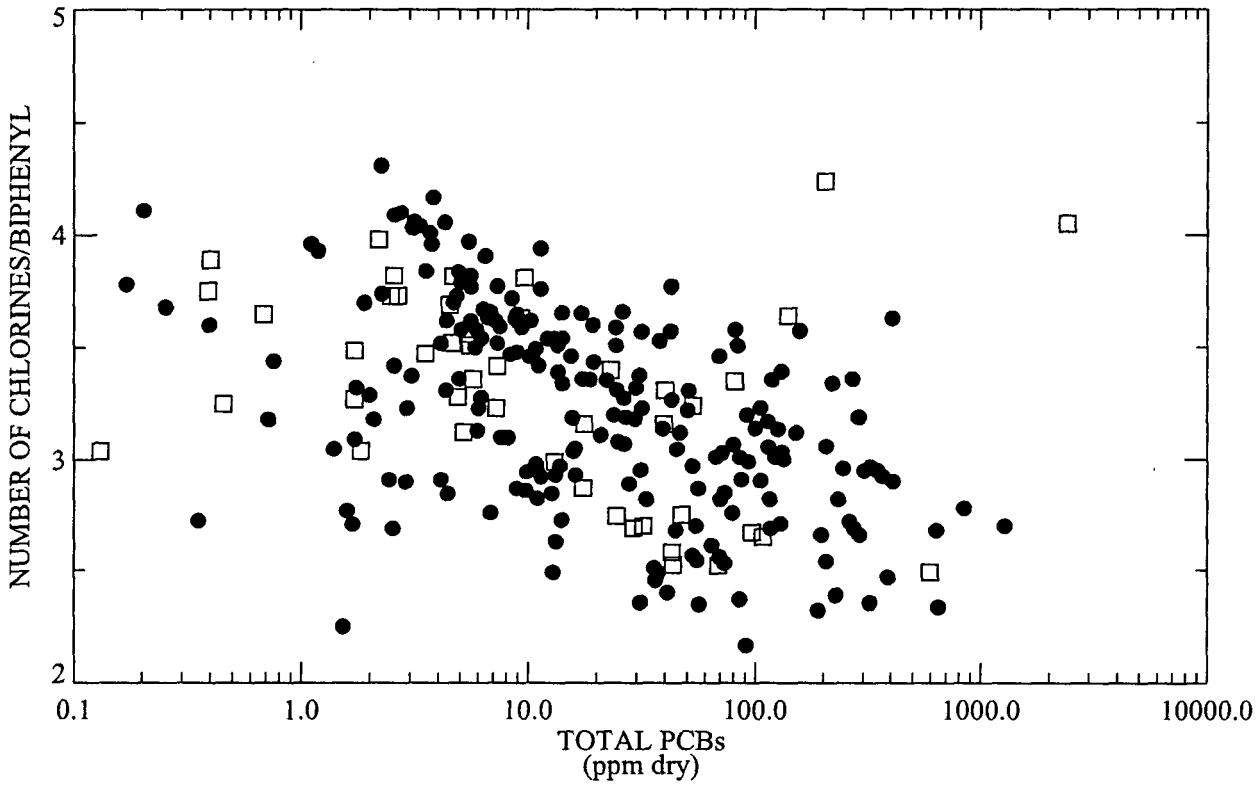


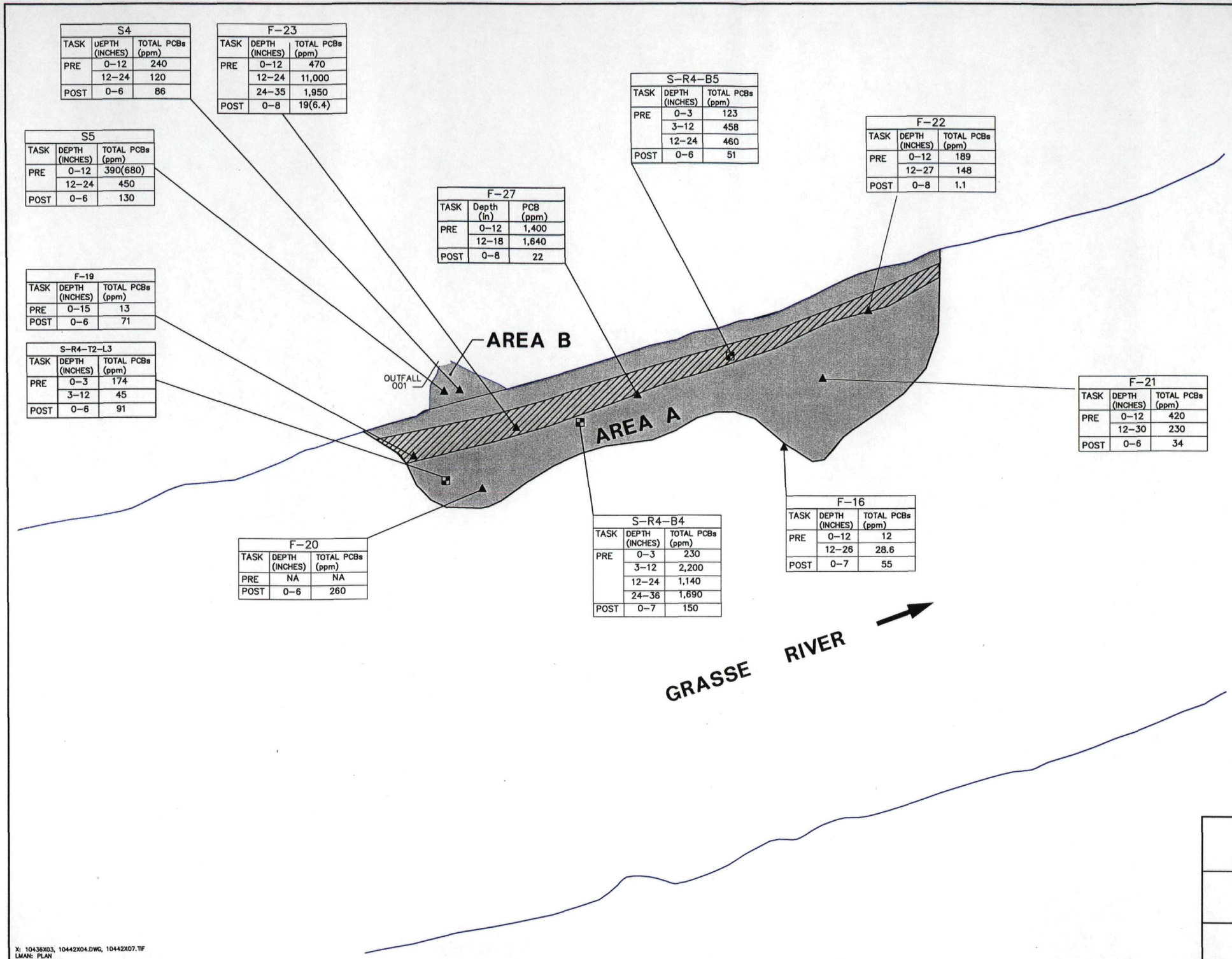
Figure 2-27. Number of Chlorines per Biphenyl and Total PCBs in Lower Grasse River Sediments.

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



S4		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	240
	12–24	120
POST	0–6	86

F–23		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	470
	12–24	11,000
	24–35	1,950
POST	0–8	19(6.4)

S5		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	390(680)
	12–24	450
POST	0–6	130

F–19		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–15	13
POST	0–6	71

S–R4–T2–L3		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–3	174
	3–12	45
POST	0–6	91

F–20		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	NA	NA
POST	0–6	260

F–27		
TASK	Depth (in)	PCB (ppm)
PRE	0–12	1,400
	12–18	1,640
POST	0–8	22

S–R4–B5		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–3	123
	3–12	458
	12–24	460
POST	0–6	51

S–R4–B4		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–3	230
	3–12	2,200
	12–24	1,140
	24–36	1,690
POST	0–7	150

F–16		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	12
	12–26	28.6
POST	0–7	55

F–22		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	189
	12–27	148
POST	0–8	1.1

F–21		
TASK	DEPTH (INCHES)	TOTAL PCBs (ppm)
PRE	0–12	420
	12–30	230
POST	0–6	34

LEGEND

- NTCRA REMOVAL AREA
- BOULDER FIELD (APPROXIMATE)
- ▲ PRE–/POST–NTCRA SAMPLING LOCATION (APPROXIMATE)
- RSI PHASE I/POST–NTCRA SAMPLING LOCATION (APPROXIMATE)
- ( ) DUPLICATE SAMPLE
- DIRECTION OF RIVER FLOW
- ppm PARTS PER MILLION
- NA NOT APPLICABLE

NOTES:

1. APPROXIMATE LOCATION OF BOULDER FIELD PROVIDED BY OHM REMEDIATION SERVICES CORPORATION.
2. PRE–NTCRA SAMPLES WERE COLLECTED AUGUST 13, 1991 – SEPTEMBER 7, 1991 AND SEPTEMBER 23–28, 1993. POST–NTCRA SAMPLES WERE COLLECTED ON SEPTEMBER 8, 1995.
3. ALL PCB RESULTS ARE TOTAL AROCLORS.

0 80' 160'

APPROXIMATE GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

ANALYSIS OF ALTERNATIVES REPORT

PRE/POST-NTCRA SEDIMENT DATA

ALCOA

FIGURE 2-28

X: 10436X03, 10442X04.DWG, 10442X07.TIF
LMAN: PLAN
P: PAGESET: DL
5/28/02 SYR-54-CBM LAS JER
10442005/10442C07.DWG

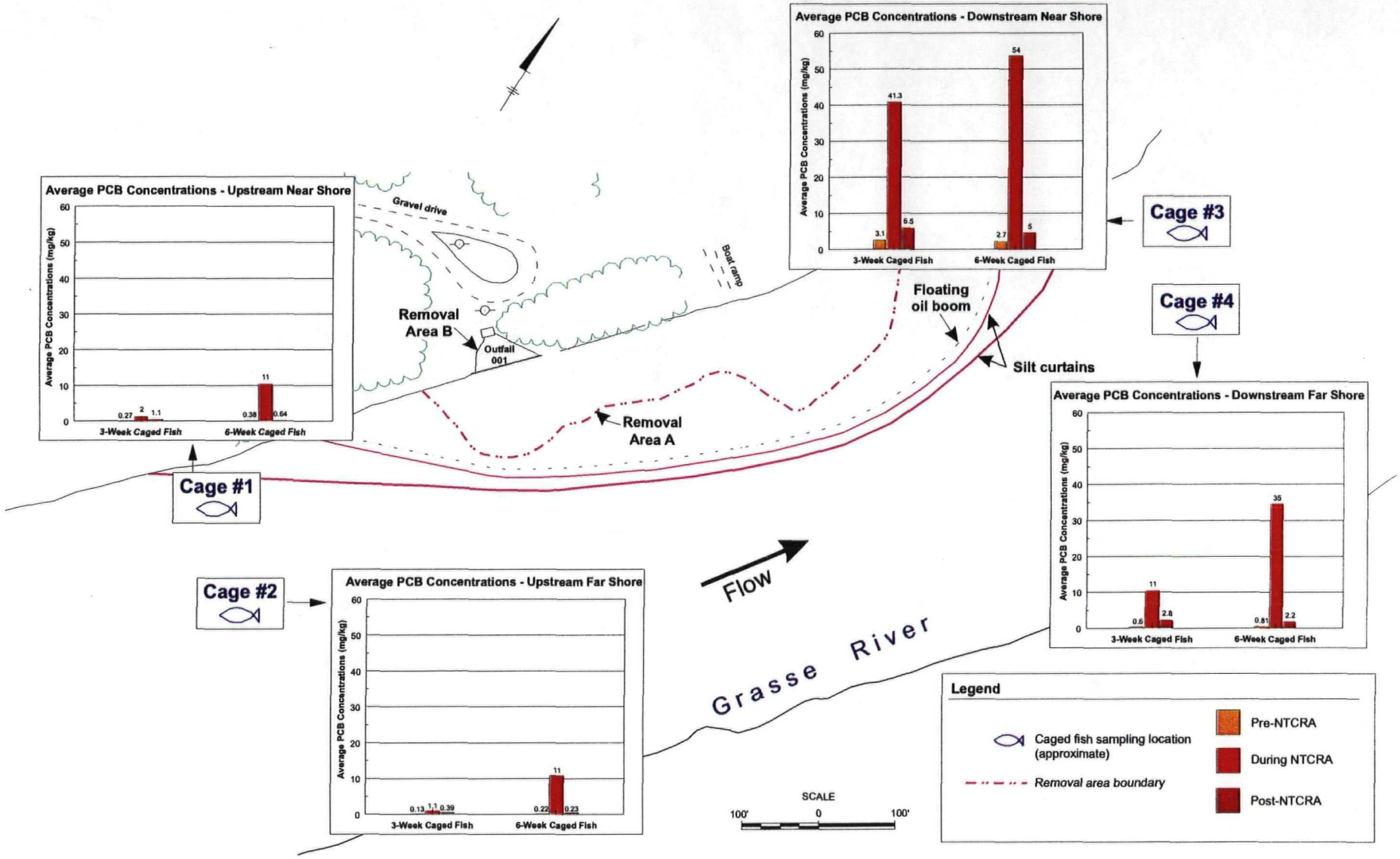


FIGURE 2-29. NTCRA Average PCB Concentrations at Caged Fish Locations

06/02-SYR-DIV12/MFE
GRAArept/Fig2-29.cdr

Study Area Characteristics

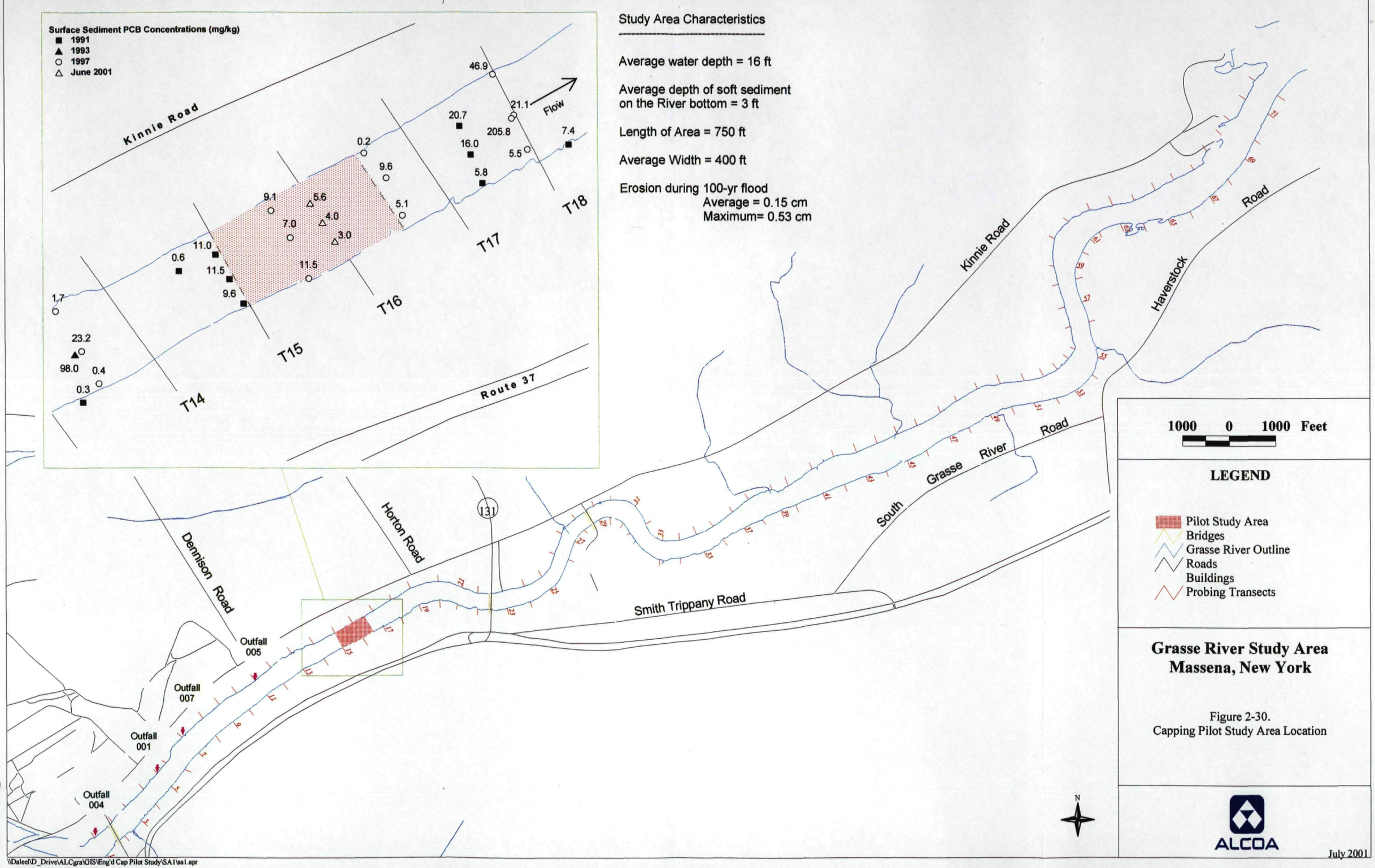
Average water depth = 16 ft

Average depth of soft sediment on the River bottom = 3 ft

Length of Area = 750 ft

Average Width = 400 ft

Erosion during 100-yr flood
Average = 0.15 cm
Maximum= 0.53 cm

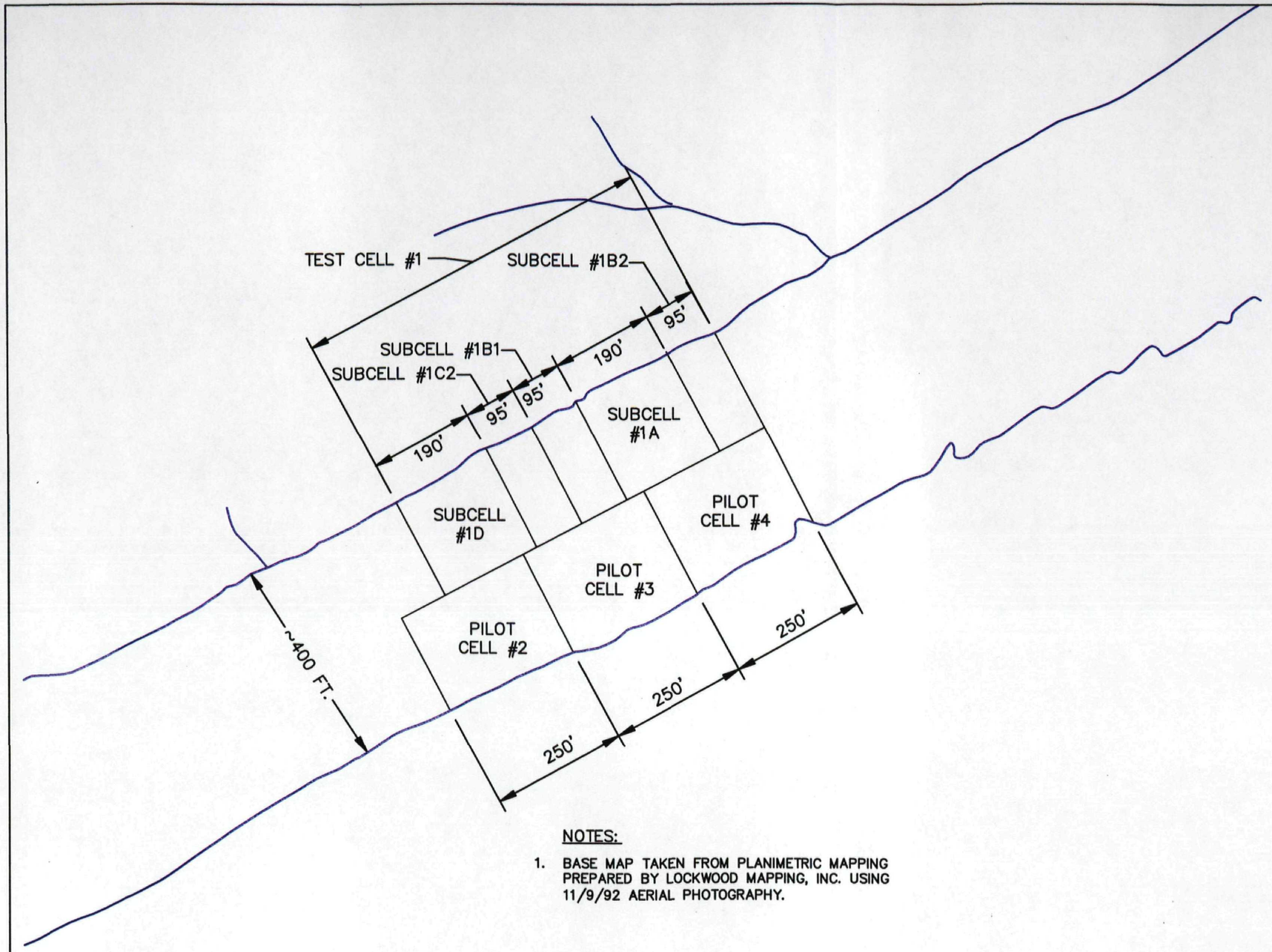


Grasse River Study Area
Massena, New York

Figure 2-30.
Capping Pilot Study Area Location

July 2001

\\Daleel\D_Drive\ALCgra\GIS\Eng'd Cap Pilot Study\SA1\sa1.apr



LEGEND:

T14 — 1992 SEDIMENT PROBING TRANSECT LOCATION

— RIVER BOUNDARY

NOTES:

1. BASE MAP TAKEN FROM PLANIMETRIC MAPPING PREPARED BY LOCKWOOD MAPPING, INC. USING 11/9/92 AERIAL PHOTOGRAPHY.

0 200' 400'

GRAPHIC SCALE

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

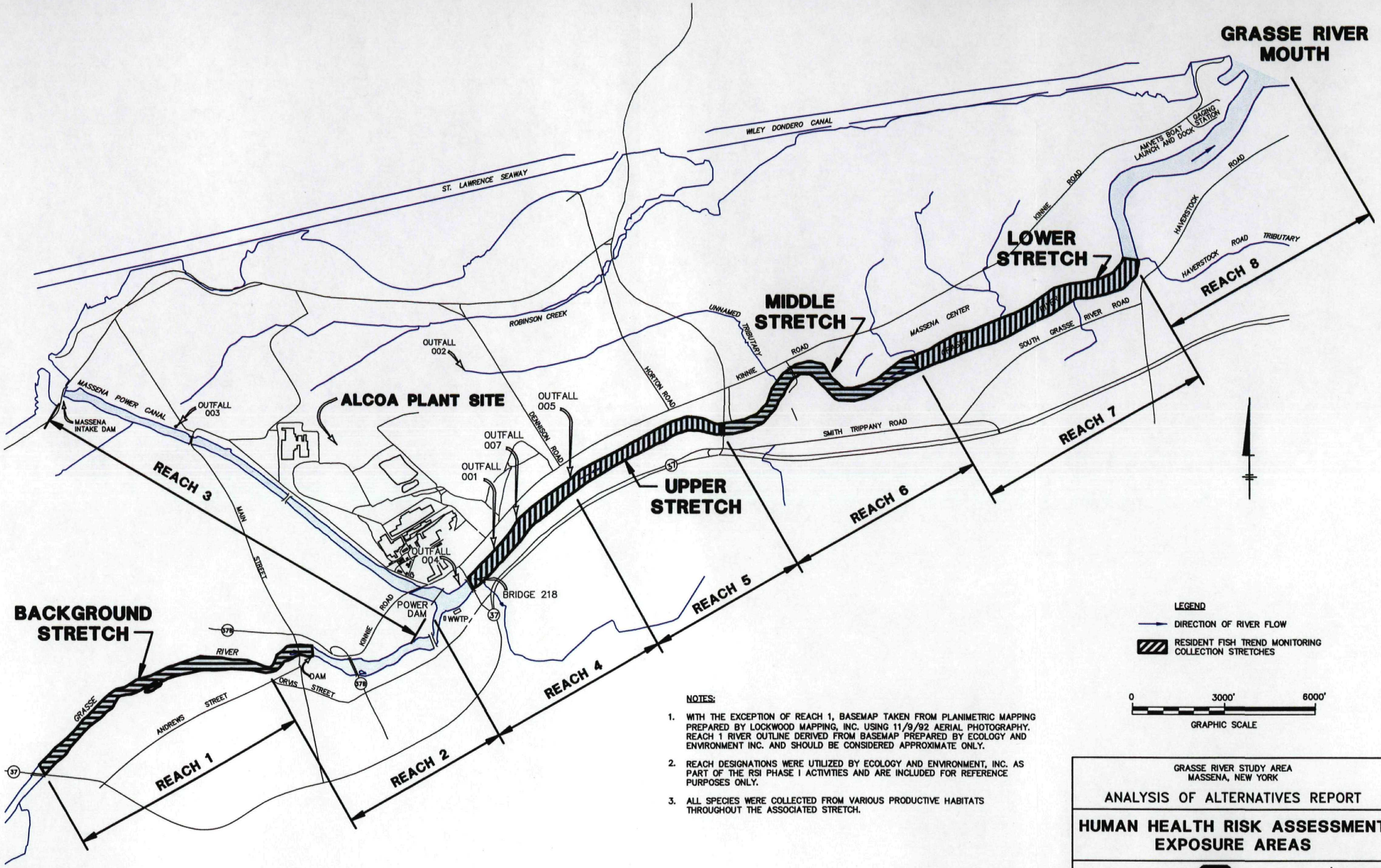
ANALYSIS OF ALTERNATIVES REPORT

CAPPING PILOT STUDY CELL CONFIGURATION

ALCOA

FIGURE 2-31

X: 10442X05.DWG, 10442X07.TIF
L: ON=*, OFF=REF
P: PAGESET/BL
5/28/02 SYR-54-GMS LAS JER
10442005/10442C11.DWG



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

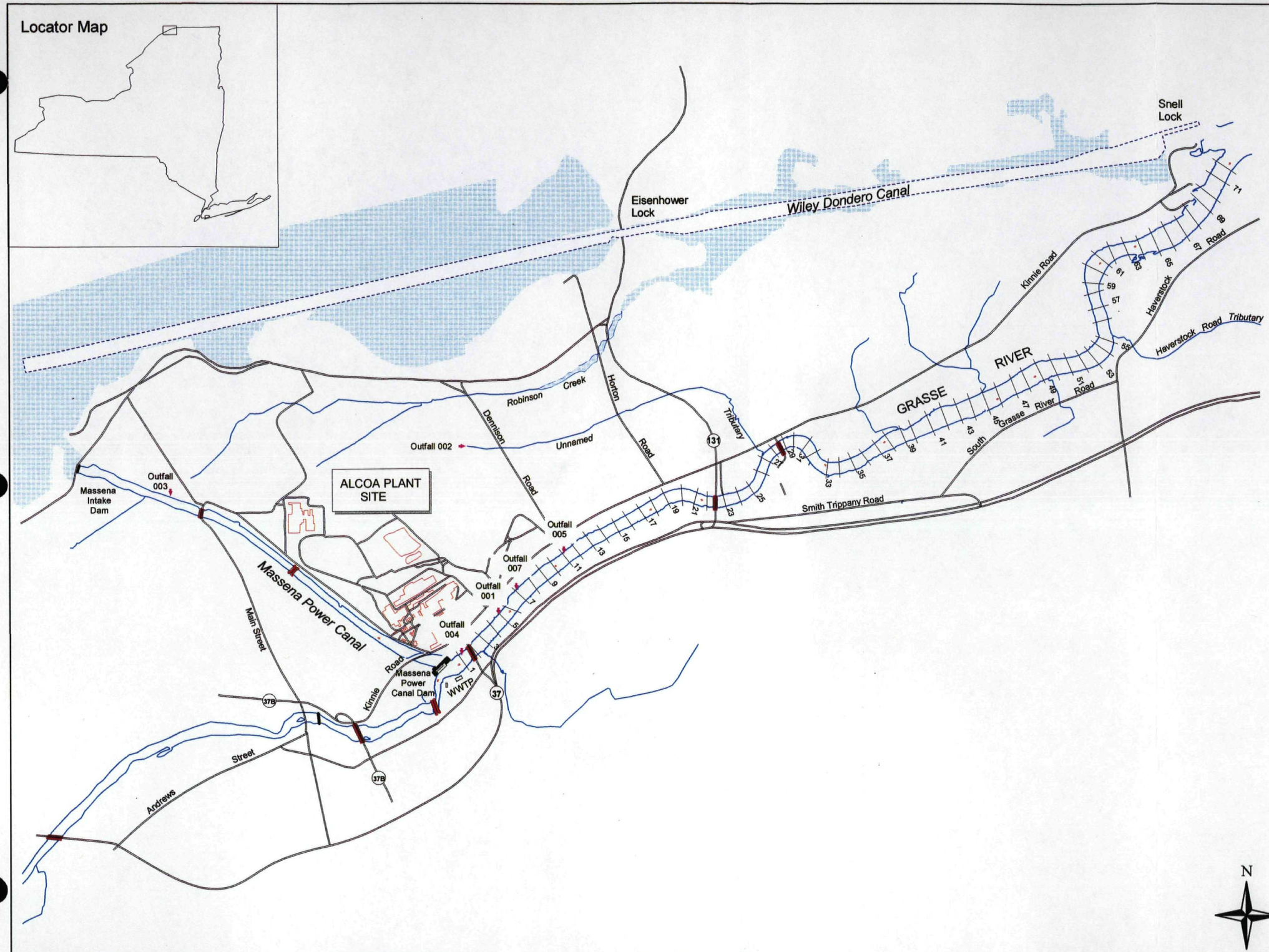
ANALYSIS OF ALTERNATIVES REPORT

HUMAN HEALTH RISK ASSESSMENT EXPOSURE AREAS

ALCOA

FIGURE 3-1

X: 10442X01.DWG, 10442X07.TIF
L: ON=*, OFF=REF*
P: PAGESET/BL
5/28/02 SYR-54-KLN KMD LAS
10442005/10442C12.DWG



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 5-1.
Alternative 2
Monitored Natural Recovery

Based on GIS matrix 010629

ALCOA

Dec 2001

\\EC\D_Drive\ALCgra\GIS\Model\model_matrix\AoA_alternatives_011228\AoA_alternatives_011228.apr

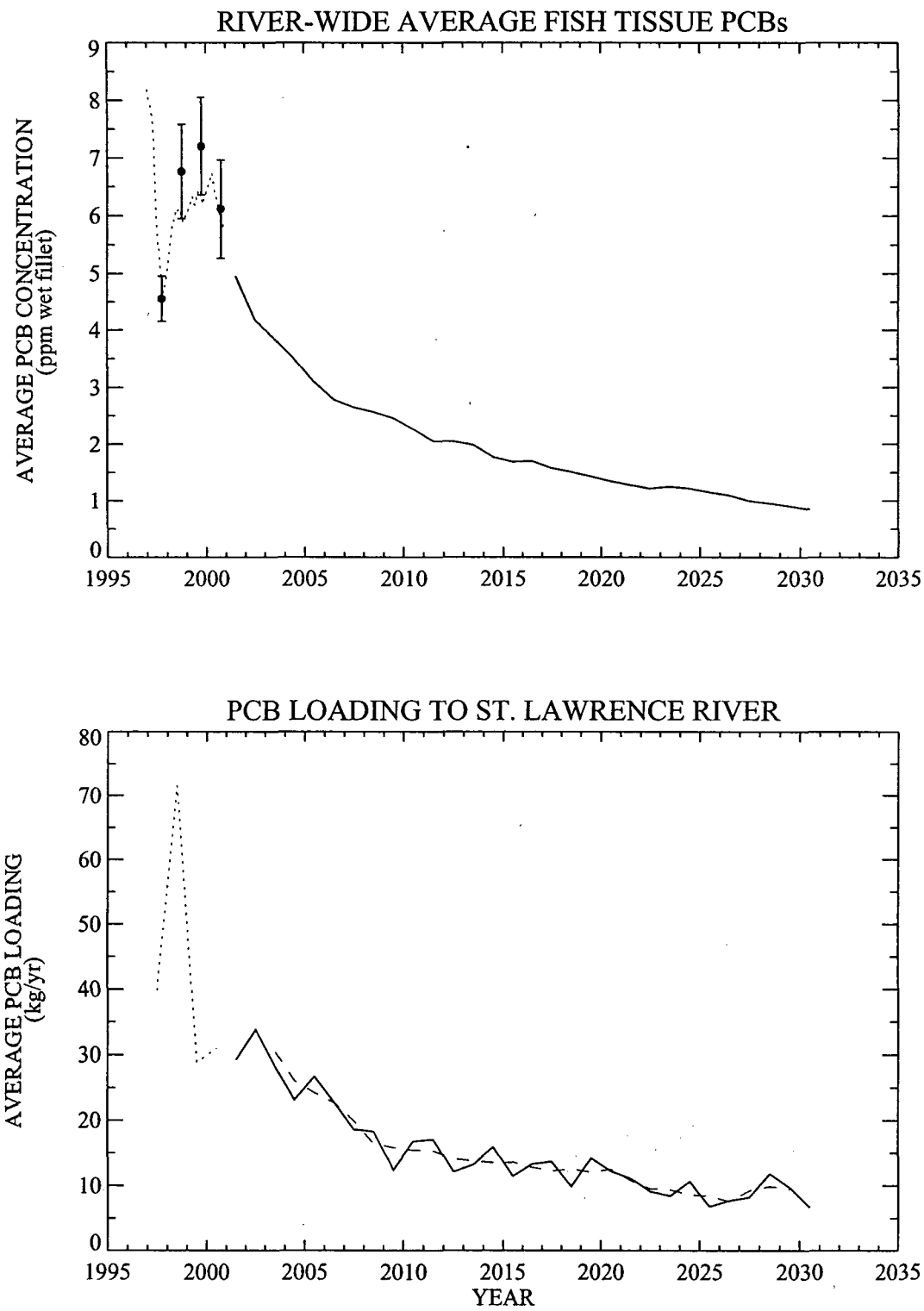


Figure 5-2. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 2 - Monitored Natural Recovery.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

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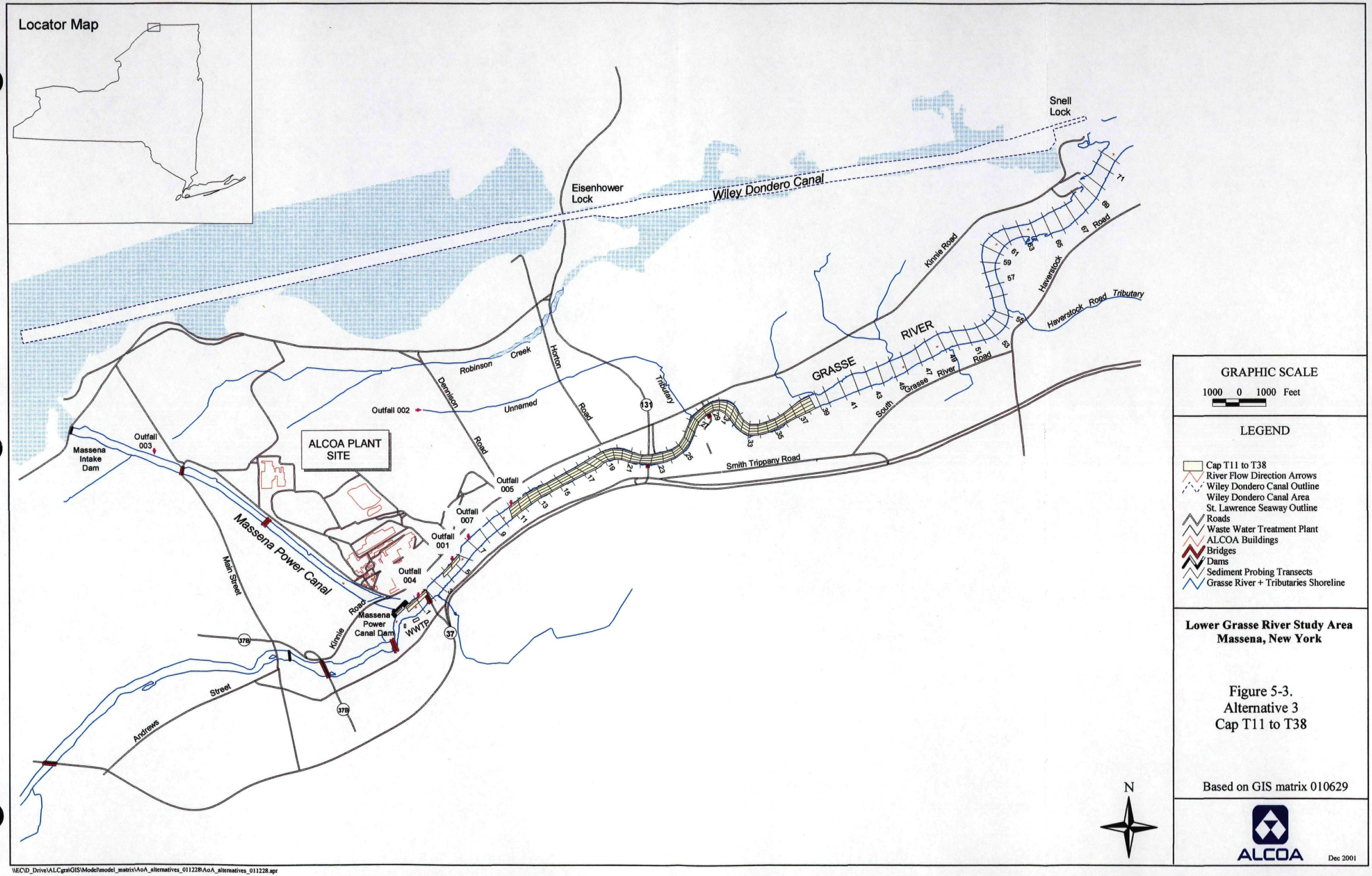

Lower Grasse River Study Area
Massena, New York

Figure 5-3.
Alternative 3
Cap T11 to T38

Based on GIS matrix 010629

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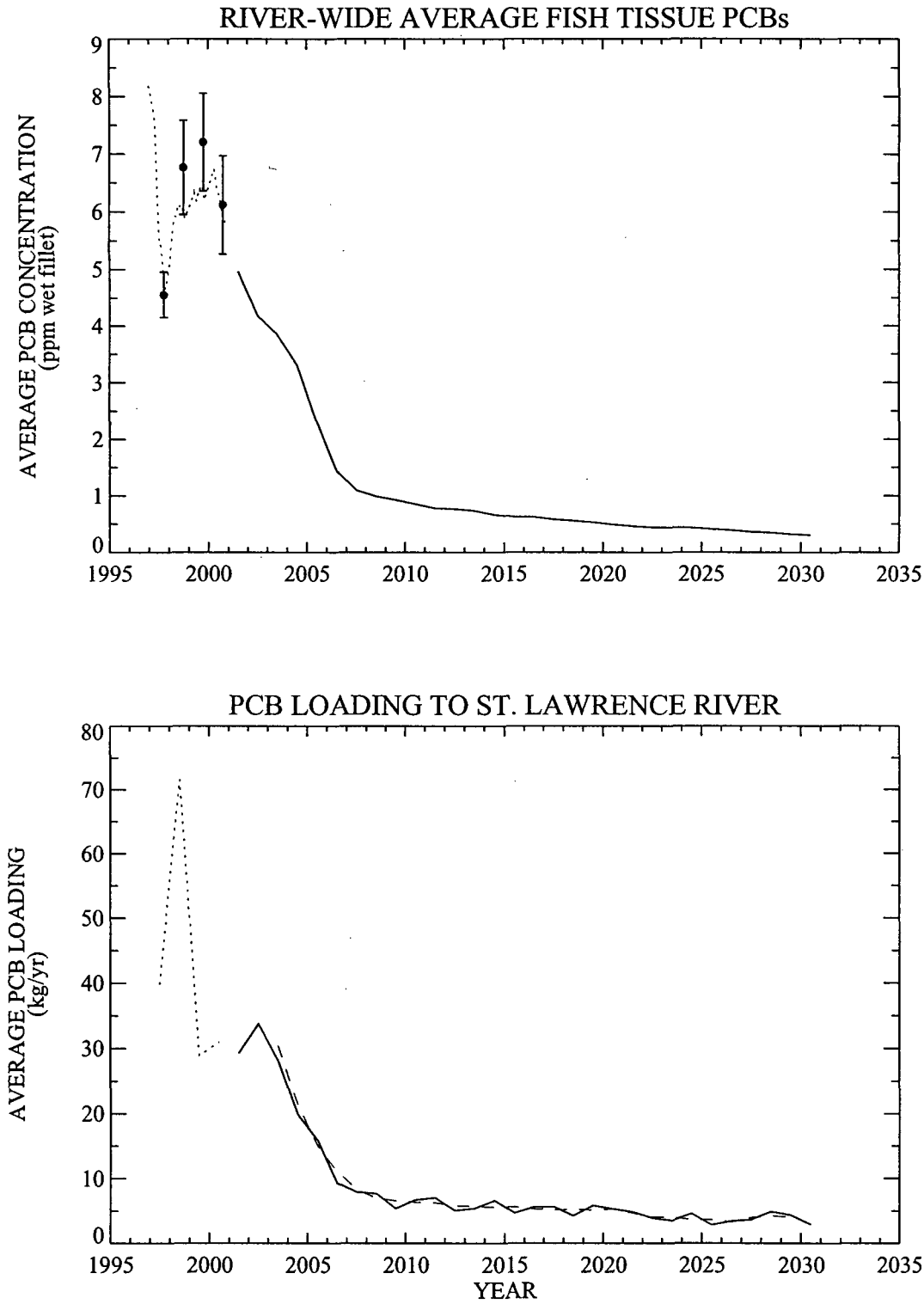

Figure 5-4. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 3 - Cap T11 to T38.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

Capping effectiveness = 90%.

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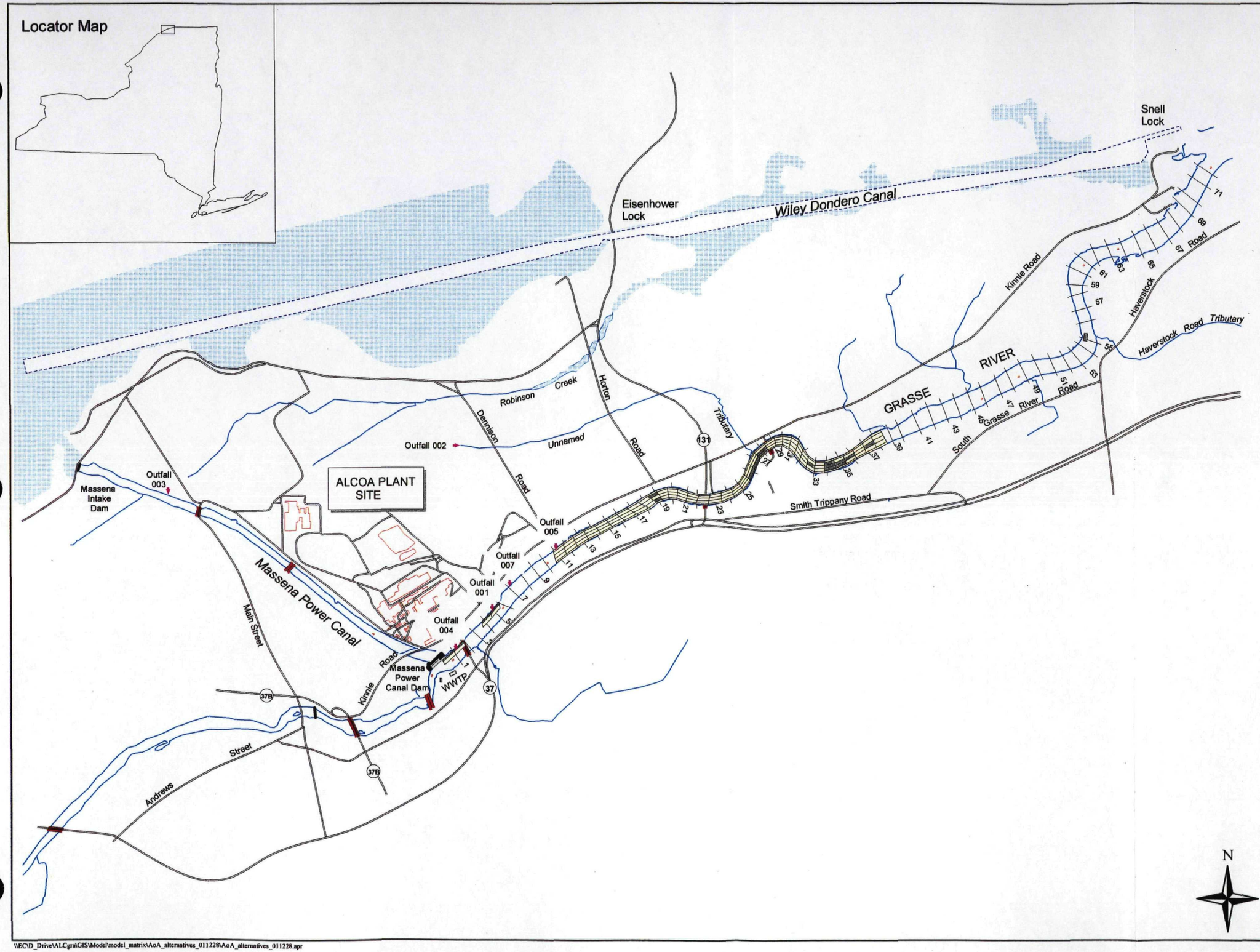

GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- Dredge PCBs ≥ 50 ppm
- Cap T11 to T38
- 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 5-5.
Alternative 4
Dredge PCBs ≥ 50 ppm;
Cap T11 to T38

Based on GIS matrix 010629

ALCOA

Dec 2001

\\EC\D_Drive\ALCgra\GIS\Model\model_matrix\AoA_alternatives_011228\AoA_alternatives_011228.apr

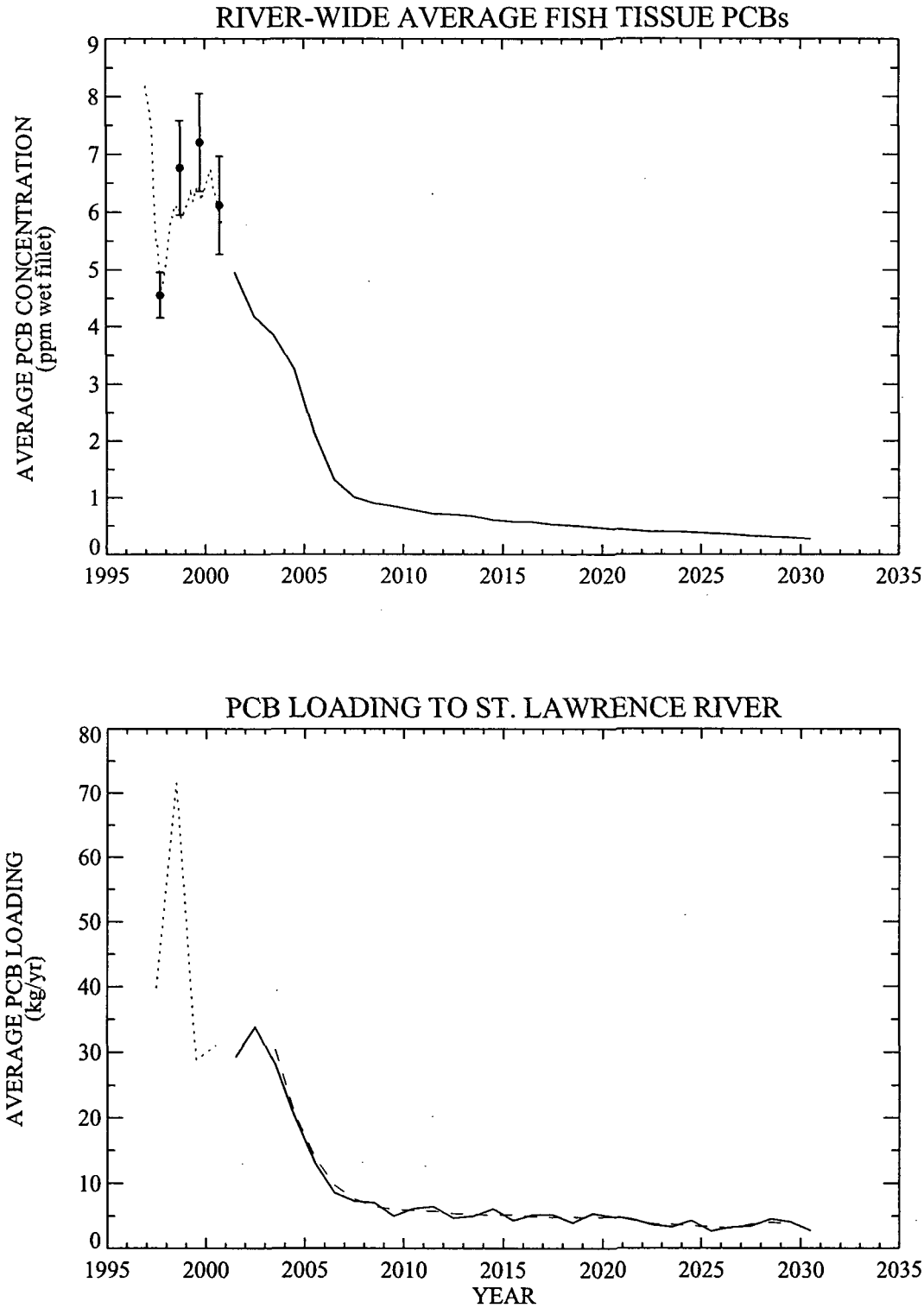

Figure 5-6. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 4 - Dredge ≥ 50 ppm; Cap T11 to T38.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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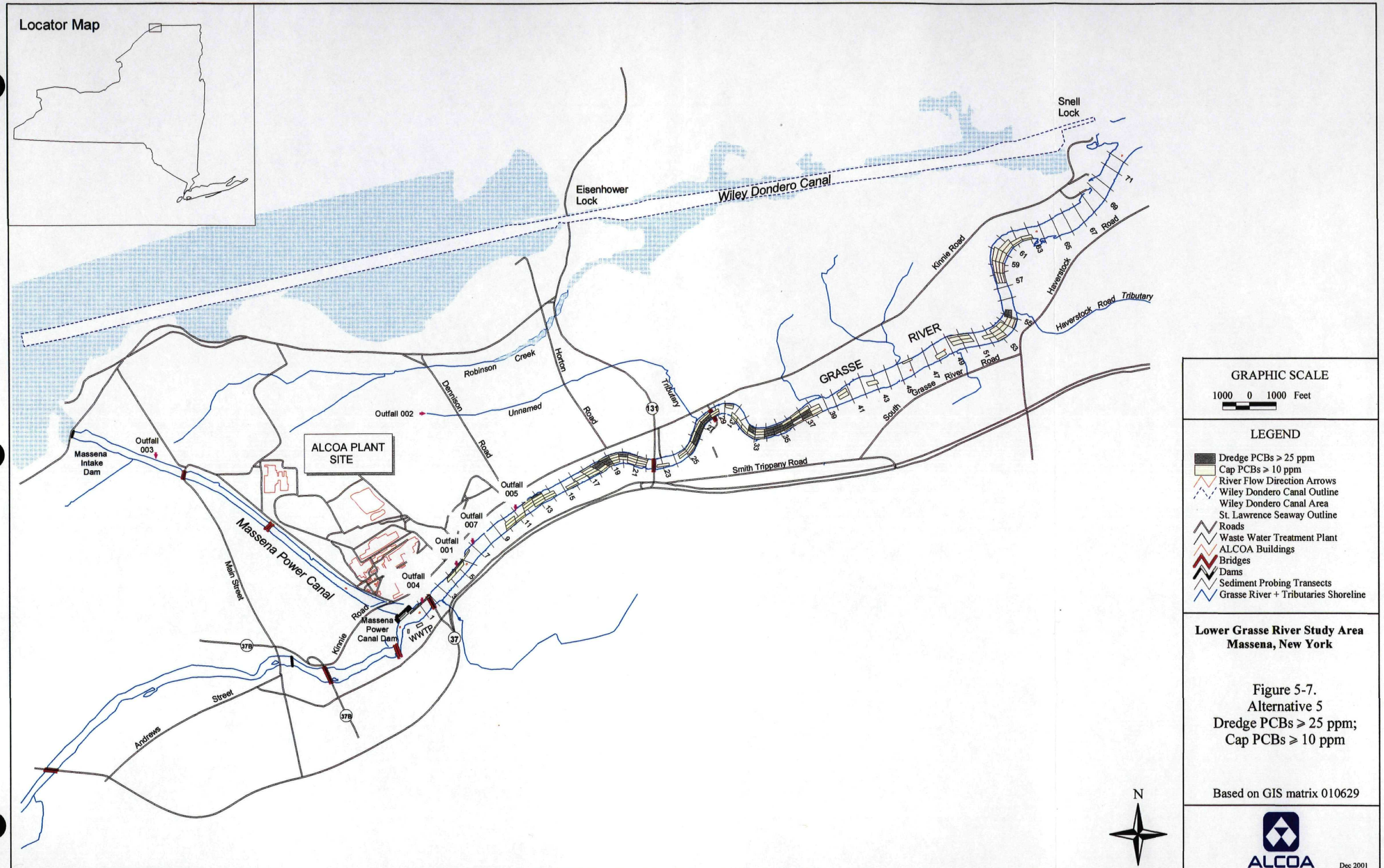

Lower Grasse River Study Area
Massena, New York

Figure 5-7.
Alternative 5
Dredge PCBs ≥ 25 ppm;
Cap PCBs ≥ 10 ppm

Based on GIS matrix 010629

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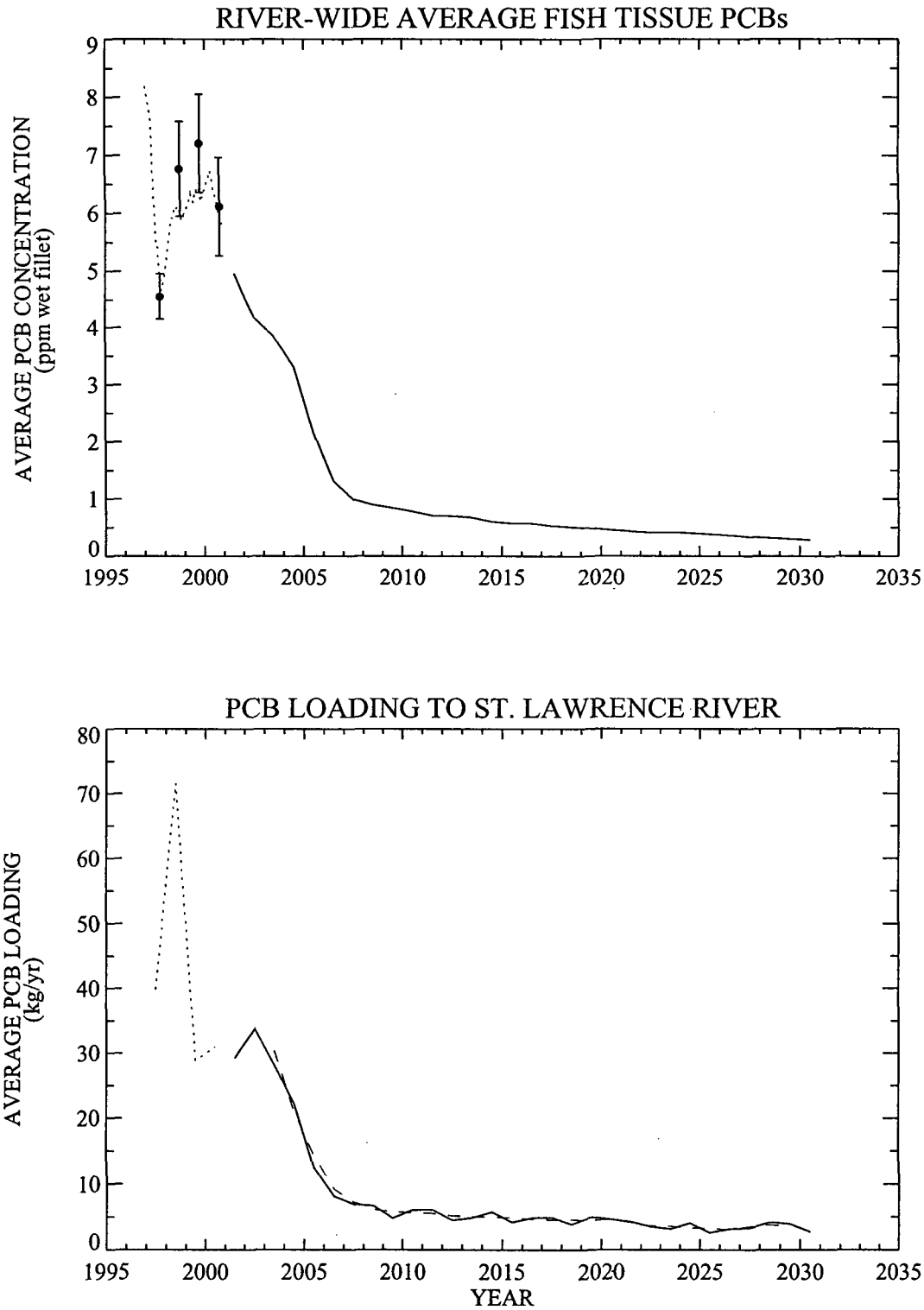

Figure 5-8. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 5 - Dredge ≥ 25 ppm; Cap ≥ 10 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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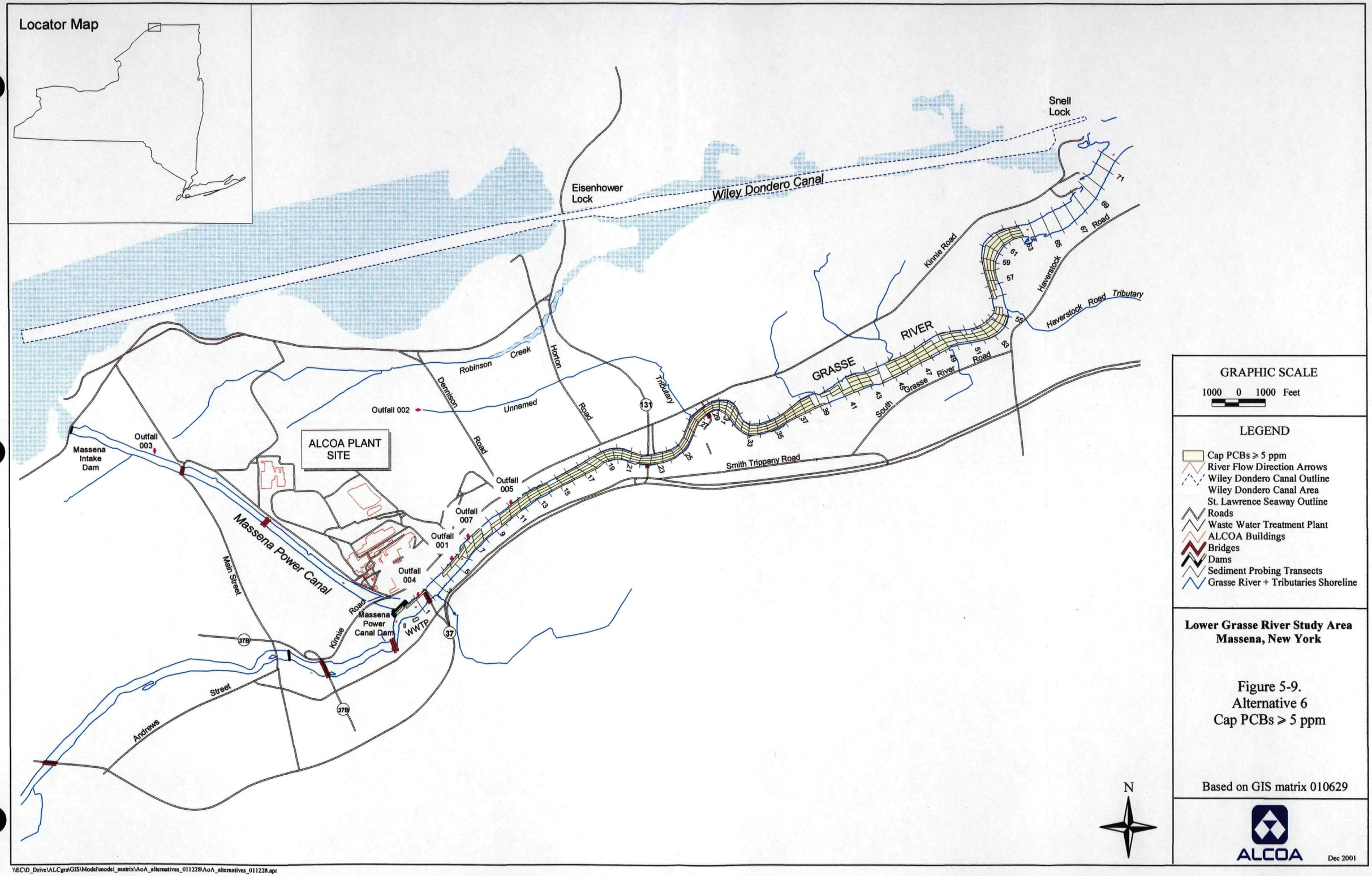

Lower Grasse River Study Area
Massena, New York

Figure 5-9.
Alternative 6
Cap PCBs ≥ 5 ppm

Based on GIS matrix 010629

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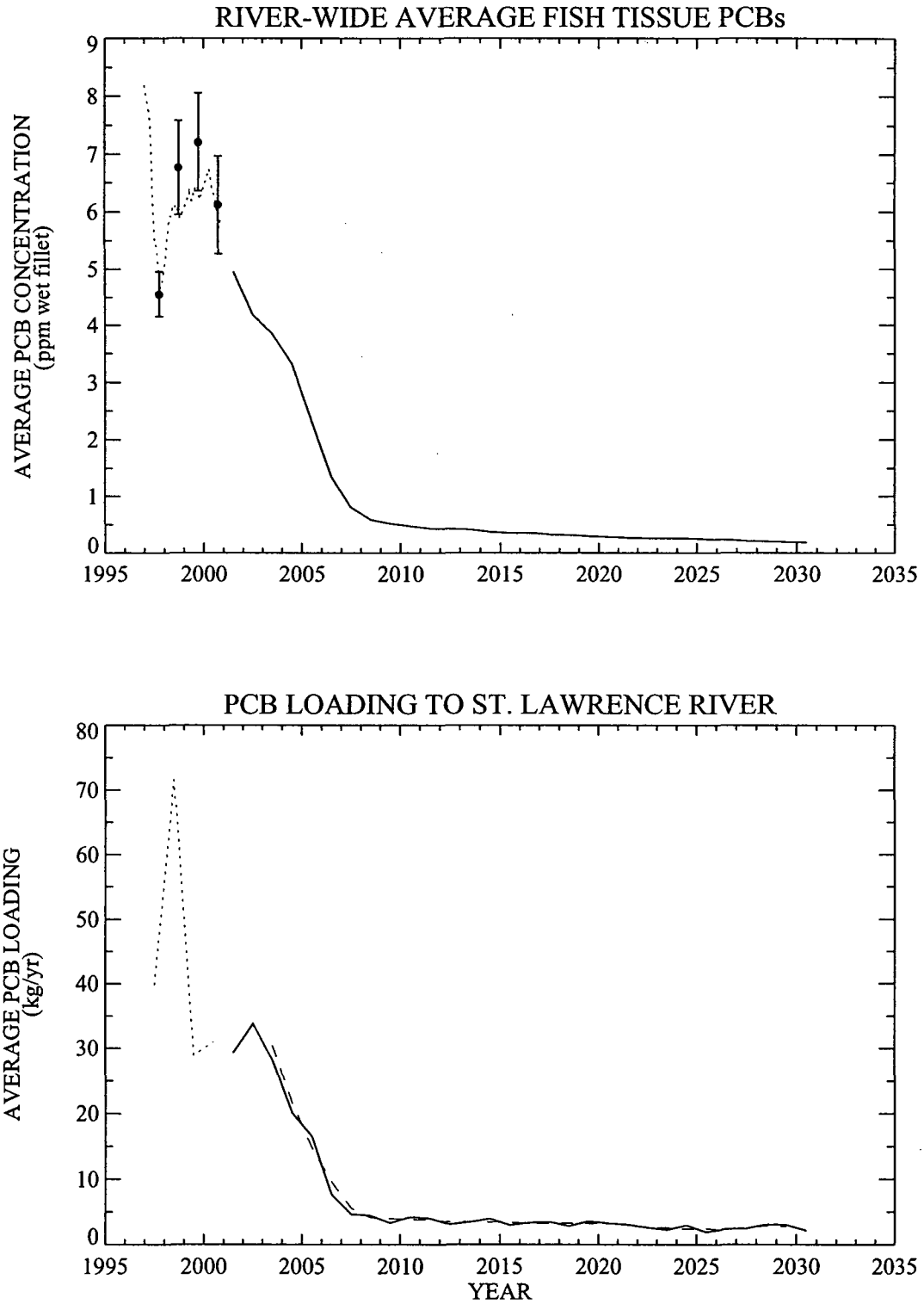

Figure 5-10. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 6 - Cap ≥ 5 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

Capping effectiveness = 90%.

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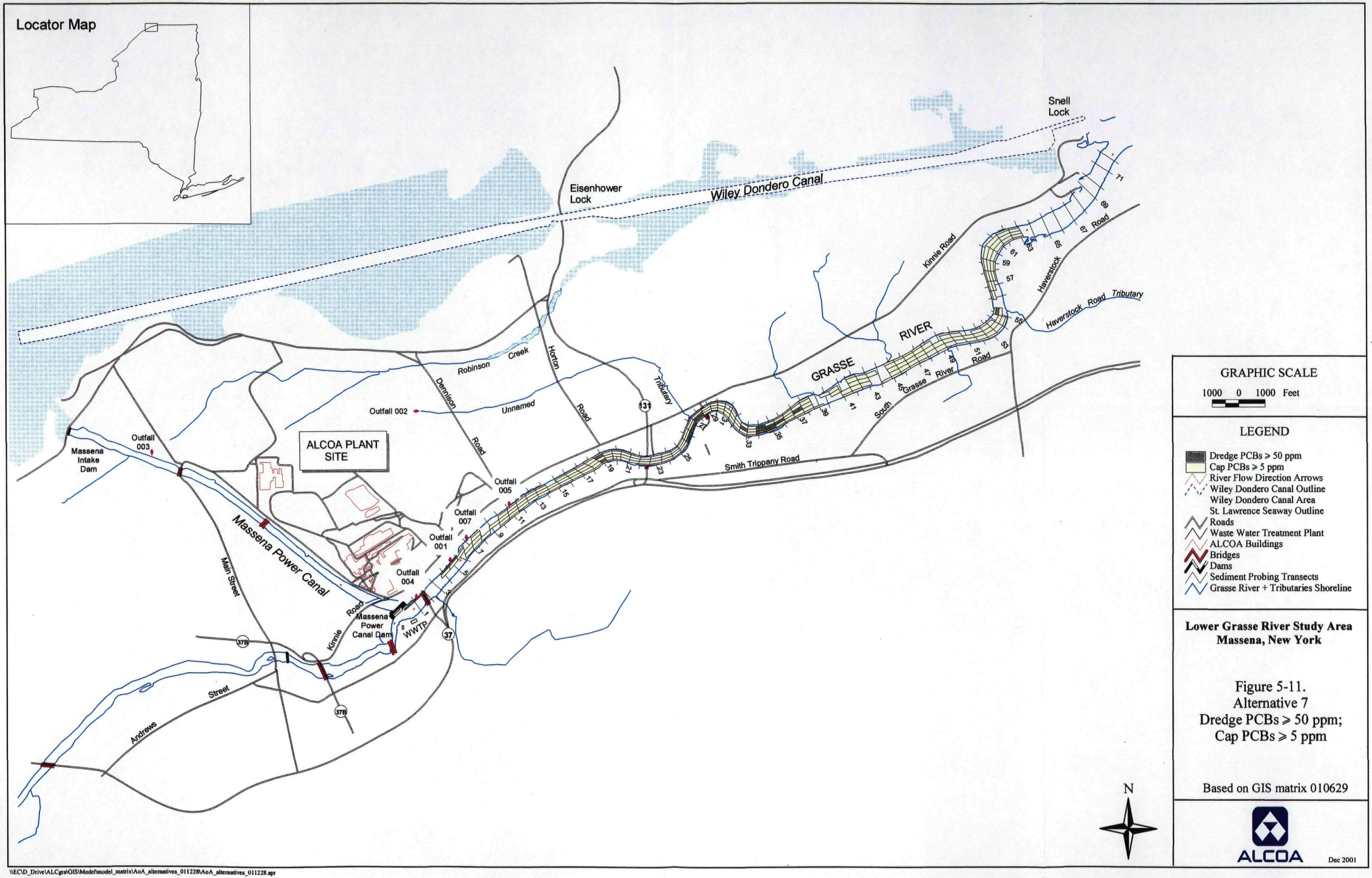

Lower Grasse River Study Area
Massena, New York

Figure 5-11.
Alternative 7
Dredge PCBs ≥ 50 ppm;
Cap PCBs ≥ 5 ppm

Based on GIS matrix 010629

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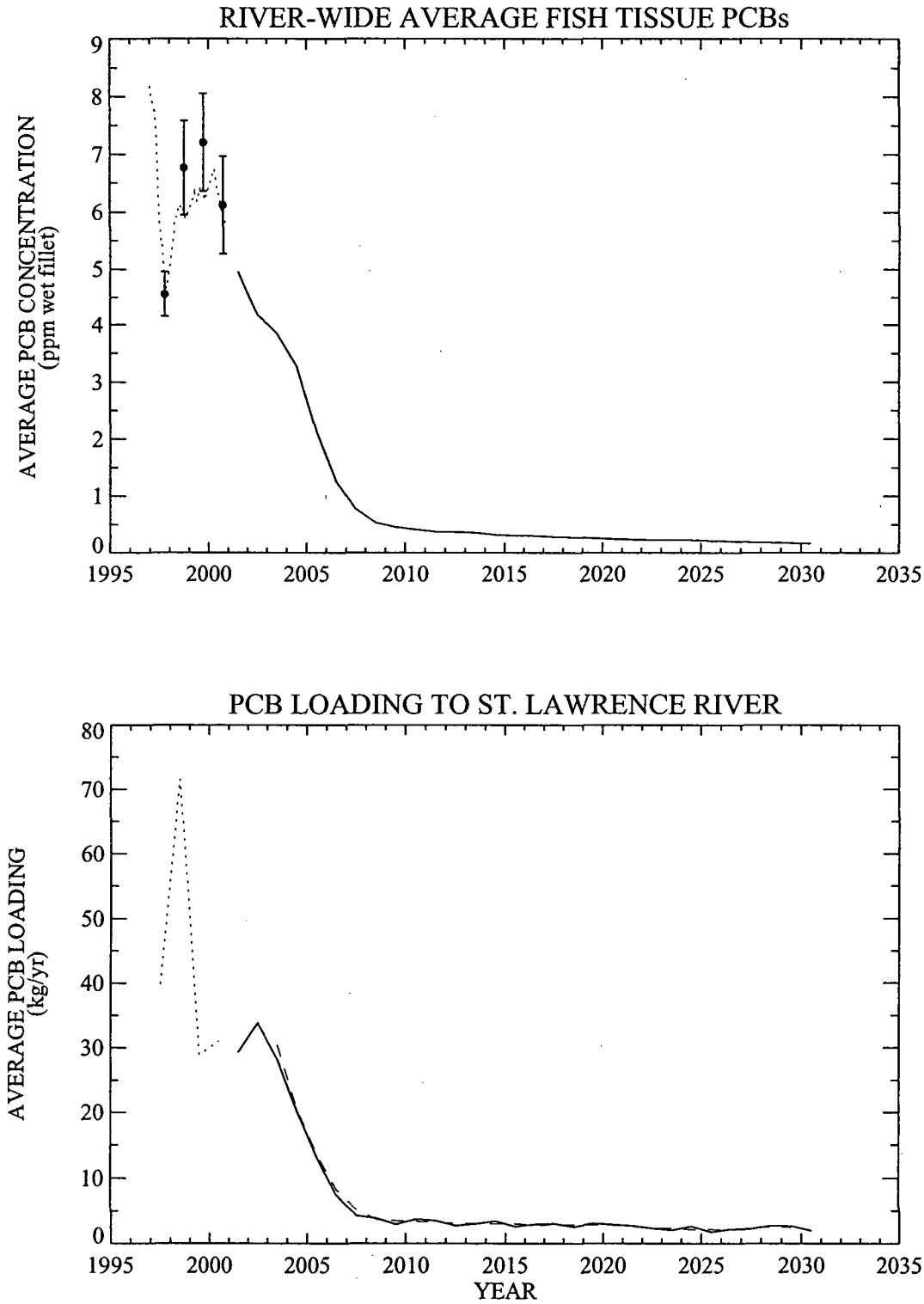

Figure 5-12. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 7 - Dredge ≥ 50 ppm; Cap ≥ 5 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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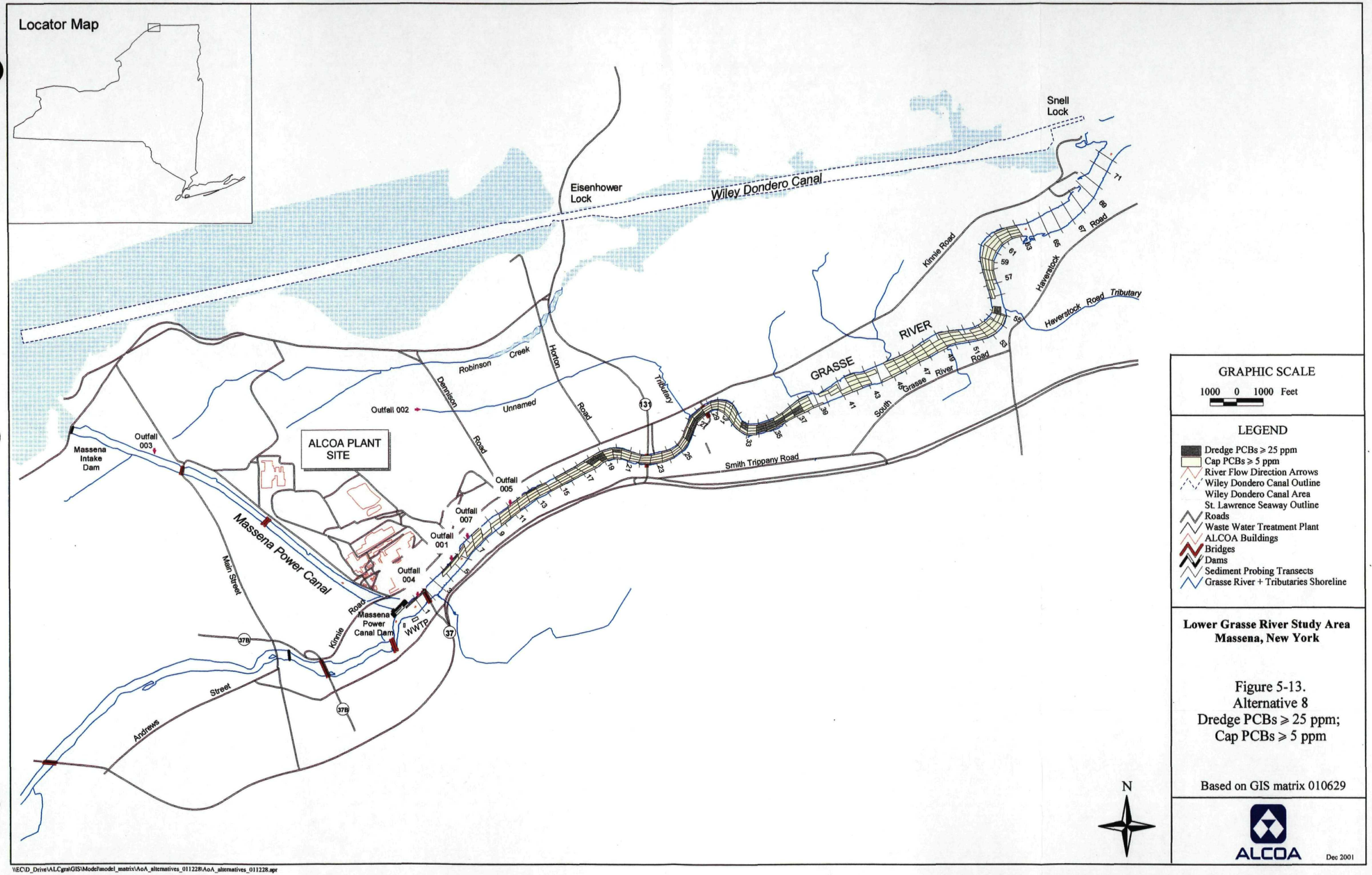

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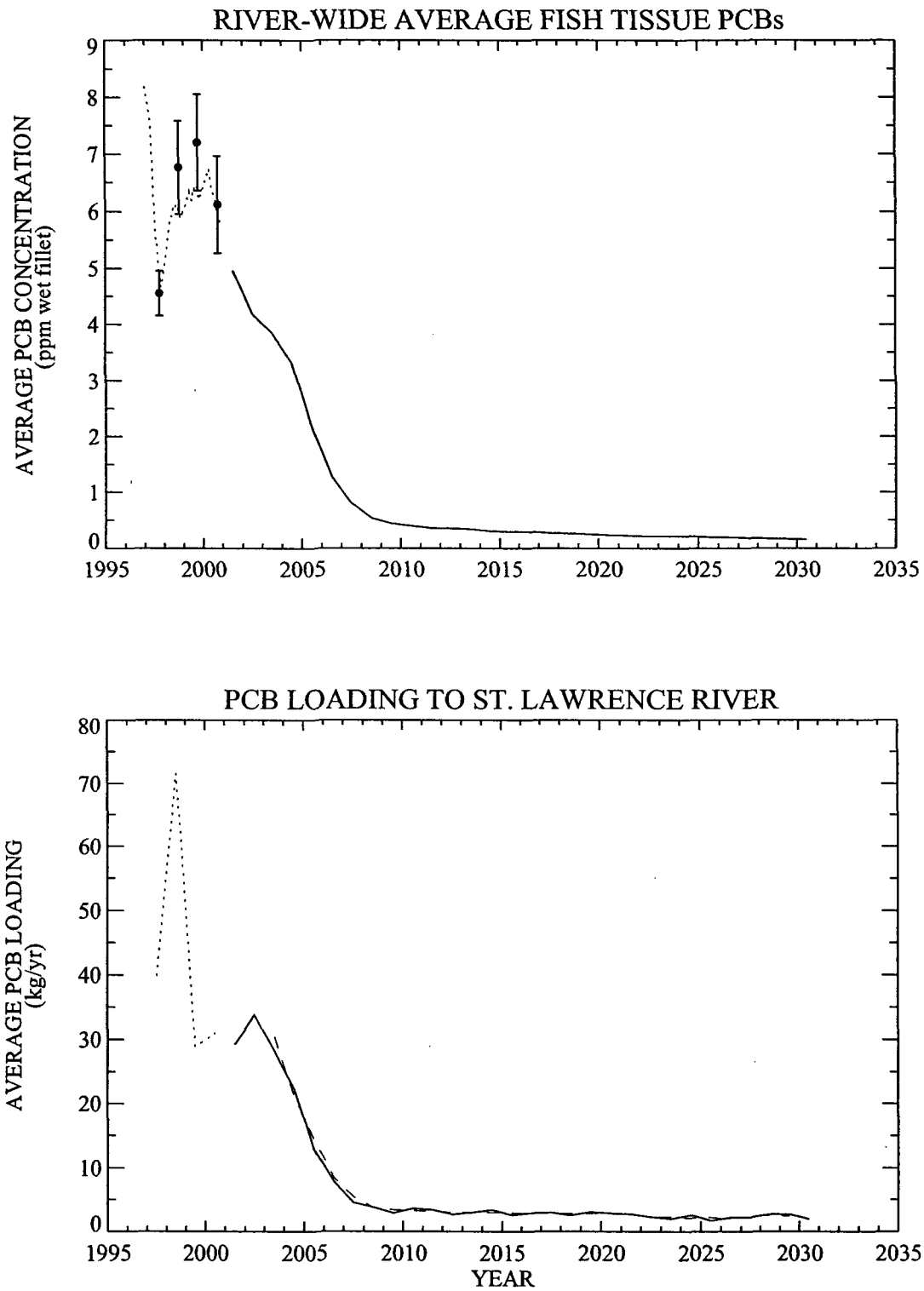

Figure 5-14. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 8 - Dredge ≥ 25 ppm; Cap ≥ 5 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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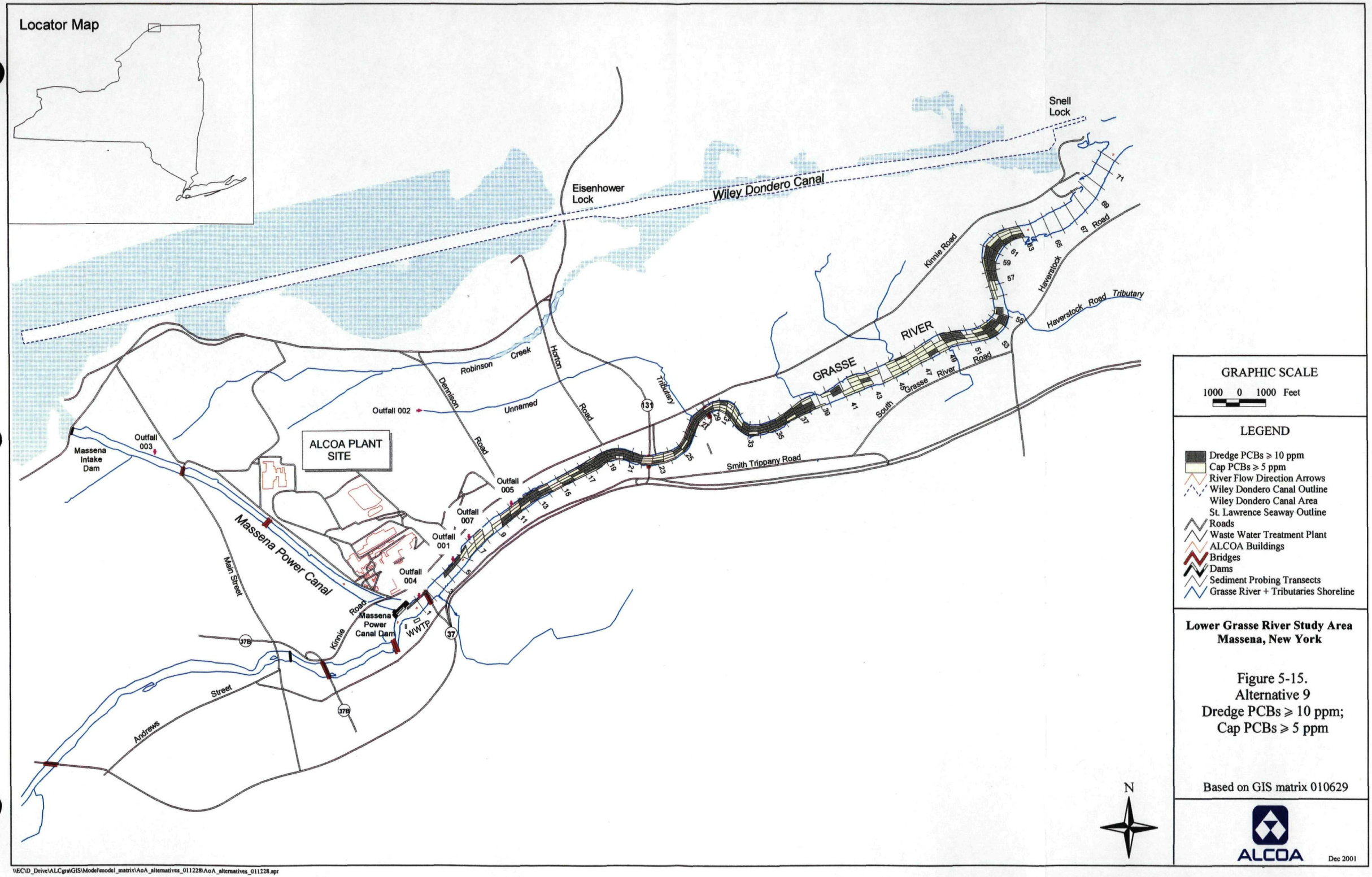

Lower Grasse River Study Area
Massena, New York

Figure 5-15.
Alternative 9
Dredge PCBs ≥ 10 ppm;
Cap PCBs ≥ 5 ppm

Based on GIS matrix 010629

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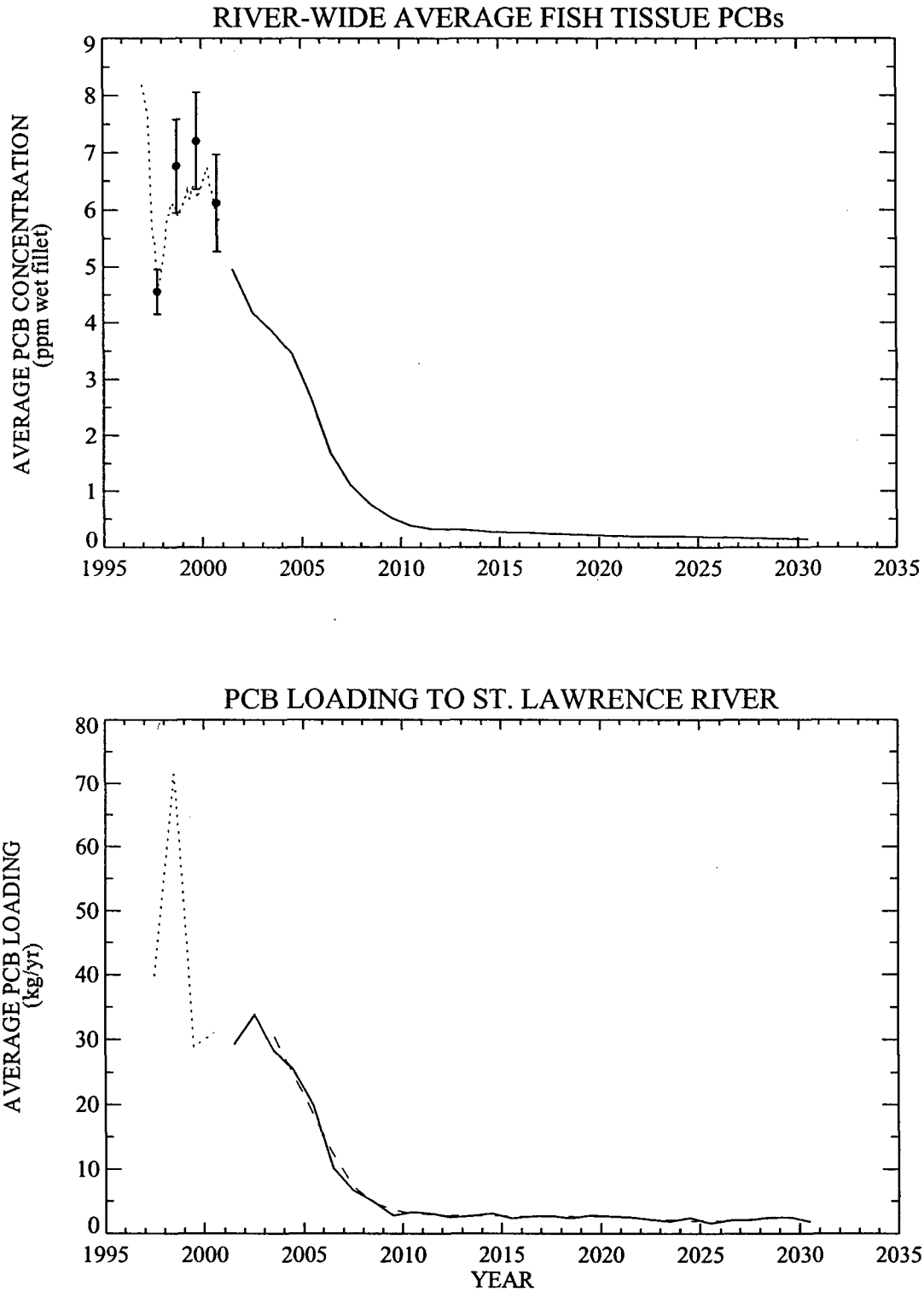

Figure 5-16. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 9 - Dredge ≥ 10 ppm; Cap ≥ 5 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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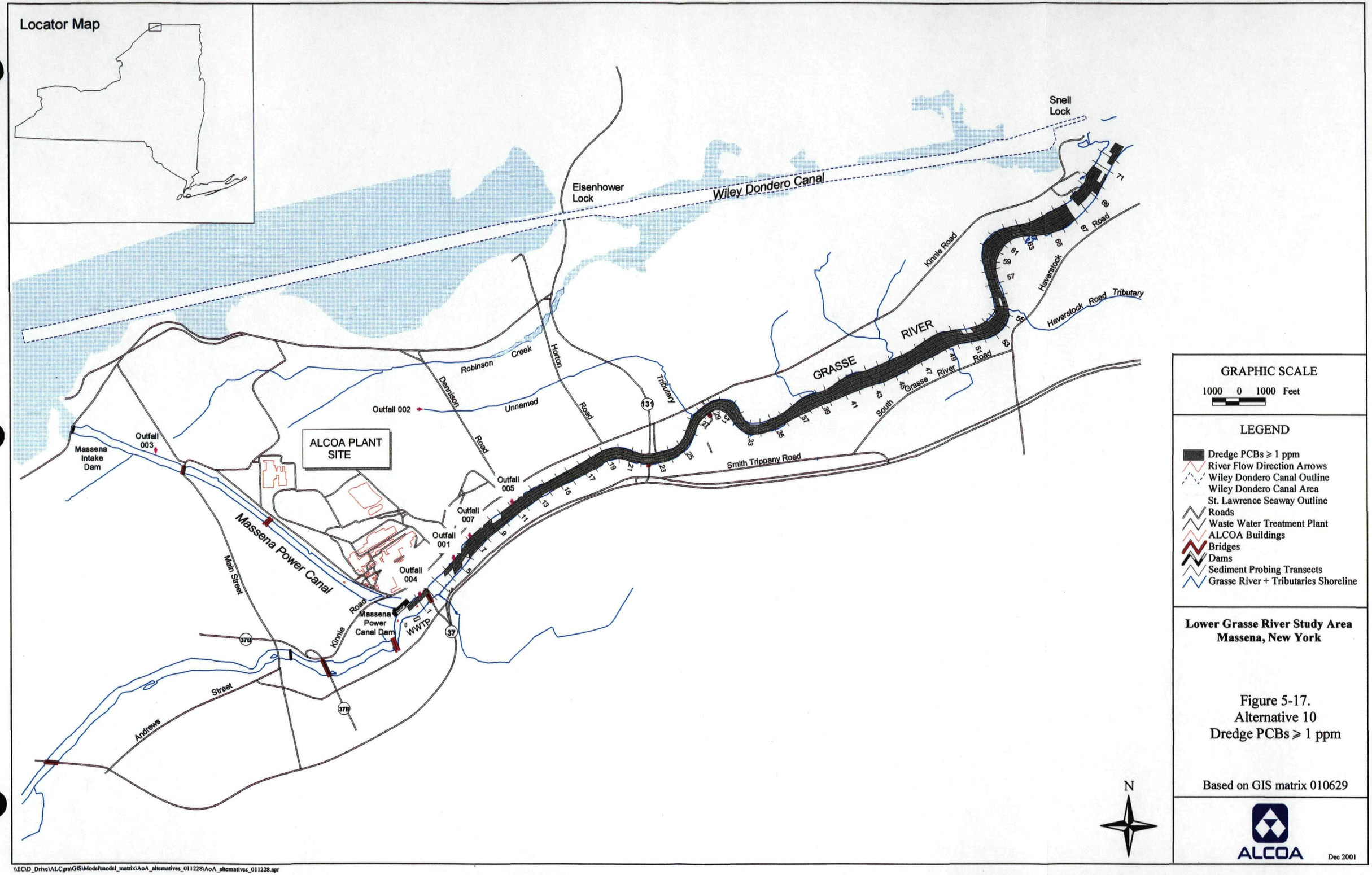

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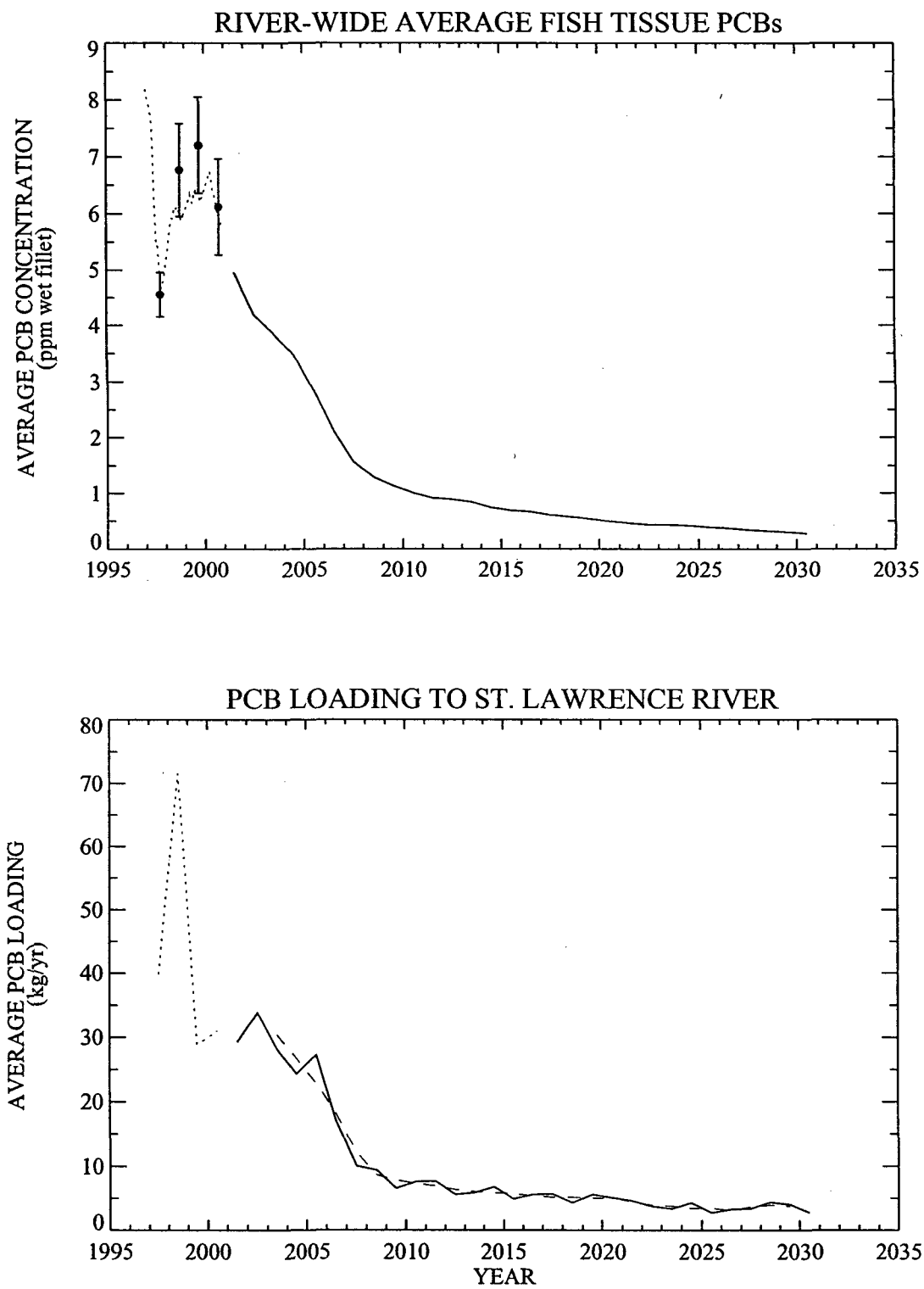

Figure 5-18. Predicted Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River. Alternative 10 - Dredge ≥ 1 ppm.

Symbols represent annual average fish PCB data, +/- two standard errors.

Dotted lines represent results from model calibration: fish tissue PCB concentrations are daily averages and PCB loadings are annual averages.

Solid lines represent annual average results from model projection. Dashed line in bottom panel represents 3-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm.

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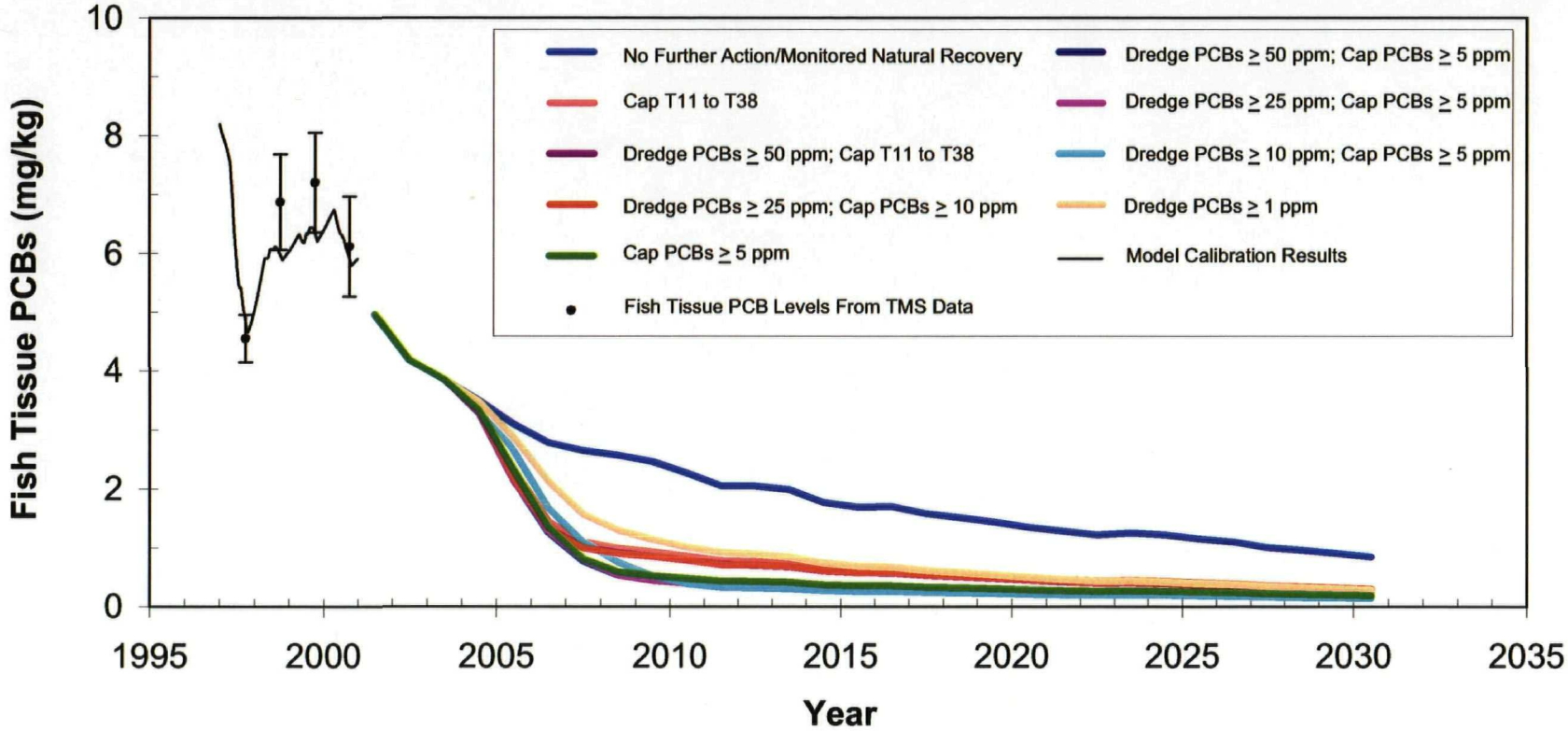

Figure 6-1. Comparison of Fish Tissue PCB Levels for Each Alternative.

Symbols represent river-average fish tissue PCB levels computed from Trend Monitoring data collected during calibration period, +/- two standard errors.

Solid line between 1997 and 2000 represents calibration results from bioaccumulation model.

Solid lines after 2001 represent projected annual species-averages computed from PCB levels in smallmouth bass and brown bullhead, area-weighted by River stretch.

Dredging assumptions: 0.1% PCB release during dredging; 2.5 ppm post-dredging PCB residual

Capping assumptions: 90% effectiveness

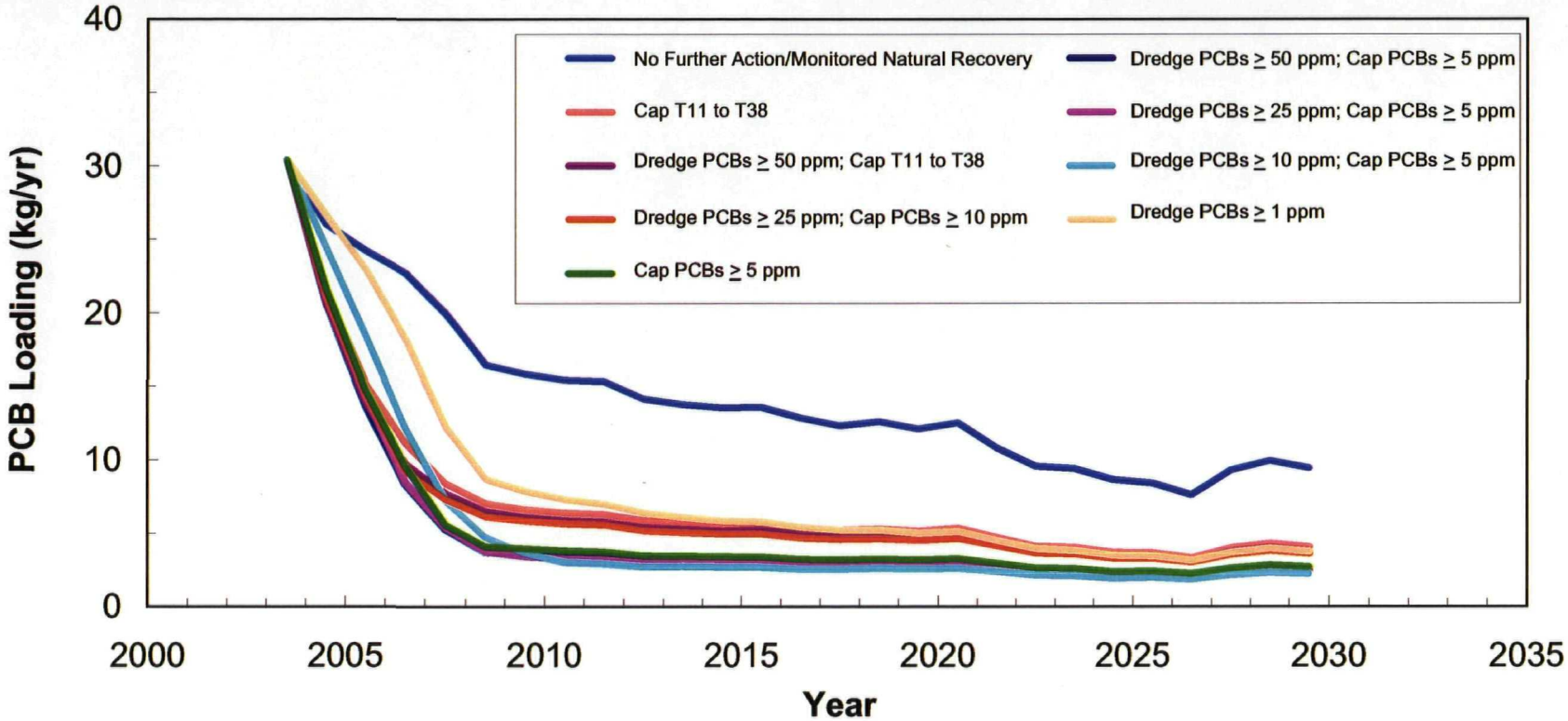

Figure 6-2. Comparison of PCB Loading to the St. Lawrence River for Each Alternative.
Values represent three-year moving averages of PCB loadings to the St. Lawrence River.
Base conditions in 2003 computed as average of PCB loadings between 2001 and 2003.
Moving averages (e.g., PCB loadings in 2006 represent the average loading between 2005 and 2007) were computed to damp the year-to-year variations associated with the fluctuations in annual river flows used in the synthetic hydrograph.
Dredging assumptions: 0.1% PCB release during dredging; 2.5 ppm post-dredging PCB residual
Capping assumptions: 90% effectiveness

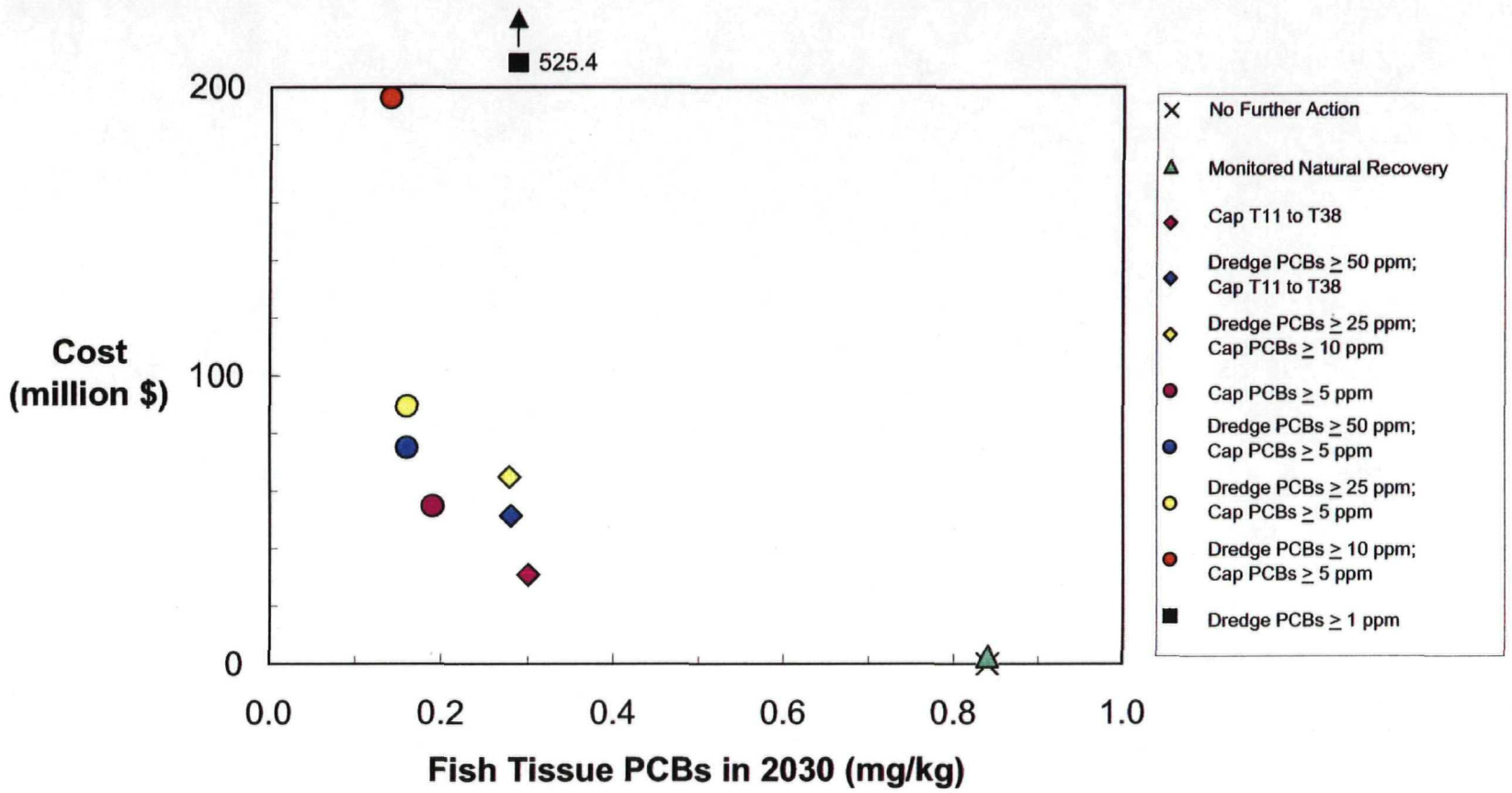

Figure 6-3. Cost of as a Function of Predicted Fish Tissue PCB Levels in 2030.

Values represent species-averages in 2030 computed from PCB levels in smallmouth bass and brown bullhead, area-weighted by River stretch.

Dredging assumptions: 0.1% PCB release during dredging; 2.5 ppm post-dredging PCB residual

Capping assumptions: 90% effectiveness

IMPACTS OF BOAT PROP-WASH ON SEDIMENT BED STABILITY IN THE GRASSE RIVER

Prepared for:

Alcoa Inc.

Massena, New York

ALCOA

June 2002

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Table A3-2. Impacts of Accelerating Boat in Shallow Water.

SECTION 1
INTRODUCTION

Turbulence will be generated in the water behind a recreational boat in the 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 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)

$$U_o = 9.72\left(\frac{P}{D}\right)^{1/3} \qquad \text{(A2-1)}$$

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 A2-1). 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 A2-1, which will be referred to as the center-line plane.

The distance between the propeller axis and the sediment bed is

$$Z = h - Z_p \tag{A2-2}$$

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

$$X_{con} = 4.71\,Z \tag{A2-3}$$

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)

$$\begin{aligned} U_b &= U_o\left(\frac{2.8D}{x}\right)e^{-15.4\left(\frac{Z}{x}\right)^2} &, \quad x \geq X_{con} \\ &= 0 &, \quad x < X_{con} \end{aligned} \tag{A2-4}$$

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 (A2-4) 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

$$X_{\max} = 5.55\,Z \qquad \text{(A2-5)}$$

where X_{max} = distance behind propeller at which maximum U_b occurs (ft). Inserting X_{max} into Equation (A2-4) yields

$$U_{b,\max} = 0.31\frac{DU_o}{Z} \qquad \text{(A2-6)}$$

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)

$$\tau_{\max} = \rho_w C_f U_{b,\max}^2 \qquad \text{(A2-7)}$$

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 (A2-7). The bottom friction coefficient for hydraulically rough flow is (van Rijn, 1993)

$$C_f = 0.24\left(\log\frac{12h}{k_s}\right)^{-2} \tag{A2-8}$$

where k_s = effective sediment bed roughness (cm). Note that water depth (h) is converted from ft to cm prior to use in Equation (A2-8). The effective bed roughness is determined from (van Rijn, 1993)

$$k_s = 3D_{90} \tag{A2-9}$$

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)

$$\varepsilon = A\left(\frac{\tau - \tau_{cr}}{\tau_{cr}}\right)^n, \quad \tau > \tau_{cr} \tag{A2-10}$$

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 Grasse River cohesive sediment). Site-specific values of A and n were determined from cohesive resuspension data collected during field studies on the 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 (A2-10), 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

$$R_{con} = \frac{\varepsilon}{3600} \qquad \text{(A2-11)}$$

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 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 (A2-11) 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

$$R = B\,e^{-Bt}\,\varepsilon \qquad \text{(A2-12)}$$

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 (A2-12) can be integrated over that time period to determine the total mass of sediment resuspended by the boat prop-wash

$$\varepsilon_{boat} = \left(1 - e^{-BT_{bed}}\right)\varepsilon_{\max} \qquad \text{(A2-13)}$$

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 (A2-10) 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

$$d_{bed} = \frac{\varepsilon_{boat}}{\rho_{bed}} \qquad \text{(A2-14)}$$

where d_{bed} = depth of bed erosion (cm) and ρ_{bed} = dry density of bed sediment (0.7 g/cm^3 for Grasse River cohesive sediment). Note that using Equation (A2-12) instead of the first-order approximation of a constant resuspension rate, i.e., Equation (A2-11), to calculate erosion rate results in greater predicted scour depths.

The time that boat prop-wash impacts the bed at a particular location is

$$T_{bed} = 0.682\frac{L_{bed}}{V_{boat}} \qquad \text{(A2-15)}$$

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 (A2-15). The velocity of a boat depends on the power applied by the motor (P, in hp) and the size of the boat (Baumeister, 1967)

$$V_{boat} = 16.3\frac{\left(PL_{boat}\right)^{1/3}}{W_{boat}} \qquad \text{(A2-16)}$$

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

$$L_{bed} = 1.68Z \tag{A2-17}$$

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 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 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 (A2-16) 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 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 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 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 A3-1). Note that in the reach of the Grasse 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, about 15% 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 A3-1. 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	15.4	0.032	0.160
5 → 7	4.2	0.002	0.011
7 → 10	7.4	< 0.001	0.003
10 → 20	63	< 0.001	0.001
> 20	10	< 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, 2001) predicted that 2,984 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 367 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

$$W_{max} = 1.25Z \tag{A3-1}$$

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 44,000 and 380,000, 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 A3-1.

The spring 1997 flood resuspended about eight 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 eight. The number of boats equivalent to the spring 1997 flood ranges between 5,400 and 47,000, 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)

$$V(t) = \left(\frac{V_{boat}}{T_{acc}}\right)t \tag{A3-2}$$

where T_{acc} = time of acceleration (10 s). Similarly, the length of bed impacted by the accelerating boat is

$$L_{acc} = \frac{1}{2} V_{boat}\, t^2 \qquad \text{(A3-3)}$$

Thus, time-variable boat velocity, from Equation (A3-2), 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

$$C_{TSS} = 32.81 \frac{\varepsilon}{h} \qquad \text{(A3-4)}$$

where C_{TSS} = TSS concentration (mg/L); ε = mass of resuspended sediment calculated using Equation (A2-10) (mg/cm^2); and h = water depth (ft). Note that a unit conversion factor (32.81) is included in Equation (A3-4).

A summary of results for case 1 and 2 boats is presented in Table A3-2. 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 A3-2. 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 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 about 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; about 15% 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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FIGURES

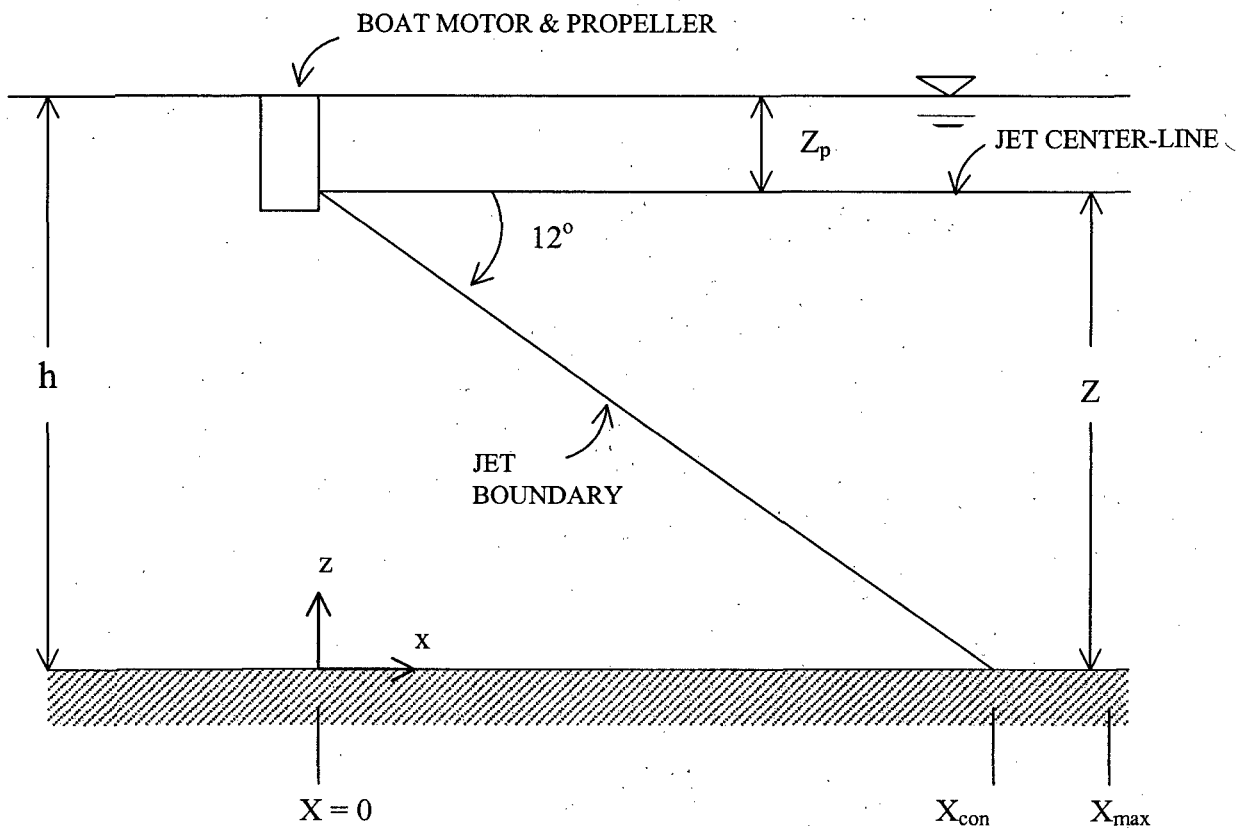

Figure A2-1. Geometry of Propeller Jet and Corresponding Nomenclature.

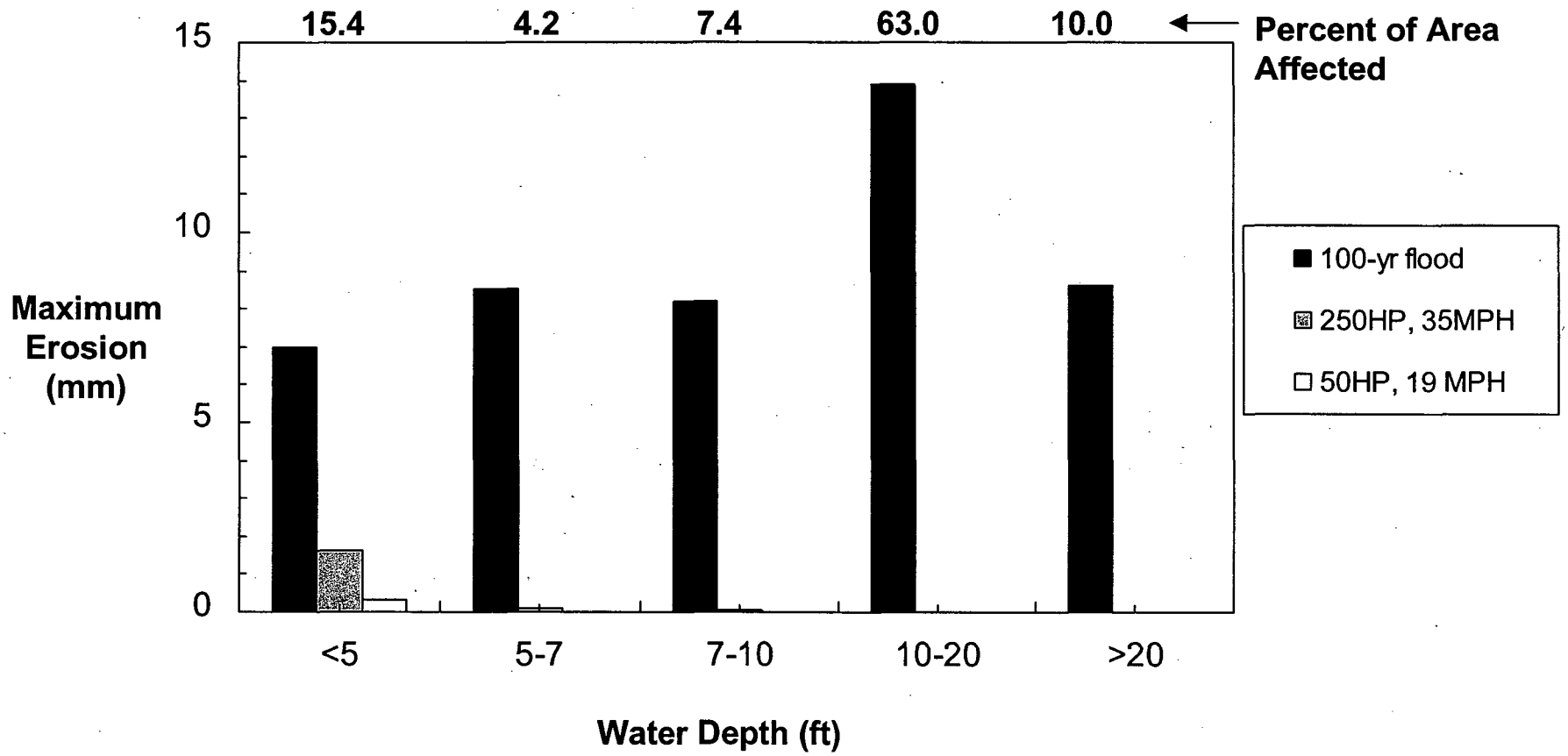

Figure A3-1. Comparison of Maximum Erosion Depths Caused by a 100-Year Flood and Boat Prop-Wash.

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.

PCB FATE IN THE LOWER GRASSE RIVER: SIMULATIONS OF FUTURE CONDITIONS

Prepared for:

Alcoa Inc.

Massena, New York

ALCOA

June 2002

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Figure B5-3. Predicted Diffusive Flux of PCB Through 6-Inch Cap to the Overlying Water Column.

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 the field sampling, laboratory experiments, data evaluation and interpretation and literature reviews that were performed during the 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 presented in the Comprehensive Characterization of the Lower Grasse River (CCLGR) Report (Alcoa, 2001b). The PCB model was developed for two reasons. First, a model, by integrating site data and the scientific knowledge of the physical, chemical and biological processes that govern PCB fate within the lower Grasse River, provides a tool to assist in data interpretation and determination of PCB fate and transport. Second, a model, if reasonably accurate, provides scientifically reliable estimates of future PCB levels. Properly constructed, a model can be used to assess, with greater confidence than any other method currently available, the potential impacts of various scenarios on downstream PCB transport and PCB levels in fish.

Since its presentation in the CCLGR Report, the model has been updated to include pertinent data that were collected during field sampling activities performed in 2001 as part of Alcoa's continued monitoring of PCBs in the lower Grasse River. These activities included:

- continuation of the 2000 Supplemental Sediment Sampling (SSS);
- routine water column monitoring;
- float survey;
- current velocity monitoring (as part of the Capping Pilot Study); and
- resident fish trend monitoring.

Details regarding these surveys are presented in the 2001 SRS Program Summary Report (Alcoa, 2002a).

This Appendix presents the updates made to the model resulting from these collection efforts 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 provides an overview of the sub-models that comprise the PCB model of the lower Grasse River, the updates made to each of the sub-models since submittal of the CCLGR Report and the updated model calibration results for each of the sub-models. Section 3 details the approach, development and assumptions used to simulate future conditions under several remedial alternatives, while the results of these simulations are provided in Section 4. Finally, Section 5 presents modeling analyses of PCB migration through a cap.

SECTION 2
MODEL UPDATES

2.1 INTRODUCTION

The model described herein was applied to the stretch of the Grasse River extending between the Massena Dam and the mouth of the River (the confluence with the St. Lawrence River; Figure B2-1). The model consists of four sub-models: hydrodynamics, sediment transport, PCB fate and PCB bioaccumulation. A bounding calculation approach was employed during calibration where conservative estimates of several model parameters were assumed. These upper bound estimates were selected such that reasonable maximum estimates of sediment erosion and reasonable minimum estimates of natural recovery were achieved. That is, this conservative approach was used to yield projected times for natural recovery that are longer than what is expected to occur and projected depths of sediment scour that are greater than what is expected.

An overview of the sub-models, updates made to each of these sub-models since the CCLGR Report and updated model calibration results for each of the sub-models are provided below. Note this re-calibration of the model was completed in summer 2001. The sub-models were not extended through 2001 due to time limitations associated with the schedule for preparation of the Analysis of Alternatives (AA) Report. Therefore, the calibration period remained the same as was used in the CCLGR (i.e., January 1997 through December 2000).

2.2 HYDRODYNAMIC SUB-MODEL

2.2.1 Overview of the Hydrodynamic Sub-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 overall downstream transport of PCBs.

2.2.2 Summary of the Hydrodynamic Sub-Model Development

A two-dimensional, vertically-averaged approach was applied to the hydrodynamic sub-model for the Grasse River. The model was discretized using 107 longitudinal and 5 lateral grid elements, for a total of 535 model grid elements for the modeled stretch (between the Massena Dam and the mouth of the River) (Figure B2-2). Of the 535 model grid elements, 460 are situated in the lower Grasse River (i.e., between the Massena Power Canal and the mouth). These model grid elements vary in size from 0.18 to 1.90 acres/element, with an overall average of 0.88 acres/element.

Bathymetric data collected in 1992 and 1996 were used to specify the water depth in the model. Due to the lack of historic flow records for the Grasse River at Massena, River flows entering from upstream were estimated from flow records from the Oswegatchie River (Alcoa, 2001b). Flow discharges from 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 events in 1997. Stage data measured in the St. Lawrence River at Cornwall near the confluence of the Grasse River were used to specify stage height at the downstream boundary of the model. Finally, upper-bound estimates of the bottom roughness coefficient and horizontal eddy viscosity were assumed during the calibration period to provide conservative estimates of bottom shear stresses and, therefore, sediment erosion.

Due to the lack of site-specific current velocity information during the calibration period, the hydrodynamic model was not calibrated. However, predicted current velocities were compared to measured and/or estimated velocities in the River for various flow conditions. These comparisons indicate that, for the range of flows evaluated, the model tends to overpredict

current velocities in the River (i.e., the model predictions are conservative). This is attributed to the use of bounding values for several model parameters, as discussed above.

2.2.3 Updates to the Hydrodynamic Sub-Model

Data collected during 2001 did not affect parameterization of the hydrodynamic sub-model. However, current velocities measured in the River during the 2001 Capping Pilot Study provide an additional data set upon which to further evaluate the accuracy of the hydrodynamic model.

As part of the 2001 Capping Pilot Study, three RD Instrument's Workhorse Series 1,200 kHz Acoustic Doppler Current Profilers (ADCPs) were deployed in the lower Grasse River to collect continuous in-situ current velocity measurements. The ADCPs were deployed on the Riverbed at equally spaced locations across sediment probing Transect T19 (at ¼, ½ and ¾ points) (Figure B2-3). The ADCPs measured current speed and direction in one-half meter increments vertically in the water column every 30 seconds. In addition to the ADCPs, two water levels recorders were placed in the River to collect water surface elevation (in 1-minute intervals). The instruments remained in the River for a four-week period (August 10 to September 10, 2001).

Current velocities were similar at the three locations during the first two weeks of deployment. However, during the second two-week period (August 24th to September 10th), current velocities measured by the ADCP deployed along the northern bank of the River were, at times, lower than those measured at the mid-channel and southern bank meters. In addition, the northern bank ADCP did not always record current reversals that were apparent in the other meters. All meters passed inspection upon retrieval (i.e., physical condition, working sensors), suggesting that meter malfunction was not the cause of the observed differences.

Typical daily profiles of water surface elevation and current velocities observed during the deployment period are presented in Figure B2-4. Water surface elevations exhibit a daily fluctuation of about 1-foot that is the result of water releases from the Robert Moses-Robert

Saunders Power Dam to meet electrical demand (Dan Parker and Cindy LaVean, New York Power Authority, personal communication, October 2001). Intermixed with the daily fluctuations are intermittent water level changes on the order of 0.15 to 0.35 feet. These smaller fluctuations are associated with flow reversals and occur 8 to 10 times per day (Figure B2-5). These smaller increases in water surface elevation are coincident with current moving upstream and are believed to be associated with the opening of the Snell Lock on the St. Lawrence Seaway near the mouth of the Grasse River (Alcoa, 2002b).

Vertically-averaged downstream current velocities measured during this one-month period averaged about 0.11 feet per second (fps) (estimated flows during this time ranged from 80 to 2,700 cubic feet per second [cfs]), with a maximum of about 0.70 fps noted on September 3rd. The intermittent flow reversals were characterized by short periods (i.e., less than 5 minutes) of upstream water velocities. Upstream velocities during these reversals averaged about 0.1 fps, with maximum vertically-averaged velocities of 0.45 fps noted during the deployment period.

Examination of the vertical distribution of current velocities indicates that maximum downstream velocities occur at the water surface and minimum downstream velocities occur at the deepest measurement point. Maximum downstream velocities of about 0.95 fps were measured at the water surface on September 3rd. During flow reversals, the opposite was true; maximum velocities were observed at depth and the lowest velocities were observed at the water surface. Maximum upstream velocities of about 0.65 fps were measured near the Riverbed on August 15th.

The current velocities measured during this one-month period were used to evaluate the accuracy of the velocities predicted by the hydrodynamic model. Because the model is a 2-D, vertically-averaged representation of the River, vertically-averaged velocities measured by the ADCPs were compared to the model results. The hydrodynamic model was not extended into 2001, therefore, direct comparisons of measured and predicted velocities were not possible. Instead, measured velocities were compared to velocities predicted by the model under matching flow conditions. For example, estimated flows during the first day of ADCP deployment (i.e., August 10th) were about 280 cfs. The velocities measured on this day were compared against

predicted velocities on days where River flows in the model were as close to 280 cfs as possible. On occasions where similar flows were specified for multiple days in the model, velocities were averaged and compared to measured values. Comparisons of observed and predicted velocities at the southern shore and mid-channel locations are presented in Figure B2-6. Comparisons of observed and predicted current velocities measured at the northern shore location were not performed due to the atypical behavior (as described above) observed in measurements obtained from this location.

For extremely low velocities (i.e., less than 0.10 fps), the hydrodynamic model predicts mid-channel current velocities that are similar to the vertically-averaged velocities measured in the River. For current velocities greater than 0.10 fps, the model predicts mid-channel current velocities that are, on average, 1.2 times higher than the measured values. At the southern shore location, the model also exhibits a consistent high bias; predicted velocities are about 2.2 times higher than the measured values. The tendency for the model to overpredict current velocities in the River is attributable to the use of bounding values for several hydrodynamic model parameters (Alcoa, 2001b). Bounding values were used to ensure conservatism in model predictions, and the comparisons to the current velocity data support that, for the range of flows observed during the monitoring period, the velocity predictions in the model are conservative.

2.3 SEDIMENT TRANSPORT SUB-MODEL

2.3.1 Overview of the Sediment Transport Sub-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 sub-model uses the output of the hydrodynamic sub-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 sub-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 sub-model.

2.3.2 Summary of the Sediment Transport Sub-Model Development

The sediment transport sub-model was developed using the same model grid as the hydrodynamic model. A two-dimensional, vertically-averaged approach was employed. Flows and current velocities predicted by the hydrodynamic sub-model served as input to the sediment transport sub-model. A sediment rating curve (i.e., TSS concentration as a function of River flow) was developed using site-specific TSS data and used to define sediment loading at the upstream boundary. TSS discharges from the plant outfalls were specified using measurements made during SPDES monitoring. The lower Grasse River bed map, which delineates areas of cohesive and non-cohesive sediments and hard bottom (i.e., rocky), was developed using visual observations recorded during sediment probing surveys conducted in the River. These data were supplemented with side scan sonar information collected in the upper stretch of the lower Grasse River (between sediment probing Transects T1 and T14). Resuspension properties of the sediments were determined through in-situ shaker and SedFlume studies performed in 1998 and 2000. Upper-bound estimates of erosion potential measured during these studies were applied in the model to provide conservative estimates of sediment scour. Sediment bulk properties were defined using data collected throughout the River.

The sediment transport sub-model was calibrated to two storm events that occurred in March and April 1998. Peak flows during these storms were about 6,900 cfs and 9,200 cfs. Predicted TSS concentrations compare well to observed values, although the model tends to slightly underpredict TSS levels during the falling limb of the second storm. Results of long-term simulations (i.e., 30 years) indicate the model predicts deposition rates that are consistent with sedimentation rates estimated from ^{210}Pb measurements (ca. 0.2 centimeters per year [cm/yr]; Alcoa, 2001b). 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 accurately describes the principal processes governing sediment transport in the lower Grasse River.

2.3.3 Updates to the Sediment Transport Sub-Model

Data collected during 2001 did not affect parameterization of the sediment transport sub-model. Because changes were not made to the sediment transport sub-model or the hydrodynamic sub-model, which provides current velocities and shear stress information as input into the sediment transport sub-model, model re-calibration was not necessary. Therefore, the calibration results for the sediment transport sub-model, as presented in the CCLGR Report and discussed above, were used as input into the PCB fate sub-model.

2.4 PCB FATE SUB-MODEL

2.4.1 Overview of the PCB Fate Sub-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 sub-model includes mechanistic descriptions of these transport, transfer and reaction processes (Figure B2-7). 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.

2.4.2 Summary of the PCB Fate Sub-Model Development

The PCB fate sub-model was developed using the same grid as was used in the hydrodynamic and sediment transport sub-models. The output from the hydrodynamic and sediment transport sub-models served as input to the fate sub-model, providing information such

as current velocities, water depths and resuspension and deposition fluxes. PCB levels entering from upstream, as well as those from plant outfalls, were determined from available site-specific information. Sediment data were used to define the physical properties of the sediment bed, as well as the initial PCB concentrations in the sediments (see Section 2.4.3). Laboratory and field data were used to define the relevant process descriptions such as partitioning and mass transfer across the sediment-water interface. Upper-bound values of the depth and intensity of particle mixing were assumed to provide minimum estimates of natural recovery. Other processes such as molecular diffusivity and volatilization were specified using values from the published literature.

2.4.3 Updates to the PCB Fate Sub-Model

Two PCB fate sub-model parameters were updated as a result of the data collection efforts performed in 2001: initial sediment PCB concentrations; and sediment total organic carbon (TOC) levels. A brief description of the sampling program and the development of these model parameters are provided below. Additional detail on the sampling program and results are provided in the 2001 SRS Program Summary Report (Alcoa, 2002a).

Sediment core and surface grab samples (0 to 3 inches) were collected from 170 locations in 2001, as part of the continuation of the 2000 SSS Program. These samples were submitted to Northeast Analytical, Inc. (NEA) and analyzed for PCB and TOC levels. The resulting data were incorporated with previously collected data and refined estimates of the average PCB and TOC levels in each sediment grid element of the model were then developed. These estimates form the initial condition in the sediments at the start of model simulations.

Initial PCB concentrations in the sediment bed were based on the integration of sediment data collected between 1991 and 2001 (Table B2-1). Although the Capping Pilot Study conducted in the summer 2001 placed clean materials over a 7-acre section of the upper stretch of the River (between sediment probing Transects T15 and T16.5), the pre-capping sediment PCB data were used to define initial PCB concentrations in the model. 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, an averaging segmentation consisting of four 3-inch layers was selected (i.e., 0-3", 3-6", 6-9", and 9-12"). For samples with a coarser segmentation, a uniform concentration was specified for the corresponding averaging layers (e.g., for a sample with a 0-6" core segment, the same concentration was specified for 0-3" and 3-6"). 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-centimeter [cm] slices throughout, the top seven slices with a weight of 1.0 and the 7-8 cm slice with a weight of 0.62 were combined to produce a single 0-3" [0-7.5 cm] average).

Table B2-1. Lower Grasse River Sediment Sampling Programs Used to Develop Initial PCB Concentrations in the Bed Model

Sampling Program	Segmentation	Approximate # Locations
1991 RSI Phase I	0 - 3 inches 3 - 12 inches	90 75
1993 RSI Phase II	Variable Surface Segment (0 - < 12 inches) 0 - > 12 inches	35 5
1995 Pre-NTCRA	Surface Cores (0-1, 1-6, 6-12 inches)	5
1995 Post-NTCRA	Variable Surface Segment (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)	110 10
2001 SSS	Surface Grabs (top 3 inches) Cores (3-inch slices)	160 10

Once the data from each unique sediment sampling location were defined for each of the four 3-inch layers, the averages were spatially assigned to corresponding model grid elements by creating concentration-based Theissen polygons and then taking an area-weighted average concentration within each model grid element for the four averaging strata (i.e., 0-3", 3-6", 6-9", and 9-12"). Maps of the Thiessen polygons for the 0 to 3-inch slices are presented in Figures B2-8 and B2-9. Similar polygons were developed for the remaining strata (3-6", 6-9" and 9-

12"). 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 1-3 were assigned the same concentration as the 0-3" average).

Initial conditions at the upstream and downstream boundaries of the model grid were not changed as a result of the data collection efforts in 2001. Therefore, grid elements upstream of the Massena Power Canal were 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 0-3" average PCB concentrations for the lower Grasse River PCB fate model grid are shown in Figures B2-10 and B2-11. Based on this polygon approach, the surface sediment PCB concentrations in the lower Grasse River average about 11 milligrams per kilogram (mg/kg). In the region between Outfall 001 (River mile [RM] 6.3) and about RM 3.3 (between sediment probing Transects T5 and T38), surface sediment PCB concentrations average about 18 mg/kg. Downstream of RM 3.3 surface sediment PCB concentrations average about 6 mg/kg. Except for several samples located between RM 1.8 and RM 1.5 (between sediment probing Transects T54 and T57), surface sediment PCB concentrations in the lower 3.3 miles of the River generally are below 10 mg/kg and decline to about 1 to 2 mg/kg near the River mouth.

Spatially-variable organic carbon values specified in the model for the sediment bed were updated using the same approach employed for initial PCB concentrations; Theissen polygons were developed for each unique sampling location and area-weighted averages for each model grid were computed. The resulting surface sediment organic carbon fraction values assigned to each model grid element are shown in Figures B2-12 and B2-13. 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. Values of f_{oc} within the middle portion of the model domain are higher, averaging approximately 5 percent (%). In the downstream-most portion of

the model grid, the surface sediment f_{oc} used in the model is typically less than 5%. The sediment f_{oc} values were temporally constant for all model simulations.

2.4.4 Updated PCB Fate Sub-Model Calibration Results

The updating of initial PCB and TOC levels for the sediment bed in the model changed calculated water column PCB levels slightly, however, re-calibration of the model was not necessary. An updated discussion of the model-data comparisons (relative to that in the CCLGR Report) is provided below.

Comparisons of predicted and measured water column PCB concentrations at water column Transects WC007, WC007A, and WC011 during 1997 through 2000 are presented in Figures B2-14 through B2-16. A seasonal cycle in concentration (i.e., minimum in winter and maximum in mid-summer), interrupted by occasional spikes associated with high flow is evident in the measured water column PCBs. The model generally reproduces this seasonal trend as well as the absolute concentrations. However, the model does overpredict water column PCB concentrations during the extreme low-flow period during late June 1997 and late August through early September period of 1997. The latter may be due to variance in the year-to-year timing of the abrupt decline in early fall water column PCB concentrations evident in the data. Although fewer data are available for 1998 through 2000 for model-data comparison, the model closely matches the observed data, again following the general seasonal trend of low winter and spring concentrations followed by a peak in mid-summer.

Model predictions also were compared to water column data collected from the Route 131 Bridge during high-flow events in early and late March 1998 (Figure B2-17). Although the data are limited, they provide some check on the relative magnitude of sediment resuspension predicted during these flow events, although uncertainty in the timing of the event and the River flows (both are based on extrapolation from the flows in the Oswegatchie River) makes paired comparisons problematic. Two samples were collected during the rising limb of the first event; the first had a PCB concentration of 142 nanograms per liter (ng/L) and PCBs were not detected (nominal detection limit of 20 ng/L) in the second. The model brackets these results, reaching a

maximum concentration of about 40 ng/L at the peak of the event. Two samples were taken during the falling limb; PCBs were not detected in either (nominal detection limit of 20 ng/L). The model predicts a declining trend during this period. Overall, 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 B2-18). PCBs generally increase from near the nominal detection limit of 20 ng/L at monitoring Transect WC004 to approximately 100 ng/L at monitoring Transect WC012, located about 5 miles downstream. The decline in PCB levels below RM 1.0 (ca. sediment probing Transect T63) is likely a result of exchange with the downstream boundary. The model accurately reproduces this pattern, as the error bars of the data generally encompass the distribution of 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 B2-19). The median ratio of model predictions to water column PCB observations was 1.0, with approximately 83 percent of the ratios between 0.5 and 2.0. These values indicate that the majority of the model predictions were within a factor of two of the field observations. As shown in Figure B2-19, all of the water column model-data comparisons are within an order-of-magnitude of each other, which indicates there are no gross over- or underpredictions of the observed data. Moreover, the normal distribution of the ratio, as indicated by the linear relations between the model-data ratio on the log probability plot, and its center (median) at the ratio of 1.0 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.

Summary

Model-data comparisons under low-flow conditions indicate the model accurately reproduces the spatial patterns exhibited by the water column PCB data. Although the data are limited, the model predicts average PCB levels that generally are consistent with those observed during the storm events that occurred in March and April 1998. Finally, comparisons of predicted and observed water column PCB concentrations suggest the model is unbiased, predicting observed water column PCB concentrations generally within a factor of two. The ability of the model to predict water column PCB concentrations during the calibration period indicates that it provides a reasonable representation of the principal processes governing PCB fate in the lower Grasse River, supporting its use in evaluating potential impacts of various remedial actions on PCB transport within the system.

2.5 PCB BIOACCUMULATION SUB-MODEL

2.5.1 Overview of the PCB Bioaccumulation Sub-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 sub-model consists of a simplified food web consisting of particulate matter, invertebrates, forage fish and predators. Empirically defined trophic transfer factors are used for calculating PCB levels in invertebrates, while a mechanistic, dynamic simulation framework is used for computing PCB levels in fish. The sub-model framework is based on the principles of conservation of mass and energy and mechanistically describes the uptake and loss of PCBs by forage and predatory 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.

2.5.2 Summary of the PCB Bioaccumulation Sub-Model Development

Bioaccumulation calculations were performed for two stretches of the River; the Upper Stretch (between sediment probing Transects T1 and T41) and the Lower Stretch (sediment probing Transect T41 to the mouth of the River) (Figure B2-20). The River was split into these two stretches because data collection and modeling efforts indicate that the majority of the PCB flux from the sediments to the water column occurs in the Upper Stretch of the River. The food web in the sub-model contains four trophic levels: particulate matter, invertebrates, forage fish and predators. Particulate matter includes water column and surface sediment particulate matter. Invertebrates are represented by two functional groups, benthic macroinvertebrates (BMI) associated with the sediment bed and phytophilous macroinvertebrates (PMI) associated with particulate matter and periphyton in contact with the water column. Forage fish are represented by two species, pumpkinseed and brown bullhead. Predators are represented by smallmouth bass.

The diet of each of the model species was based on extensive natural history information and data analyses conducted for similar food webs (Alcoa, 2001b). Bioenergetics were determined from the published literature, while body composition (i.e., dry weight fractions, lipid contents) were derived from the fish data collected in the River. Finally, dissolved and particulate PCB concentrations computed by the PCB fate sub-model were used as PCB exposures for the food web.

2.5.3 Updates to the PCB Bioaccumulation Sub-Model

Data collected during 2001 did not directly affect parameterization of the bioaccumulation sub-model. However, updates to the PCB fate sub-model result in an updated set of water column and sediment exposure concentrations for input to the bioaccumulation sub-model, necessitating re-simulation of the bioaccumulation sub-model for the calibration period. The updated exposure concentrations for the Upper and Lower Stretches are presented in Figures B2-21 and B2-22, respectively.

2.5.4 Updated PCB Bioaccumulation Sub-Model Calibration Results

Model results and data collected in the lower Grasse River were compared on an age-specific basis. Smallmouth bass were primarily ages 2 through 5 while brown bullhead were mainly ages 3, 4 and 5, based on length/weight measurements. Although the model was not extended to 2001, data collected during the 2001 Trend Monitoring Survey are similar to PCB levels predicted by the model in 2000 (Alcoa, 2002a), and are included in the figures for comparative purposes.

Results of the four-year simulation period for the Upper and Lower Stretches are presented in Figures B2-23 and B2-24, respectively. Predicted PCB levels in smallmouth bass and brown bullhead generally reproduce the levels and trends observed over the simulation period. For example, the model reproduces the increases in smallmouth bass and brown bullhead wet-weight PCB concentrations between 1998 and 1999. Although high, computed PCB levels in the Upper Stretch are within about a factor of two of the data. Similar results are observed in the Lower Stretch. Both observed and predicted PCB levels in smallmouth bass of the Lower Stretch exhibit less temporal variability than in the Upper Stretch. In addition, computed levels are within 20 to 30 percent of the Aroclor-based values. Although the computed PCB levels in brown bullhead are similar to those measured in 1997, the model underpredicts 1998, 1999 and 2000 levels by about a factor of two. This may be due to the assumption that Lower Stretch brown bullhead do not spend time in the Upper Stretch where they would be exposed to higher sediment PCB concentrations. The limited spatial variation observed in resident fish PCB levels and data collected as part of the brown bullhead marking program suggest that brown bullhead are motile and accumulate PCBs from several portions of the lower Grasse River. If the assumption of no Upper Stretch exposure is incorrect, the model will under estimate the response of these fish to remediation in the Upper Stretch and overestimate their response to remediation in the Lower Stretch. This uncertainty should be recognized in interpreting projections of remedial action effectiveness.

Model predictions are not sensitive to input assumptions related to the food web structure and sub-model parameterization; predictions of future fish PCB levels are most sensitive to

changes in exposure concentrations (predicted by the PCB fate sub-model) and the response of these fish to changes in exposure concentrations (determined from published literature). Because the bioaccumulation sub-model predicts PCB levels in fish reasonably well, it can provide reasonable projections of fish tissue PCB concentrations under natural recovery and active remediation scenarios.

SECTION 3
APPROACH AND ASSUMPTIONS USED TO SIMULATE NATURAL RECOVERY AND ACTIVE REMEDIATION

3.1 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 and the effects of active remediation, including in-place containment (i.e., capping) and sediment removal (i.e., dredging). These forecasts were made using assumptions about future River flow, solids loading, PCB loading, geomorphology and the structure and function of the food web. These assumptions were made based on site-specific data, laboratory studies, field studies and published literature. The conservative estimates assigned to several model parameters during model calibration were carried forward and applied to the model projections to provide a conservative analysis of predicted future conditions under the natural recovery scenario. In addition, conservative assumptions regarding several model parameters required to simulate remediation in the River also were specified. The decision to use conservative assumptions was a response to requests that were made by the United States Environmental Protection Agency (USEPA), the New York State Department of Environmental Conservation (NYSDEC) and the Saint Regis Mohawk Tribe (SRMT) (collectively referred to as the Agencies). Some of these assumptions are not consistent with data from the Grasse River and/or other sites. Of particular significance are the rate of natural recovery, assumptions associated with dredging effectiveness (i.e., PCB releases during dredging and the ability of dredging to achieve low post-dredging residual PCB concentrations in the surface sediments), and capping effectiveness. The fact that natural recovery may be faster than is indicated by the model, dredging may be less effective than is indicated by the model, and capping may be more effective than is indicated in the model need to be considered in evaluating the projections presented in this Appendix.

This section describes the approach, development and assumptions used in each sub-model to simulate future conditions in the River. It also presents analyses performed to evaluate

the sensitivity of model predictions to assumptions made regarding remedial alternative effectiveness.

3.2 HYDRODYNAMIC SUB-MODEL

The 30-year projection simulations required the development of synthetic hydrographs to specify discharge at the upstream boundary of the Study Area. A time series of flows was generated based upon 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 application of the daily hydrograph from the year in the historical record whose annual average most closely matched the generated value. This procedure was used to produce a 30-year daily synthetic hydrograph.

Historical United States Geological Survey (USGS) flow rate data collected at the Pyrites gaging station were used to develop the synthetic hydrograph. Flow data were collected at the Pyrites gaging station from 1925 through 1976. Prorating of drainage areas was used to estimate the discharge at Massena from the Pyrites flow data. The drainage area increases from 333 square miles at Pyrites to 606 square miles at Massena, so Pyrites flows were adjusted to account for these differences as follows (FEMA, 1980):

$$Q_M = Q_P \left[\frac{DA_M}{DA_P} \right]^{0.96} \qquad \text{(B3-1)}$$

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)
DA_P	=	drainage area of the Grasse River at Pyrites (L^2).

The 52-year record of calculated annual-average flow rates at Massena was used to generate the synthetic hydrograph needed for projection simulations. 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):

$$Q_n = Q_{mean} + R_a\left(Q_{n-1} - Q_{mean}\right) + t_n S_a\left(1 - R_a^2\right)^{1/2} \qquad \text{(B3-2)}$$

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
t_n	=	normally distributed, serially independent random variable with zero mean and unit standard deviation.

Equation B3-2 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 52-year record of annual average flow rates yielded values for Q_{mean}, S_a and R_a that were used in Equation B3-2. A random number generator was used to specify t_n in year n. A synthetic hydrograph was generated using Equation B3-2 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). The projection simulation was to start in 2001, so it was desired that the synthetic hydrograph represent an extension of conditions observed in 2000. A random number was used to specify the year at which to begin analyzing the synthetic hydrograph. Starting from this year (year 321), the next year with an annual average discharge closely corresponding to the observed annual average for 2000 (1,332 cfs) was identified. It was found that year 374 was within 0.6 percent of the 2000 annual-average discharge. Thus, the following year in the synthetic hydrograph (year 375) was chosen as the first year of the projection hydrograph, which extended from years 375 through 404. Figure B3-1 shows the generated synthetic hydrograph together with estimated historical

flows at Massena. The resulting synthetic hydrograph is seen to be a realistic extension of the observed hydrograph.

The synthetic hydrograph described above produced a time-series of annual-average flow rates. However, model input requires specification of daily-average flow rates. The estimated historical record at Massena, with 52 years of measured daily discharge, 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 52-year 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 1-5 days before January 1 to 1-5 days after that date, depending upon the degree of the discontinuity. The 30-year hydrograph resulting from this process, and used in projection simulations, is shown in Figure B3-2. It was assumed that the projection simulation began on January 1, 2001.

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, 2001b), 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 B3-3.

The values assigned to other model parameters during calibration, including the upper-bound estimates of bottom roughness coefficient and horizontal eddy viscosity, were carried forward and applied to the model projections.

3.3 SEDIMENT TRANSPORT SUB-MODEL

Future solids loading from the upstream boundary of the Study Area was calculated using the generated time series of daily River flow and the suspended solids rating curve developed from the historical record of TSS and River flow (Alcoa, 2001b). Composition of the incoming sediment load was specified using a flow-dependent relation (Alcoa, 2001b). Annual sediment loading to the lower Grasse River during the 30-year projection period is presented in Figure B3-4. Solids loading from each of the plant outfalls was based on the assumption that TSS levels in Outfalls 001, 004 and 007 were half the detection limit (detection limit equal to 1.4 mg/L). 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.

3.4 PCB FATE SUB-MODEL

Several model parameters required specification in order to simulate future conditions in the River, including boundary and initial conditions, external PCB loadings to the River and assumptions regarding the nature and effectiveness of each potential remedial process option (i.e., natural recovery, capping and dredging). A discussion of these assumptions is provided below. The values assigned to other model parameters during calibration, including the upper-bound estimates of depth and intensity of particle mixing in the sediments, were carried forward and applied to the model projections.

3.4.1 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.

Boundary conditions for the PCB fate model projections were the same as those specified for the calibration period. To maintain continuity between the calibration and projection simulations, initial water column and sediment PCB concentrations for the future PCB fate and transport simulations were defined by the model results at the end of the calibration period.

3.4.2 External PCB Loading

PCBs enter the lower Grasse River from the upstream boundary and the Alcoa plant site outfalls. The PCB level in the water entering from upstream is on the order of 1 ng/L, suggesting that precipitation is the predominant source of PCBs (Alcoa, 2001b). Trends observed in PCB levels in Great Lakes region precipitation (Simcik et al., 2000), suggest that regional levels are declining. The rate of decline is uncertain but is approximately exponential with a half-life of about 5 years. The importance of this uncertainty was assessed by comparing 30-year predictions in which the upstream boundary PCB concentration remained constant at 1 ng/L or declined exponentially from 1 ng/L at a half-life of 5 years. These simulations indicated that the

assumption regarding the upstream boundary PCB concentration has little effect on water column and fish tissue PCB levels over the 30-year simulation period. For example, assuming a constant PCB concentration of 1 ng/L at the upstream boundary results in an average PCB loading to the St. Lawrence River that is about 5% higher than if PCB levels were assumed to decline over time. Less of an impact is observed in the fish PCB predictions; average fish tissue PCB levels differ by less than 1% over the simulation period. Therefore, the conservative assumption of a constant upstream boundary PCB concentration of 1 ng/L was specified in the model projections.

The importance of uncertainty in future PCB loads from Outfalls 001, 004 and 007 also was evaluated through a sensitivity analysis. Two simulations were performed: one with zero PCB discharge from plant outfalls and one with PCBs set equal to half the detection limit (detection limit equal to 65 ng/L). Results indicate differences in both average water column and average fish tissue PCB predictions of about 1 to 2%. Therefore, the assumption of PCBs equal to half the detection limit was assumed for model projections. As described above, Outfall 005 was not included in the model projections.

3.4.3 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.

Remediation was assumed to begin in May 2004. Remediation rates for engineered capping (420,000 square feet per month [ft^2/mo]), capping (450,000 ft^2/mo) and dredging (1,250 – 1,300 cubic yards per day [cy/day], depending on the size of the program) 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. It was assumed for these schedules that remediation occurs in an upstream-to-downstream progression with no overlap between capping and dredging operations. Remediation schedules were discretized over time in the model according to when remediation would be completed in each group of model grid elements. For capping, the time remediation was completed 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 (e.g., ft^2/mo), and the surface area of the model elements targeted for capping. For dredging, the time remediation was completed 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 (e.g., cy/day), and the volume of soft sediments targeted for removal. An example model remediation schedule, depicting the progression of model grid element completion over time, is shown for Alternative 4 in Figure B3-5.

3.4.4 Capping Assumptions

Cap Design

In accordance with the design guidance set forth by the USEPA (Palermo et al., September 1998) and 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 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, 2001a). 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[1] (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 A). 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 (Federal Emergency Management Agency [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. 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 B). 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.

PCB Resuspension During Capping

PCB releases during capping were based on results of the Capping Pilot Study conducted in the Grasse River in 2001. Extensive water column monitoring of PCB, TSS and turbidity levels during the study showed that water quality impacts associated with capping were minimal. Average PCB levels measured inside and adjacent to the capping area during implementation

[1] 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.

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, 2002b).

Capping Effectiveness

Capping effectiveness is defined by two components: 1) the ability to obtain the areal coverage of the targeted capping 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 Capping Pilot Study in the Grasse River.

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 video taping. Details regarding these measurement techniques are provided in the Grasse River Capping Pilot Study Documentation Report (Alcoa, 2002b). 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, except for the steep side slopes where only a few inches of material remained after placement. 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, 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. 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 part per million (ppm) (except for one sample at 1.51 ppm), and were almost exclusively

seen at the interval immediately above the native sediments. These data suggest a typical cap/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, 2002b).

Representation of Capping in the Model

Although results of the Capping Pilot Study indicate a capping effectiveness in excess of 90%, a conservative value of 90% was assumed in an attempt to consider the difficulties in capping of side slopes. 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 10% of the surface sediment (0 to 3 inches) PCB concentration prior to capping. For example, if a model element targeted for capping contained a surface sediment PCB concentration of 10 ppm, capping was simulated by assigning each of the 12 new 1-inch layers a PCB concentration of 1 ppm. 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.

PCB release during capping was assumed to be negligible (i.e., set equal to zero), based on results of the Capping Pilot Study. Finally, the cap material was assumed to possess the same physical properties as the native sediment (i.e., bulk density and erosion potential).

3.4.5 Engineered Capping Assumptions

An engineered cap would consist of a 6-inch layer of 1- to 1.5-inch diameter gravel overlain on 18 inches of unwashed run-of-bank (ROB) material containing a wide variety of particles sizes. In the model, engineered capping was simulated in the same manner as capping (no PCB releases during application, 90% effectiveness, and the engineered cap maintained the same physical properties of the native sediments). The only difference between capping and engineered capping in the model was the rate at which each of these caps were placed (see Section 3.4.3 of this Appendix).

3.4.6 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 Grasse River and other sites 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. At the request of the Agencies, a PCB release rate during dredging of 0.1% of the targeted PCB mass was assumed in the model projections.

Alcoa conducted a Non-Time-Critical Removal Action (NTCRA) between July and September 1995 in the Grasse River and removed approximately 2,600 cubic yards (cy) of PCB-laden sediments (and approximately 400 cy of boulder/debris) in the vicinity of its plant discharge at Outfall 001. Approximately 7,800 pounds (lbs) of PCB mass were removed during the dredging operations. Water column monitoring during the dredging operations consisted of TSS, turbidity and PCB measurements upstream of, adjacent to and downstream of the dredging area. Increased PCB levels were observed at the adjacent and downstream sampling locations during the dredging activities, although correlations with TSS and turbidity measurements were not apparent. Based on the water column data collected during these construction activities, it was estimated that between 5 and 30 pounds of PCBs escaped from the dredging area, despite the use of a double-, and sometimes triple-, tiered containment system (BBL, 1995b). This loss represents about 0.1% of the PCB mass removed from the River.

Data from other dredging projects[2] during dredging typically range between 2% and 10% of the total PCB mass removed, which indicates there is some uncertainty in release rates that

[2] Fox River SMU 56/57 (QEA et. al, 2001; Montgomery Watson, 2000; BBL, 1999); Fox River Deposit N (FRRAT, 2000); Manistique River and Harbor (Thibodeaux, 2000).

would actually be observed during dredging. In order to understand the effect of this uncertainty, sensitivity runs were conducted on this parameter (see Section 3.4.7).

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. At the request of the Agencies, a post-dredging sediment PCB concentration of 2.5 ppm was assumed in the model projections.

A number of dredging remediation projects for PCB-contaminated sediments have been completed in the United States, including the NTCRA on the Grasse River. Post-dredging residual concentrations achieved as a result of these efforts have been highly variable, with the average post-dredging PCB concentrations ranging from 9 to 75 ppm[3]. For the NTCRA, the average post-dredging PCB residual was 75 ppm. Due to the uncertainty associated with post-dredging residual PCB concentrations, a sensitivity analysis was conducted for this parameter (see Section 3.4.7).

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. One exception to this is Alternative 10, where dredging of sediments with surface PCB concentrations greater than or equal to 1 ppm would not be followed by capping.

[3] Fox River SMU 56/57 (11 subunits; BBL, 2000); Fox River Deposit N (Foth & Van Dyke, 2000); Manistique Harbor – Area D (Fox River Group, 2000; USEPA, 2000); St. Lawrence River – GM, Massena (BBLES, 1996); River Rasin (Metcalf & Eddy, 1998); Sheboygan River (BBL, 1995a).

3.4.7 Sensitivity of Model Predictions to Dredging Assumptions

At the request of the Agencies, values of 0.1% for PCB release during dredging and 2.5 ppm for post-dredging sediment PCB concentration were specified for the model projections. To the extent that these conditions are not achieved, the benefits of dredging would be less than predicted by the model. This issue was explored by assessing the sensitivity of the model predictions to various input assumptions including PCB release during dredging and post-dredging PCB concentration. Average fish tissue and water column PCB concentrations were used as the basis of comparison: 1) average PCB levels from start of remediation through the end of the simulation (to assess short-term impacts); and 2) average PCB levels at the end of the simulation (i.e., in 2030; to evaluate longer-term impacts).

Sensitivity of Model Predictions to Assumption of PCB Releases During Dredging

Figures B3-7 and B3-8 display temporal profiles of average water column and fish tissue PCB concentrations for scenarios in which 0.1% or 2.5% of the targeted PCBs are released during dredging. For the dredge sediments with surface PCBs greater than or equal to 1 ppm remedial action (dredge ≥ 1 ppm), an increase in PCB release during dredging from 0.1% to 2.5% results in short-term increases in average water column and fish tissue PCB concentrations by about a factor of 2.5 and 5.0, respectively (Figure B3-9). These increased PCB levels persist for the duration of the dredging program and result in long-term (i.e., between 2004 and 2030) average water column and fish tissue PCB levels that are about 1.6 and 2.8 times higher, respectively, than those predicted assuming a 0.1% PCB release (Figure B3-9). Increases in PCB levels also are predicted for those alternatives with dredging of sediments with surface PCBs greater than or equal to 10 ppm (dredge ≥ 10 ppm). Short-term increases are similar to those observed in the dredge ≥ 1 ppm alternative, but increases in long-term (i.e., between 2004 and 2030) average PCB levels are not as great (factor of 1.5 in water and 2.2 in fish; Figure B3-9). These simulations indicate the effects of PCB releases during dredging diminish as the magnitude of the dredging program is reduced. In some cases, as illustrated in Figure B3-10, the potential benefits of a remedial alternative can be reduced as a result of the PCB releases during dredging. In all cases, these impacts are evident for the duration of the dredging program,

however, the effects dissipate over time and by 2030 PCB levels are similar, regardless of the assumed PCB release.

Sensitivity of Model Predictions to Assumption of Residual PCB Concentrations in Sediments

Figures B3-11 and B3-12 display temporal profiles of average water column and fish tissue PCB concentrations for two dredging programs (dredge ≥ 1 ppm and dredge ≥ 10 ppm), assuming post-dredging sediment PCB concentrations of 2.5 ppm and 10 ppm. These results indicate that the assumption of post-dredging sediment PCB concentration has both short-term and long-term effects on average water column and fish tissue PCB concentrations. For the dredge ≥ 1 ppm scenario with a 10 ppm post-dredging PCB sediment concentration, average water column and fish tissue PCB levels are about 2.5 times higher than those predicted assuming a 2.5 ppm post-dredging residual (Figure B3-13). By 2030, predicted PCB levels are 3 to 3.5 times higher under the assumption of a 10 ppm PCB residual (Figure B3-14). Similar trends are observed for the dredge ≥ 10 ppm scenario, although increases in PCB levels are not as great, indicating that predicted the effects of this assumption diminish as the magnitude of the dredging program is reduced. In fact, little difference is observed in the dredge ≥ 25 ppm scenario (results not shown), due to the limited size of this scenario. Note that, except for Alternative 10 (dredge ≥ 1 ppm), it is assumed that dredged areas are subsequently remediated by capping, and thus, the associated effects of the post-dredging PCB residual assumption will be less than that presented above.

Summary

At the request of the Agencies, assumptions for PCB releases during dredging (0.1% of the PCB mass removed) and post-dredging PCB residual (2.5 ppm) were specified in the model projections. Results of the sensitivity analyses indicate that the model predictions are influenced by these assumptions. The use of these values in the model projections may underestimate actual PCB levels and risks experienced in the field, and thus, overestimate the predicted benefits of the alternatives evaluated in this AA Report. Site-specific information indicates the presence of boulders and cobbles in portions of the River, bedrock and/or hardpan under the PCB-containing

sediments, and higher PCB levels with depth; factors that can adversely impact the ability to achieve low post-dredging PCB residuals. To account for the potential for elevated PCB residuals in sediments after dredging, it was assumed for most alternatives with a dredging component that dredged areas are subsequently remediated by capping and, thus, the associated effects of the post-dredging PCB residual assumption are moderated. Nonetheless, these uncertainties require consideration during the evaluation of the model projections, especially when attempting to distinguish alternatives based on relatively small differences in both projected fish tissue PCB levels and the time predicted to achieve these levels.

3.5 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 between 1997 and 2000 were used. Values of 1.3 and 2.4 percent were applied to smallmouth bass and brown bullhead, respectively. For pumpkinseed, an average lipid content of 3.5 percent 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.

SECTION 4
PREDICTIONS OF NATURAL RECOVERY AND THE EFFECTIVENESS OF ACTIVE REMEDIATION

4.1 INTRODUCTION

This section presents the results of the model projections of natural recovery and active remediation in the lower Grasse River. A sediment mass balance of the 30-year projection period is presented in Section 4.2. The 17 potential remedial alternatives (10 carried into the detailed analysis of alternatives) evaluated using the PCB fate and bioaccumulation sub-models are listed in Section 4.3, while the results of the model projections are presented in Section 4.4.

4.2 PREDICTIONS OF FUTURE SOLIDS LOADINGS

A sediment mass balance on the lower Grasse River over the 30-year projection period is presented in Figure B4-1. The net mass deposited in the lower Grasse River during the 30-year projection was 47,240 metric tons (MT), which corresponds to a trapping efficiency of about 20%. This is significantly higher than the trapping efficiency calculated during the 4-year simulation (about 13%). The average sedimentation rate in the cohesive areas of the lower Grasse River was higher for the 30-year projection period than during the 4-year simulation period, increasing from 0.10 cm/yr to 0.15 cm/yr, which is more consistent with those estimated from ^{210}Pb measurements (Alcoa, 2001b). The most likely explanation for the increase in average sedimentation rate during the 30-year projection period is that the 4-year simulation was a relatively short simulation during which a 100-year flood occurred. Therefore, it is reasonable to assume that the 30-year projection is a better indicator of model predicted long-term deposition patterns. The predicted spatial distribution of net deposition for the 30-year projection is presented in Figures B4-2 and B4-3.

4.3 SIMULATION OF REMEDIAL ACTIONS

The projected impacts of remediation on downstream PCB transport and PCB levels in fish were predicted for 17 potential remedial alternatives, including:

- Alternative 1 - No Further Action;
- Alternative 2 - Monitored Natural Recovery;
- Alternative 3 - Cap sediments between probing Transects T11 and T38, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;
- Alternative 4 - Dredge River areas with surface sediment PCB concentrations ≥ 50 ppm, cap sediments between probing Transects T11 and T38, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;
- Alternative 5 - Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm, cap sediments with surface PCB concentrations ≥ 10 ppm, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;
- Alternative 6 - Cap sediments with surface PCB concentrations ≥ 5 ppm, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;
- Alternative 7 - Dredge River areas with surface sediment PCB concentrations ≥ 50 ppm, cap sediments with surface PCB concentrations ≥ 5 ppm, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;
- Alternative 8 - Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm, cap sediments with surface PCB concentrations ≥ 5 ppm, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;

- Alternative 9 - Dredge River areas with surface sediment PCB concentrations ≥ 10 ppm, cap sediments with surface PCB concentrations ≥ 5 ppm, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery;

- Alternative 10 - Dredge River areas with surface sediments PCB concentrations ≥ 1 ppm, and site-wide natural recovery;

- Alternative 11 - Cap sediments with surface PCB concentrations ≥ 10 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery;

- Alternative 12 - Cap sediments with surface PCB concentrations ≥ 1 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery;

- Alternative 13 - Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm and site-wide natural recovery;

- Alternative 14 - Dredge River areas with surface sediment PCB concentrations ≥ 10 ppm and site-wide natural recovery;

- Alternative 15 - Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm, cap dredged areas, and site-wide natural recovery;

- Alternative 16 - Dredge River areas with surface sediment PCB concentrations ≥ 50 ppm, cap sediments with surface PCB concentrations ≥ 10 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery; and

- Alternative 17 - Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm, cap sediments between probing Transects T11 and T38, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery.

Alternatives 1 and 2 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 17, active remediation (i.e., capping, dredging or both) was simulated.

A preliminary screening of these alternatives was accomplished through a series of technical discussions between Alcoa and the Agencies. Based on these discussions, Alternatives 1 through 10 were included in the detailed analysis of alternatives presented in Section 5 of the main body of the AA Report. Areas of the River addressed under each of these alternatives are presented in Figures B4-4 through B4-12. Results of the model projections for each of these 10 alternatives are discussed in detail below (Section 4.4). Results of the seven alternatives eliminated during this preliminary screening evaluation are presented in Section 4.5.

4.4 PREDICTIONS OF PCB FATE, TRANSPORT AND BIOACCUMULATION

Model predictions of PCB concentrations in water 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 and River-wide average fish tissue PCB concentration[4]. Long-term average PCB levels (i.e., 27-year average between the start of remediation and the end of the simulation) and average PCB levels at the end of the simulation (i.e., 2030) were examined. In addition, three metrics were selected to evaluate the long-term effectiveness and permanence provided by each potential remedy: the times needed to achieve 75 and 90 percent reductions in River-wide average fish PCB concentrations[5] and the time needed to achieve an 85 percent reduction in PCB loading to the St. Lawrence River[6]. The 75 percent reduction provides an indication of the near-term rate of decline (i.e., less than ten years) while the 90 percent reductions provides a longer-term average rates of decline in fish tissue PCBs. The 85 percent

[4] River-wide average fish tissue PCB concentrations are computed in two steps. First, two species averages are computed, one for each model stretch (i.e., Upper Stretch [T1-T41] and Lower Stretch [T41 – T72]). These species averages represent the arithmetic average of PCB concentrations in smallmouth bass and brown bullhead. Second, the River-wide average is computed as the average of the two species averages, area-weighted by model stretch.

[5] Base condition represents river-wide average fish tissue PCB concentration predicted in last full year prior to start of remediation (3.8 ppm in 2003).

[6] Three-year moving averages of the PCB loading to the St. Lawrence River were computed (e.g., PCB loadings in 2006 represent the average loading between 2005 and 2007). This was performed to reduce the year-to-year variations associated with the fluctuations in annual river flows used in the synthetic hydrograph. Base condition represents the average PCB loading prior to start of remediation (i.e., between 2001 and 2003).

reduction for the PCB loading to the St. Lawrence River was selected as a long-term indicator because the 90 percent reduction values exhibited large differences in outcomes due to the shallow slopes of the predicted PCB loading at this level, even when absolute differences between alternatives were not significant (i.e., an average difference of 0.3 ng/L between alternatives could results in up to a 8-year difference in time required to achieve this metric).

4.4.1 Predicted Fish Tissue PCB Levels and PCB Loading to the St. Lawrence River

Predicted River-wide average fish tissue PCB levels for each of the 10 alternatives considered in the detailed analysis are compared to current conditions (i.e., average PCB concentration of 6.5 mg/kg computed from 2000 Trend Monitoring Program data) in Table B4-1 and Figure B4-13. Results indicate all modeled alternatives reduce average fish tissue PCB levels from the current conditions and that, in general, reductions in PCB levels increase with the size of the remedial program. For example, River-wide average fish tissue PCB levels predicted in 2030 for Alternatives 3 and 6 (in increasing order of targeted areas for capping) are 0.30 and 0.19 mg/kg, respectively. An exception to this trend is Alternative 10 (dredge sediments with surface PCBs ≥ 1 ppm), where average fish tissue PCB levels in 2030 (ca. 0.28 mg/kg) are similar to those predicted when a smaller portion of the River sediment is capped (Alternative 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 sediments that remain in the River after dredging is complete. Similar trends are observed in other metrics (i.e., 27-year average fish tissue PCB levels, 27-year average PCB loading to the St. Lawrence River and predicted PCB loading to the St. Lawrence River in 2030 [Figures B4-13 and B4-14]).

Model results indicate the addition of dredging components to the capping alternatives results in only small incremental reductions in PCB loading and fish tissue PCB levels. For example, fish tissue PCB levels in 2030 for Alternative 6 (cap sediments with surface PCBs ≥ 5 ppm) are predicted to be about 0.19 mg/kg. The addition of dredging components in Alternatives 7 and 8 (dredge sediments with surface PCBs ≥ 50 ppm and 25 ppm, respectively) results in only a minor reduction in fish tissue PCBs (to about 0.16 mg/kg). The addition of a larger dredging component (Alternative 9, dredge sediments with surface PCBs ≥ 10 ppm) only

reduces average fish tissue levels in 2030 by about 0.05 mg/kg (to about 0.14 mg/kg). These incremental benefits are small because the reductions in surface 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. It is also important to note that these small incremental reductions in PCB loading and fish tissue PCB levels are predicted using a conservative set of assumptions regarding dredging effectiveness. If dredging is less effective than is indicated by the model, these incremental benefits could be reduced or eliminated. Therefore, these factors need to be considered when evaluating these model predictions.

4.4.2 Rate Reduction Metrics

The times to reach the 75% and 90% reductions in fish tissue PCBs and 85% reductions in PCB loading to the St. Lawrence River for the 10 alternatives considered in the detailed analysis are presented in Table B4-2. For Monitored Natural Recovery, the model predicts a 75% reduction in River-wide average fish tissue PCB concentrations (from projected 2003 levels)[7] in about 25 years, while a 90% reduction is predicted to take more than 27 years. A reduction of 85% (from average levels projected for 2001 to 2003)[7] in PCB loading to the St. Lawrence River is anticipated to require more than 25 years. Capping River sediments accelerates these reductions. The model predicts that Alternative 3 will provide a 75% reduction in River-wide average fish tissue PCB concentration in about 6 years and a 90% reduction in about 24 years; achieving an 85% reduction in PCB loading to the St. Lawrence River is anticipated to take 19 years. For Alternative 6, which address a larger surface area of the River bottom, a 75% reduction in River-wide average fish tissue PCB concentration is predicted to occur in about 4 years and a 90% reduction in about 11 years. An 85% reduction in PCB loading to the St. Lawrence River is predicted to take about 5 years under this alternative.

[7] Base conditions for fish tissue (2003) and PCB load to the St. Lawrence River (2001 to 2003) were selected so that the reductions associated with implementation of each alternative could be properly compared to other alternatives. Rates of decline from current conditions (i.e., 2000) would have included reductions associated with natural recovery processes predicted to occur prior to commencement of remediation in 2004.

Similar to the predicted PCB levels in water and fish tissue discussed above, little difference is observed between capping and combination alternatives (i.e., dredge plus cap alternatives) in the predicted times to reach the 75% and 90% reductions in River-wide average fish tissue PCB concentrations and the 85% reduction in PCB loading to the St. Lawrence River. For example, the addition of dredging components to Alternative 3 accelerates the times needed to reach the 85% reduction in PCB loading to the St. Lawrence by 1 year and 75% and 90% reductions in fish tissue PCB levels by only 1 and 2 years, respectively. The addition of dredging components to Alternative 6 (dredge sediments with surface PCBs ≥ 50 ppm [Alternative 7] and 25 ppm [Alternative 8]) is predicted to require the same time to achieve the 75% reduction in fish tissue PCBs and 85% reduction in PCB load to the St. Lawrence River; the time to reach the 90% reduction in fish tissue PCBs is accelerated by about 3 years. In fact, the addition of a larger dredging component (Alternative 9, dredge sediments with surface PCBs ≥ 10 ppm) results in a longer timeframe needed to achieve the 75% reduction in fish tissue PCBs and 85% reduction in PCB load to the St. Lawrence River. The small incremental benefits associated with the addition of dredging components to the cap-only alternatives indicate dredging does not significantly affect the time needed to achieve these reduction metrics because the reductions in surface sediment PCB exposure levels are being controlled by the placement of a cap over the dredged areas. In addition, if dredging is less effective than is indicated by the model, these incremental benefits could be reduced or eliminated.

4.4.3 Temporal Profiles of PCBs in Water, Sediment and Fish

Temporal profiles of PCB levels in water, sediment and fish are presented for each of the 10 alternatives considered in the detailed analysis in Figures B4-15 through B4-32. 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, average surface (0-3 inch) sediment PCB concentrations, area-weighted for lower Grasse River model elements, 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 each modeled stretch (i.e., Upper Stretch and Lower Stretch) and the entire lower River.

4.5 ALTERNATIVES ELIMINATED DURING PRELIMINARY SCREENING EVALUATION

Seven of the 17 potential alternatives evaluated for the lower Grasse River were eliminated during the initial screening that took place during technical discussions between Alcoa and the Agencies. Specifically, Alternatives 11 through 17 were eliminated due to: 1) similarity in scope and effectiveness of alternatives that were selected to undergo detailed analysis; 2) concerns about remedy effectiveness; or 3) implementation-related concerns. The technical justifications for eliminating these alternatives from further consideration are presented below. Model projection results for these seven alternatives are provided in Tables B4-3 and B4-4.

Alternative Number	Alternative Description	Reason for Elimination
11	Cap sediments with surface PCB concentrations ≥ 10 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery	Similar in scope and effectiveness to Alternative #3
12	Cap sediments with surface PCB concentrations ≥ 1 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery	Remedy implementation concerns
13	Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm and site-wide natural recovery	Remedy effectiveness concerns
14	Dredge River areas with surface sediment PCB concentrations ≥ 10 ppm and site-wide natural recovery	Remedy effectiveness concerns
15	Dredge River areas with surface sediment PCB concentrations ≥ 25 ppm, cap dredged areas, and site-wide natural recovery	Remedy effectiveness concerns
16	Dredge River areas with surface sediment PCB concentrations ≥ 50 ppm, cap sediments with surface PCB concentrations ≥ 10 ppm, engineered cap near Outfalls 001 and 004, and site-wide natural recovery	Similar in scope and effectiveness to Alternative #4
17	Dredge River areas with surface PCB concentrations ≥ 25 ppm, cap sediments between probing Transects T11 and T38, engineered cap sediments near Outfalls 001 and 004, and site-wide natural recovery	Similar in scope and effectiveness to Alternative #5

SECTION 5
CAP MODELING STUDIES

5.1 INTRODUCTION

The potential long-term effectiveness of capping was evaluated through the application of a one-dimensional (1-D) transport model of the sediment bed and overlying cap. This model simulates processes within the sediment bed and overlying cap such as sorption, sedimentation, chemical dispersion, molecular diffusion, and advection to determine if capping would prevent PCBs from the underlying sediment from migrating into the water column. These processes are mechanistically described and parameterized using site-specific data collected from the lower Grasse River. This section presents the theory, parameterization, and results of the 1-D transport model.

5.2 MODEL THEORY

The transport of PCBs within the sediment bed is described using Equation B5-1. The first term represents the dispersive flux of total chemical (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 last term represents the net sedimentation of solids onto the sediment bed. Data collected from the lower Grasse River suggest pore water advection is not a significant transport mechanism within the sediment bed (Alcoa, 2001b) and, therefore, was not included.

$$\frac{\partial C_T}{\partial t} = \frac{\partial}{\partial z}\left(E_{disp}\frac{\partial C_T}{\partial z}\right) + \frac{\partial}{\partial z}\left[D_s\frac{\partial C_d}{\partial z}\right] - \frac{\partial u_z C_T}{\partial z} \qquad \text{(B5-1)}$$

where:

C_T = total PCB concentration (sediment and pore water) (mg/L)

t = time of simulation (days)

z	=	segment depth (cm)
E_{disp}	=	dispersion coefficient (cm^2/sec)
D_s	=	molecular diffusion coefficient (cm^2/day)
C_d	=	dissolved PCB concentration (pore water only) (mg/L)
u_z	=	sedimentation rate (cm/year)

In solving this equation, the dissolved phase PCB concentrations were computed as the product of the total PCB concentration (C_T) and the fraction of the total that is in dissolved form (f_d):

$$C_d = C_T f_d \tag{B5-2}$$

where:

$$fd = \frac{\phi}{\phi + K_{oc} f_{oc} \rho} \tag{B5-3}$$

and:

f_{oc}	=	fraction organic carbon in the sediments (g OC/g sediment)
K_{oc}	=	organic carbon partition coefficient (cm^3/g OC)
ρ	=	bulk density of the sediments (g/cm^3)
ϕ	=	porosity of the sediments (unitless)

5.3 MODEL PARAMETERIZATION

The sediment bed model was constructed based on a sediment depth of 165 cm (65 inches). This sediment bed was then subdivided into 660 layers, each 0.25-cm thick. Molecular diffusion and bed dispersion coefficients were based upon experience on other systems and values applied in the PCB fate model developed for the lower Grasse River (Alcoa, 2001b). The molecular diffusion coefficient (D_s) was set to 0.20 cm^2/day throughout all layers in the model and a dispersion coefficient (E_{disp}) that approximates complete mixing (5 x 10^7 cm^2/sec) was

applied to the top 5 cm and declined to a value of 10^{-8} cm^2/sec at 10 cm depth. Below 10 centimeters this value was set to zero. This is a conservative estimate of the depth of biological mixing, based on the ^{210}Pb data that suggests biological mixing occurs only in the top few centimeters of the sediment bed (Alcoa, 2001b). The model was run under two sets of conditions, one using a conservative net sedimentation rate (u_z) of zero, and the other using a value calculated from sediment loading data collected in the lower Grasse River (0.15 cm/yr).

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, 2001a). 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 B5-1). The use of the lower K_{oc} values for hepta- and octa-chlorobiphenyls in the modeling simulations provides a conservatively high overestimate of the diffusive flux of these homologs through the cap. A fraction organic carbon (f_{oc}) value of 0.02 was used to represent the capping material.

Table B5-1. Partition Coefficients Used in Simulations

Homolog Group	Log K_{oc}	Log K_{ow} [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)

Initial concentrations of PCBs and bulk density were determined from high-resolution sediment core data collected from the lower Grasse River in the fall of 1997 (cores 7M, 18M, 23N, 30S, and 32S). Using these data, an average depth profile of total PCB concentration was constructed (Figure B5-1). Model simulations for each PCB homolog were performed for a period of 5,000 years. Results of the simulations are discussed below.

5.4 PCB MIGRATION THROUGH A 12-INCH 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 B5-2. The top panel (panel "a") 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 lack of mono-chlorinated biphenyls in the lower Grasse River water (Alcoa, 2001b). The bottom panel (panel "b") provides the predicted composition of the total diffusive flux through the cap over the simulation period (in 200-year intervals).

Under the conservative assumption that no sedimentation occurs, PCBs migrating through the cap by molecular diffusion would eventually reach the zone of bioturbation where particle mixing would make them available at the sediment surface. The model indicates that mono-chlorobiphenyl would reach the sediment surface about 120 years after capping (using 0.001 ug/cm^2/yr as a threshold; Figure B5-2). Di-chlorobiphenyl would begin to appear after about 250 years. The flux of PCBs with 3 or more chlorine atoms (PCB_{3+}) to the water column would begin after about 2,180 years and would reach a steady-state value of approximately 0.006 ug/cm^2/yr after about 5,000 years. This flux is less than one percent of the current total PCB flux (about 1.7 ug/cm^2/yr). If net sedimentation were to continue into the future at a rate of 0.15 cm/yr, PCBs would not break through the cap.

5.5 PCB MIGRATION THROUGH A 6-INCH CAP

An evaluation of PCB migration through a 6-inch cap also was performed. For this evaluation, the model inputs and parameterization remained the same as the evaluation of a 12-inch cap, except for the cap thickness and the length of the simulation (2,000 years). Results of this evaluation are presented in Figure B5-3. Under the conservative assumption that no sedimentation occurs, the model indicates that mono-chlorobiphenyl would reach the sediment surface about 15 years after capping (using 0.001 ug/cm^2/yr as a threshold; Figure B5-3). Di-chlorobiphenyl would begin to appear after about 30 years. The flux of PCBs with 3 or more chlorine atoms (PCB_{3+}) to the water column would begin after about 125 years and would reach a steady-state value of approximately 0.08 ug/cm^2/yr after about 1,800 years. This flux is less than 5 percent of the current total PCB flux (about 1.7 ug/cm^2/yr). If net sedimentation were to continue into the future at a rate of 0.15 cm/yr, PCBs would not break through the cap.

5.6 SUMMARY

Results of the PCB transport modeling studies indicate that the placement of a cap over Grasse River sediment would be effective at reducing flux from the PCB-containing sediments to the overlying water column. The 6-inch cap design would be effective in the long-term, with the peak PCB flux through the cap to the water column is predicted to occur after about 1,800 years and equal less than 5% of the current flux estimated by the PCB fate model. The 12-inch cap, which incorporates an additional buffer for chemical isolation, would provide further isolation from PCB-containing sediments. Under this scenario, the peak PCB flux through the cap to the water column is predicted to occur after about 5,000 years and equal less than 1% of the current flux in the River.

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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TABLES

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

Table B4-1.
Summary of Predicted PCB Fate and Bioaccumulation Model Projection Results for Alternatives Included in the Detailed Analysis

ALTERNATIVES		DREDGING	CAPPING			WATER COLUMN		SEDIMENT		FISH TISSUE	
Alternative Number	Scenario	Volume of Soft Sediments Addressed (cy)	Surface Area Addressed Engineered Cap (acres)	Surface Area Addressed Cap (acres)	Volume of Capping Material Required (cy)	PCB Load to St. Lawrence River 2004-2030 (kg/yr)	PCB Load to St. Lawrence River 2030 (kg/yr)	River-wide Average 2004-2030 (mg/kg)	River-wide Average 2030 (mg/kg)	River-wide Average 2004-2030 (mg/kg)	River-wide Average 2030 (mg/kg)
1	No Further Action	---	---	---	---	13.4	6.7	3.92	2.08	1.75	0.84
2	Monitored Natural Recovery	---	---	---	---	13.4	6.7	3.92	2.08	1.75	0.84
3	Engineered Cap 001/004; Cap Transects T11-T38	---	5	122	210,000	6.2	2.9	1.67	0.77	0.78	0.30
4	Dredge PCBs >= 50 ppm; Engineered Cap 001/004; Cap Transects T11-T38	48,000	5	122	210,000	5.7	2.7	1.49	0.69	0.73	0.28
5	Dredge PCBs >= 25 ppm; Cap PCBs >= 10 ppm	101,000	5	116	200,000	5.6	2.7	1.29	0.58	0.73	0.29
6	Cap PCBs >= 5 ppm	---	5	235	390,000	4.5	2.1	0.99	0.38	0.57	0.19
7	Dredge PCBs >= 50 ppm; Cap PCBs >= 5 ppm	48,000	5	235	390,000	4.0	2.0	0.85	0.31	0.52	0.16
8	Dredge PCBs >= 25 ppm; Cap PCBs >= 5 ppm	101,000	5	235	390,000	4.1	1.9	0.83	0.30	0.51	0.16
9	Dredge PCBs >= 10 ppm; Cap PCBs >= 5 ppm	515,000	5	235	390,000	4.5	1.8	0.87	0.25	0.55	0.14
10	Dredge PCBs >= 1 ppm	1,650,000	---	---	---	7.3	2.8	1.65	0.63	0.89	0.28

NOTES:

1. Values cited below represent portion of Grasse River between the Massena Power Canal and the mouth.
   Total Volume of Soft Sediments 1,900,000 cy
   Total Surface Area 17,600,000 ft2
   405 acres
2. All sediment PCB concentrations reflect surface sediments (0-3 inches). Volumes and areas provided herein are based on individual model grid segments.
3. Capping alternatives assume an engineered cap will be applied to sediments near Outfalls 001 and 004. Engineered capping includes placement of 18 inches of soil on top of native sediment with 6 inches of gravel on the cap material.
4. Required volume of capping material estimated assuming 18 inches needed for an engineered cap (not including 6 inches of gravel) and 12 inches needed for cap.
5. Current fish tissue PCB concentrations determined from data collected during the 2000 Resident Fish Trend Monitoring Program.
   River-wide 6.5 mg/kg
6. *Current PCB loading to the St. Lawrence River computed for last year of PCB fate model calibration (i.e., 2000).*
   PCB Loading 31.9 kg/yr
7. Current surface sediment PCB concentration computed for last year of PCB fate model calibration (i.e., Massena Power Canal to mouth, 0-3 inches, 2000).
   PCB Concentration 9.3 mg/kg
8. Model assumptions are as follows:
   Outfall PCBs set equal to 0.5*DL (DL = 65 ppt).
   Upstream PCBs set at constant 1 ng/L.
   PCB releases during dredging assumed to equal 0.1% of PCB mass removed.
   Post-dredging PCB residuals set equal to 2.5 ppm.
   Capping effectiveness set equal to 90%.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

Table B4-2.
Summary of Predicted Reductions of PCBs in Fish and PCB Loading to the St. Lawrence River for Alternatives Included in the Detailed Analysis

ALTERNATIVES		DREDGING	CAPPING		PCB LOAD TO ST. LAWRENCE RIVER	RIVER-WIDE AVERAGE FISH TISSUE PCB LEVELS	
Alternative Number	Scenario	Volume of Soft Sediments Addressed (cy)	Surface Area Addressed Engineered Cap (acres)	Cap (acres)	Predicted Time to Achieve 85% Reduction (years)	Predicted Times to Achieve 75% Reduction (years)	90% Reduction (years)
1	No Further Action	—	—	—	> 25	25	> 27
2	Monitored Natural Recovery	—	—	—	> 25	25	> 27
3	Engineered Cap 001/004; Cap Transects T11-T38	—	5	122	19	6	24
4	Dredge PCBs >= 50 ppm; Engineered Cap 001/004; Cap Transects T11-T38	48,000	5	122	18	5	22
5	Dredge PCBs >= 25 ppm; Cap PCBs >= 10 ppm	101,000	5	116	18	5	22
6	Cap PCBs >= 5 ppm	—	5	235	5	4	11
7	Dredge PCBs >= 50 ppm; Cap PCBs >= 5 ppm	48,000	5	235	5	4	8
8	Dredge PCBs >= 25 ppm; Cap PCBs >= 5 ppm	101,000	5	235	5	4	8
9	Dredge PCBs >= 10 ppm; Cap PCBs >= 5 ppm	515,000	5	235	6	5	8
10	Dredge PCBs >= 1 ppm	1,650,000	—	—	18	8	23

NOTES:

1. Predicted times to reach PCB reductions from base conditions. Base conditions for PCB loading to the St. Lawrence River defined as average PCB levels predicted between 2001 and 2003. Base conditions for fish tissue PCBs defined as average PCB levels during last full year before start of remediation (i.e., 2003).
2. Predicted times to reach reductions in PCB loadings to the St. Lawrence River estimated using 3-year moving averages (e.g., loading in 2006 represents average PCB loading between 2005 and 2007). This was performed to damp the year-to-year variations in PCB loadings that result from fluctuations in annual River flows in the synthetic hydrograph.
3. Fish tissue values respresent species-average PCBs for smallmouth bass and brown bullhead, area-weighted by River stretch.
4. Volumes and areas provided herein are based on individual model grid elements.
5. Model assumptions are as follows:
   Outfall PCBs set equal to 0.5*DL (DL = 65 ppt).
   Upstream PCBs set at constant 1 ng/L.
   PCB releases during dredging assumed to equal 0.1% of PCB mass removed.
   Post-dredging PCB residuals set equal to 2.5 ppm.
   Capping effectiveness set equal to 90%.

Table B4-3.
Summary of Predicted PCB Fate and Bioaccumulation Model Projection Results for Alternatives Eliminated During Preliminary Screening Evaluation

ALTERNATIVES		DREDGING	CAPPING			WATER COLUMN		SEDIMENT		FISH TISSUE	
Alternative Number	Scenario	Volume of Soft Sediments Addressed (cy)	Surface Area Addressed: Engineered Cap (acres)	Surface Area Addressed: Cap (acres)	Volume of Capping Material Required (cy)	PCB Load to St. Lawrence River 2004-2030 (kg/yr)	PCB Load to St. Lawrence River 2030 (kg/yr)	River-wide Average 2004-2030 (mg/kg)	River-wide Average 2030 (mg/kg)	River-wide Average 2004-2030 (mg/kg)	River-wide Average 2030 (mg/kg)
11	Cap PCBs >= 10 ppm	---	5	116	200,000	5.9	3.0	1.43	0.67	0.78	0.32
12	Cap PCBs >= 1 ppm	---	5	347	570,000	3.8	1.7	0.81	0.22	0.47	0.11
13	Dredge PCBs >= 25 ppm	101,000	---	---	---	9.0	4.5	2.43	1.26	1.20	0.55
14	Dredge PCBs >= 10 ppm	515,000	---	---	---	6.8	3.1	1.62	0.73	0.88	0.34
15	Dredge and Cap PCBs >= 25 ppm	101,000	5	21	46,000	8.7	4.3	2.36	1.23	1.17	0.53
16	Dredge PCBs >= 50 ppm; Cap PCBs >= 10 ppm	48,000	5	116	200,000	5.8	2.8	1.32	0.61	0.74	0.29
17	Dredge PCBs >= 25 ppm; Engineered Cap 001/004; Cap Transects T11-T38	101,000	5	122	210,000	5.7	2.7	1.46	0.67	0.72	0.27

NOTES:

1. Values cited below represent portion of Grasse River between the Massena Power Canal and the mouth.
   Total Volume of Soft Sediments 1,900,000 cy
   Total Surface Area 17,600,000 ft2
   405 acres
2. All sediment PCB concentrations reflect surface sediments (0-3 inches). Volumes and areas provided herein are based on individual model grid segments.
3. Capping alternatives assume an engineered cap will be applied to sediments near Outfalls 001 and 004. Engineered capping includes placement of 18 inches of soil on top of native sediment with 6 inches of gravel on the cap material.
4. Required volume of capping material estimated assuming 18 inches needed for an engineered cap (not including 6 inches of gravel) and 12 inches needed for cap.
5. Current fish tissue PCB concentrations determined from data collected during the 2000 Resident Fish Trend Monitoring Program.
   River-wide 6.5 mg/kg
6. Current PCB loading to the St. Lawrence River computed for last year of PCB fate model calibration (i.e., 2000).
   PCB Loading 31.9 kg/yr
7. Current surface sediment PCB concentration computed for last year of PCB fate model calibration (i.e., Massena Power Canal to mouth, 0-3 inches, 2000).
   PCB Concentration 9.3 mg/kg
8. Model assumptions are as follows:
   Outfall PCBs set equal to 0.5*DL (DL = 65 ppt).
   Upstream PCBs set at constant 1 ng/L.
   PCB releases during dredging assumed to equal 0.1% of PCB mass removed.
   Post-dredging PCB residuals set equal to 2.5 ppm.
   Capping effectiveness set equal to 90%.

GRASSE RIVER STUDY AREA
MASSENA, NEW YORK

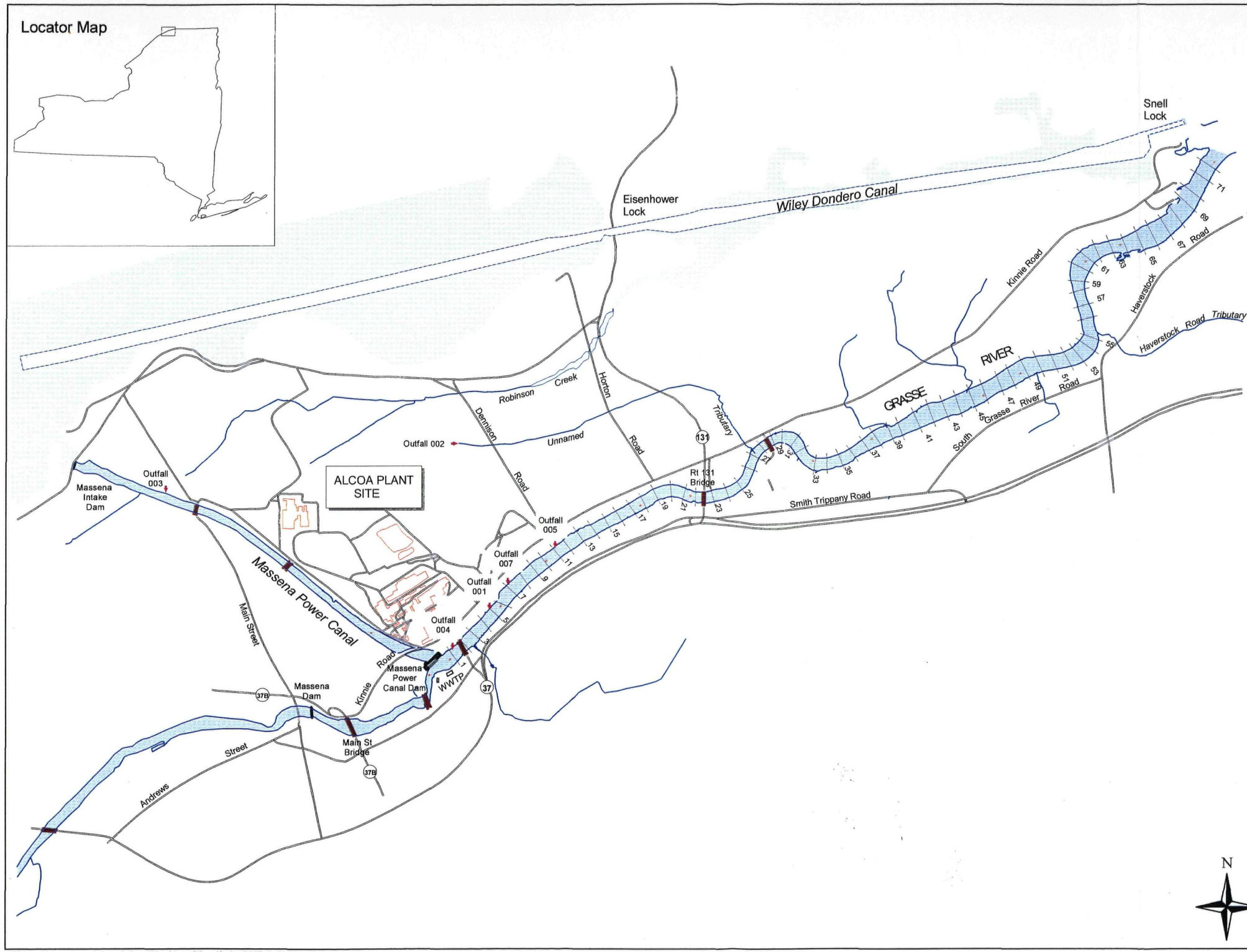
Table B4-4.
Summary of Predicted Reductions of PCBs in Fish and PCB Loading to the St. Lawrence River for Alternatives Eliminated During Preliminary Screening Evaluation

ALTERNATIVES		DREDGING	CAPPING		PCB LOAD TO ST. LAWRENCE RIVER	RIVER-WIDE AVERAGE FISH TISSUE PCB LEVELS	
Alternative Number	Scenario	Volume of Soft Sediments Addressed (cy)	Surface Area Addressed Engineered Cap (acres)	Cap (acres)	Predicted Time to Achieve 85% Reduction (years)	Predicted Times to Achieve 75% Reduction (years)	90% Reduction (years)
11	Cap PCBs >= 10 ppm	---	5	116	18	6	24
12	Cap PCBs >= 1 ppm	---	5	347	5	4	6
13	Dredge PCBs >= 25 ppm	101,000	---	---	>25	16	>27
14	Dredge PCBs >= 10 ppm	515,000	---	---	19	8	26
15	Dredge and Cap PCBs >= 25 ppm	101,000	5	21	>25	15	>27
16	Dredge PCBs >= 50 ppm; Cap PCBs >= 10 ppm	48,000	5	116	18	5	23
17	Dredge PCBs >= 25 ppm; Engineered Cap 001/004; Cap Transects T11-T38	101,000	5	122	18	5	21

NOTES:

1. Predicted times to reach PCB reductions from base conditions. Base conditions for PCB loading to the St. Lawrence River defined as average PCB levels predicted between 2001 and 2003. Base conditions for fish tissue PCBs defined as average PCB levels during last full year before start of remediation (i.e., 2003).
2. Predicted times to reach reductions in PCB loadings to the St. Lawrence River estimated using 3-year moving averages (e.g., loading in 2006 represents average PCB loading between 2005 and 2007). This was performed to damp the year-to-year variations in PCB loadings that result from fluctuations in annual River flows in the synthetic hydrograph.
3. Fish tissue values respresent species-average PCBs for smallmouth bass and brown bullhead, area-weighted by River stretch.
4. Volumes and areas provided herein are based on individual model grid elements.
5. Model assumptions are as follows:
   Outfall PCBs set equal to 0.5*DL (DL = 65 ppt).
   Upstream PCBs set at constant 1 ng/L.
   PCB releases during dredging assumed to equal 0.1% of PCB mass removed.
   Post-dredging PCB residuals set equal to 2.5 ppm.
   Capping effectiveness set equal to 90%.

FIGURES



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

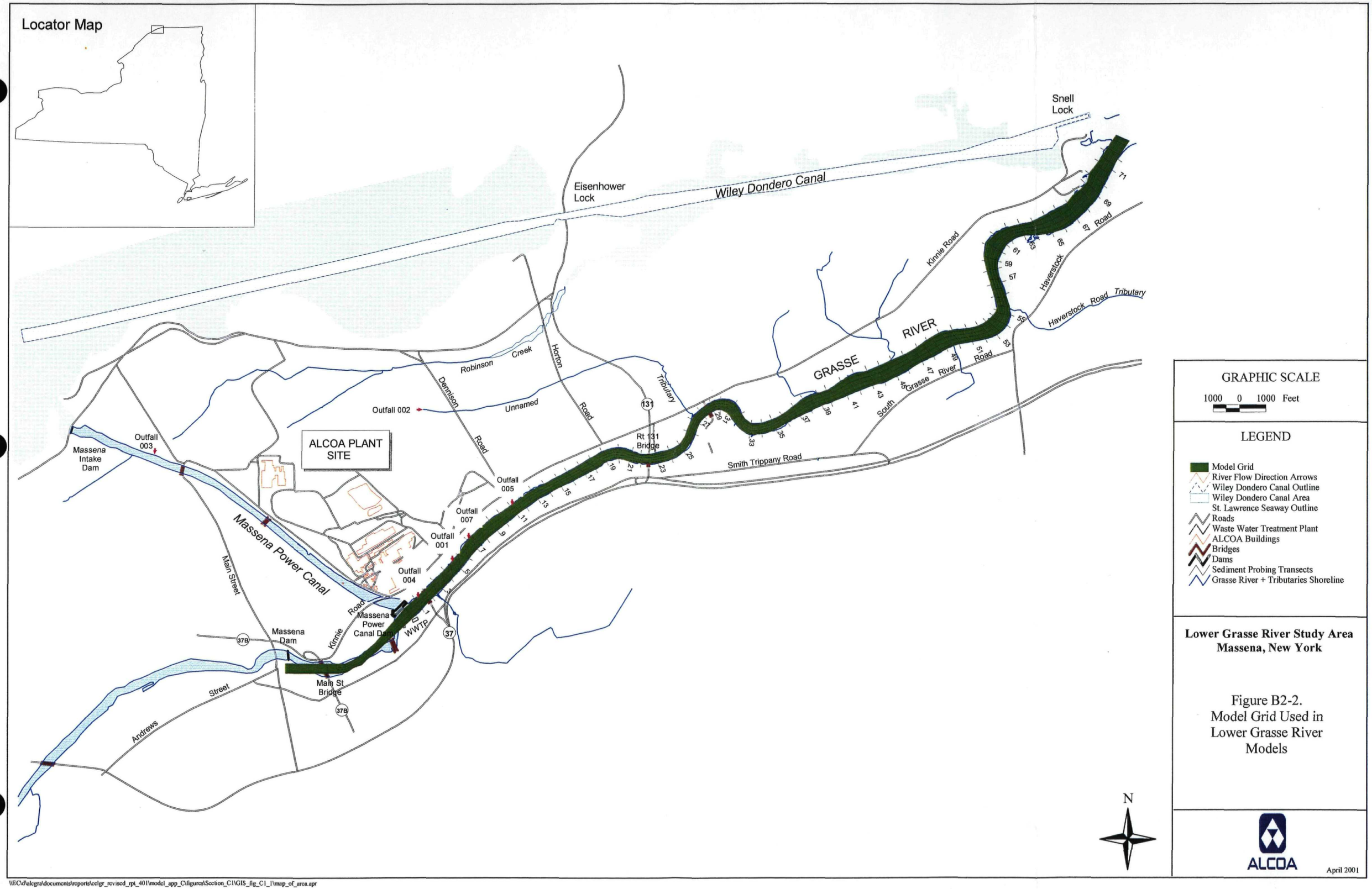
Lower Grasse River Study Area
Massena, New York

Figure B2-1.
Location Map

ALCOA

April 2001

\\EC\d\alcgra\documents\reports\cclgr_revised_rpt_401\model_app_C\figures\Section_C1\GIS_fig_C1_1\map_of_area.apr



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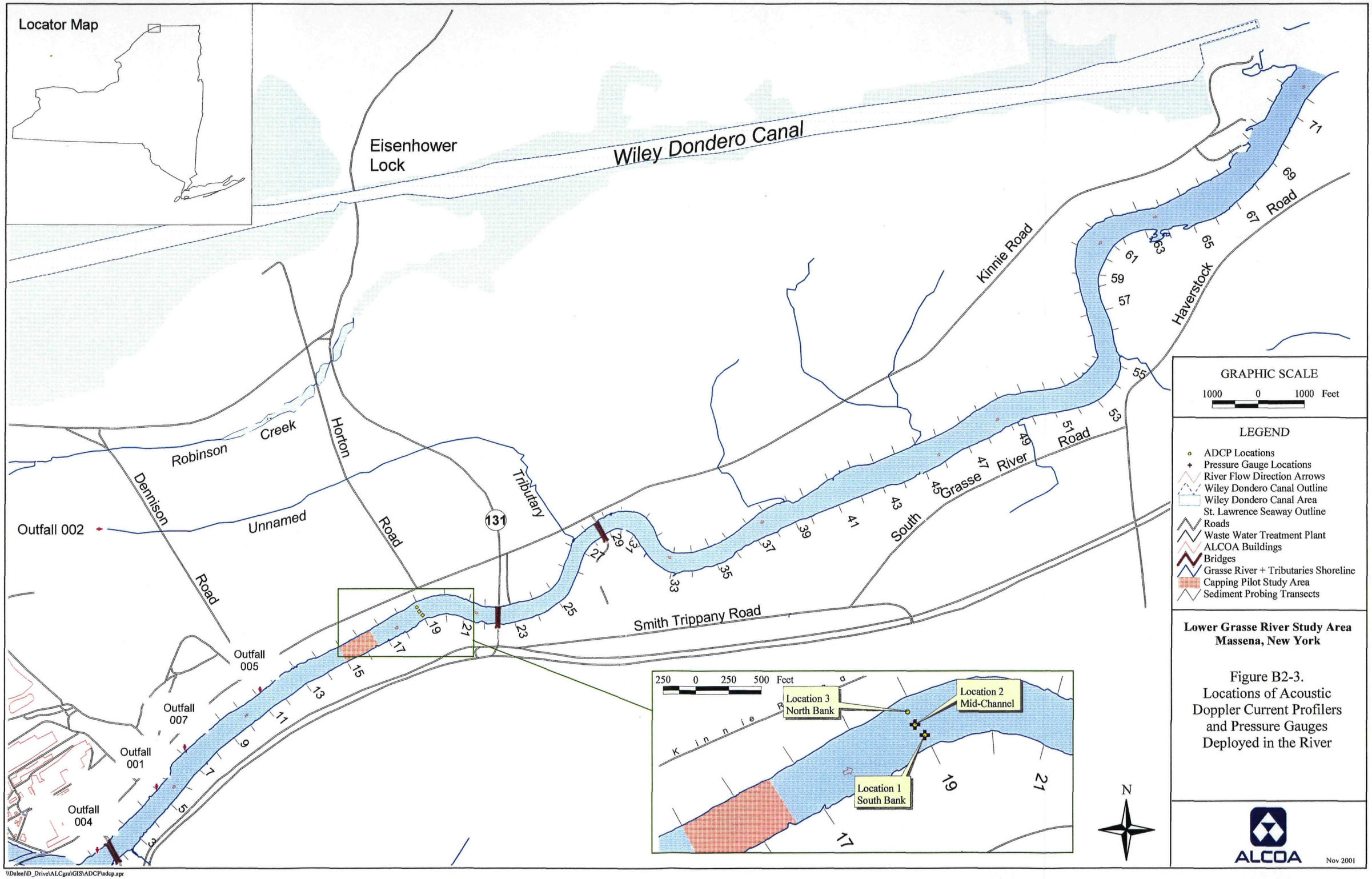

Lower Grasse River Study Area
Massena, New York

Figure B2-3.
Locations of Acoustic Doppler Current Profilers and Pressure Gauges Deployed in the River

\\Dalee\D_Drive\ALCgra\GIS\ADCP\adcp.apr

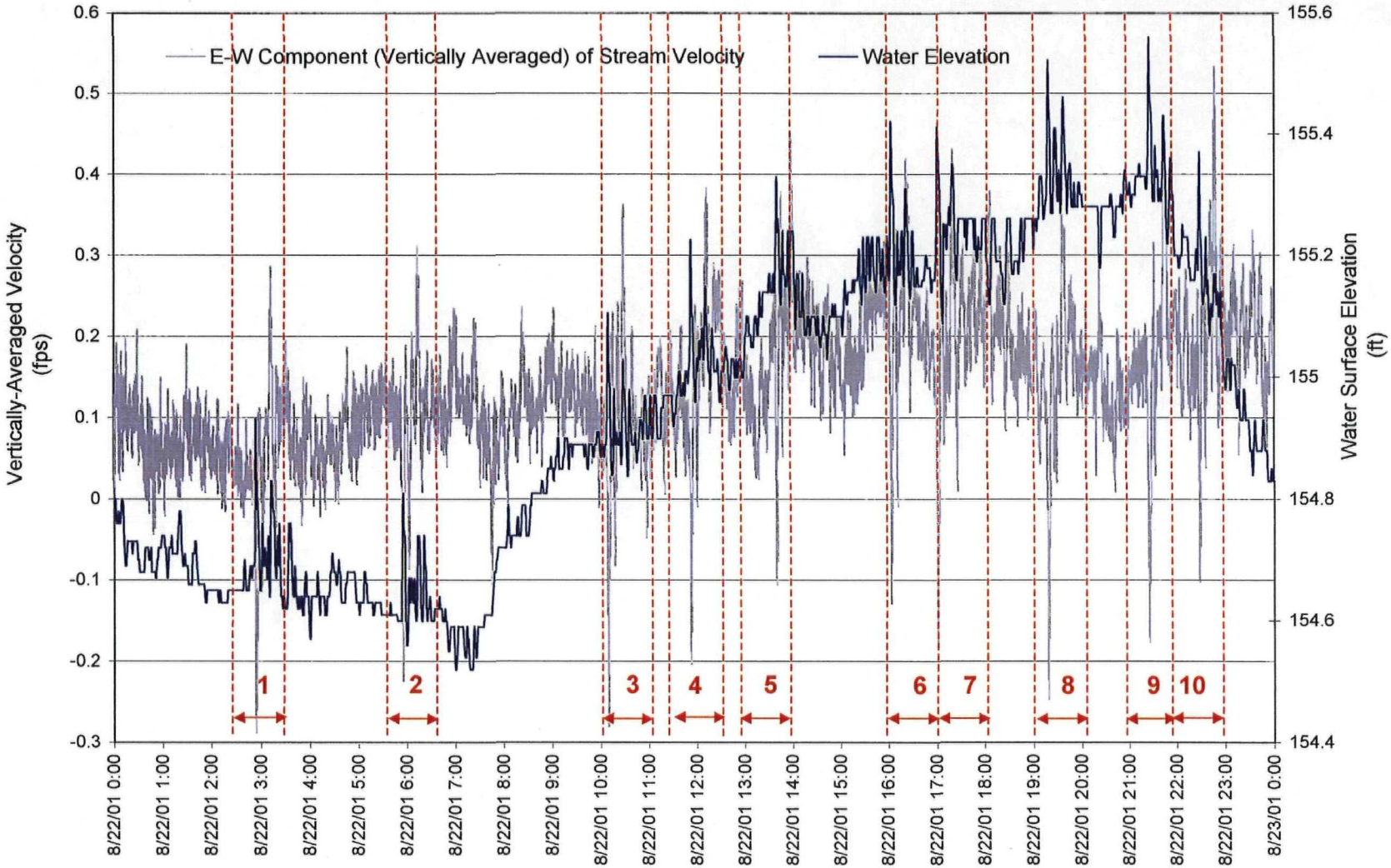

Figure B2-4. Water Surface Elevation and Velocity Measurements for Mid-Channel of Transect T19
Velocities represent the east-west component (vertically averaged). Data shown were collected on August 22, 2001.

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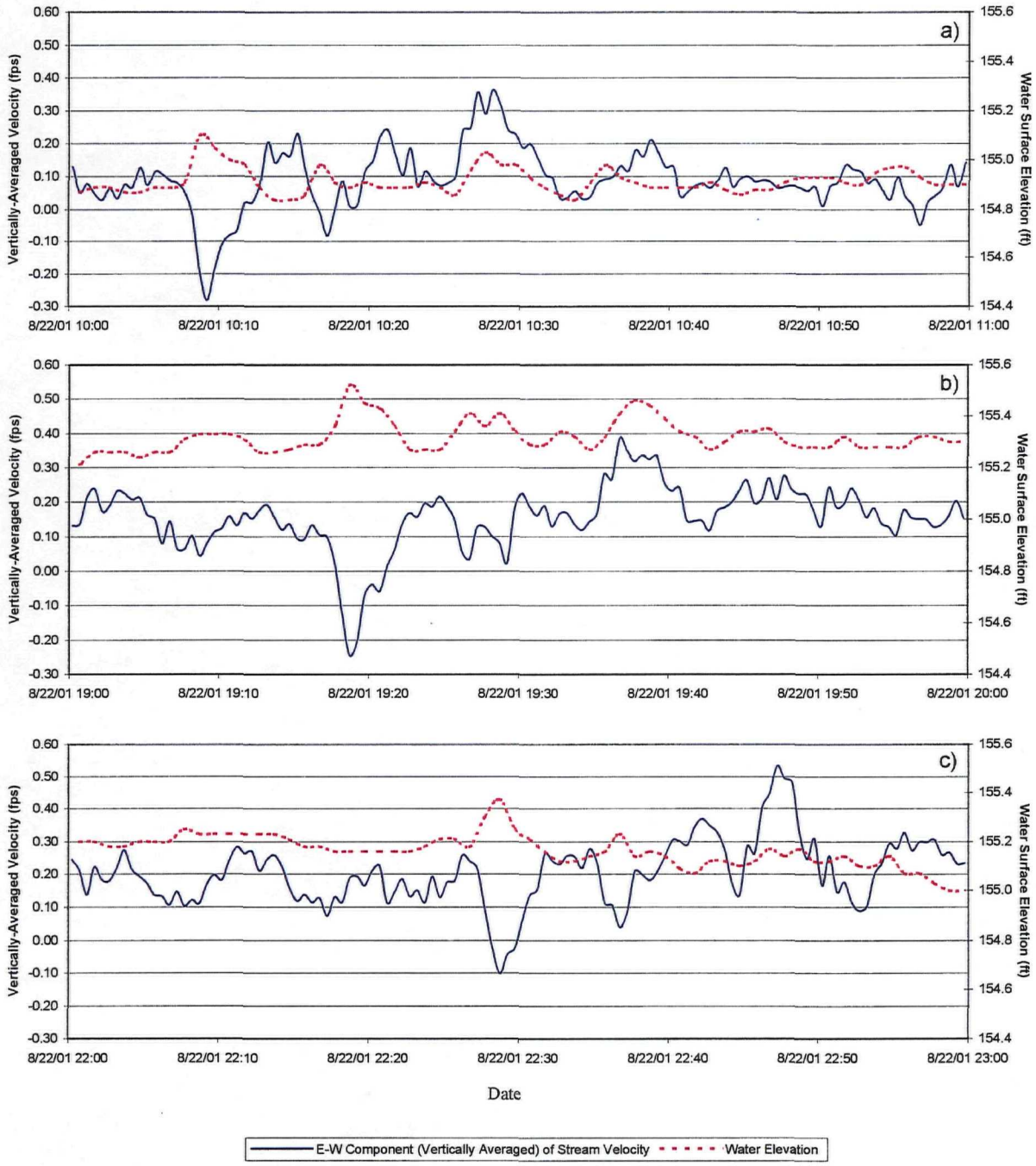

Figure B2-5. Water Surface Elevation and Velocity Measurements Collected at Mid-Channel of Transect 19 on August 22, 2001.
Velocities represent east-west component (vertically-averaged).
Panel a: 10:00 - 11:00 am
Panel b: 7:00 - 8:00 pm
Panel c: 10:00 - 11:00 pm

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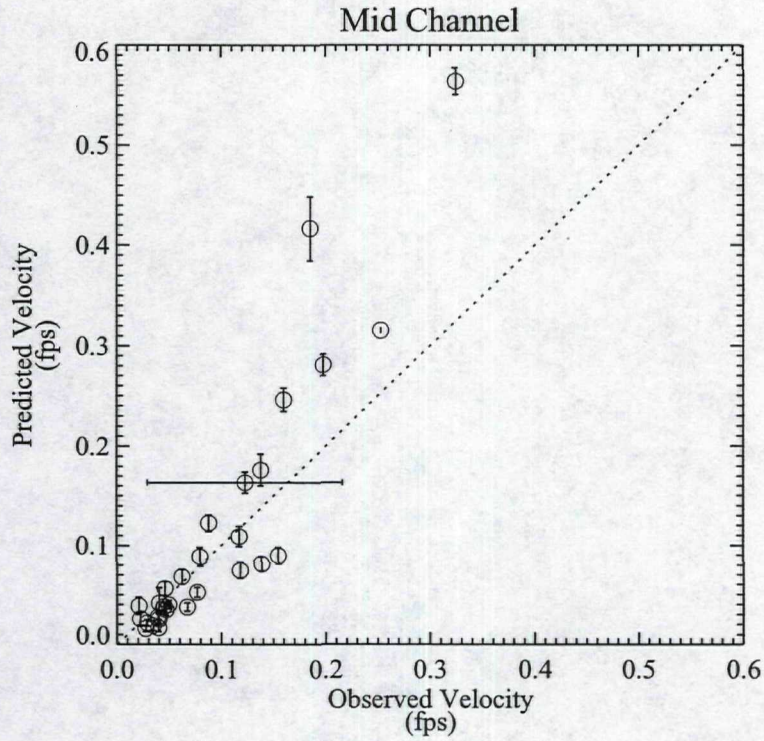

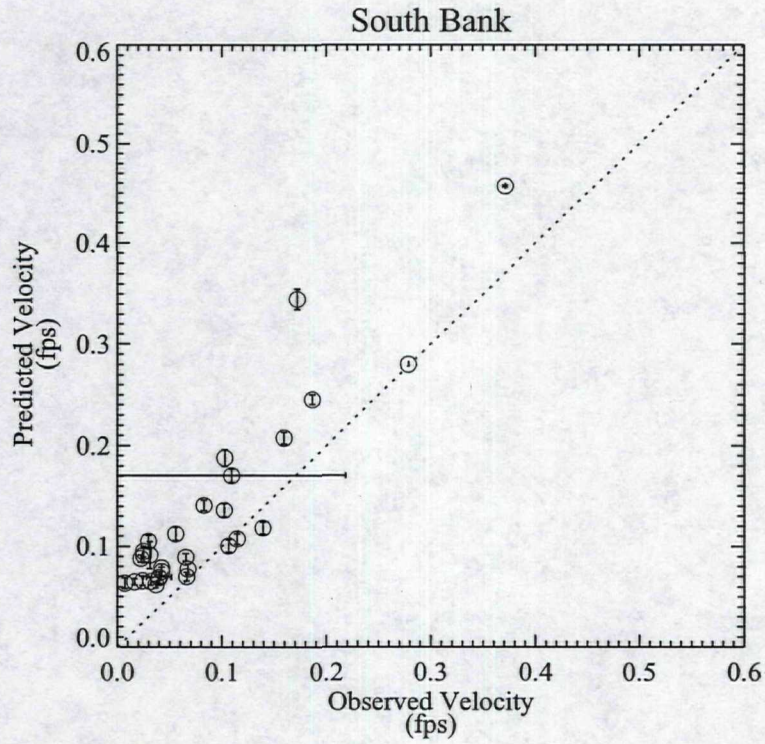

Figure B2-6. Comparison of Predicted and Observed Water Velocities

Observed vertically-averaged ADCP water velocities estimated from sampling data at T19 between 8/10 and 9/10/01. Predicted mean water velocities from hydrodynamic model output. Ranges represent +/- 2 standard errors in the mean.

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Thu Feb 07 10:08:28 2002

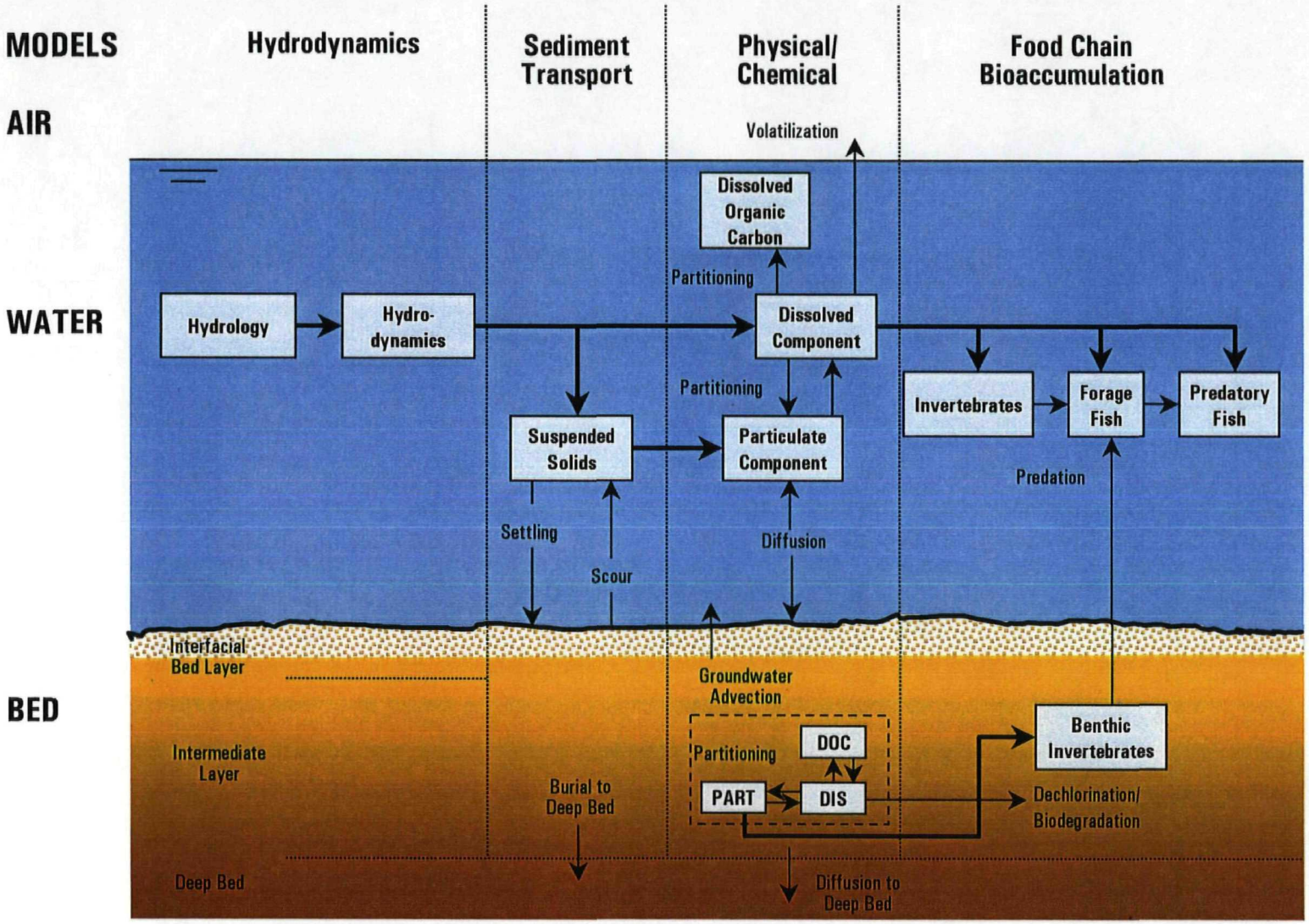

Figure B2-7. Dynamic Processes Governing Fate, Transport, and Transformation of PCBs in the Environment.

GRAPHIC SCALE

500 0 500 Feet

LEGEND

PCB Conc (0-3") (ppm-dry)
- 0 - 10
- 10 - 30
- 30 - 50
- > 50
- 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 B2-8.
Polygon Analysis of
Surface Sediment (0-3") PCB
Concentrations

1 of 2

ALCOA

Jan 2002

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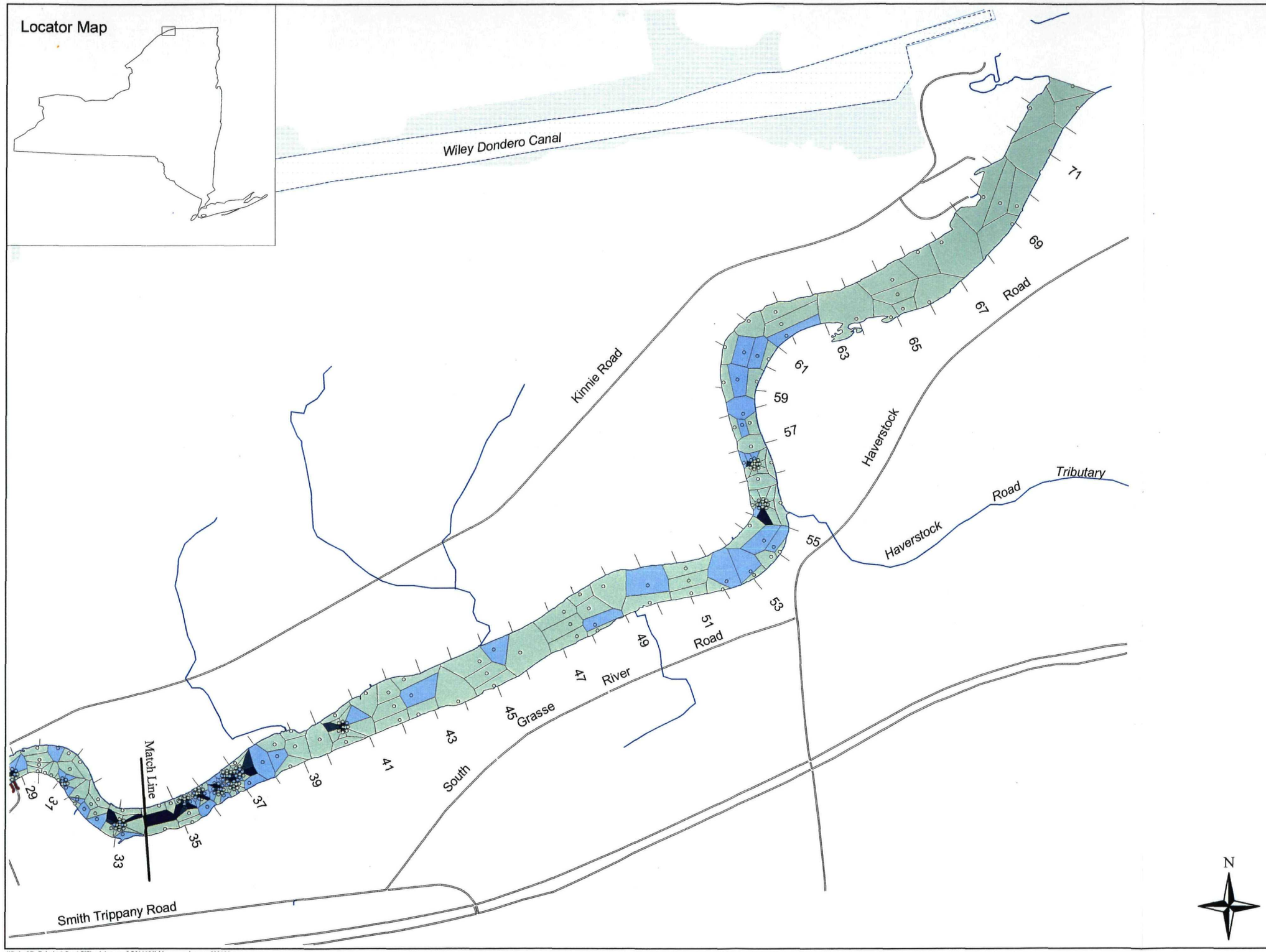

GRAPHIC SCALE

500 0 500 Feet

LEGEND

PCB Conc (0-3") (ppm-dry)

- 0 - 10
- 10 - 30
- 30 - 50
- > 50
- 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 B2-9.
Polygon Analysis of
Surface Sediment (0-3") PCB
Concentrations

2 of 2

ALCOA

Jan 2002

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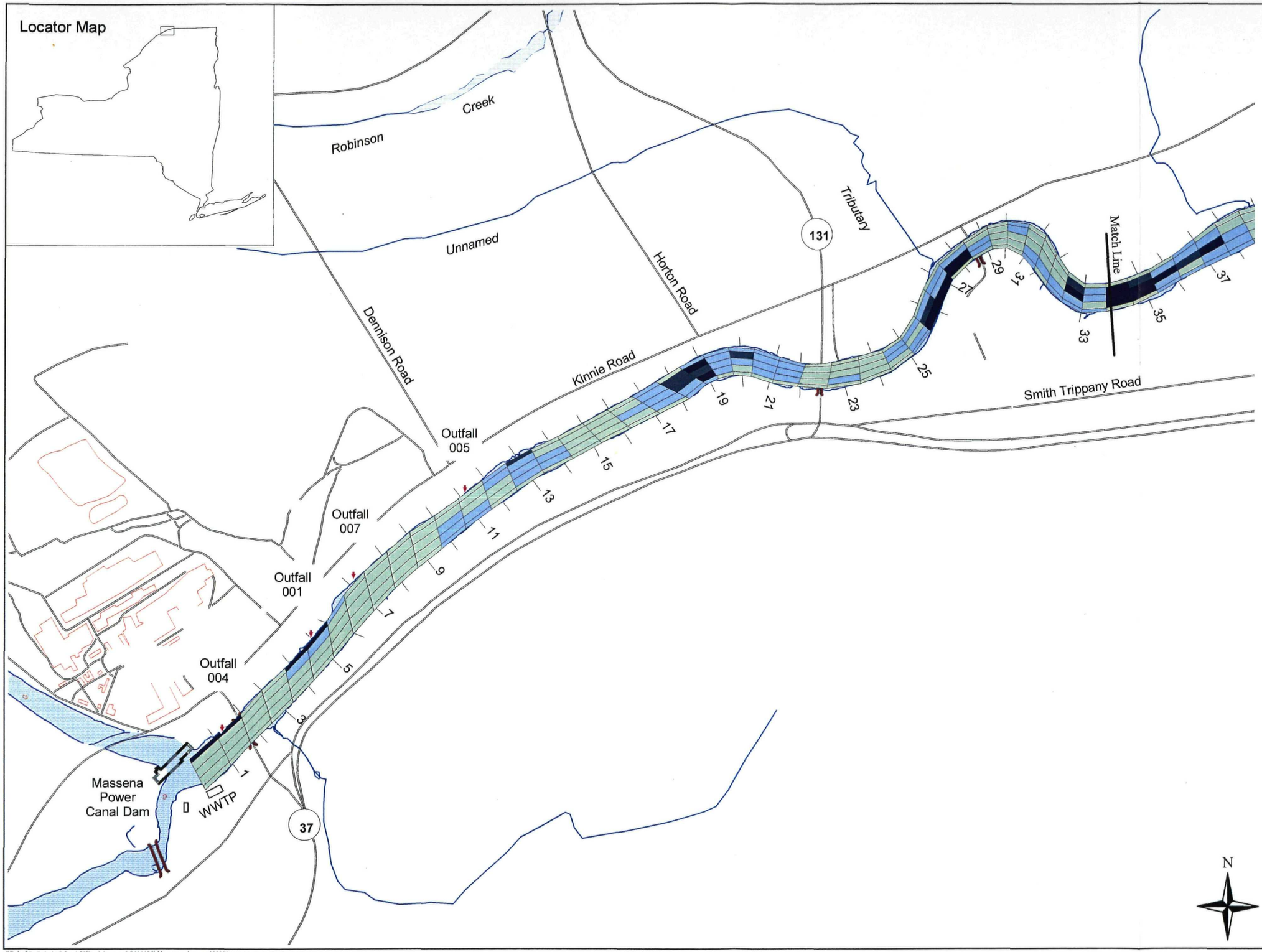

GRAPHIC SCALE

500 0 500 Feet

LEGEND

PCB Concentration 0-3" (ppm-dry)

- 0 - 10
- 10 - 30
- 30 - 50
- > 50
- 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 B2-10.
Model Grid With Surface Sediment (0-3") Total PCB Concentrations Based On Polygonal Declustering

1 of 2

ALCOA

Jan 2002

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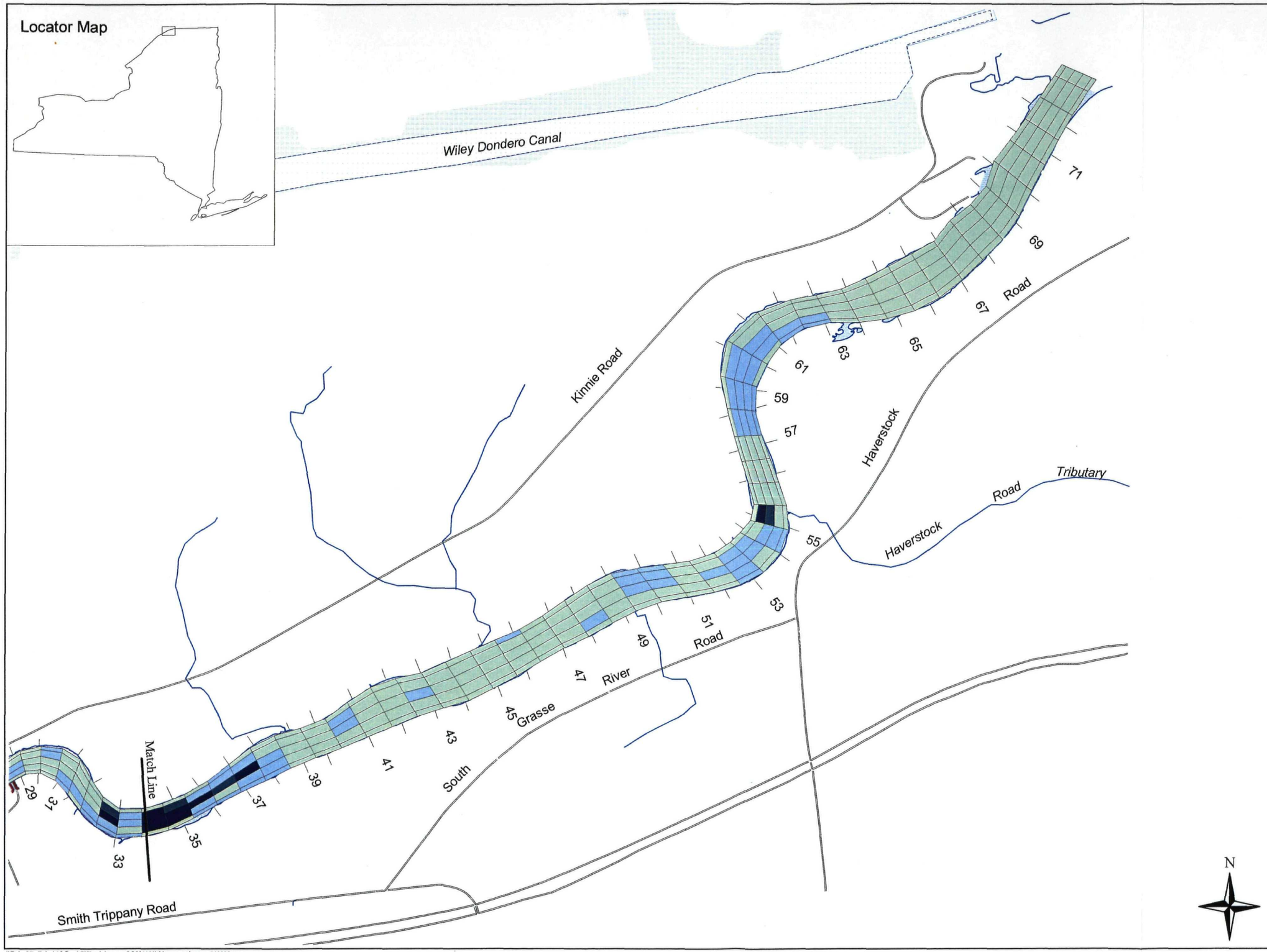

GRAPHIC SCALE

500 0 500 Feet

LEGEND

PCB Concentration 0-3" (ppm-dry)

- 0 - 10
- 10 - 30
- 30 - 50
- > 50
- 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 B2-11.
Model Grid With Surface Sediment (0-3") Total PCB Concentrations Based On Polygonal Declustering

2 of 2

ALCOA

Jan 2002

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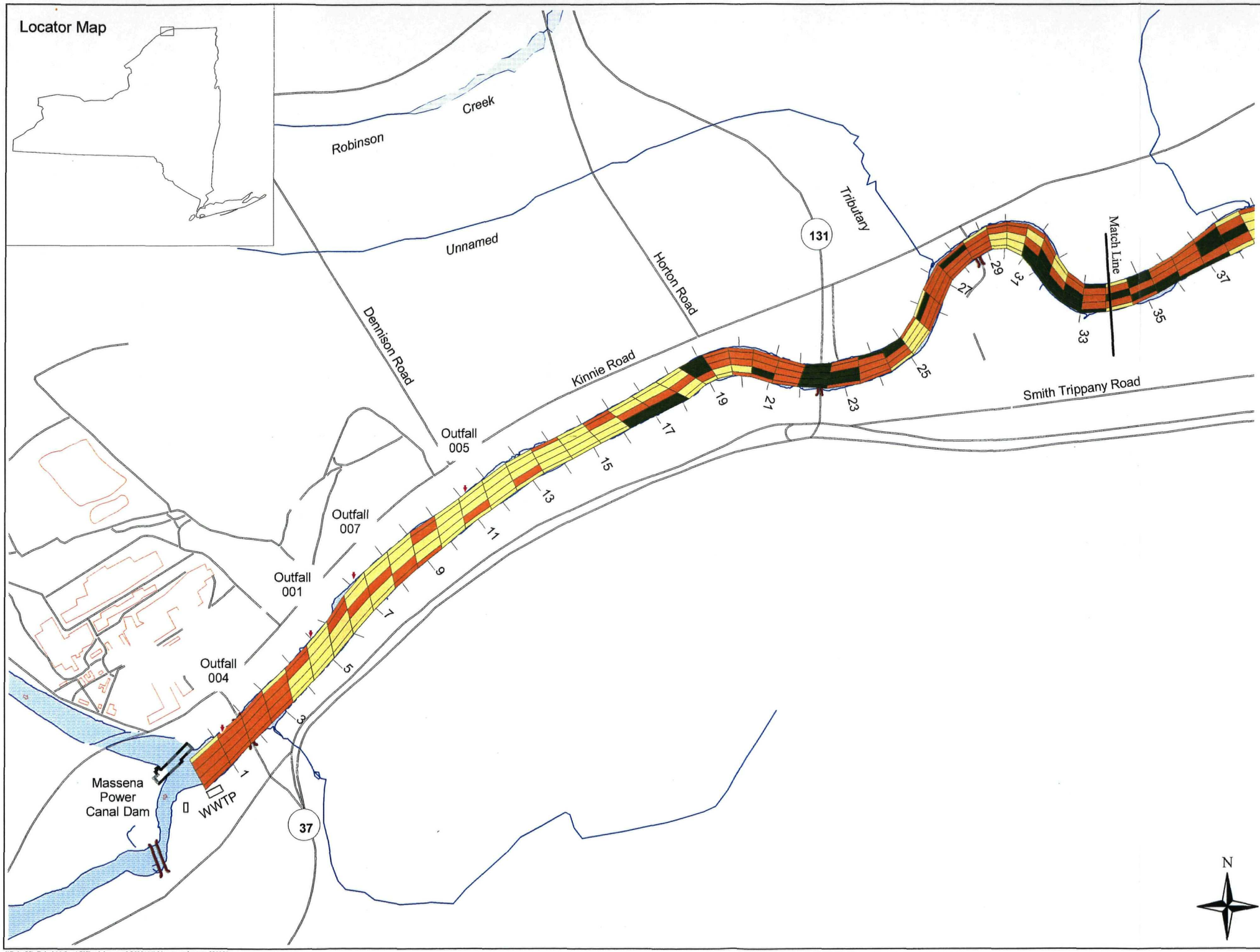

GRAPHIC SCALE

500 0 500 Feet

LEGEND

Fraction Organic Carbon (%)
- 0 - 2
- 2 - 5
- 5 - 15
- 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 B2-12.
Model Grid With Surface Sediment (0-3") Organic Carbon Fractions Based On Polygonal Declustering

1 of 2

ALCOA

Jan 2002

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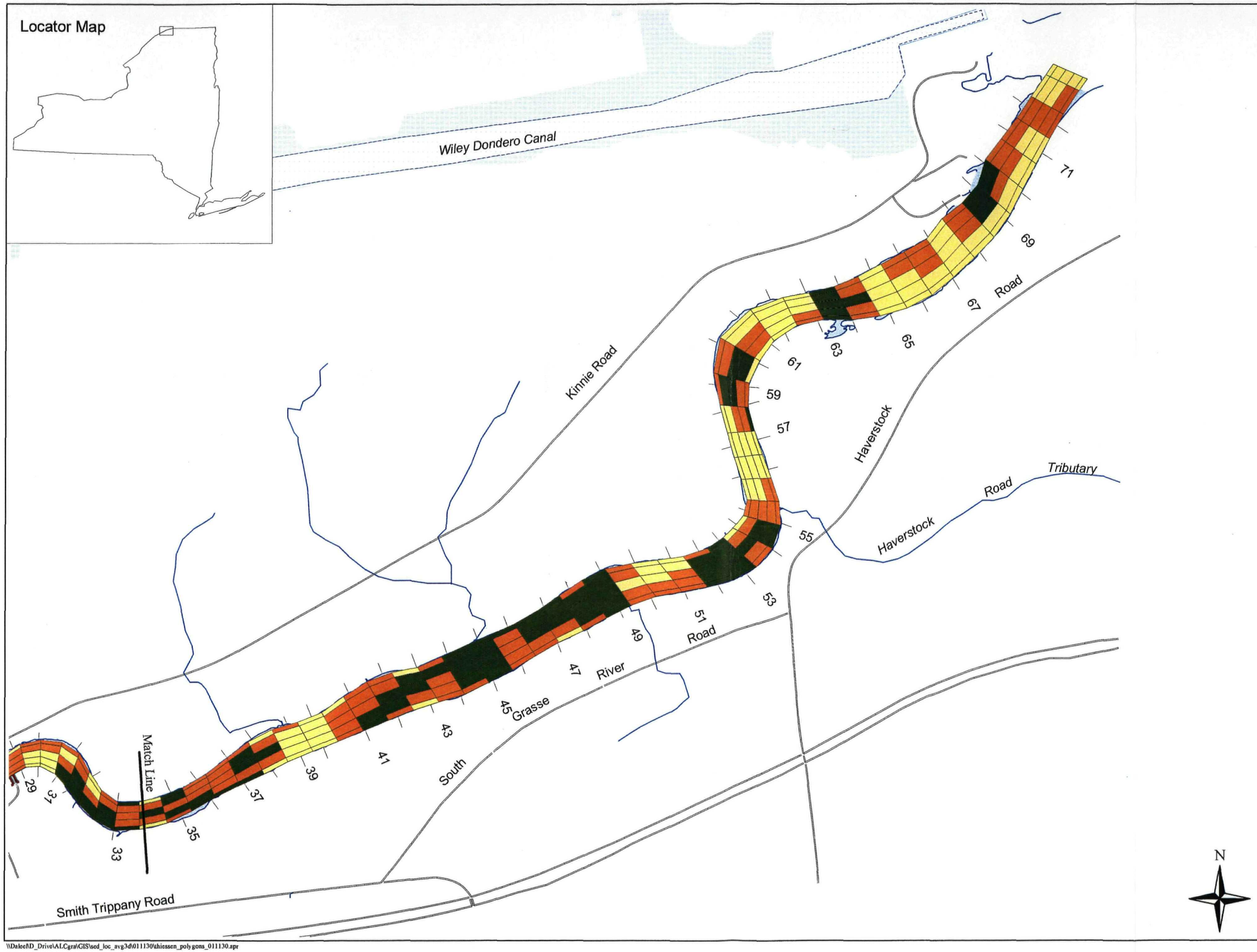

GRAPHIC SCALE

500 0 500 Feet

LEGEND

Fraction Organic Carbon (%)
- 0 - 2
- 2 - 5
- 5 - 15
- 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 B2-13.
Model Grid With Surface Sediment (0-3") Organic Carbon Fractions Based On Polygonal Declustering

2 of 2

ALCOA

Jan 2002

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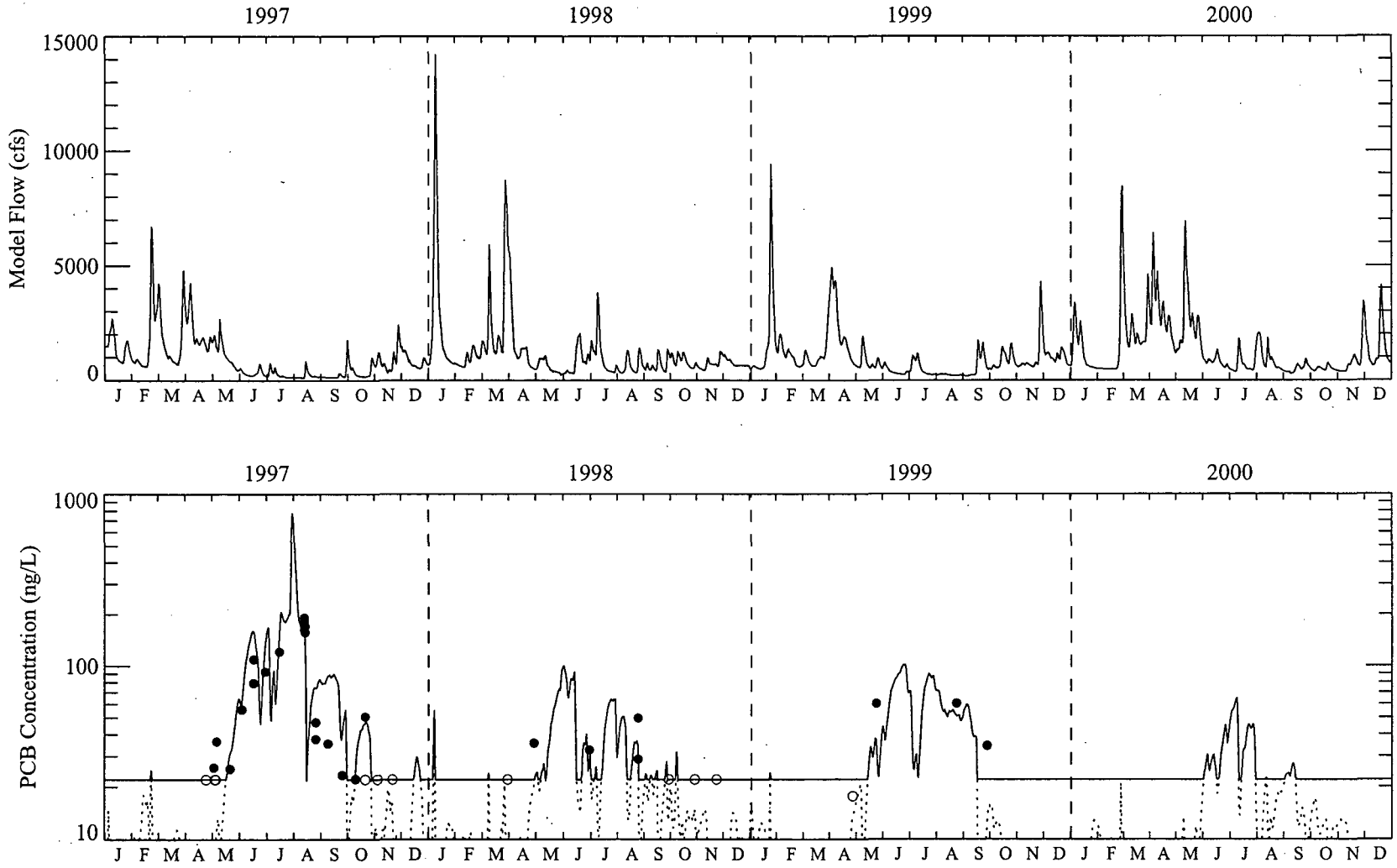

Figure B2-14. Temporal Profile of Water Column PCB Data (circles) and Model Output (line) for Water Column Transect WC007.

Note: Non-detects plotted as open symbols at MDL (22 ng/L)

Data tables: water_bz, water_iupac

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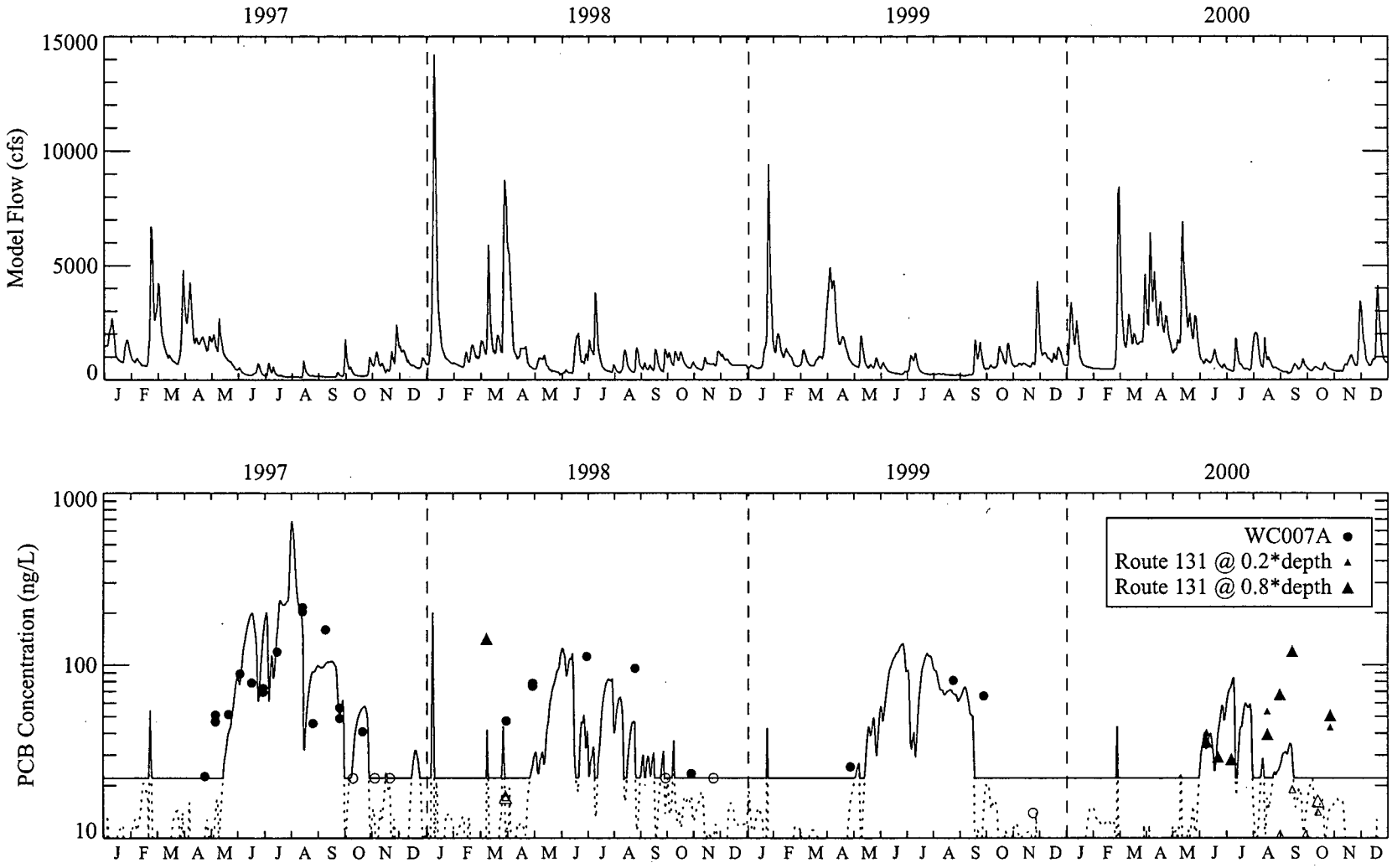

Figure B2-15. Temporal Profile of Water Column PCB Data (symbols) and Model Output (line) for Water Column Transect WC007A.

Note: Non-detects plotted as open symbols at MDL (22 ng/L)

Data tables: water_bz, water_iupac

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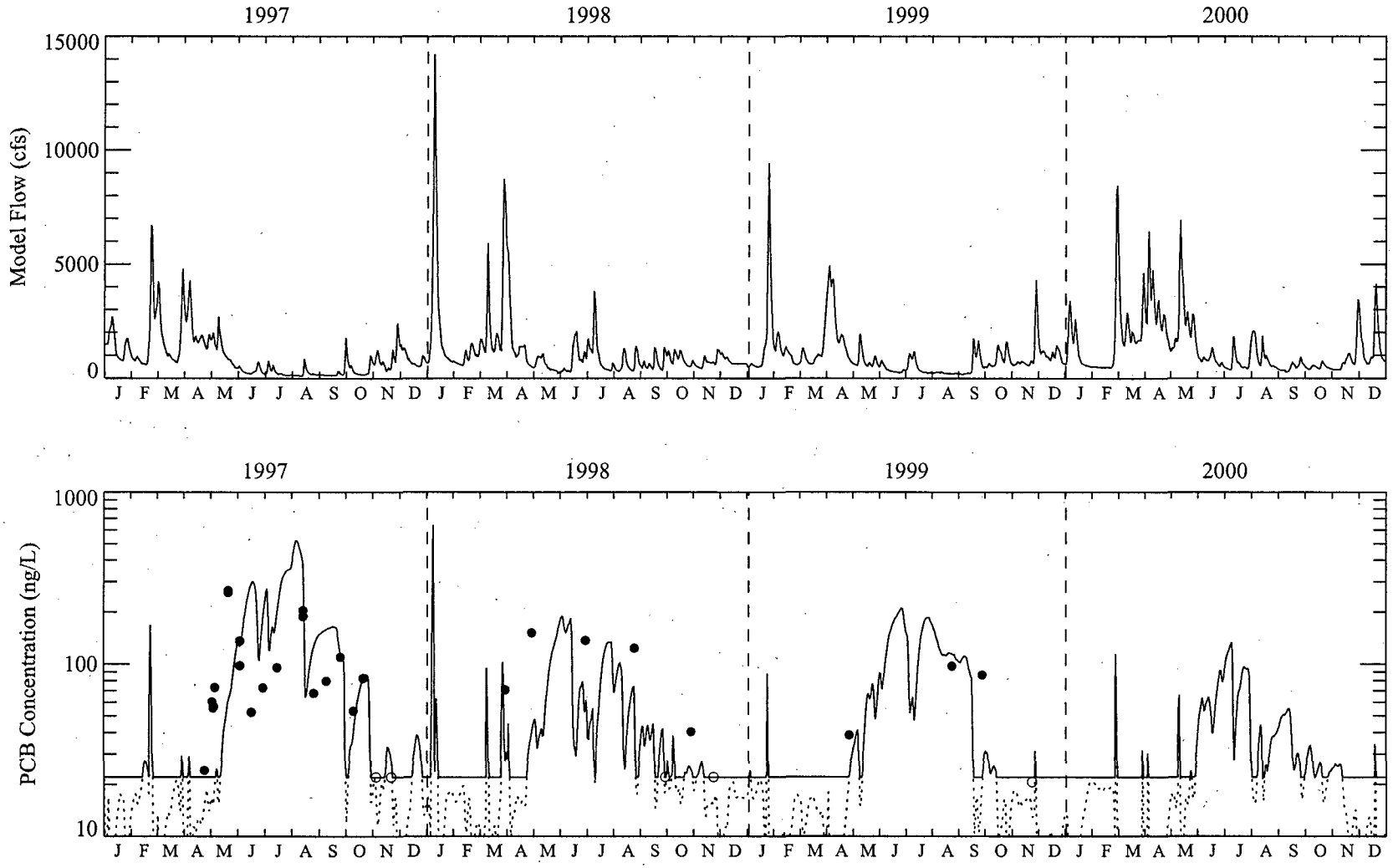

Figure B2-16. Temporal Profile of Water Column PCB Data (circles) and Model Output (line) for Water Column Transect WC011.

Note: Non-detects plotted as open symbols at MDL (22 ng/L)

Data tables: water_bz, water_iupac

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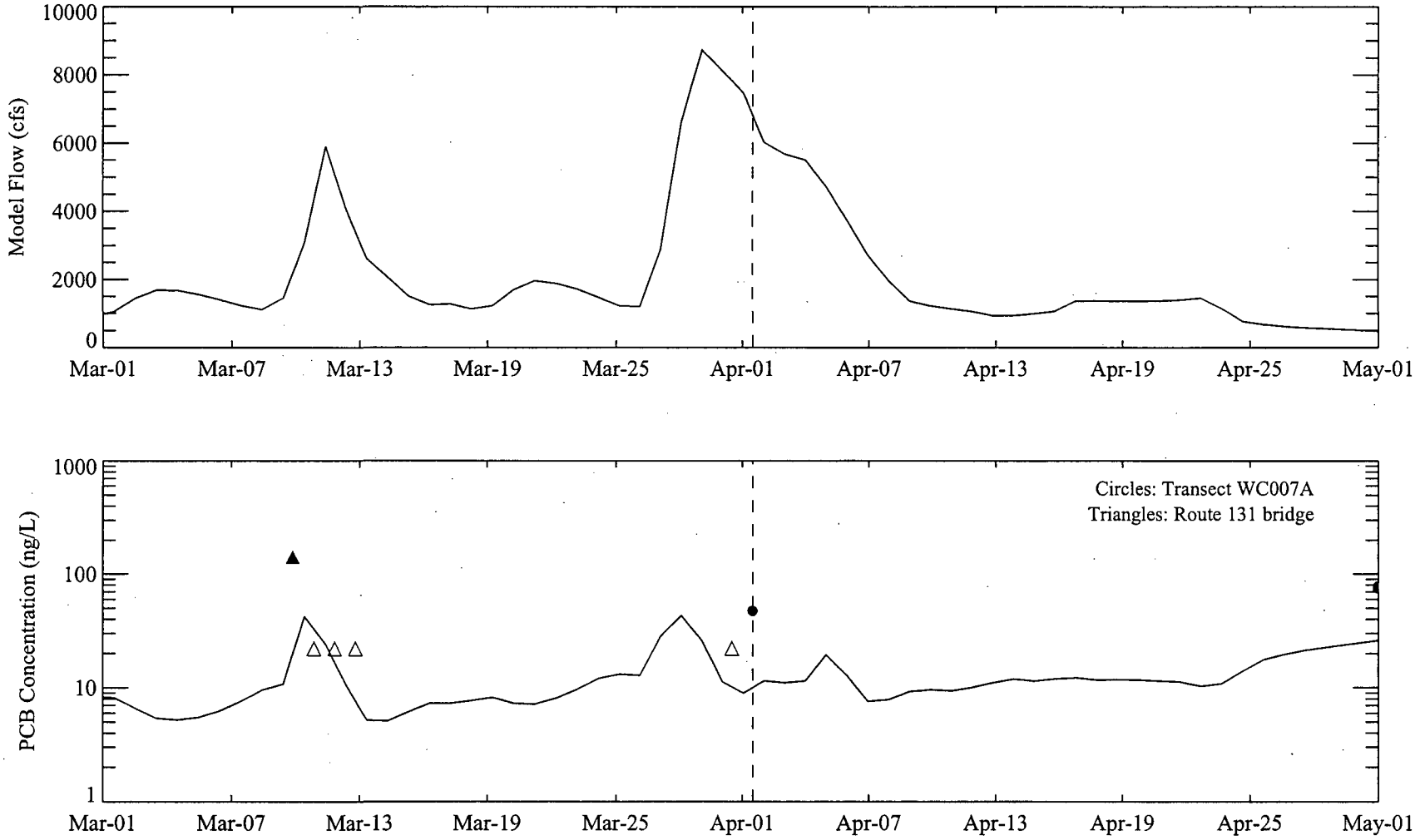

Figure B2-17. Temporal Profile of Water Column PCB Data (symbols) and Model Output (line) for Water Column Transect WC007A and the Route 131 Bridge during the March 1998 High Flow Event.

Note: Non-detects plotted as open symbols at MDL (22 ng/L)

Data tables: riverflow_hist, riverflow_trans, water_iupac

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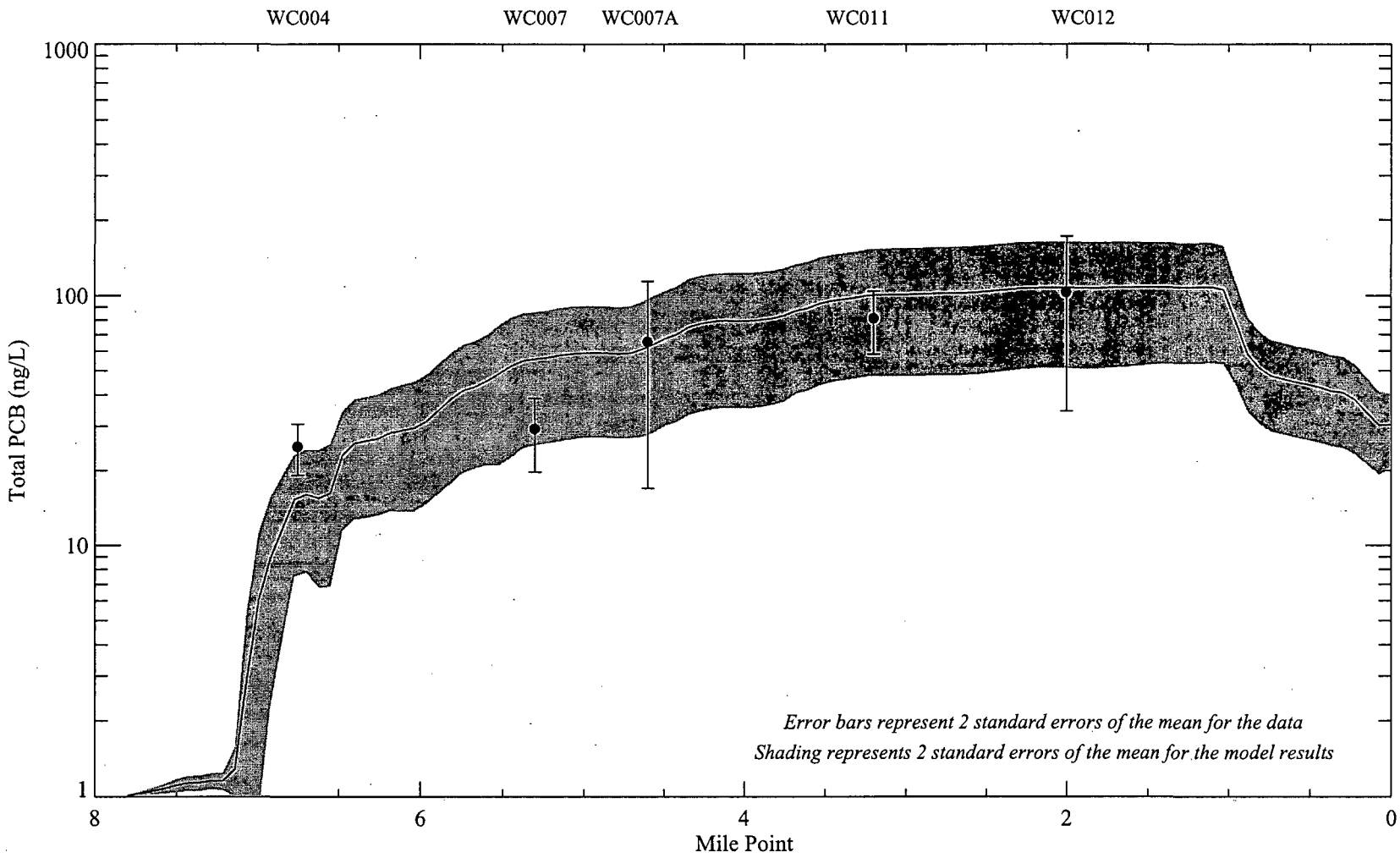

Figure B2-18. Spatial Profiles of Average Low Flow (< 1,100 cfs) Water Column PCB Data (circles) and Model Output (line) During September and October 1997.

Data tables: water_bz

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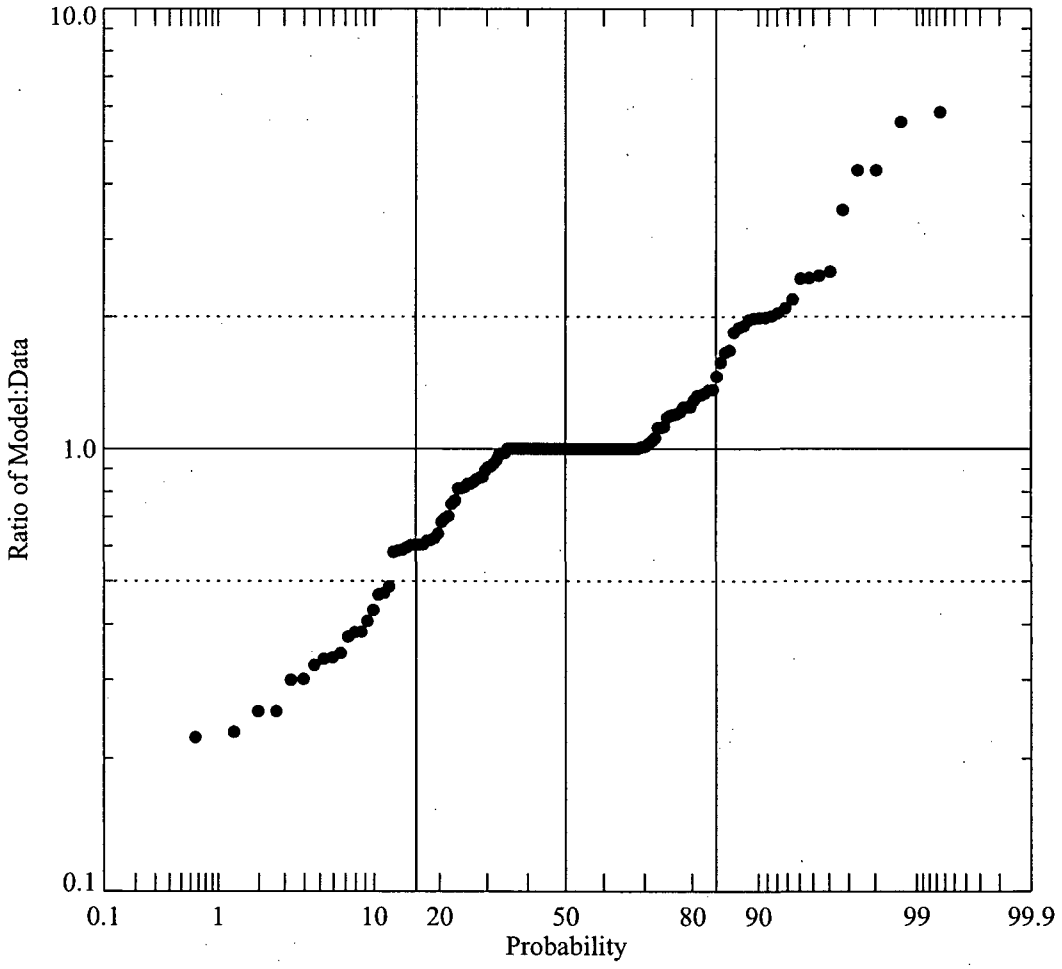

Figure B2-19. Probability Distribution of the Ratio of Model Results to Data for Water Column PCB Concentrations.
During 1997-99 Sampling Events.

Data tables: water_bz, water_iupac

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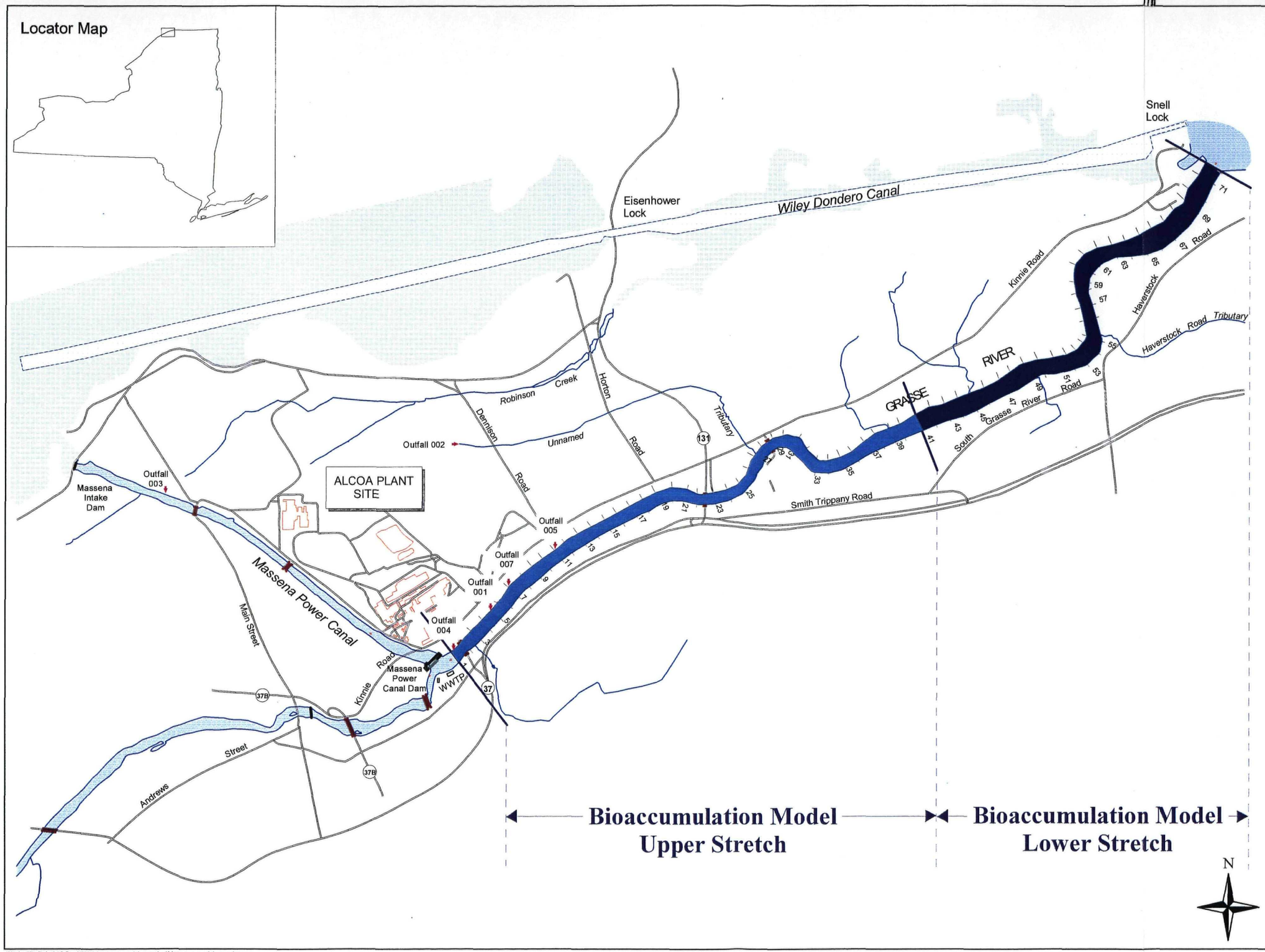

GRAPHIC SCALE

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
- Grasse River + Tributaries Shoreline
- Sediment Probing Transects

Lower Grasse River Study Area
Massena, New York

Figure B2-20.
Bioaccumulation
Model Stretches

ALCOA

Mar 2001

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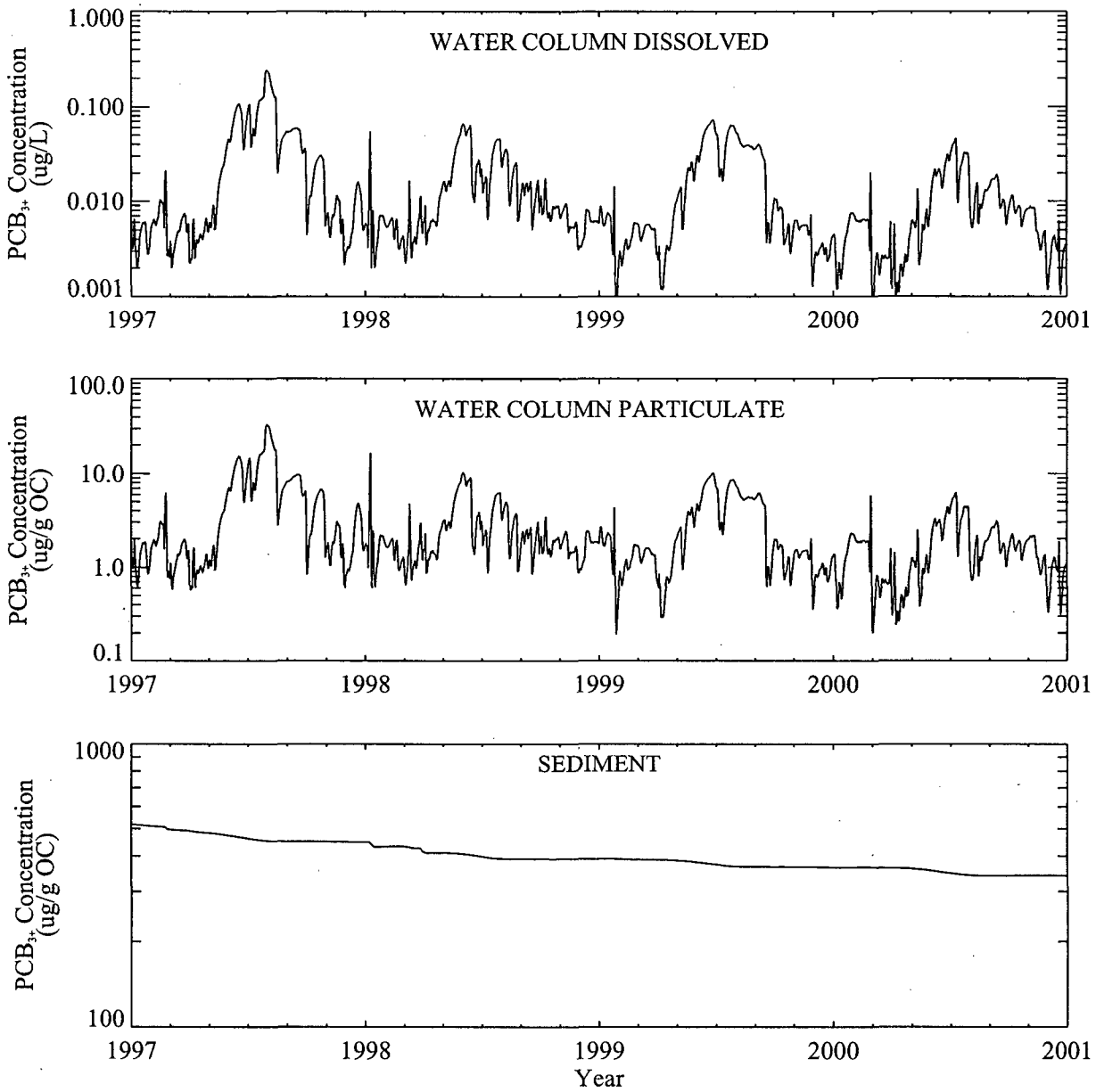


Figure B2-21. PCB_{3+} Exposure Concentrations Used in the Bioaccumulation Model for the Upper Stretch of the Grasse River.

PCB_{3+} concentrations based on total PCB levels computed by the fate model.

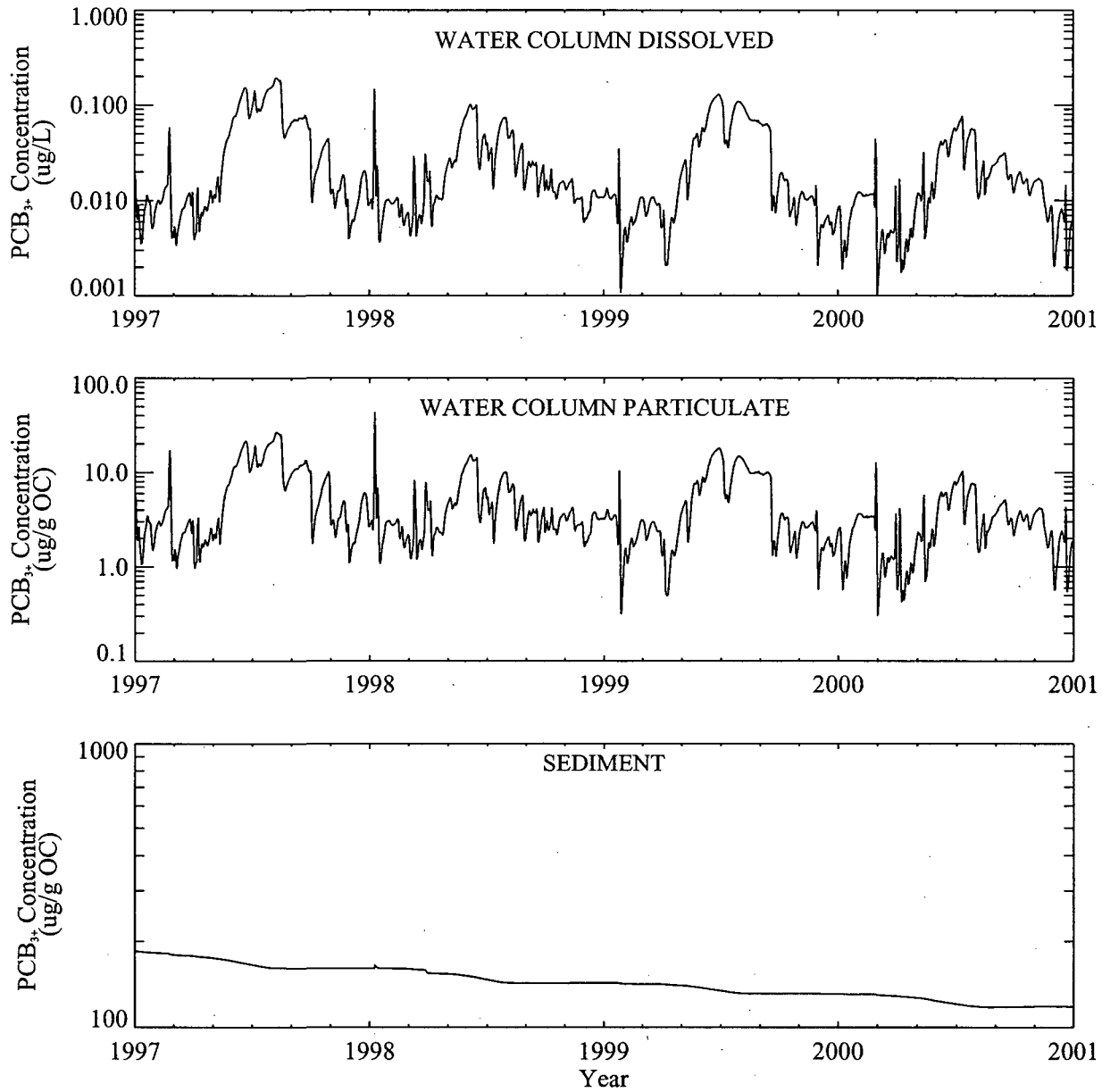


Figure B2-22. PCB_{3+} Exposure Concentrations Used in the Bioaccumulation Model for the Lower Stretch of the Grasse River.

PCB_{3+} concentrations based on total PCB levels computed by the fate model.

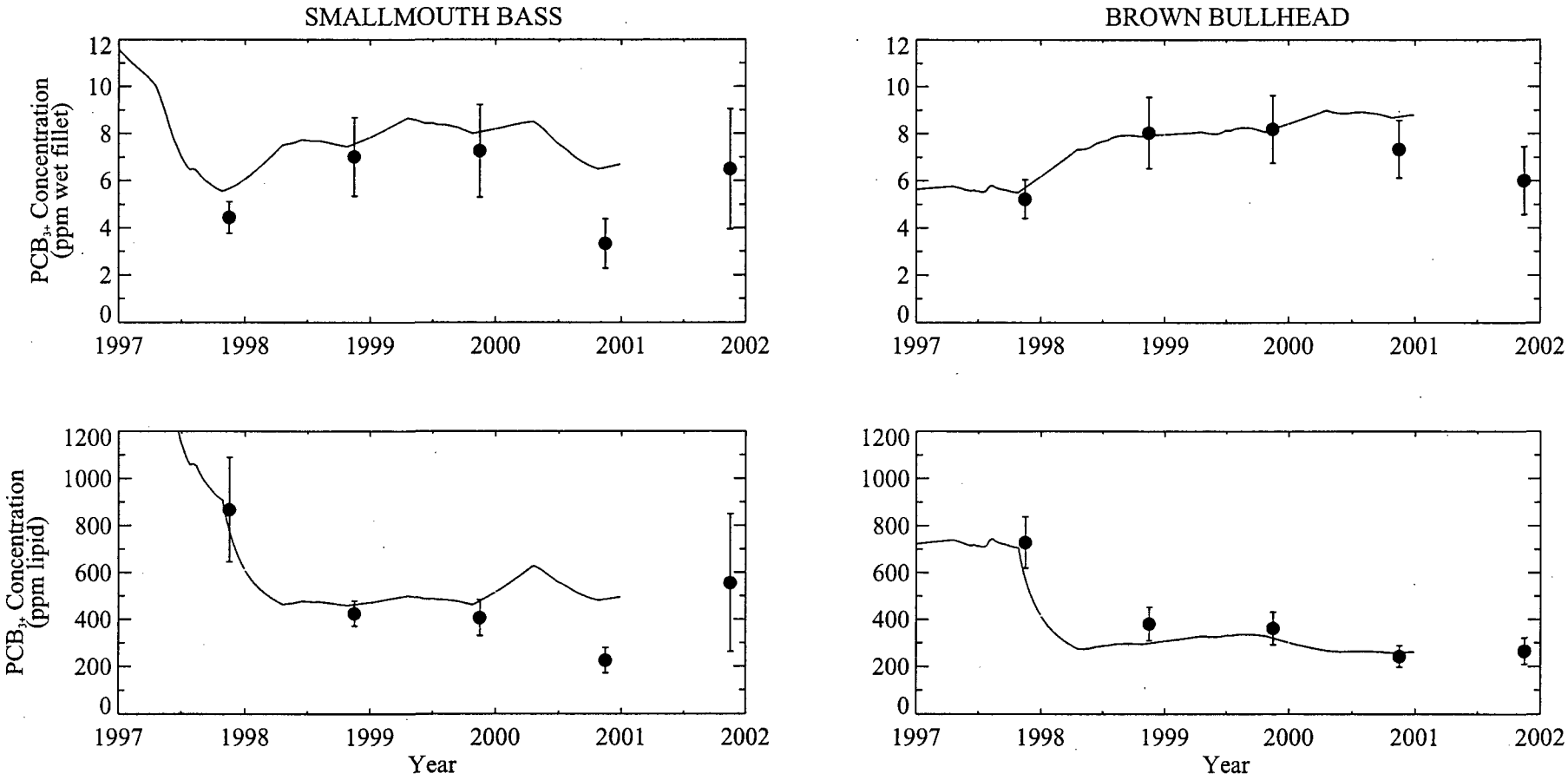


Figure B2-23. Predicted (line) and Measured (symbols) PCB_{3+} Concentrations in Smallmouth Bass and Brown Bullhead Collected from the Upper Stretch of the Grasse River.

Solid lines indicate model results.

Circles represent arithmetic means +/- 2 standard errors of Aroclor data collected from Upper and Middle Stretches.

Data table: resfish_aro

Model runs 0701-01(A-D)uppr

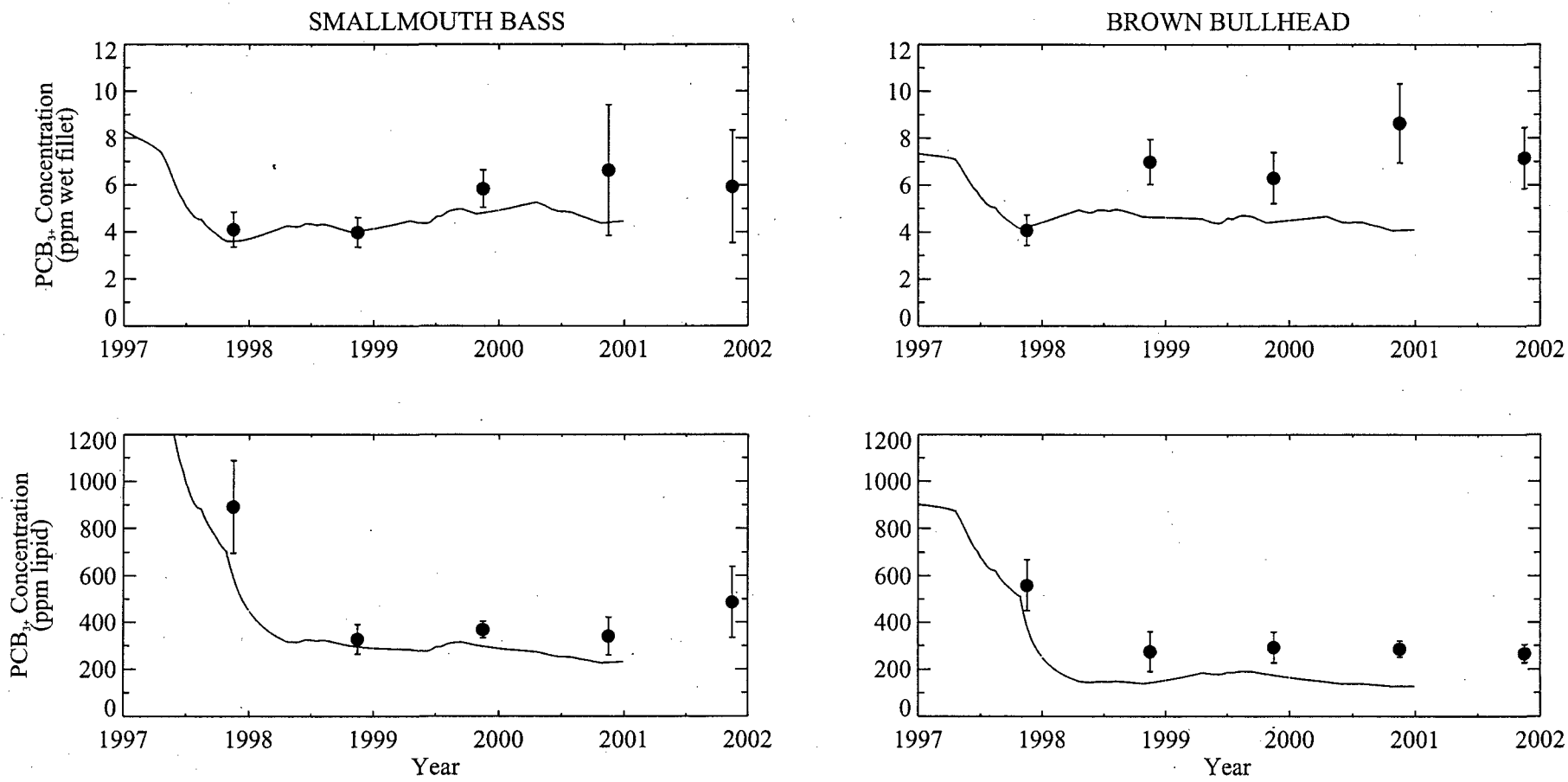


Figure B2-24. Predicted (line) and Measured (symbols) PCB_{3+} Concentrations in Smallmouth Bass and Brown Bullhead Collected from the Lower Stretch of the Grasse River.

Solid lines indicate model results.

Circles represent arithmetic means +/- 2 standard errors of Aroclor data collected from Lower Stretch.

Data table: resfish_aro

Model runs 0701-01(A-D)lowr

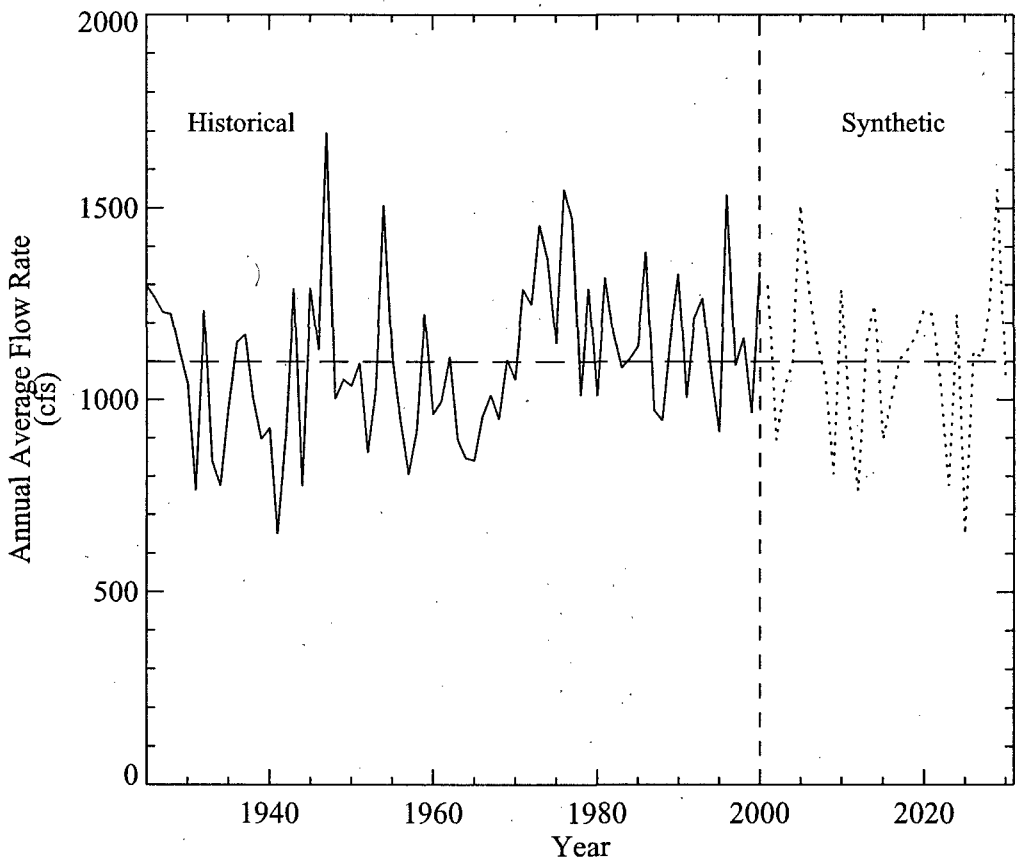


Figure. B3-1. Data-based (solid line) and Synthetic (dashed line) Hydrographs for Annual Average Flow Rate at Massena.

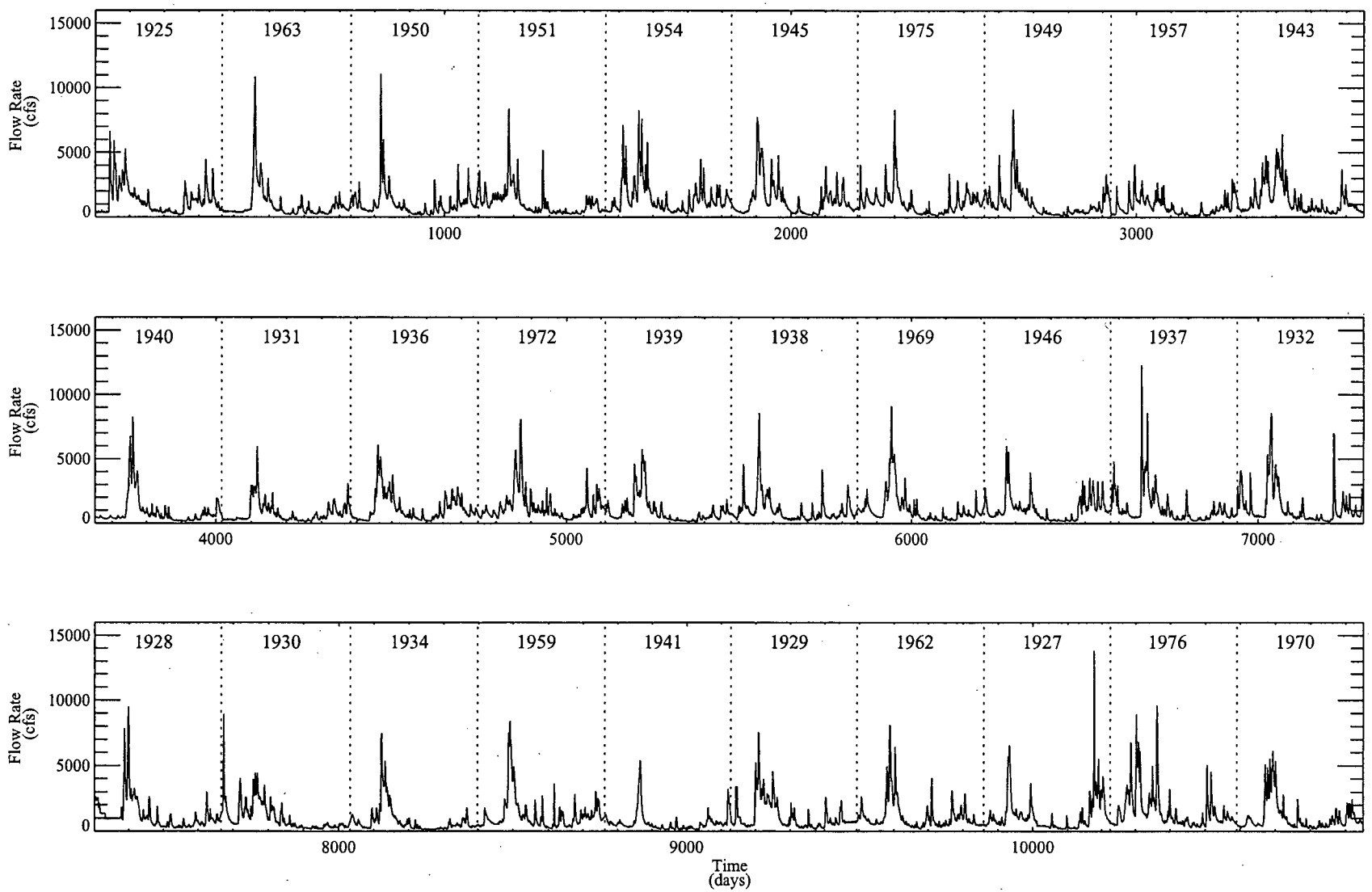


Figure B3-2. 30-year Synthetic Hydrograph (daily average discharge) Developed from Historical Grasse River Flow Rates.

DN - \\Daleel\D_Drive\ALCgra\Model\Hydro\Outputs\Hydro_Projection_0105-01\check_rorr_30yrs.pro
Mon Feb 11 12:21:37 2002

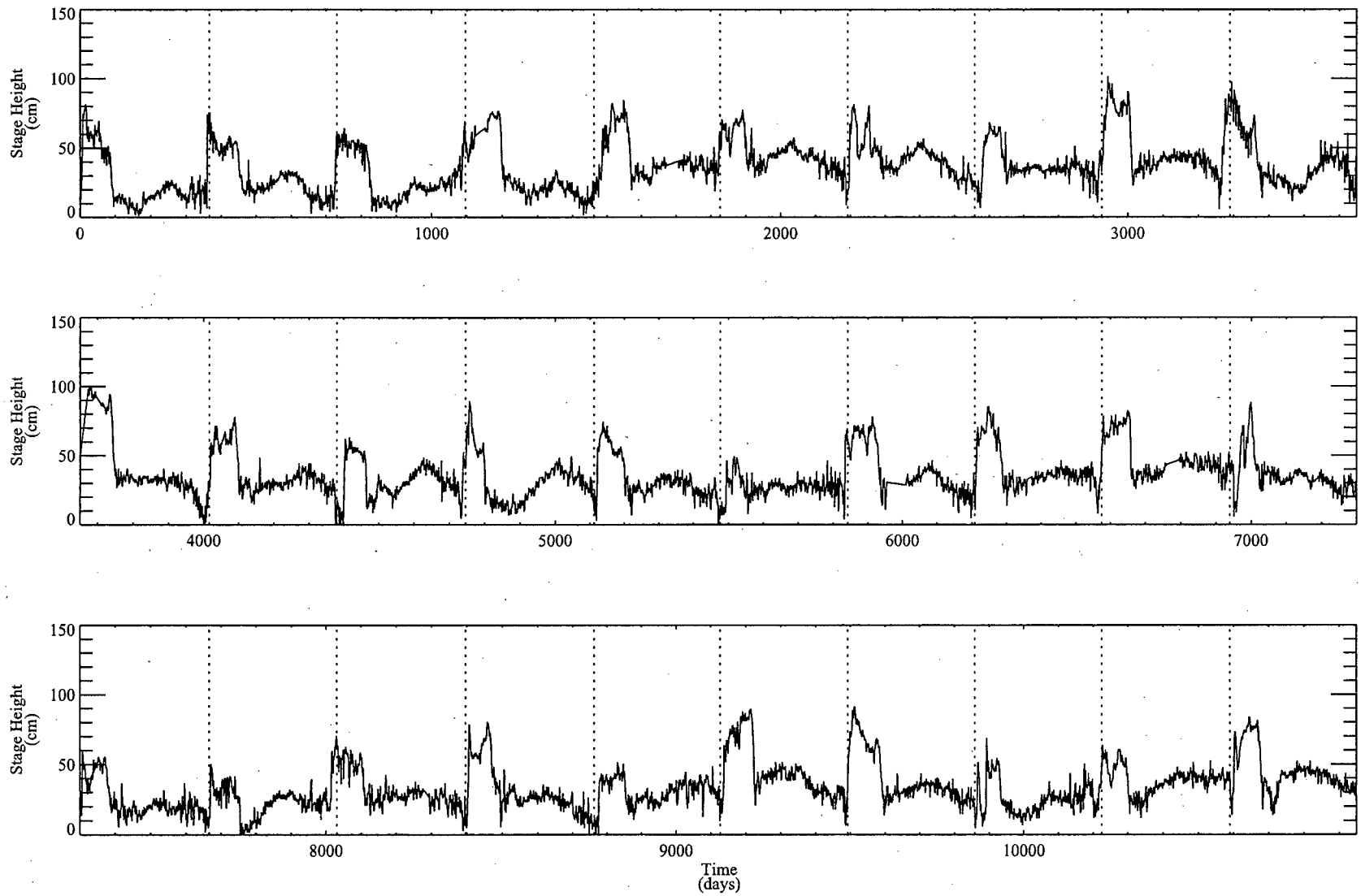


Figure B3-3. Stage Height Specified at Downstream Boundary During 30-year Simulation.

DN - \\Daleel\D_Drive\ALCgra\Analysis\Water\Flow\SYN_FLOW_STAGE\SYN_Stage\plot_stage_from_out.pro
Mon Feb 11 12:24:38 2002

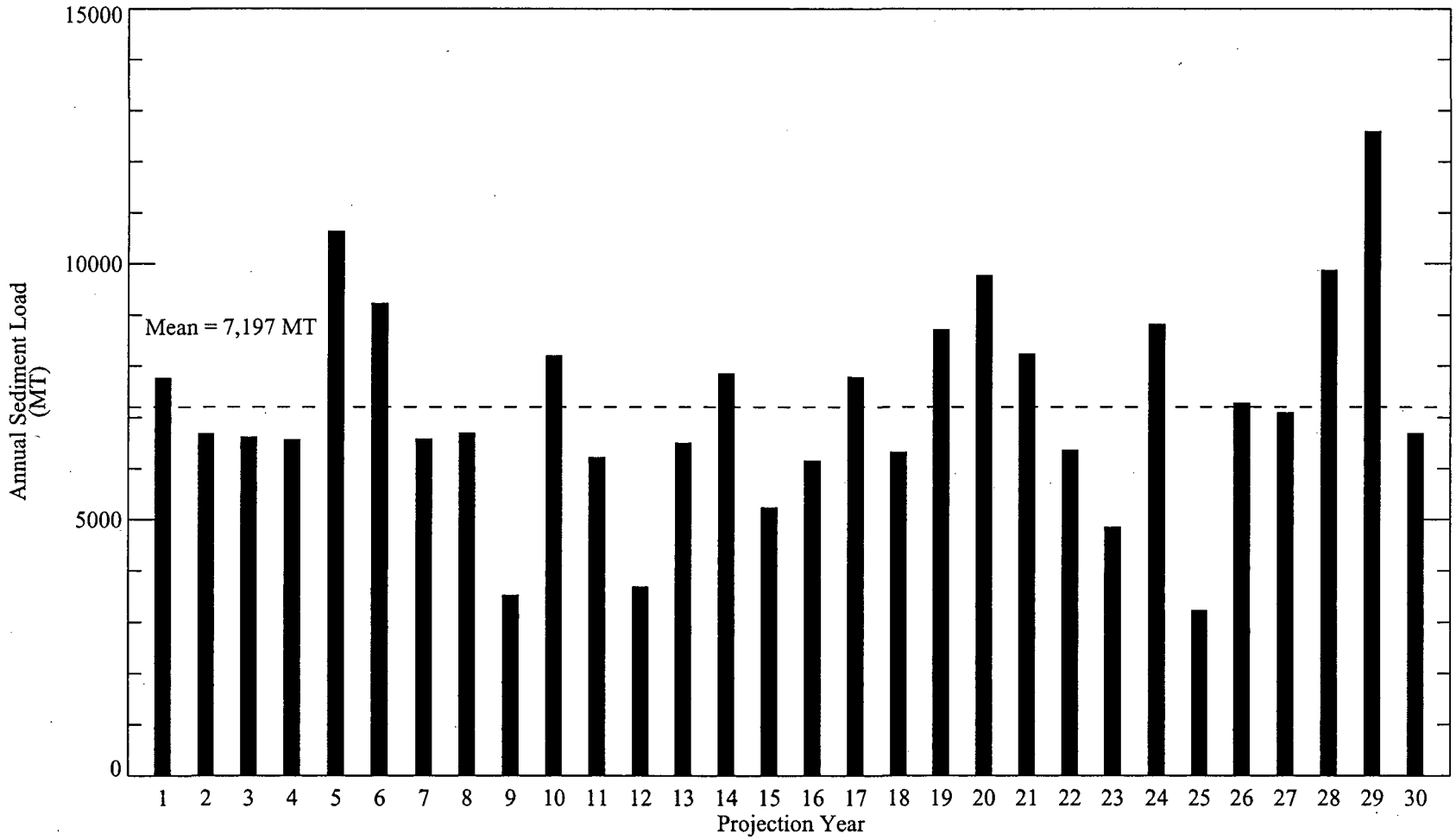
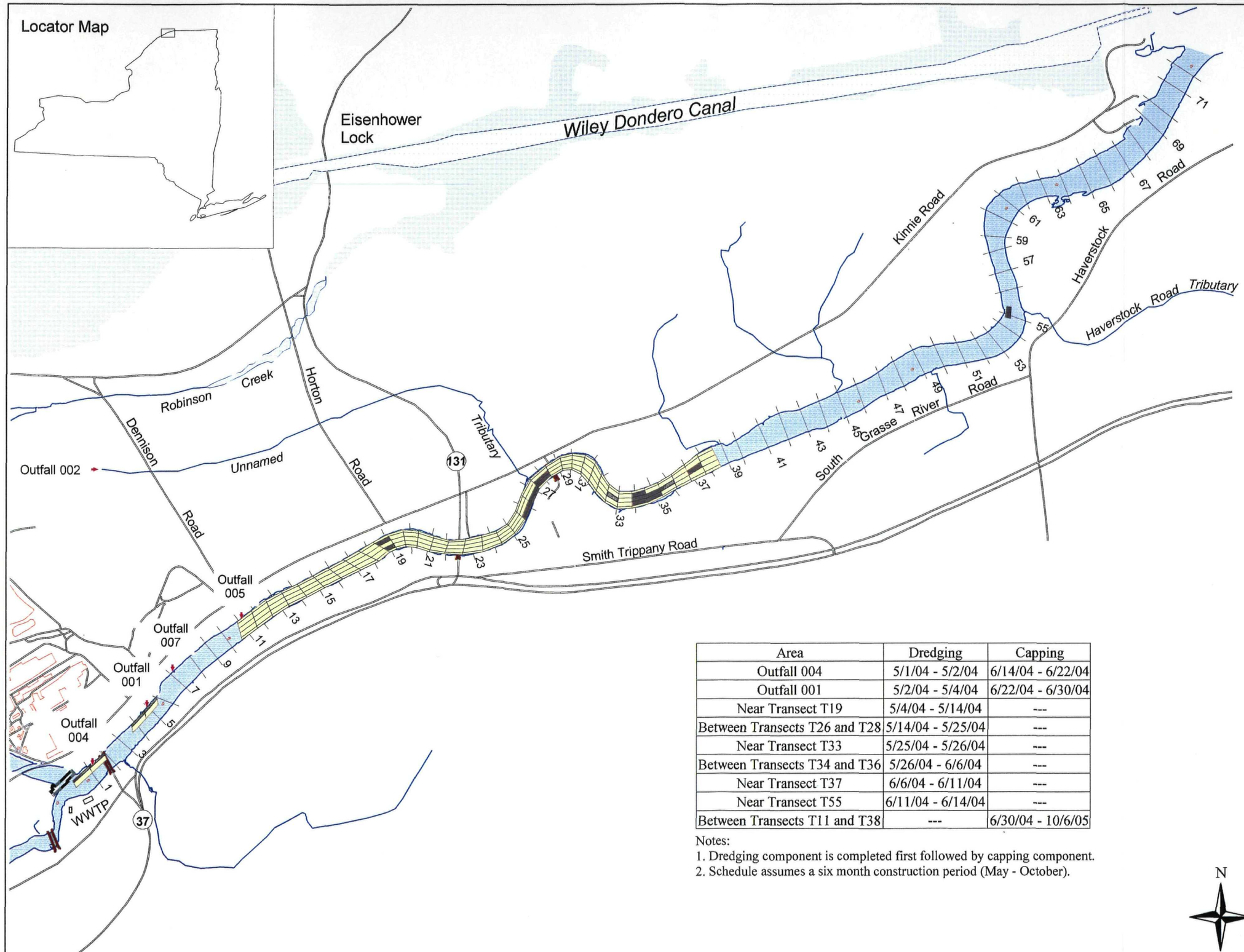


Figure B3-4. Annual Average Sediment Loading During the 30-year Projection.

DN - \\Daleel\D_Drive\ALCgra\Model\Sedtran\Sedtran_Projection_0106-01\Inputs\ann_avg_sedload_30yr_1.pro
Mon Feb 11 12:27:13 2002



Area	Dredging	Capping
Outfall 004	5/1/04 - 5/2/04	6/14/04 - 6/22/04
Outfall 001	5/2/04 - 5/4/04	6/22/04 - 6/30/04
Near Transect T19	5/4/04 - 5/14/04	---
Between Transects T26 and T28	5/14/04 - 5/25/04	---
Near Transect T33	5/25/04 - 5/26/04	---
Between Transects T34 and T36	5/26/04 - 6/6/04	---
Near Transect T37	6/6/04 - 6/11/04	---
Near Transect T55	6/11/04 - 6/14/04	---
Between Transects T11 and T38	---	6/30/04 - 10/6/05

Notes:
1. Dredging component is completed first followed by capping component.
2. Schedule assumes a six month construction period (May - October).

GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- Areas Targeted for Dredging
- Areas Targeted for Capping
- 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

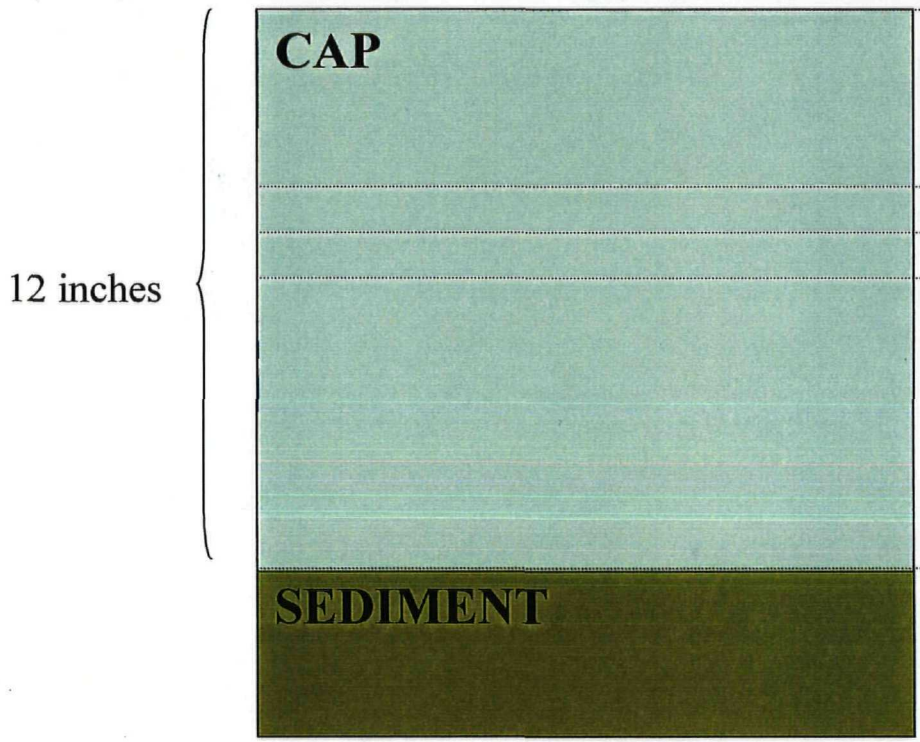
Lower Grasse River Study Area
Massena, New York

Figure B3-5.
Remediation Schedule for Alternative 4 (Dredge ⩾ 50 ppm; Cap 001/004, and T11-T38; and Site-Wide Natural Recovery) Showing Model Grid Element Completion over Time.

ALCOA

Jan 2002

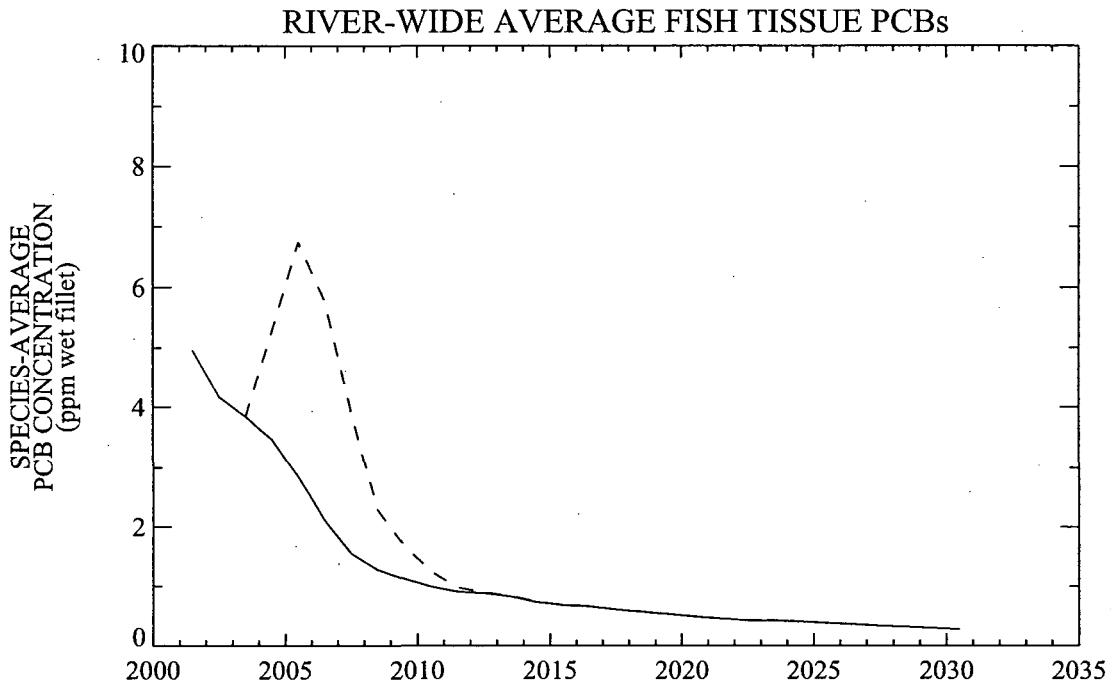
\\Dalcol\D_Drive\ALCgra\GIS\remed_sched\remed_sched.apr



	Minimum Design Depth (inches)
Bioturbation	4.0
Consolidation	1.0
Erosion	1.0
Chemical Isolation	6.0
Design Thickness	**12.0 inches**

Figure B3-6. Design Cap Thickness Determined from Evaluation of Data Collected in the Lower Grasse River.

JQ - \\Jimq\D_Drive\ALCgra\Reports\AA_0102\ModelingAppendix\Figures\cap_design_thickness.ppt
2/5/02 13:29



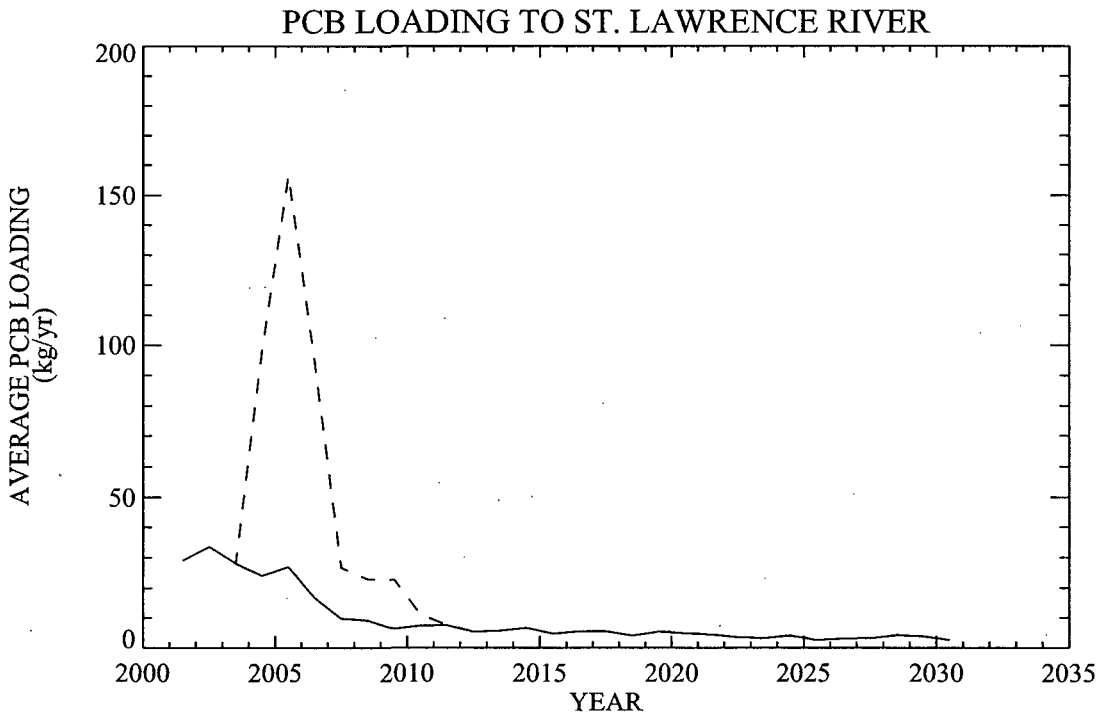


Figure B3-7. Average Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River.
Fish PCB levels represent averages of smallmouth bass and brown bullhead PCBs, area-weighted by river stretch.
Average PCB loading to the St. Lawrence River computed by PCB fate model.
Solid Lines: Dredge ≥ 1 ppm (0.1% release, 2.5 ppm residual)
Dashed Lines: Dredge ≥ 1 ppm (2.5% release, 2.5 ppm residual)

JimQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_avgfish_slr_1.pro
Mon Feb 11 13:16:17 2002

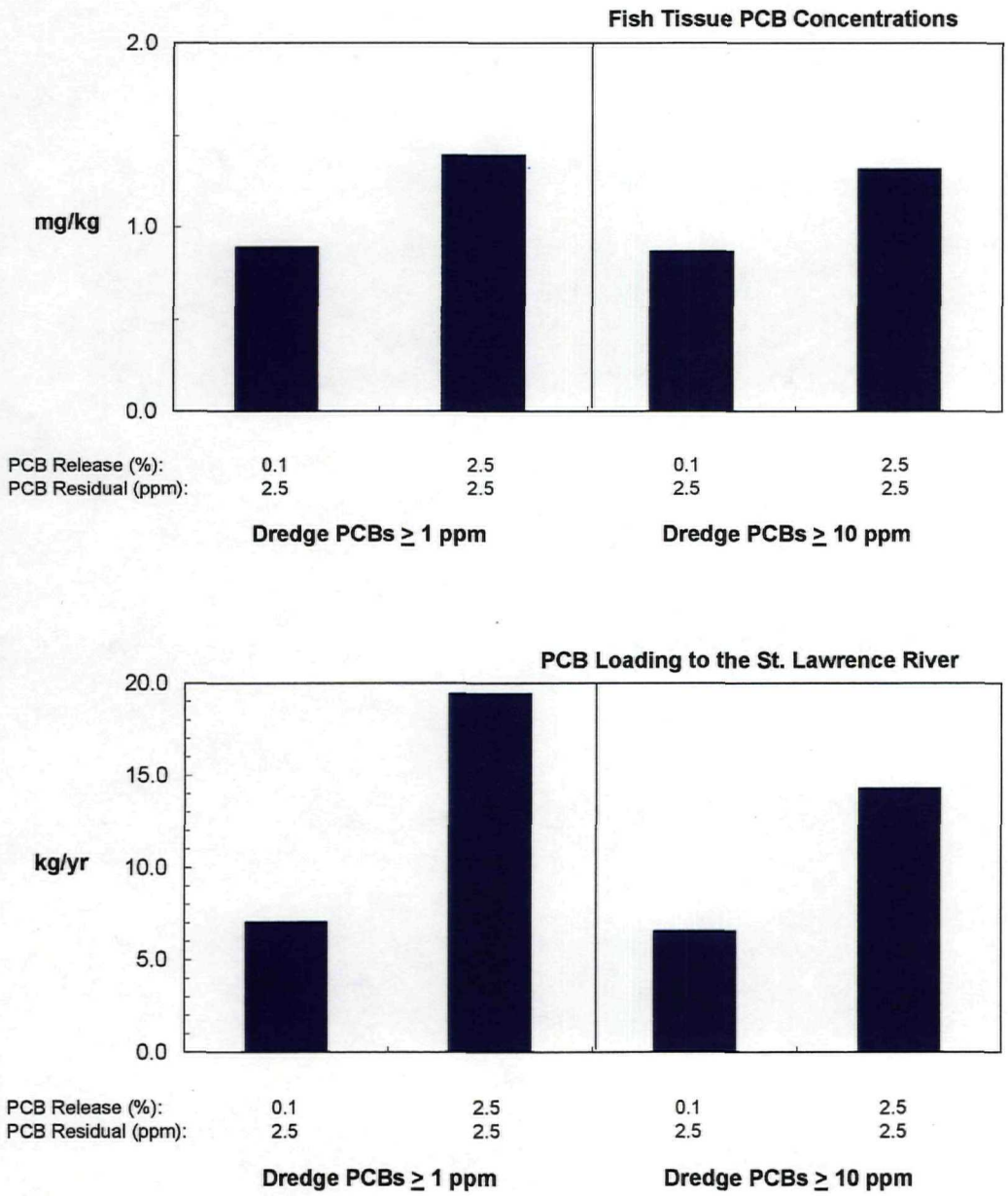
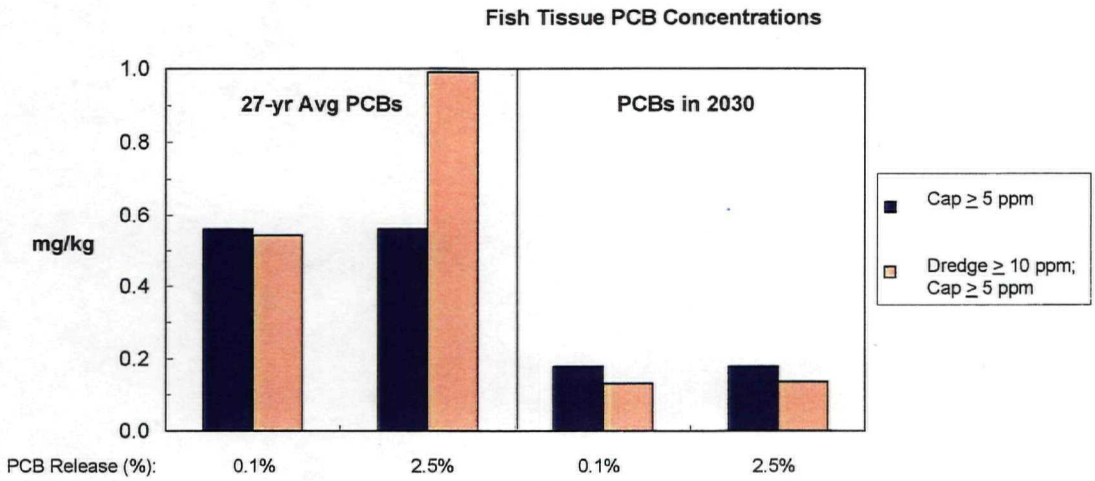


Figure B3-9. Sensitivity of Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River to Assumptions Regarding PCB Releases During Dredging.

Fish: Values represent species-average PCB levels (smallmouth bass and brown bullhead) between 2004 and 2030, area-weighted by river stretch.

Water: Values represent average PCB loading to the St. Lawrence River between 2004 and 2030.



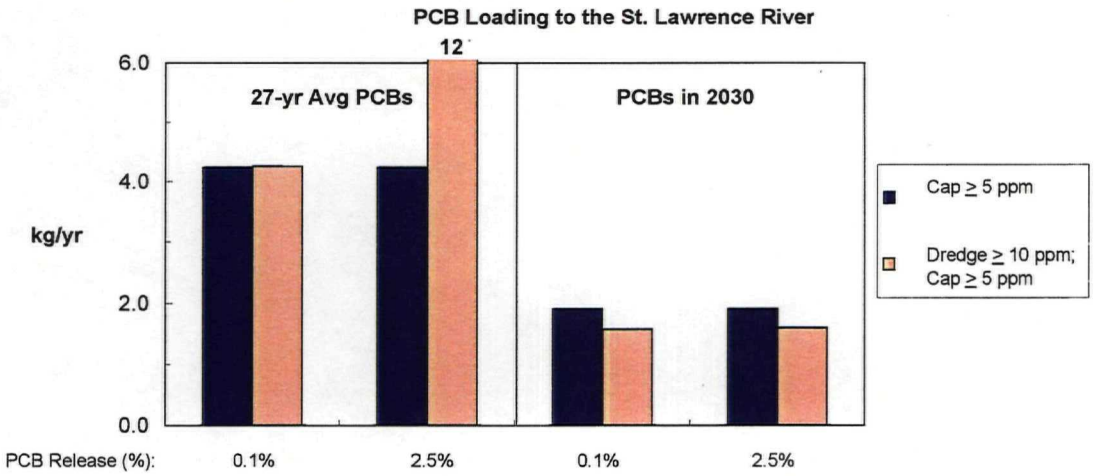
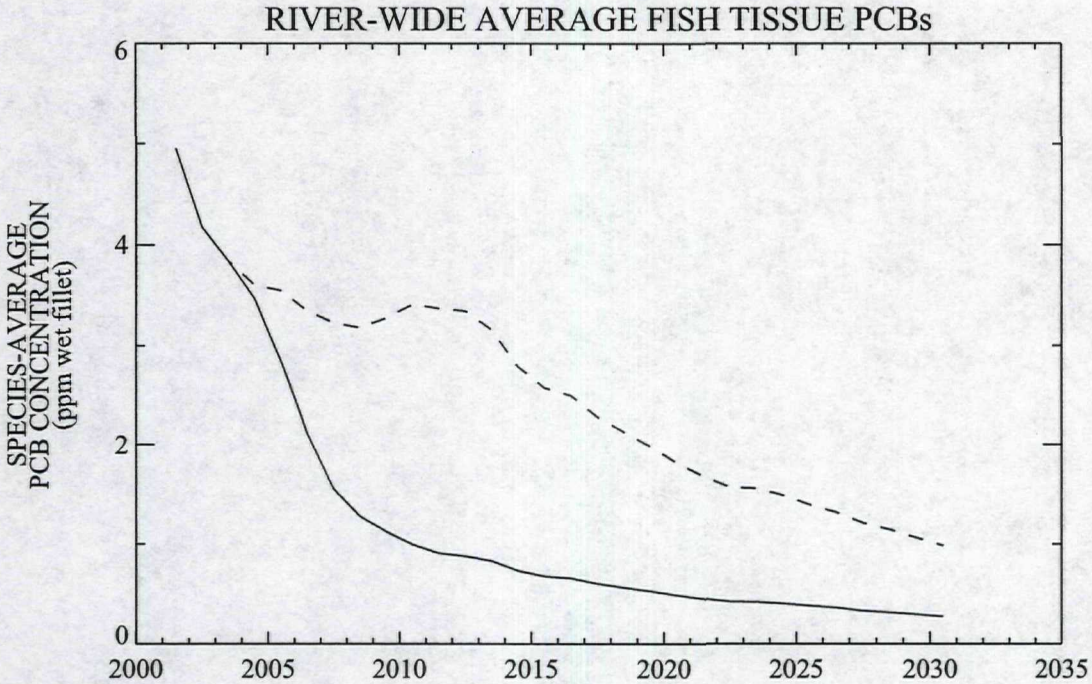


Figure B3-10. Sensitivity of Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River to Assumptions Regarding PCB Releases During Dredging (Dredge ≥ 50 ppm + Cap ≥ 5 ppm example).

2030 values represent avergae levels during last year of simulation (i.e., 2030).
27-year averages represent average PCB levels between 2004 and 2030.
Fish: Values represent species-average PCB levels (smallmouth bass and brown bullhead) between 2004 and 2030, area-weighted by river stretch.
Water: Values represent average PCB loading to the St. Lawrence River between 2004 and 2030.



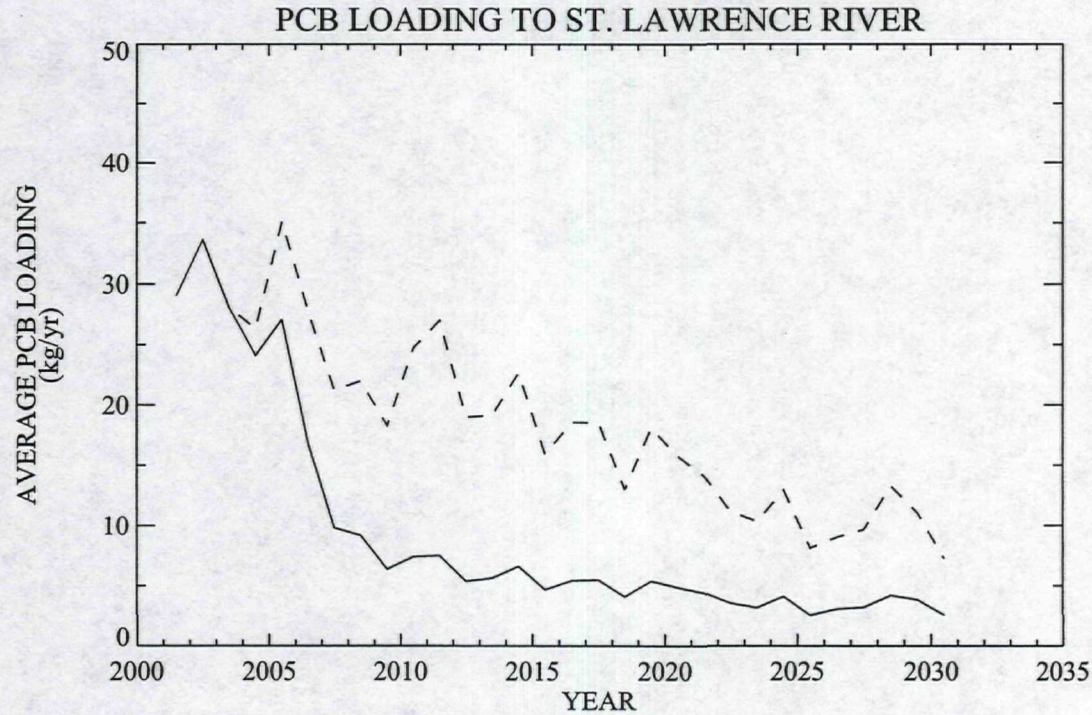


Figure B3-11. Average Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River.

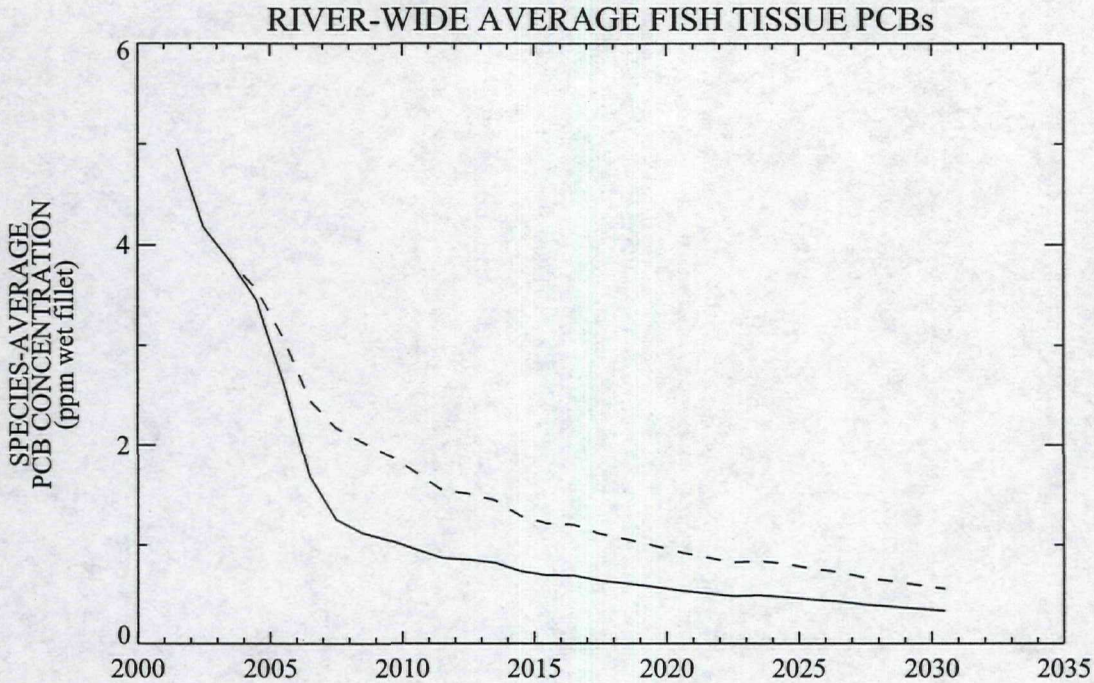
Fish PCB levels represent averages of smallmouth bass and brown bullhead PCBs, area-weighted by river stretch.

Average PCB loading to the St. Lawrence River computed by PCB fate model.

Solid Lines: Dredge ≥ 1 ppm (0.1% release, 2.5 ppm residual)

Dashed Lines: Dredge ≥ 1 ppm (0.1% release, 10.0 ppm residual)

JimQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_avgfish_slr_1.pro
Mon Feb 11 13:22:42 2002



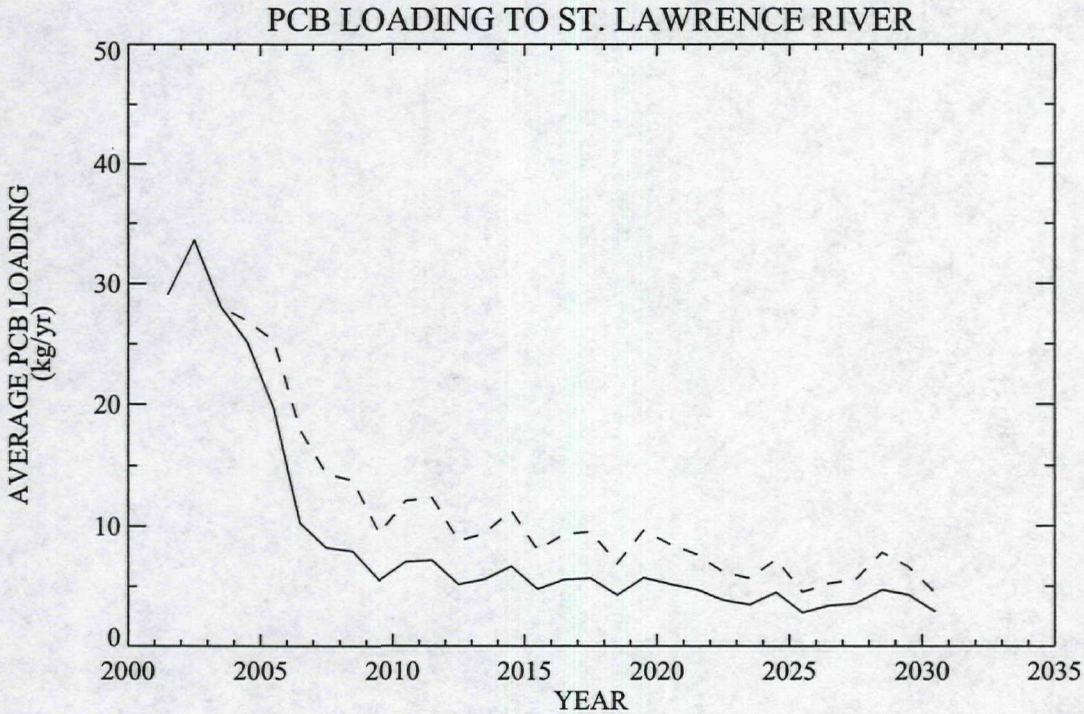


Figure B3-12. Average Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River.

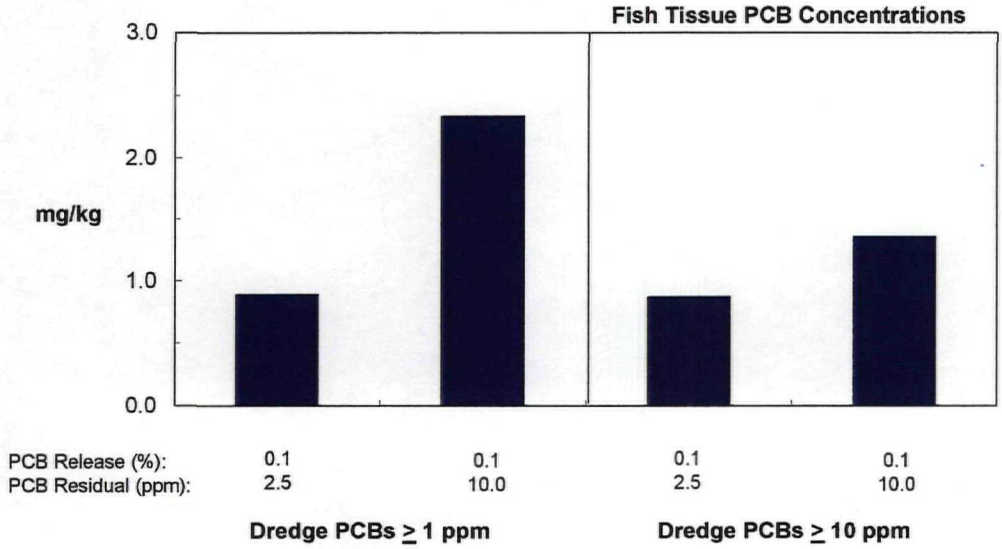
Fish PCB levels represent averages of smallmouth bass and brown bullhead PCBs, area-weighted by river stretch.

Average PCB loading to the St. Lawrence River computed by PCB fate model.

Solid Lines: Dredge ≥ 10 ppm (0.1% release, 2.5 ppm residual)

Dashed Lines: Dredge ≥ 10 ppm (0.1% release, 10.0 ppm residual)

JimQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_avgfish_slr_1.pro
Mon Feb 11 13:24:27 2002



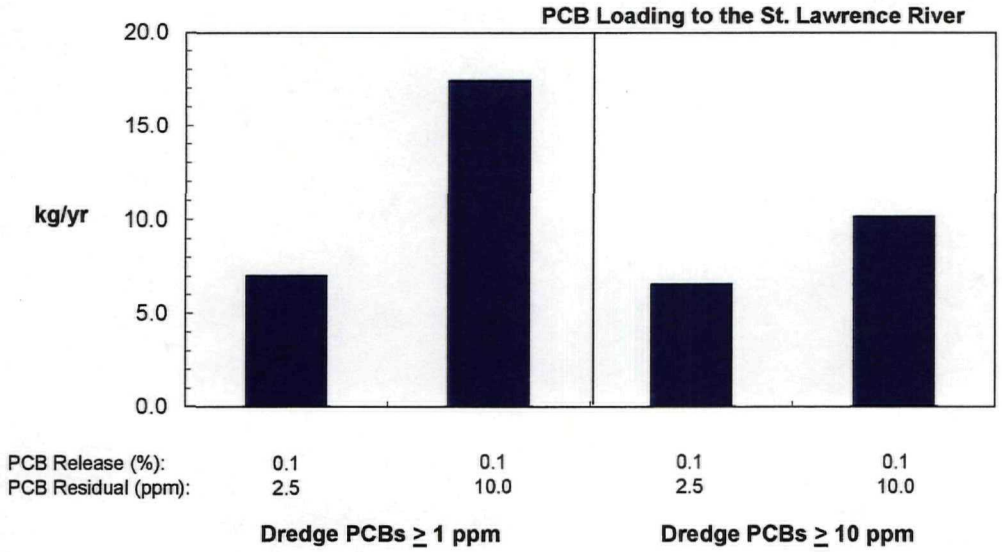
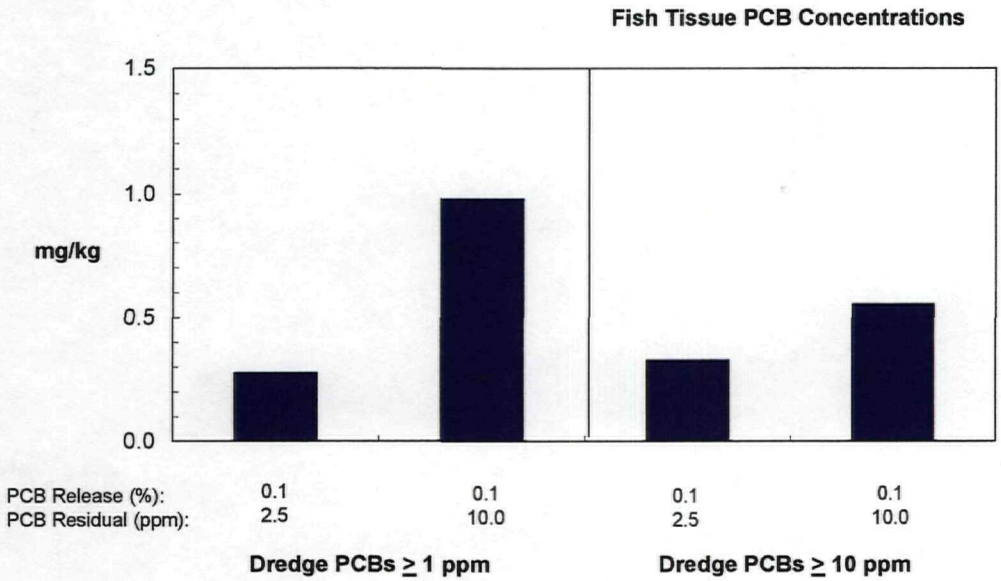


Figure B3-13. Sensitivity of Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River to Assumptions Regarding Post-Dredging PCB Residual (Average PCB levels between 2004 and 2030).

Fish: Values represent species-average PCB levels (smallmouth bass and brown bullhead) between 2004 and 2030, area-weighted by river stretch.

Water: Values represent average PCB loading to the St. Lawrence River between 2004 and 2030.



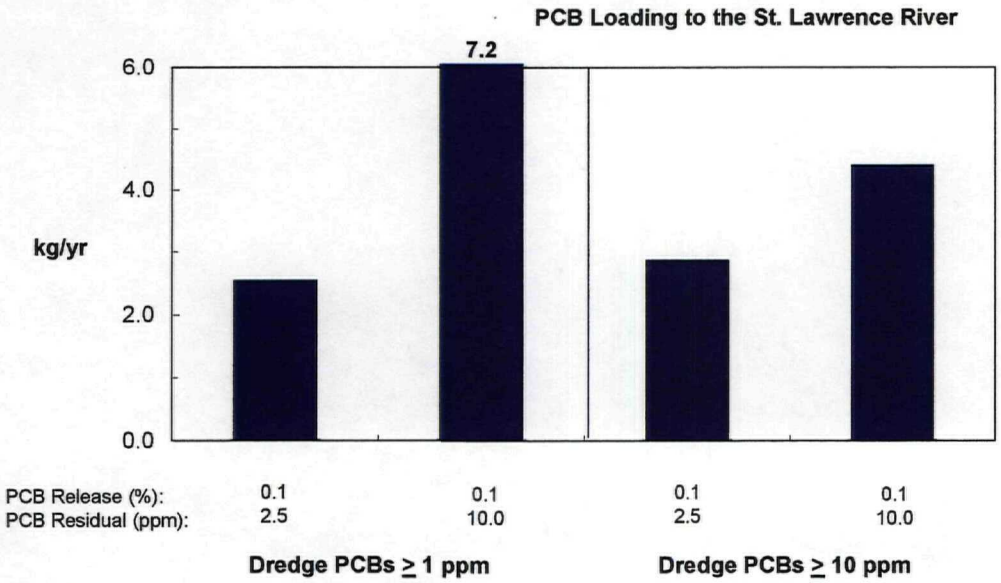


Figure B3-14. Sensitivity of Fish Tissue PCB Concentrations and PCB Loading to the St. Lawrence River to Assumptions Regarding Post-Dredging PCB Residual (Average PCB levels in 2030).

Fish: Values represent species-average PCB levels (smallmouth bass and brown bullhead) in 2030, area-weighted by river stretch.

Water: Values represent average PCB loading to the St. Lawrence River in 2030.

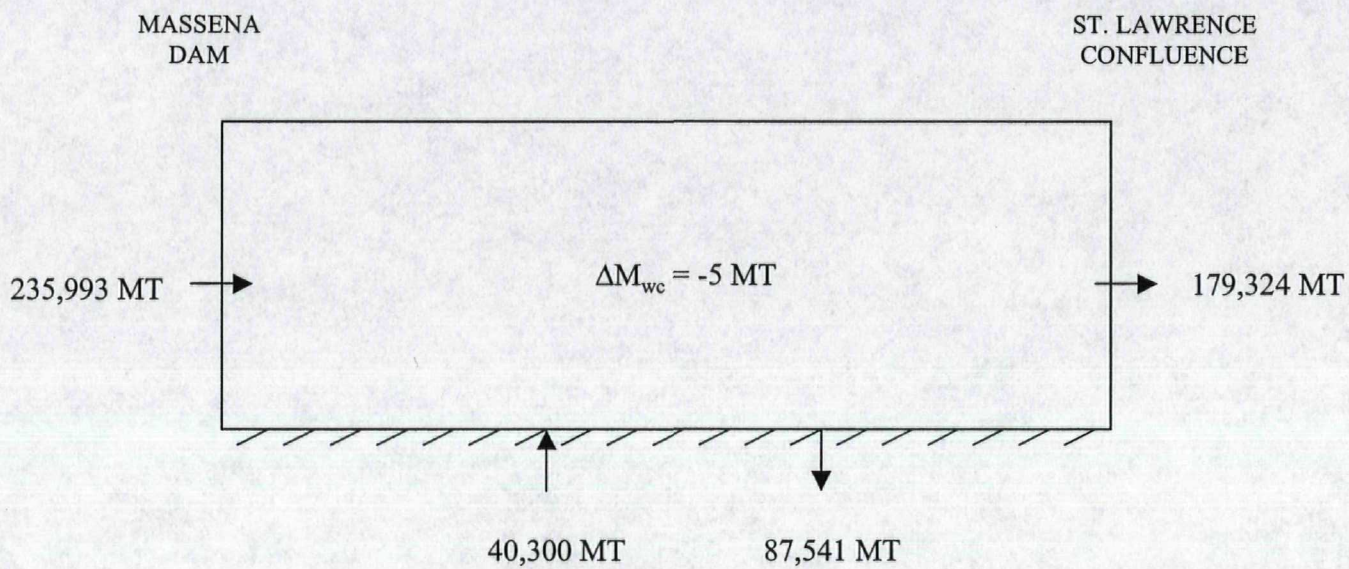
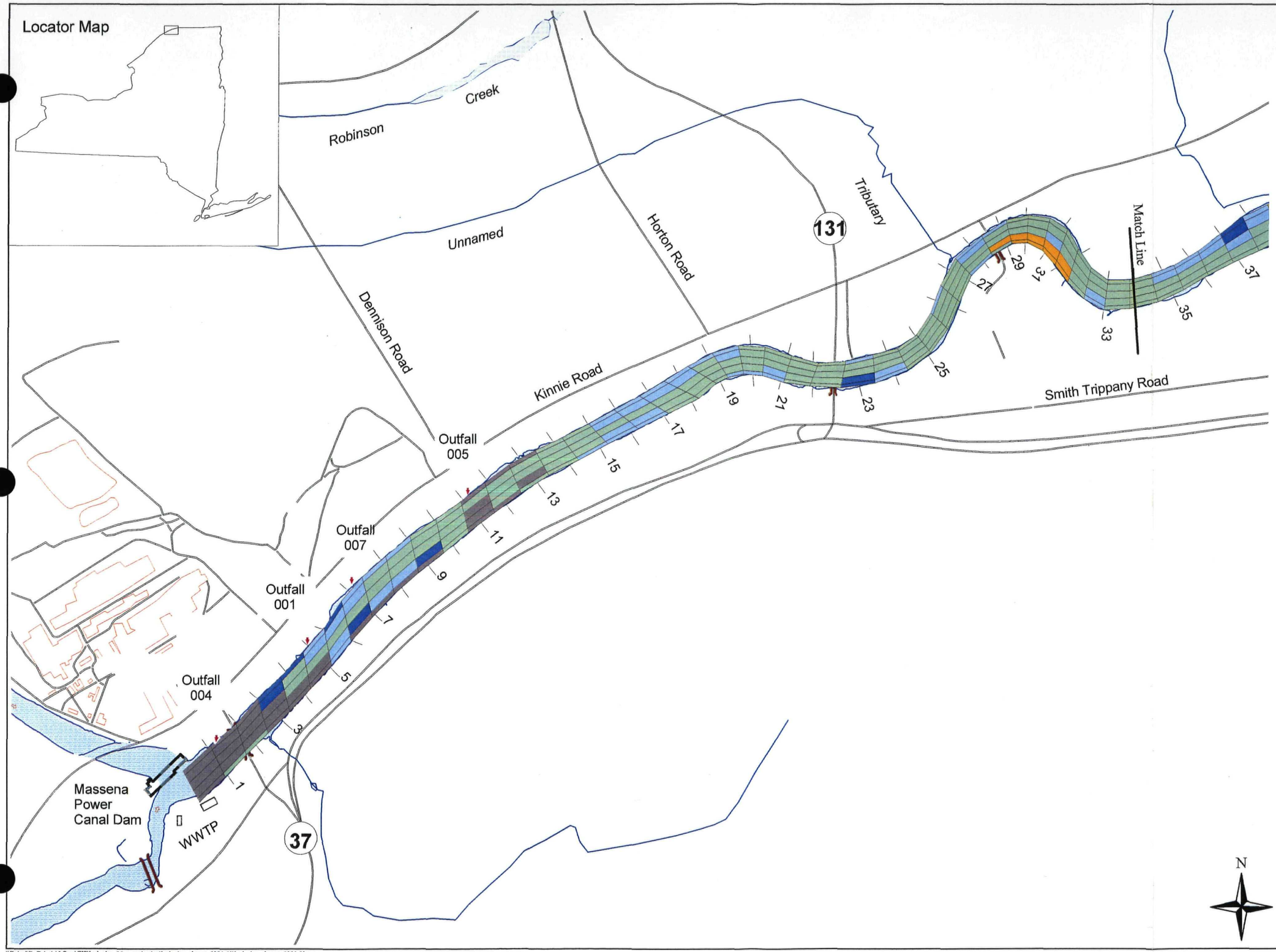


Figure B4-1. Lower Grasse River Sediment Mass Balance for the 30-Year Simulation (2001-2030).



GRAPHIC SCALE

500 0 500 Feet

LEGEND

Net Deposition (cm)
- Erosion
- Hard-bottom
- 0 - 5
- 5 - 10
- > 10

- 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

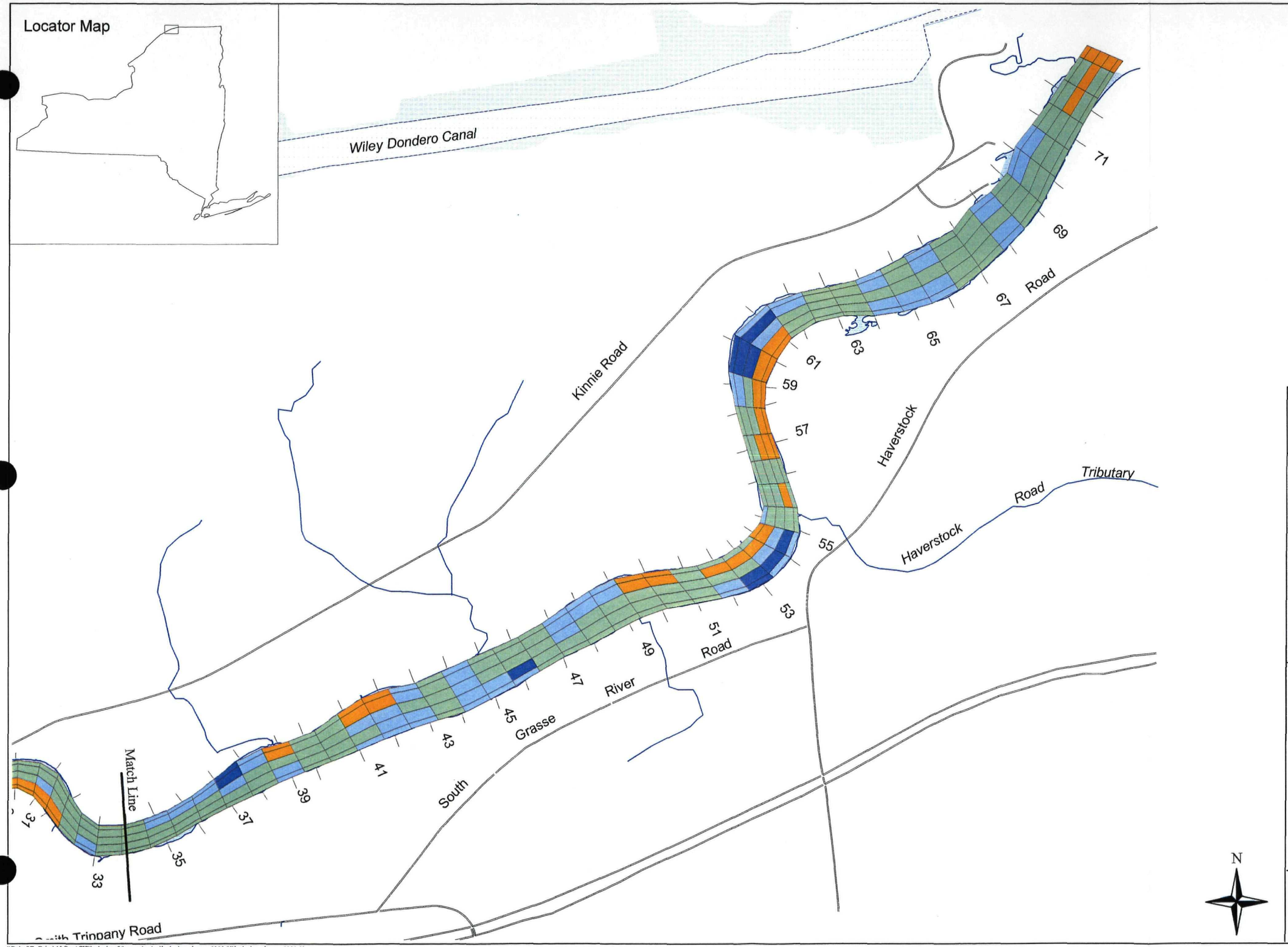
Figure B4-2.
Spatial Distribution of Net Deposition During the 30-Year Projection Period

1 of 2

ALCOA

Feb 2002

\\Daleef\D_Drive\ALCgra\GIS\bed_elev_30yr_projection\bed_elev_change_0106-01\bed_elev_change_0106-01.apr



GRAPHIC SCALE

500 0 500 Feet

LEGEND

Net Deposition (cm)
- Erosion
- Hard-bottom
- 0 - 5
- 5 - 10
- > 10
- 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 B4-3.
Spatial Distribution of Net Deposition During the 30-Year Projection Period

2 of 2

ALCOA

Feb 2002

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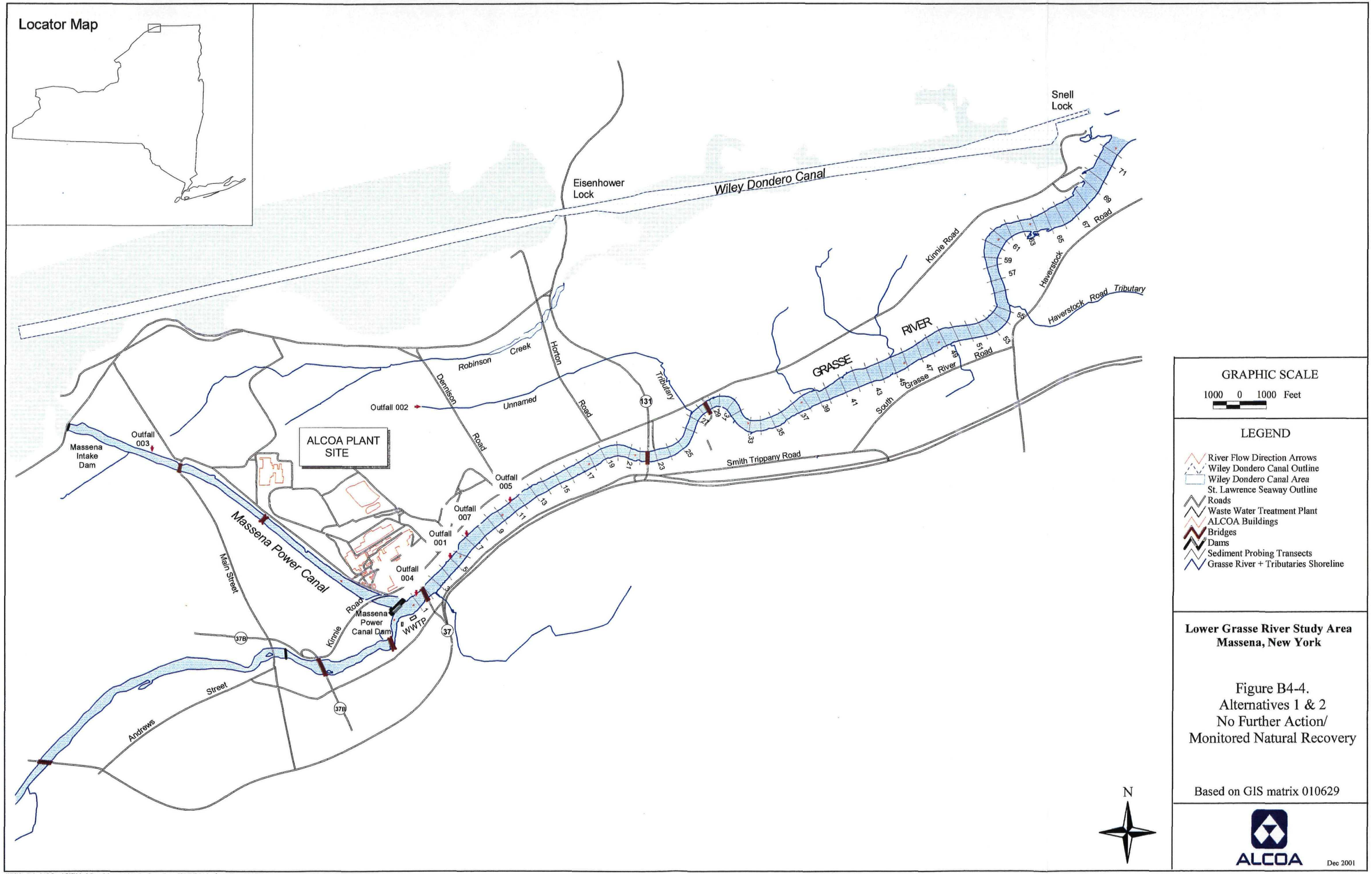

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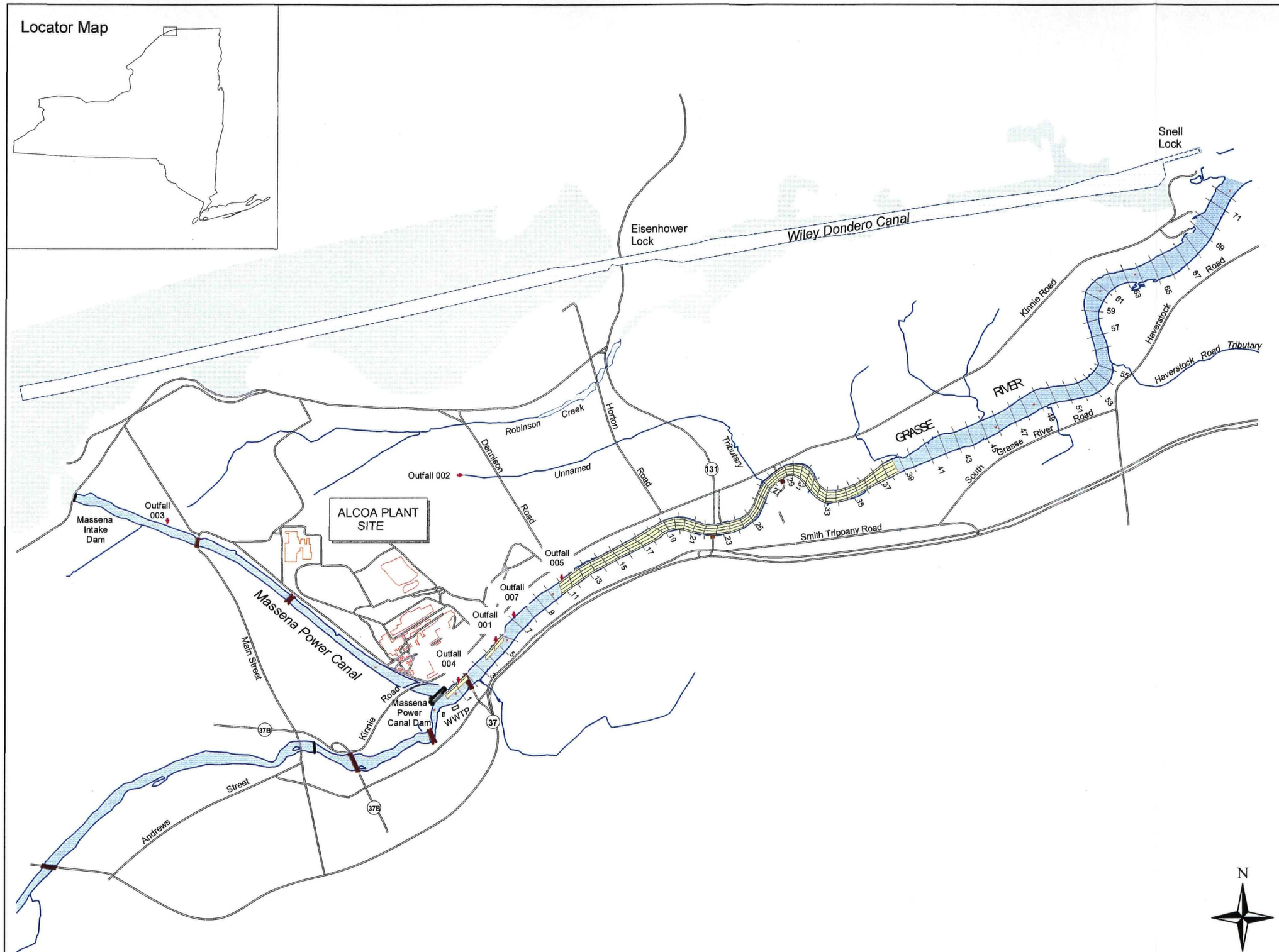


GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- Cap 001/004 and Transects T11-T38
- 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

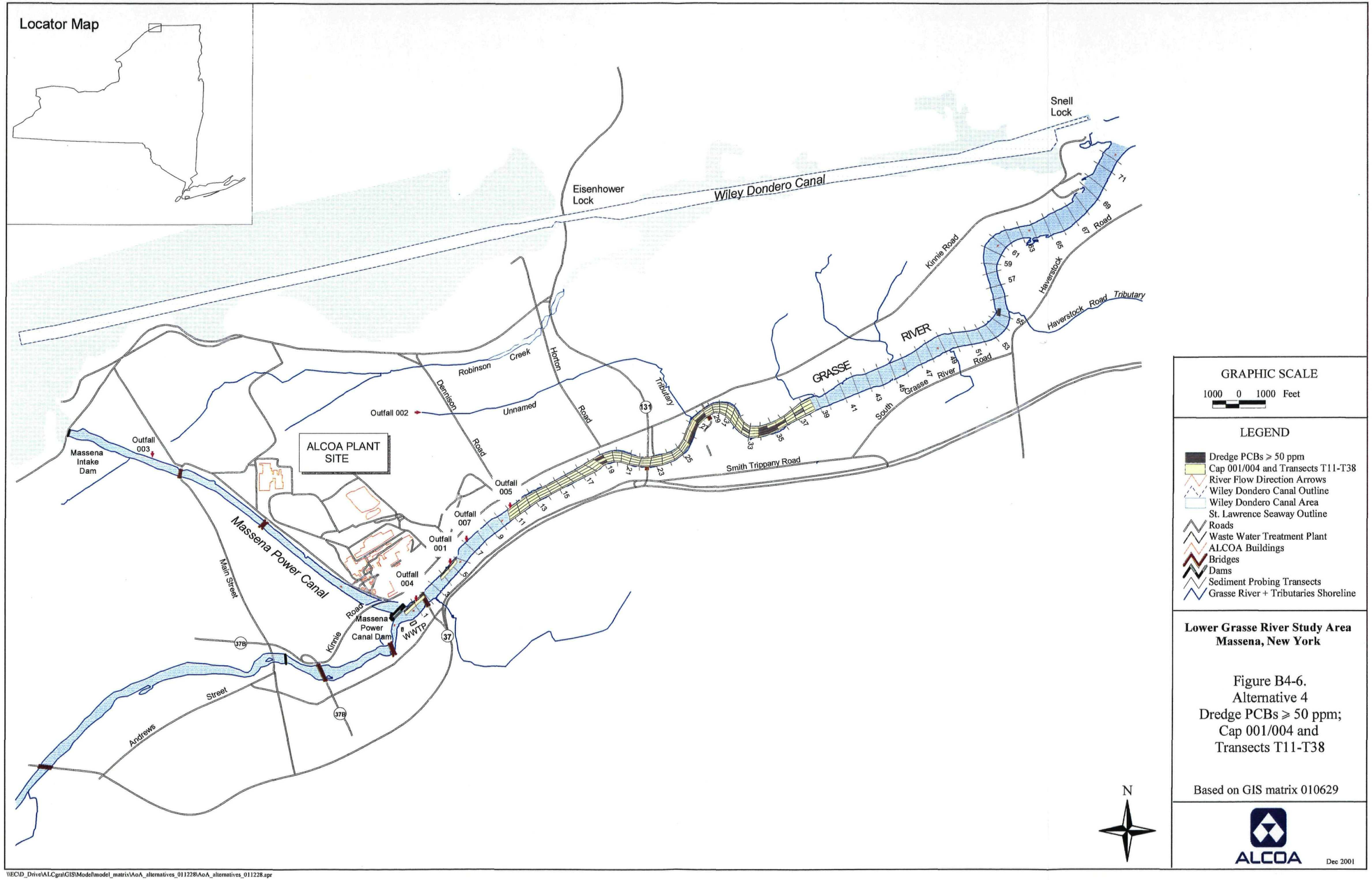
Figure B4-5.
Alternative 3
Cap 001/004 and
Transects T11-T38

Based on GIS matrix 010629

ALCOA

Dec 2001

\\EC\D_Drive\ALCgra\GIS\Model\model_matrix\AoA_alternatives_011228\AoA_alternatives_011228.apr



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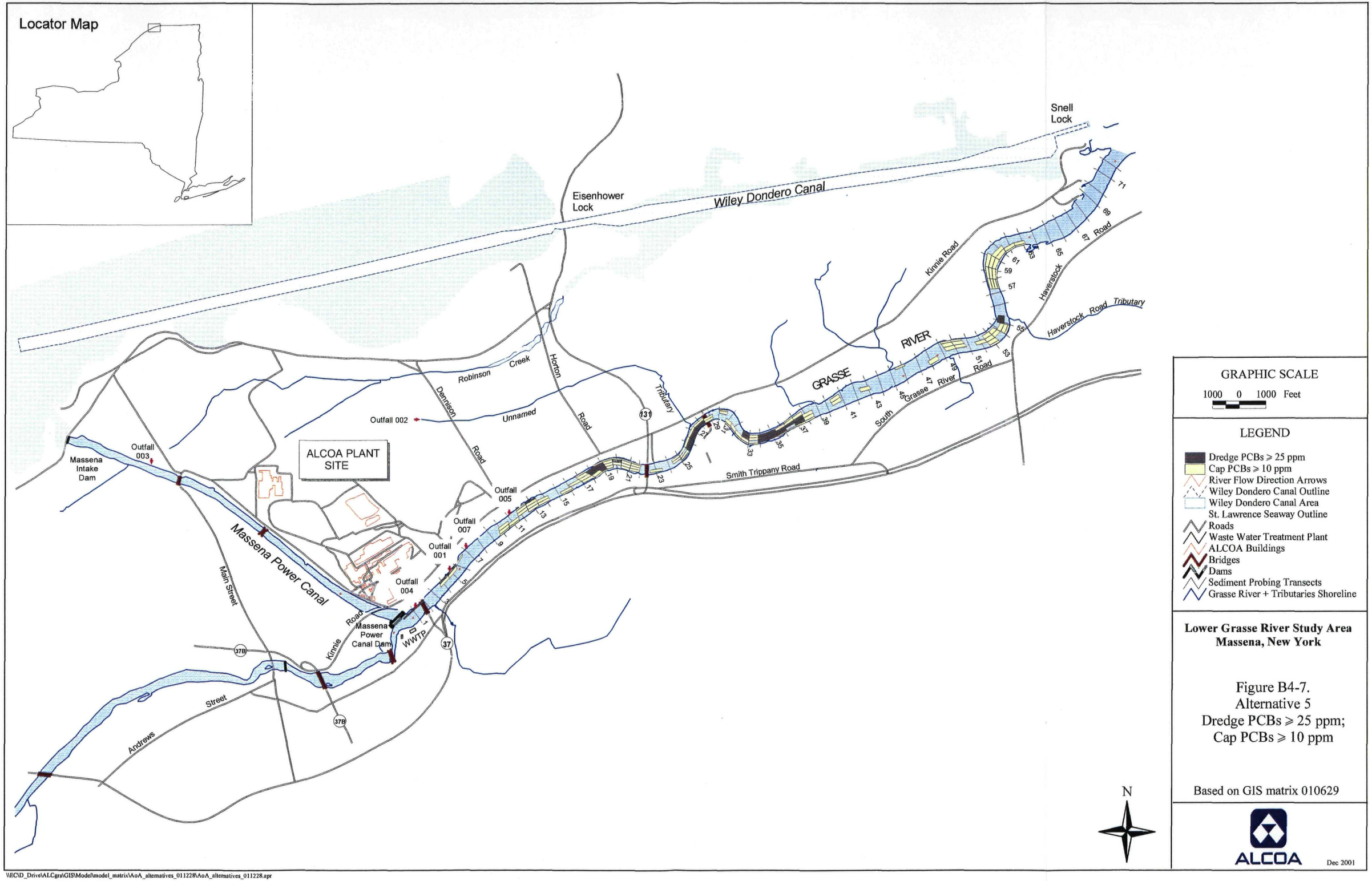

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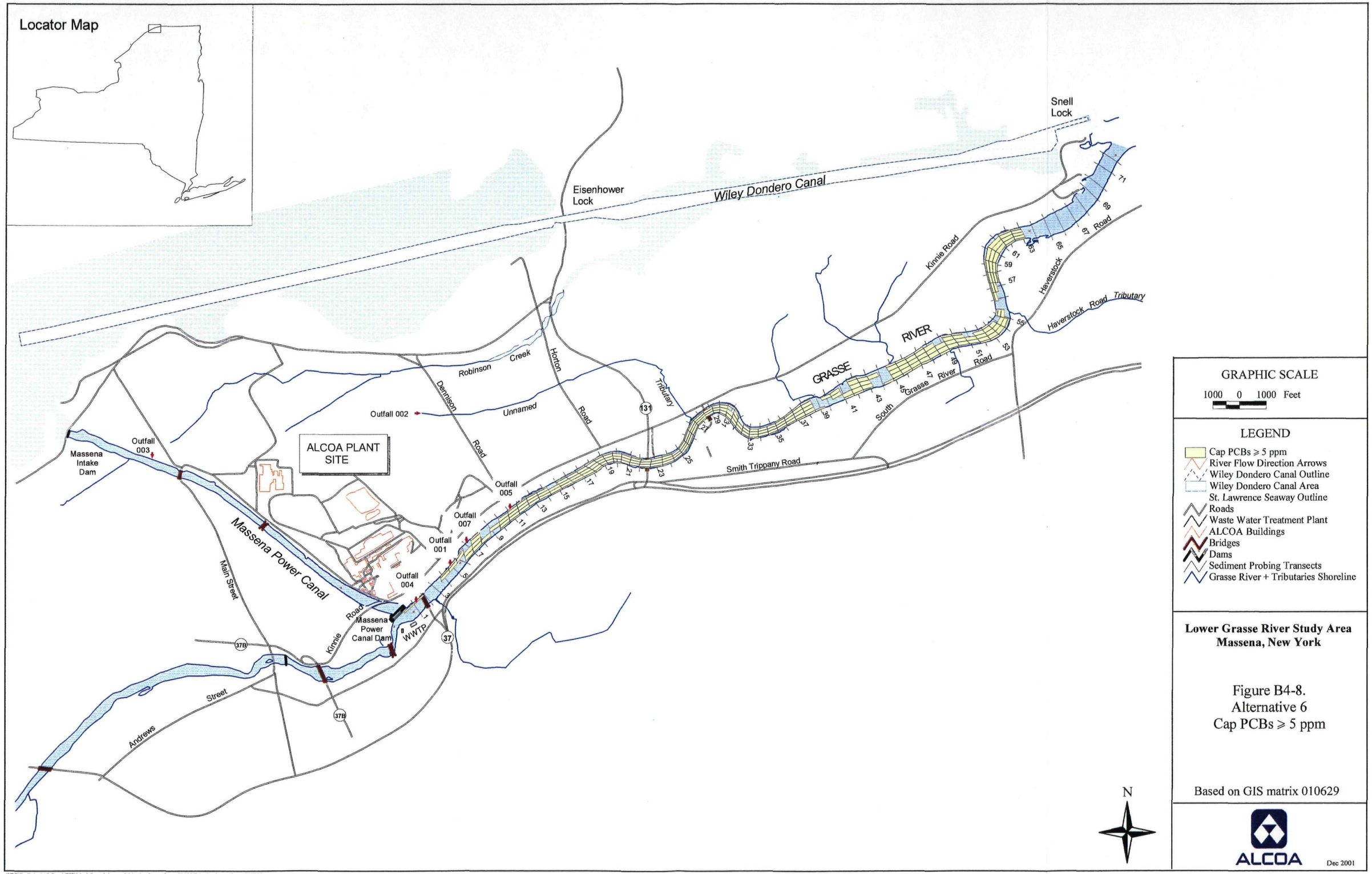
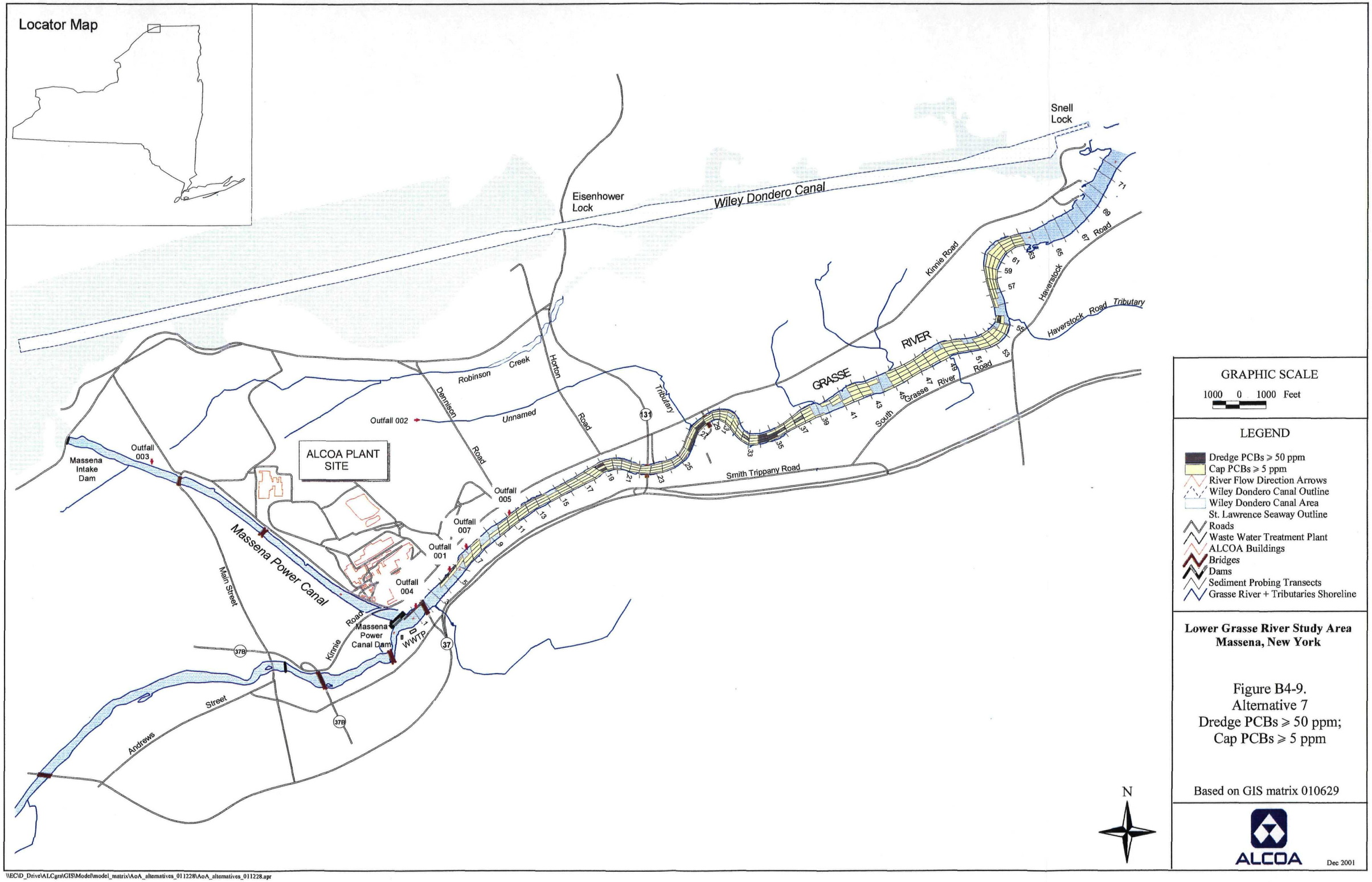


Lower Grasse River Study Area
Massena, New York

Figure B4-8.
Alternative 6
Cap PCBs ≥ 5 ppm

Based on GIS matrix 010629

\\EC\D_Drive\ALCgra\GIS\Model\model_matrix\AoA_alternatives_011228\AoA_alternatives_011228.apr



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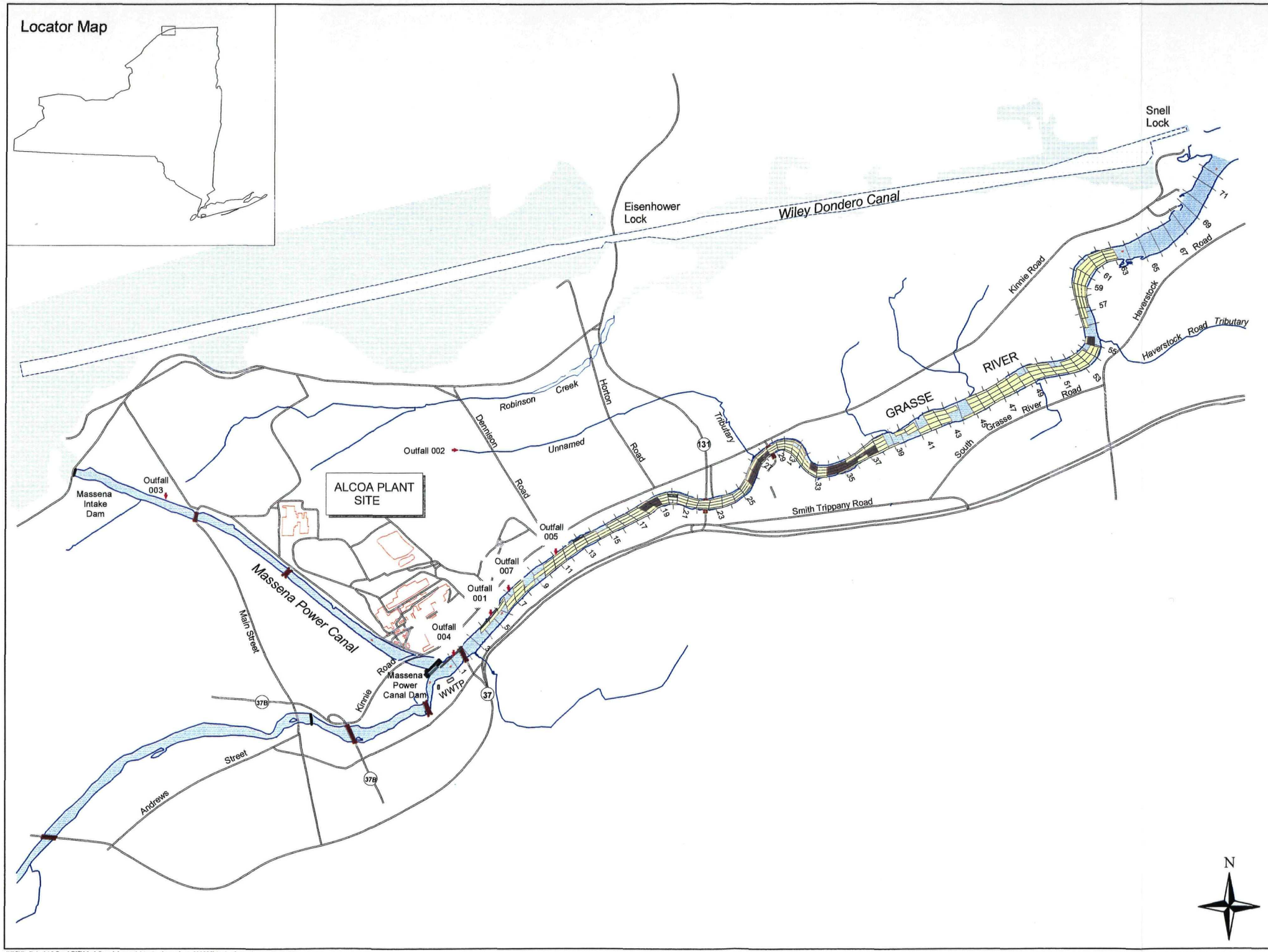


GRAPHIC SCALE

1000 0 1000 Feet

LEGEND

- Dredge PCBs ≥ 25 ppm
- Cap PCBs ≥ 5 ppm
- 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

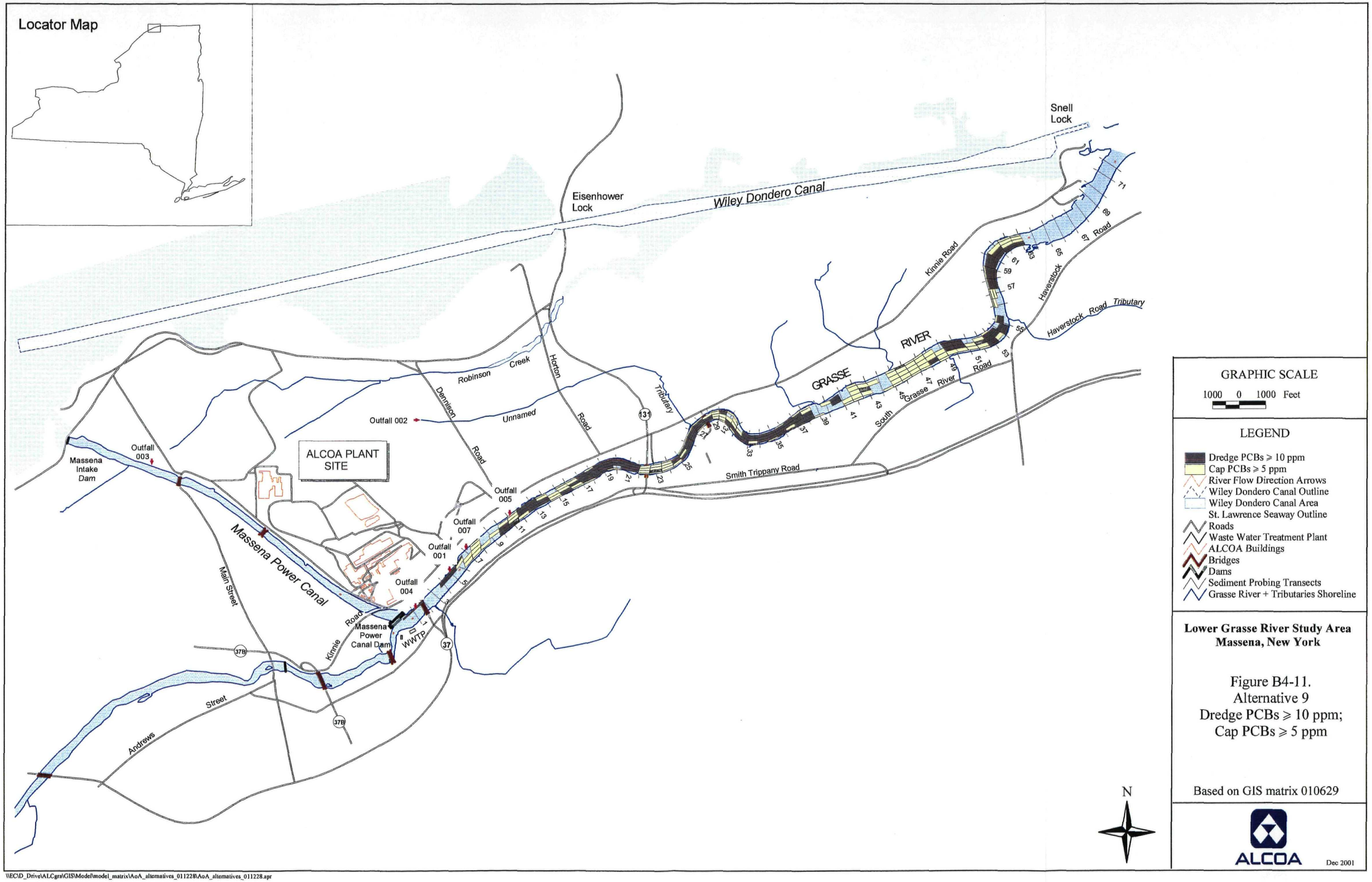
Figure B4-10.
Alternative 8
Dredge PCBs ≥ 25 ppm;
Cap PCBs ≥ 5 ppm

Based on GIS matrix 010629

ALCOA

Dec 2001

\\EC\D_Drive\ALCgra\GIS\Model\model_matrix\AoA_alternatives_011228\AoA_alternatives_011228.apr



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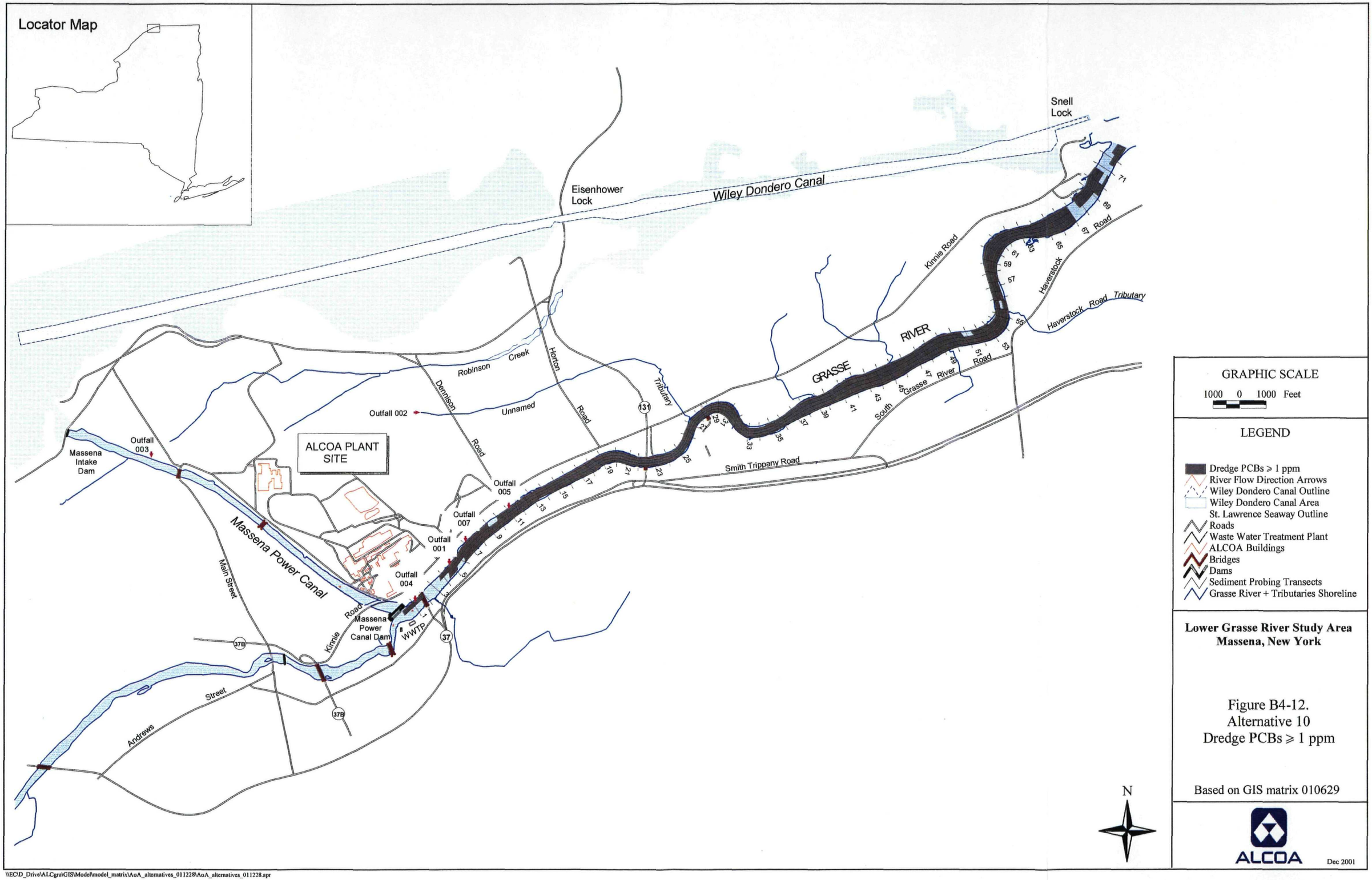

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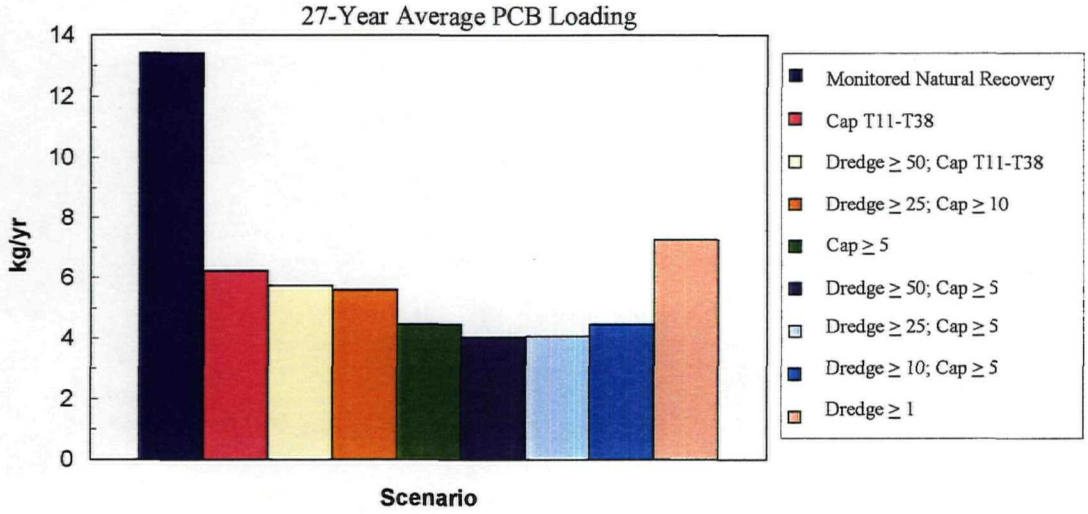


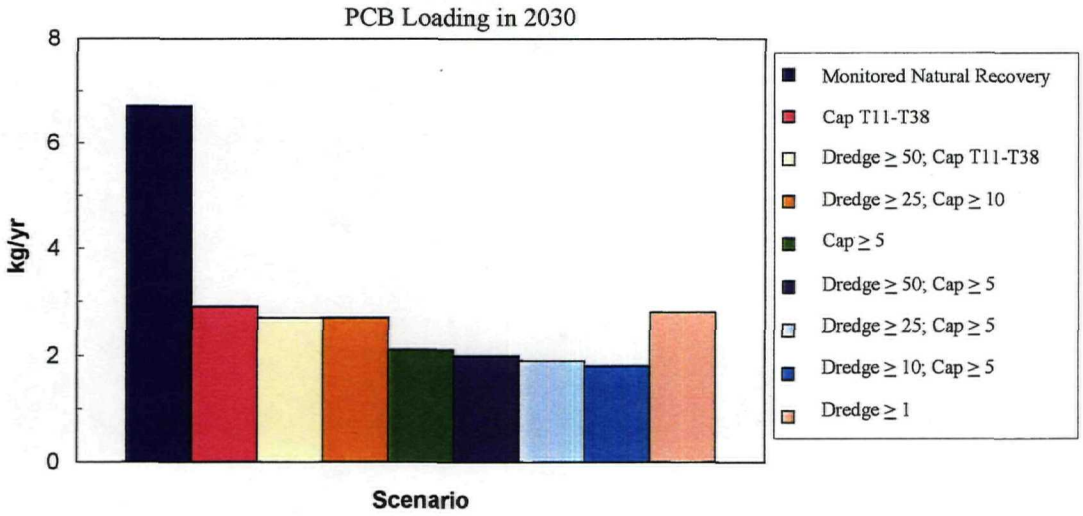
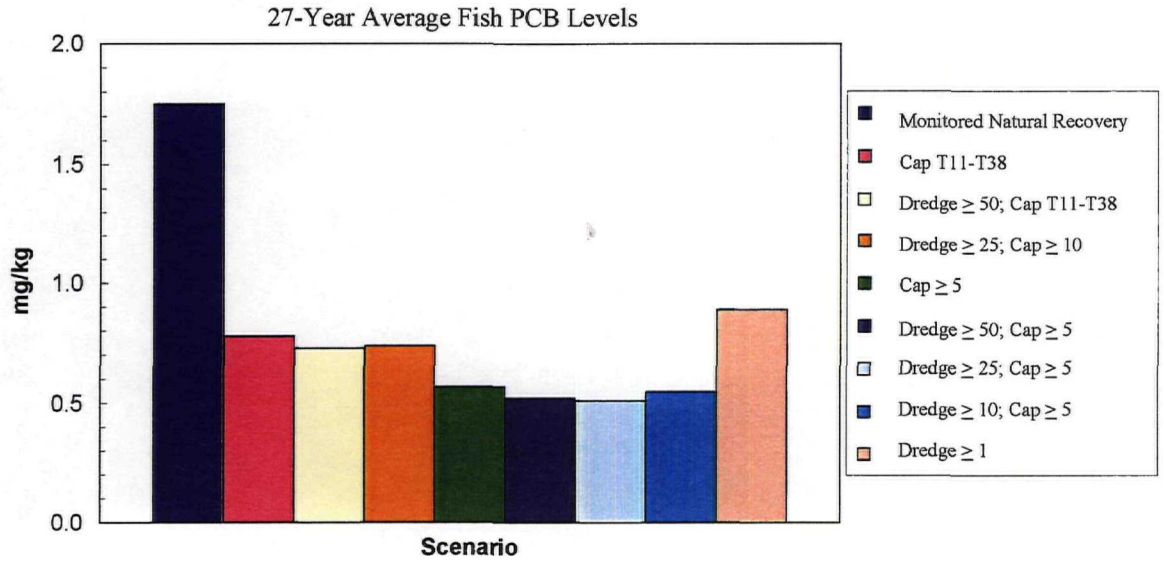


Figure B4-13. Predicted PCB Loading to the St. Lawrence River for Each Alternative.

27-year values represent average PCB loading between 2004 and 2030.
2030 values represent average PCB loading during last year of simulation.
Current conditions computed by fate model during last year of calibration (i.e., 2000).
PCB releases = 0.1% mass removed; PCB residual = 2.5 ppm
Capping effectiveness = 90%



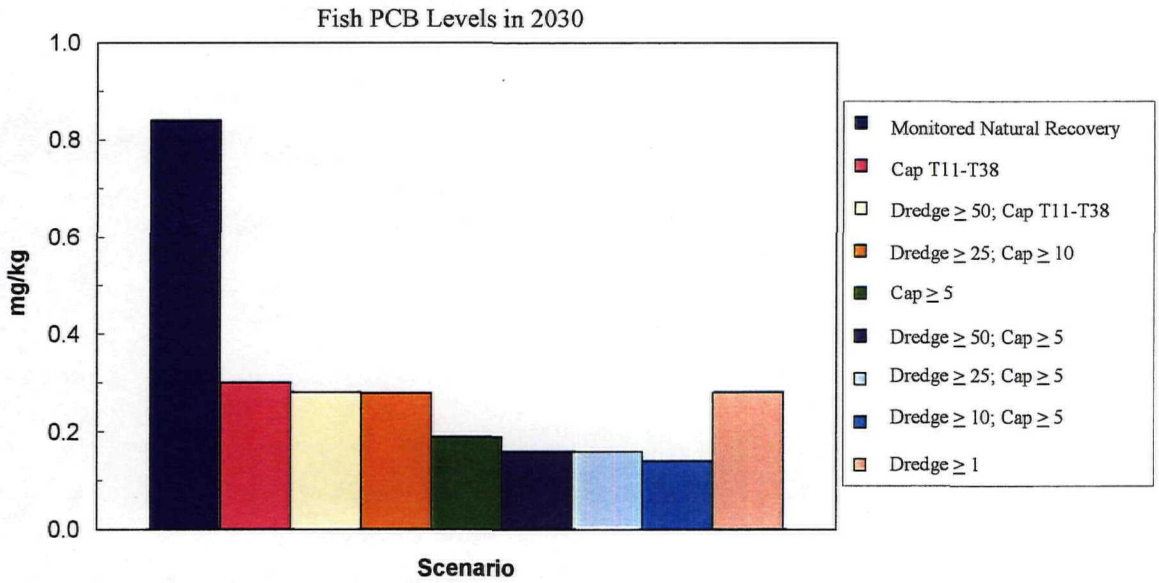


Figure B4-14. Predicted Fish Tissue PCB Levels for Each Potential Alternative.
27-year values represent average PCB levels between 2004 and 2030.
2030 values represent average PCB levels during last year of simulation.
Current conditions estimated from 2000 Trend Monitoring Survey data.
Area-weighted by river stretch; average of smallmouth bass and brown bullhead.
PCB releases = 0.1% mass removed; PCB residual = 2.5 ppm
Capping effectiveness = 90%

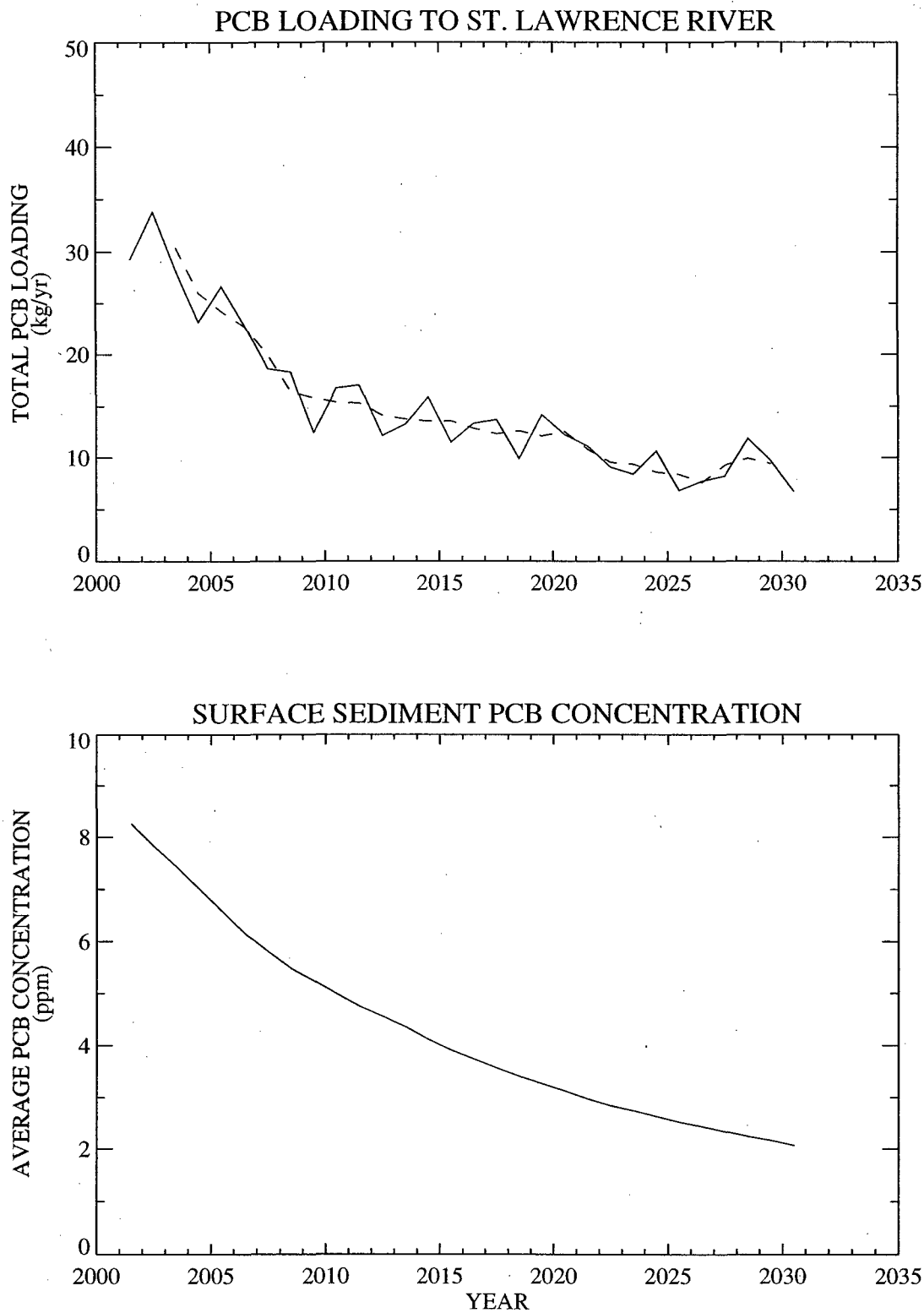


Figure B4-15. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 2 - Monitored Natural Recovery.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

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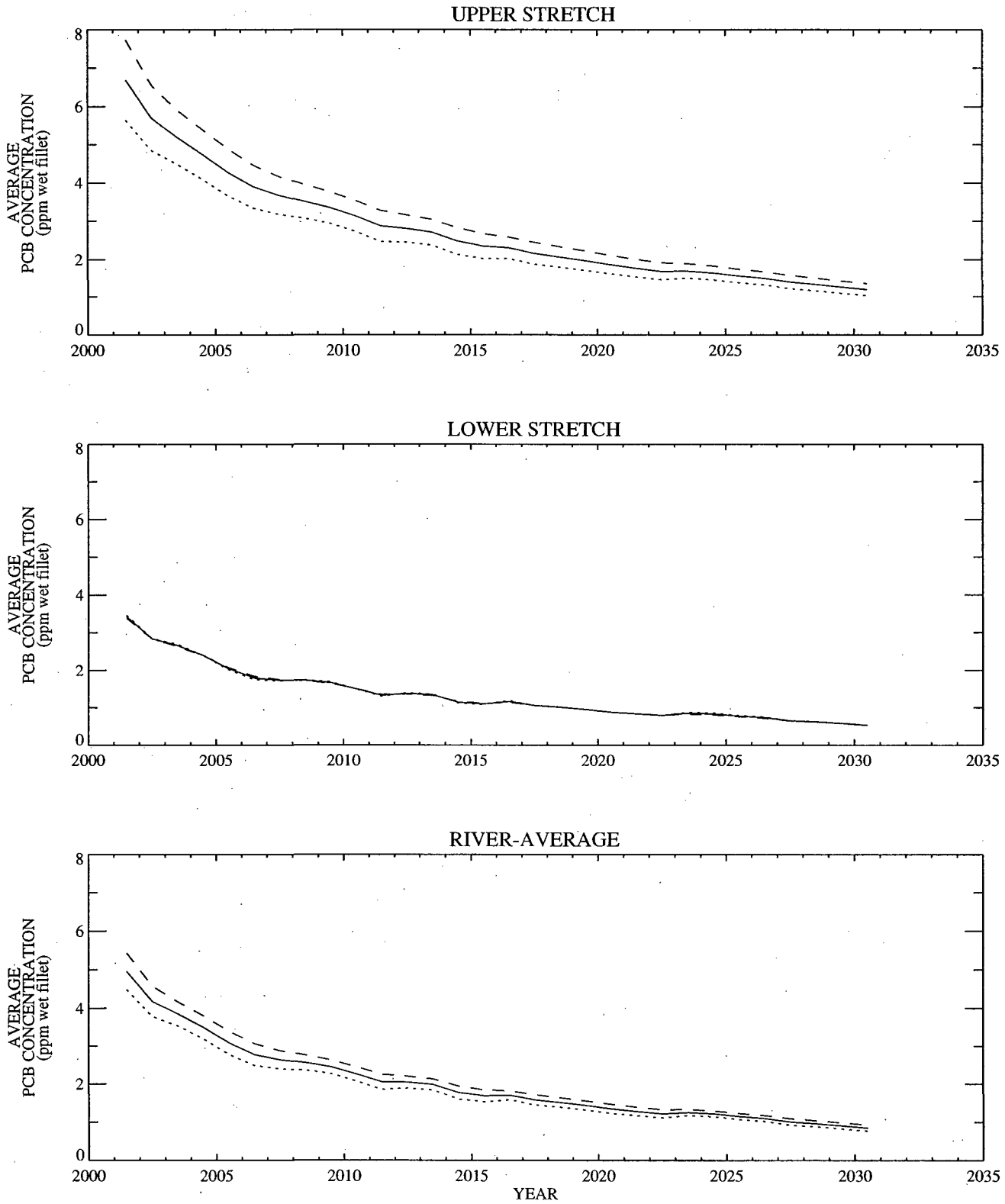

Figure B4-16. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 2: Monitored Natural Recovery

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

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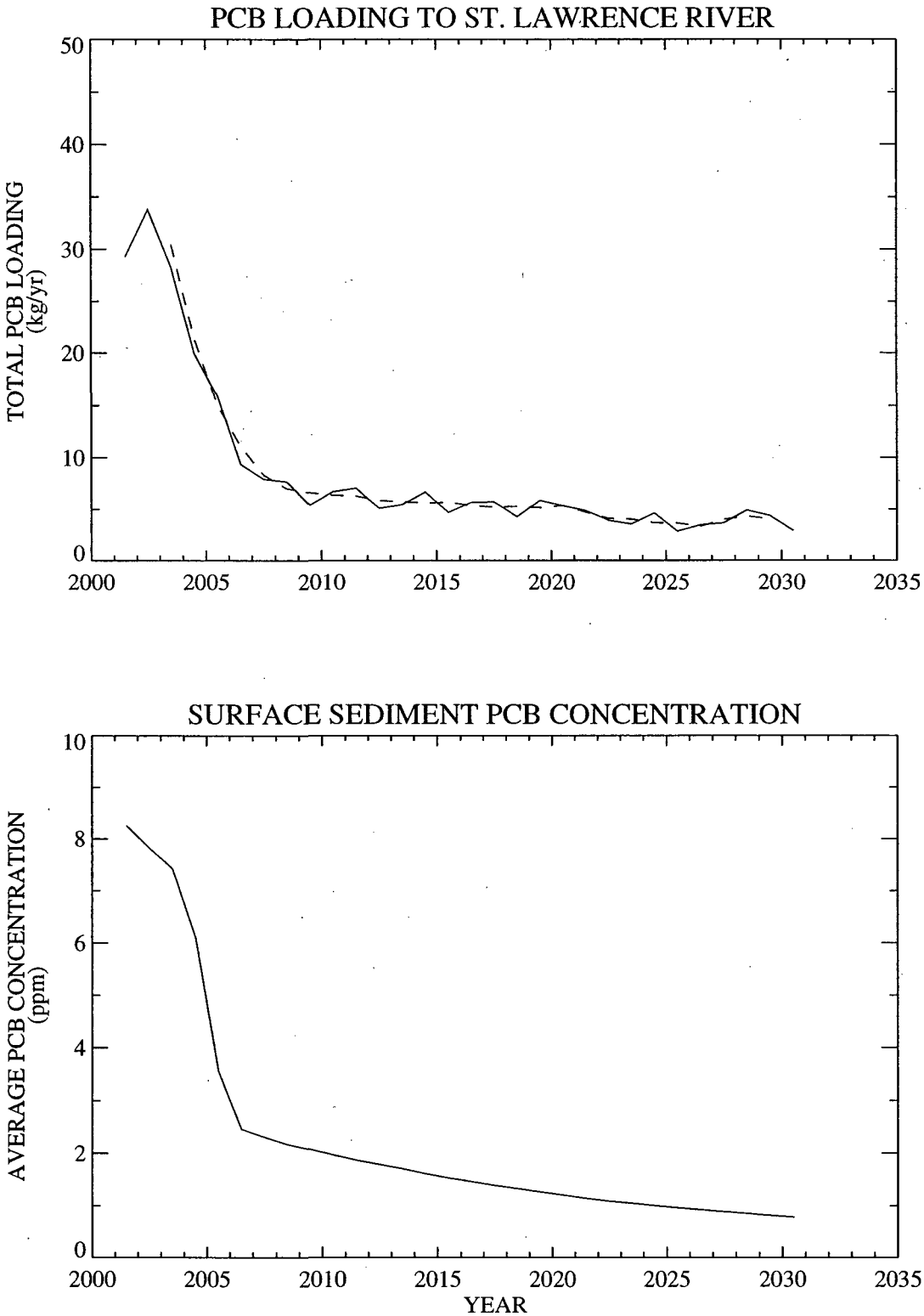

Figure B4-17. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 3 - Cap 001/004 and Transects T11-T38.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

Capping effectiveness = 90%.

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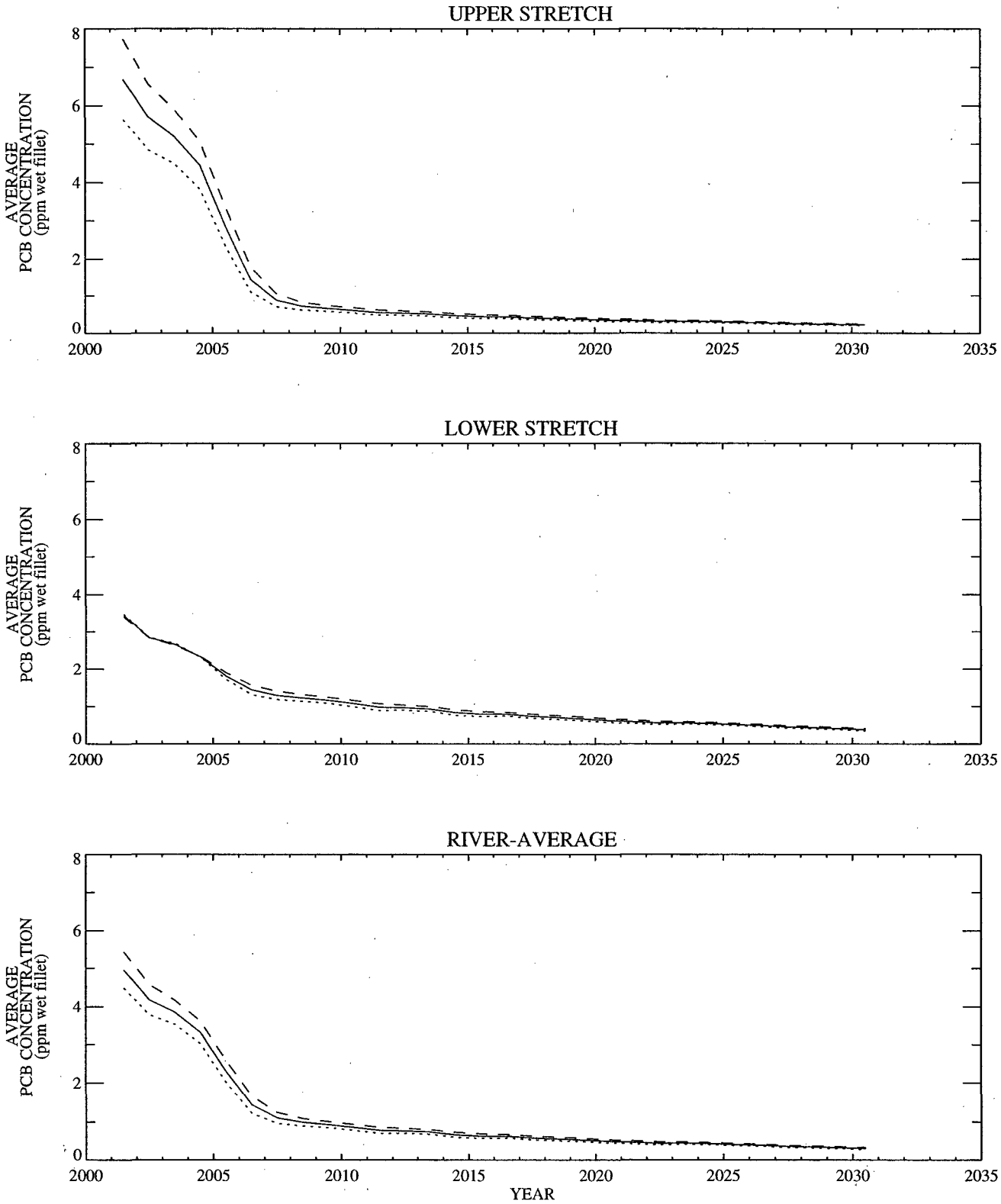

Figure B4-18. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 3: Cap 001/004 and Transects T11-T38

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

imQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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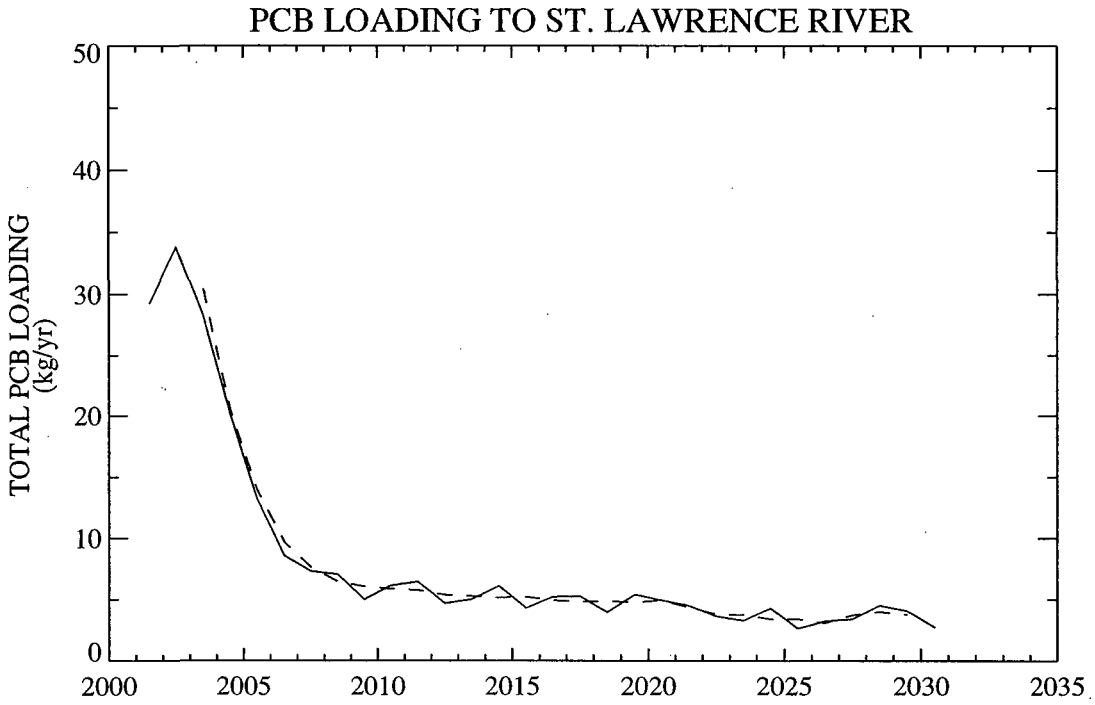

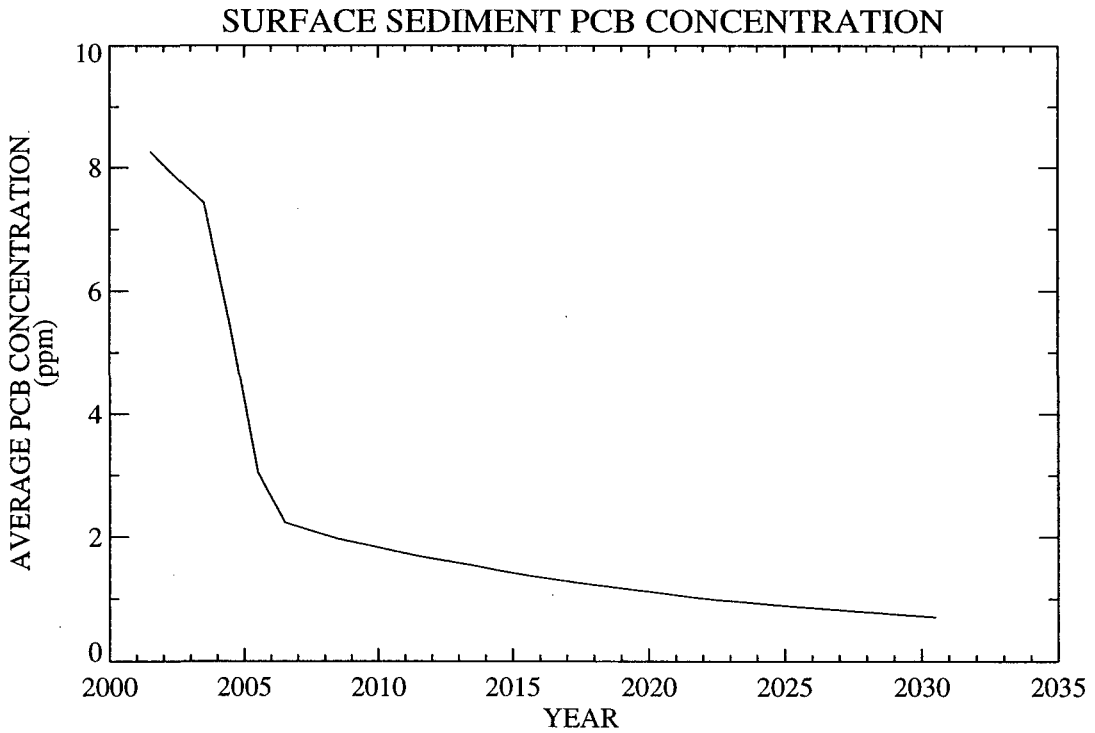

Figure B4-19. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 4 - Dredge ≥ 50 ppm; Cap 001/004, and T11-T38.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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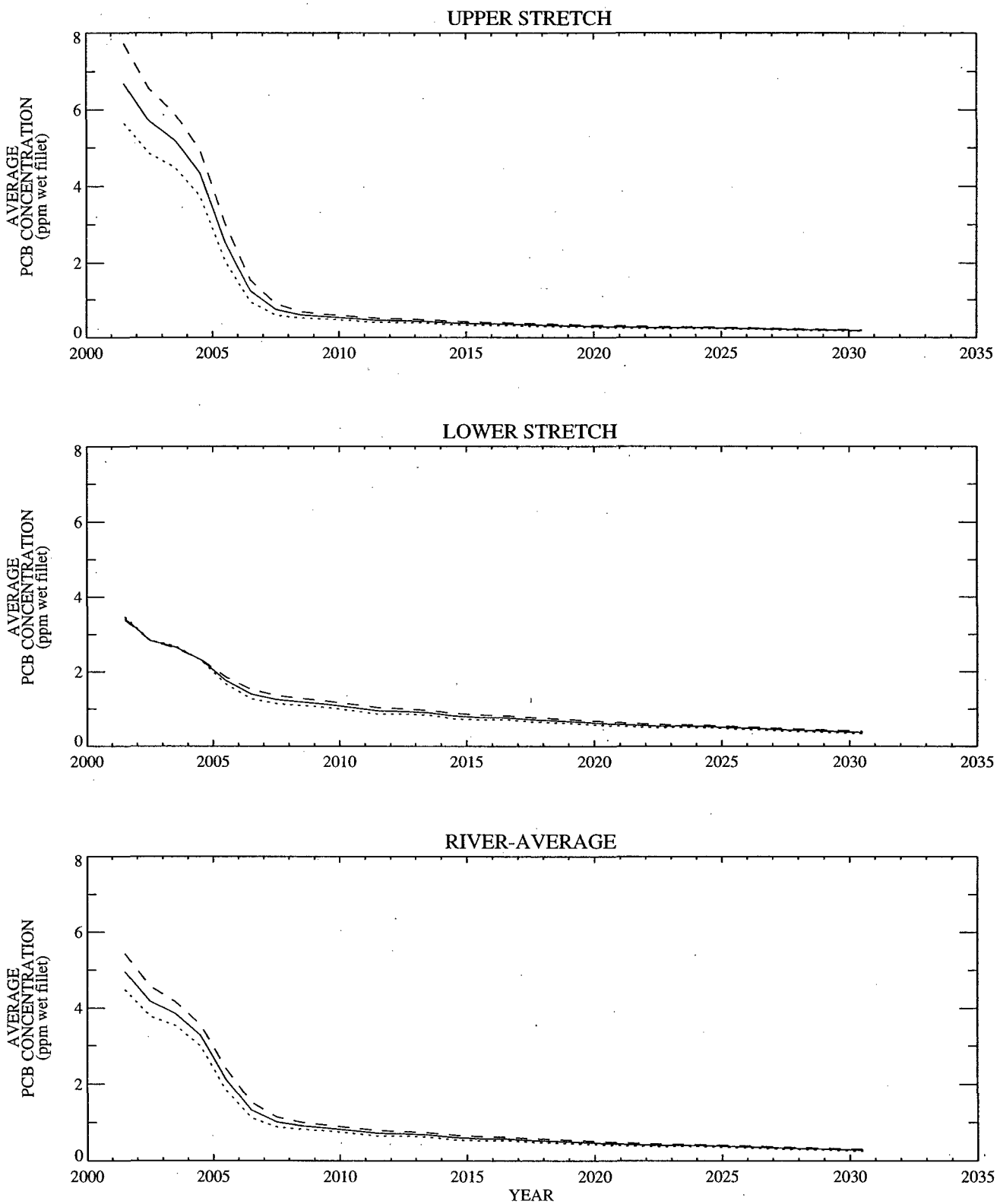

Figure B4-20. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 4: Dredge ≥ 50 ppm (0.1% release, 2.5% residual); Cap 001/004, and Transects T11-T38

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

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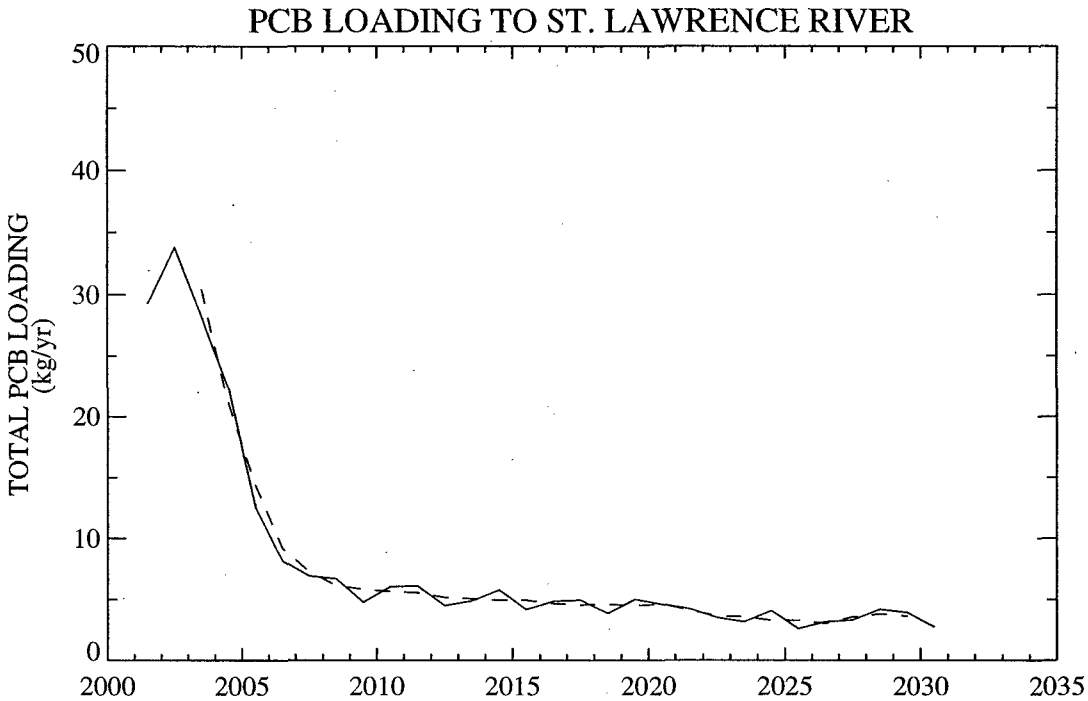

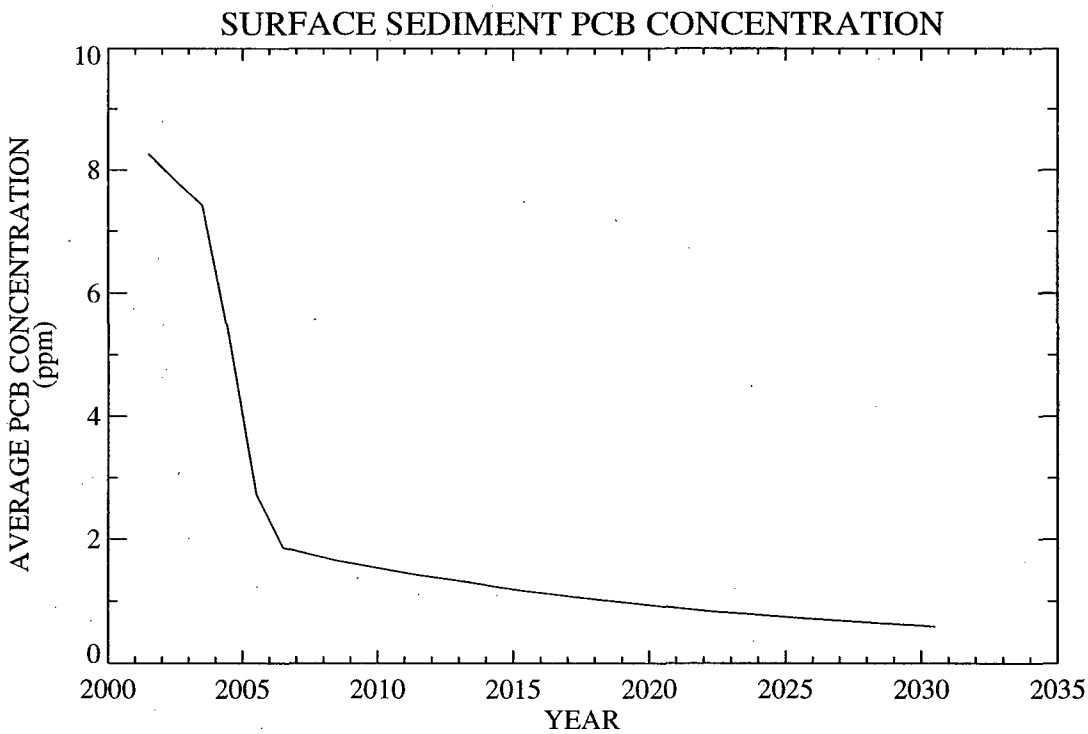

Figure B4-21. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 5 - Dredge ≥ 25 ppm; Cap ≥ 10 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

DN - D:\ALCgra\Model\PCBfate\Outputs\PLOTS\projection\base_plots\SLR_SED\plot_slr_sed_1.pro
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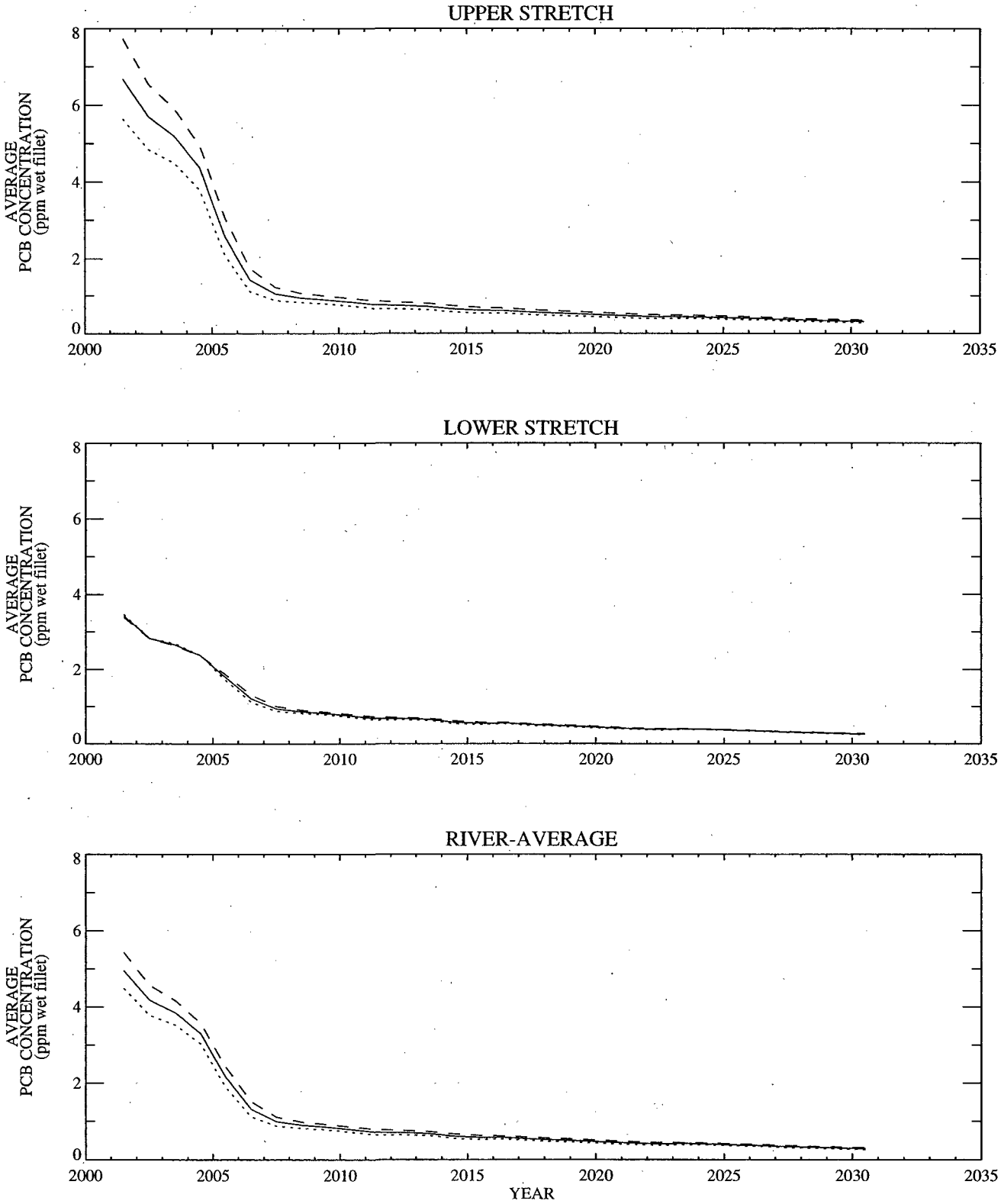

Figure B4-22. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 5: Dredge ≥ 25 ppm (0.1% release, 2.5% residual); Cap ≥ 10 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

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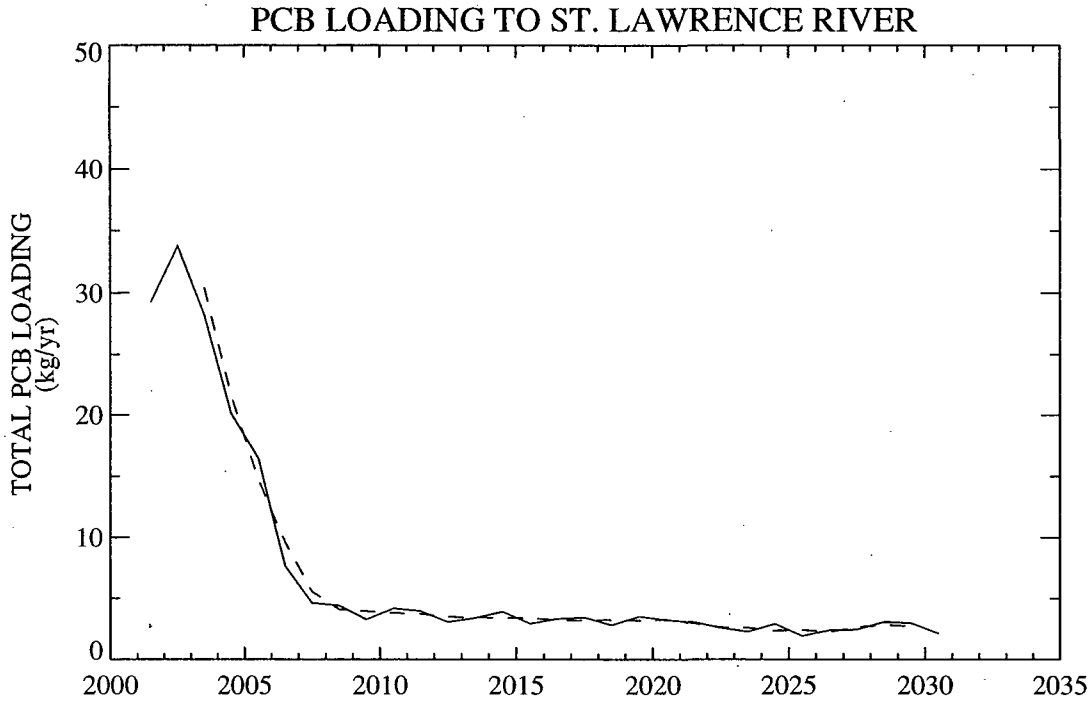

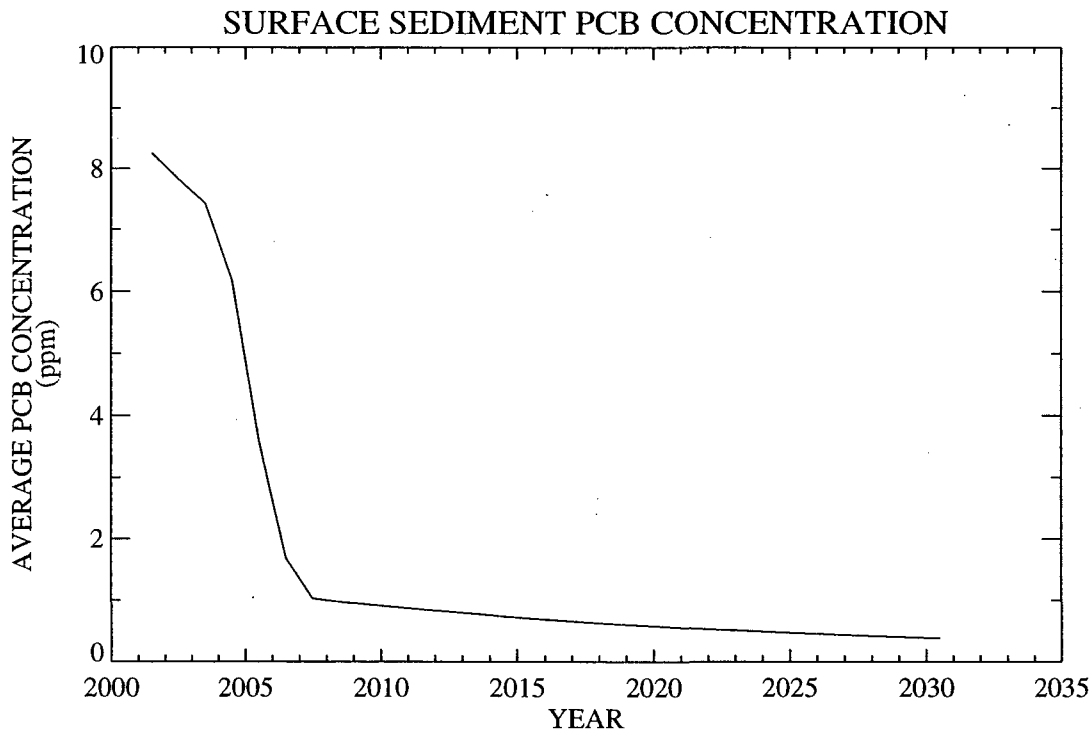

Figure B4-23. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 6 - Cap ≥ 5 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

Capping effectiveness = 90%.

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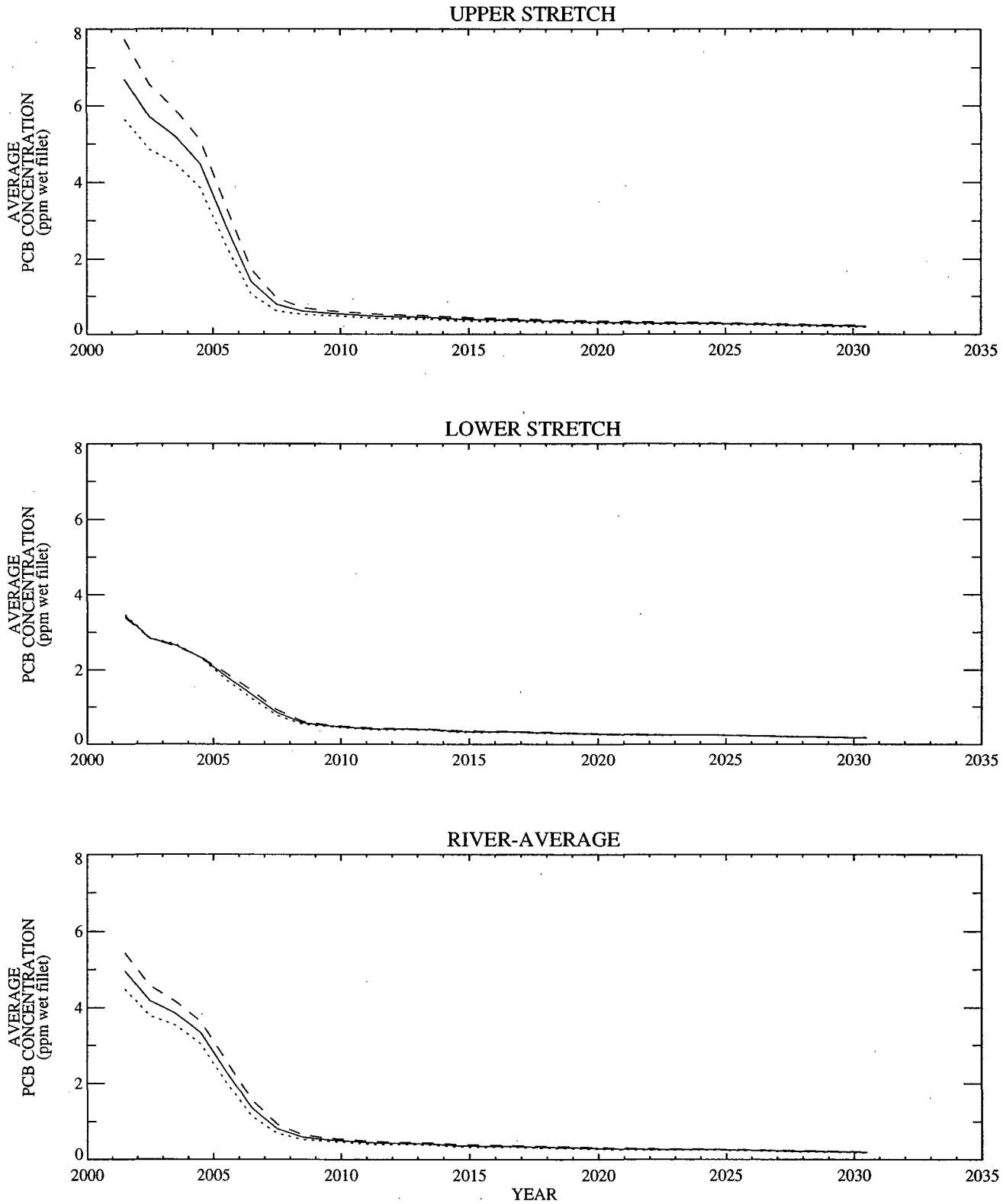

Figure B4-24. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 6: Cap ≥ 5 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

imQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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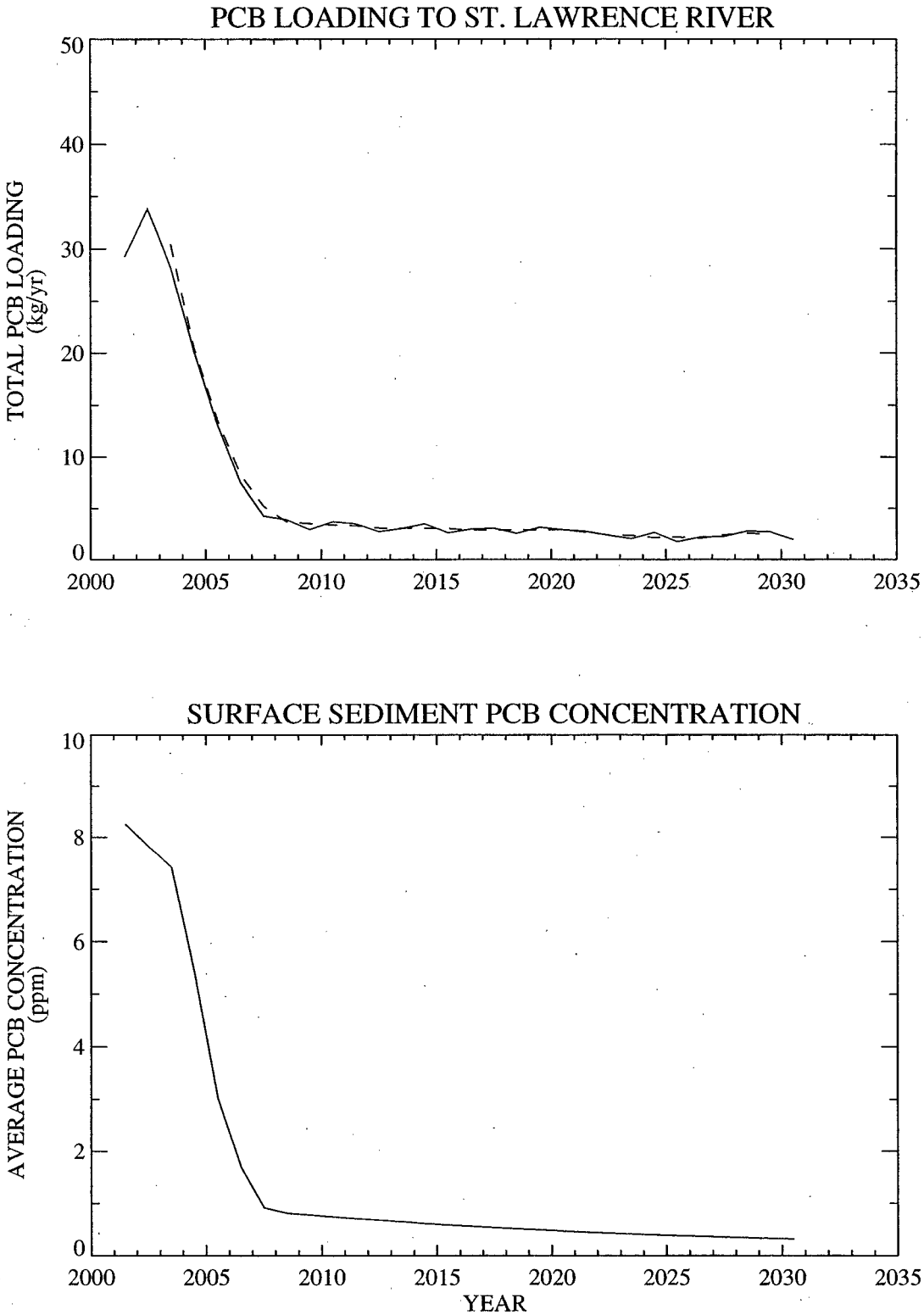

Figure B4-25. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 7 - Dredge ≥ 50 ppm; Cap ≥ 5 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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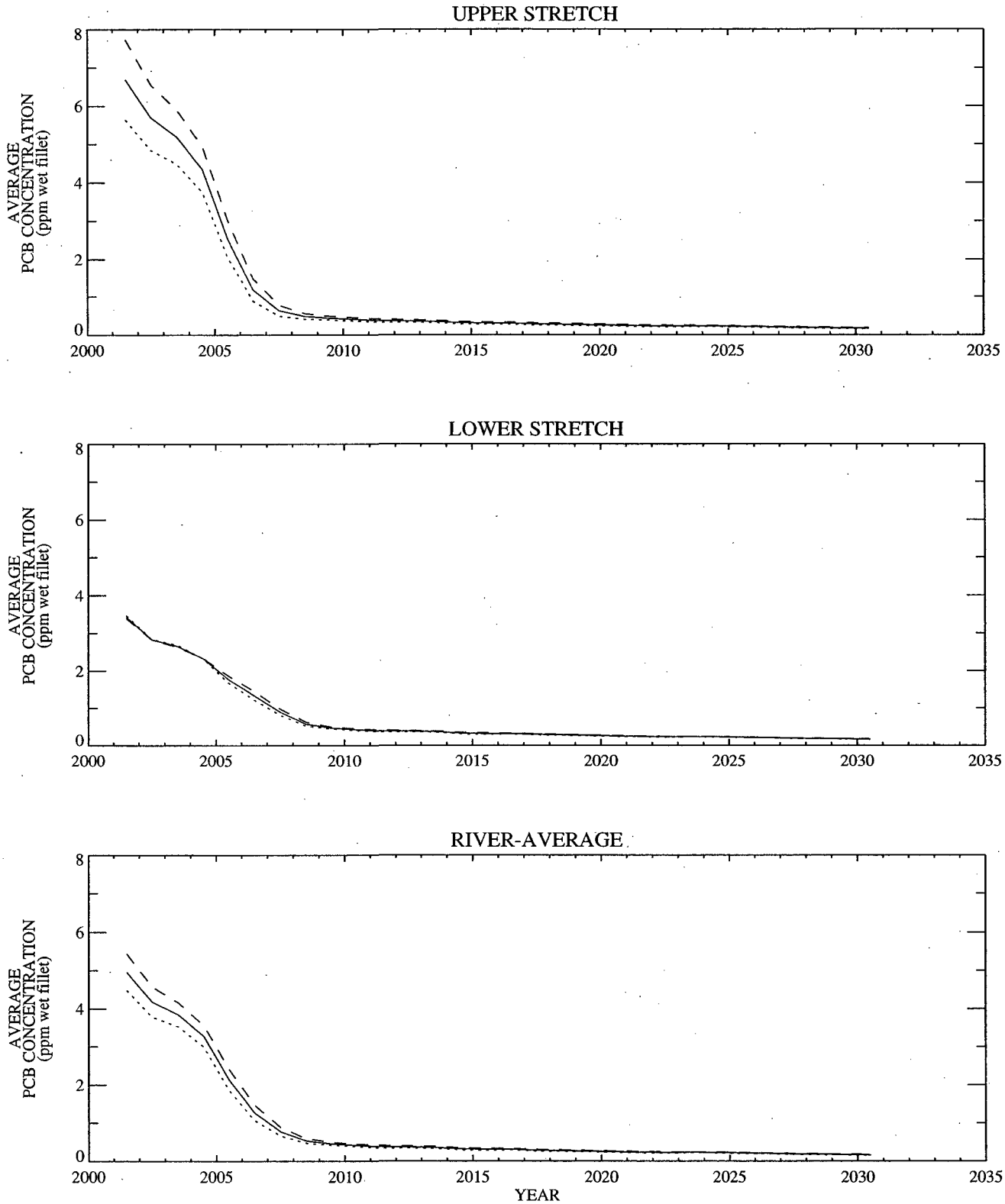

Figure B4-26. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 7: Dredge ≥ 50 ppm (0.1% release, 2.5% residual); Cap ≥ 5 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

imQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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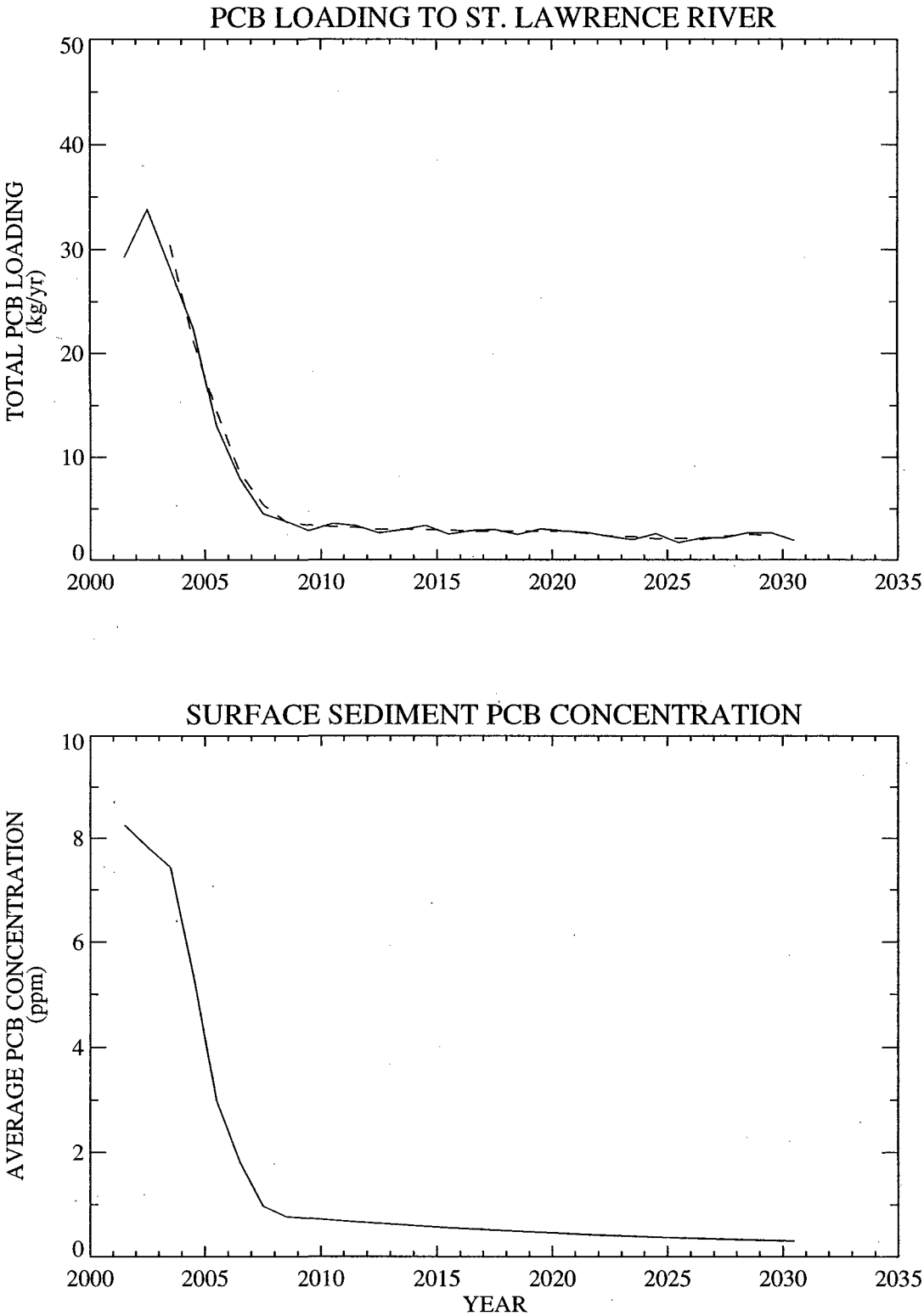

Figure B4-27. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 8 - Dredge ≥ 25 ppm; Cap ≥ 5 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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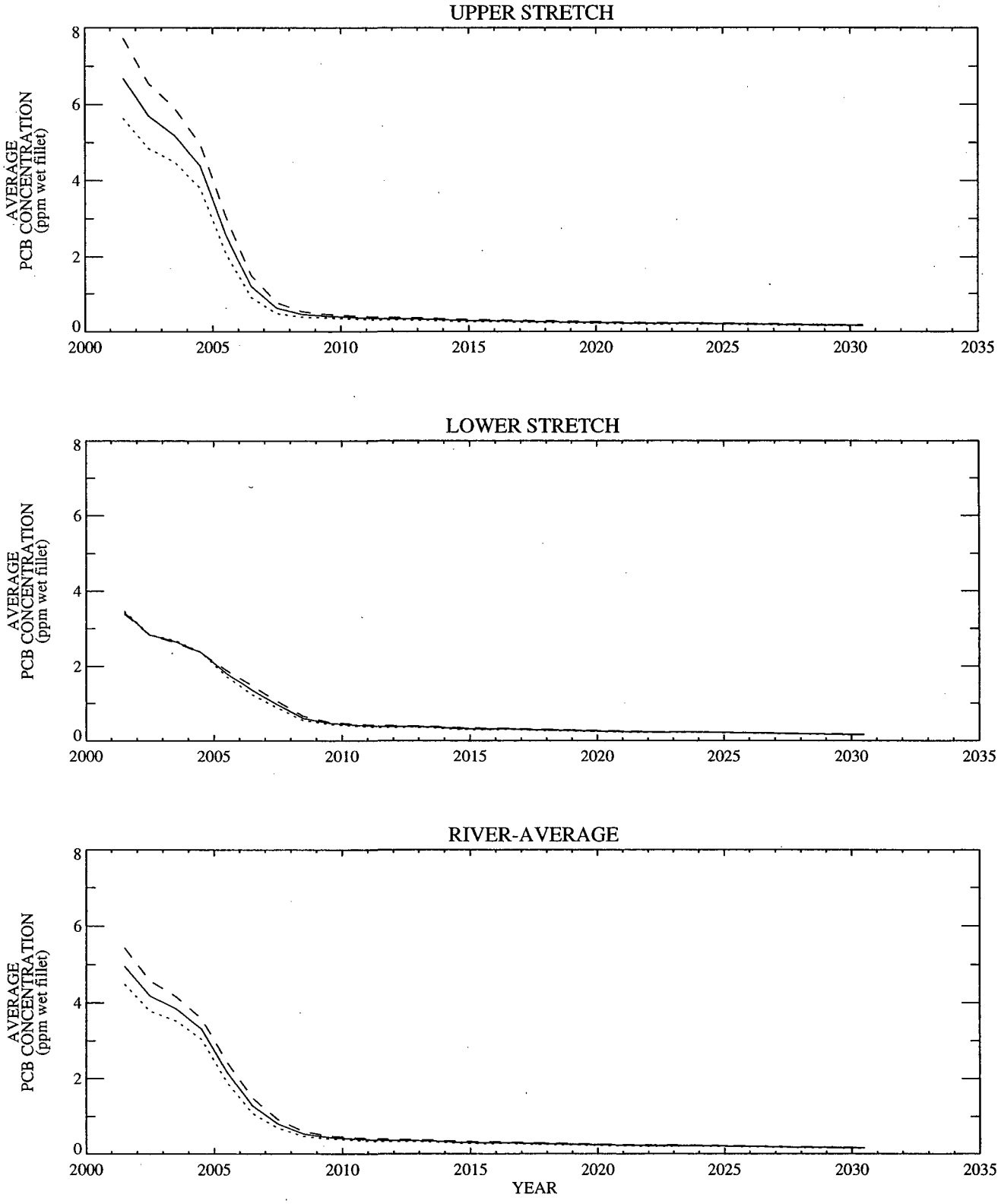

Figure B4-28. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 8: Dredge ≥ 25 ppm (0.1% release, 2.5% residual); Cap ≥ 5 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

imQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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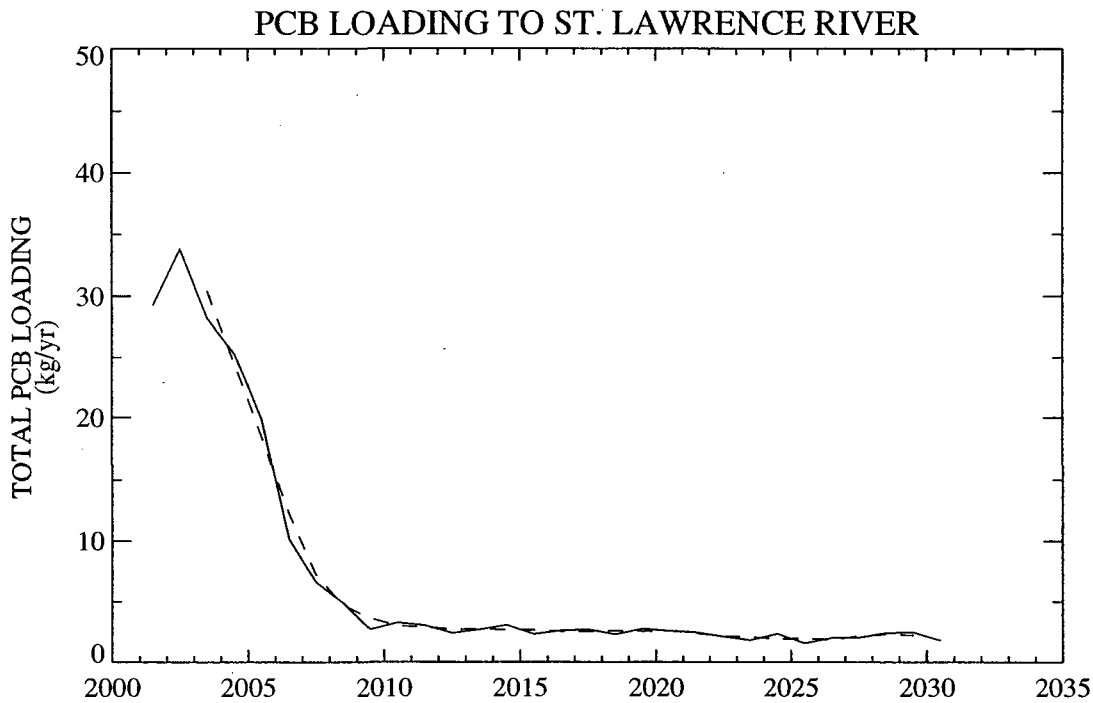

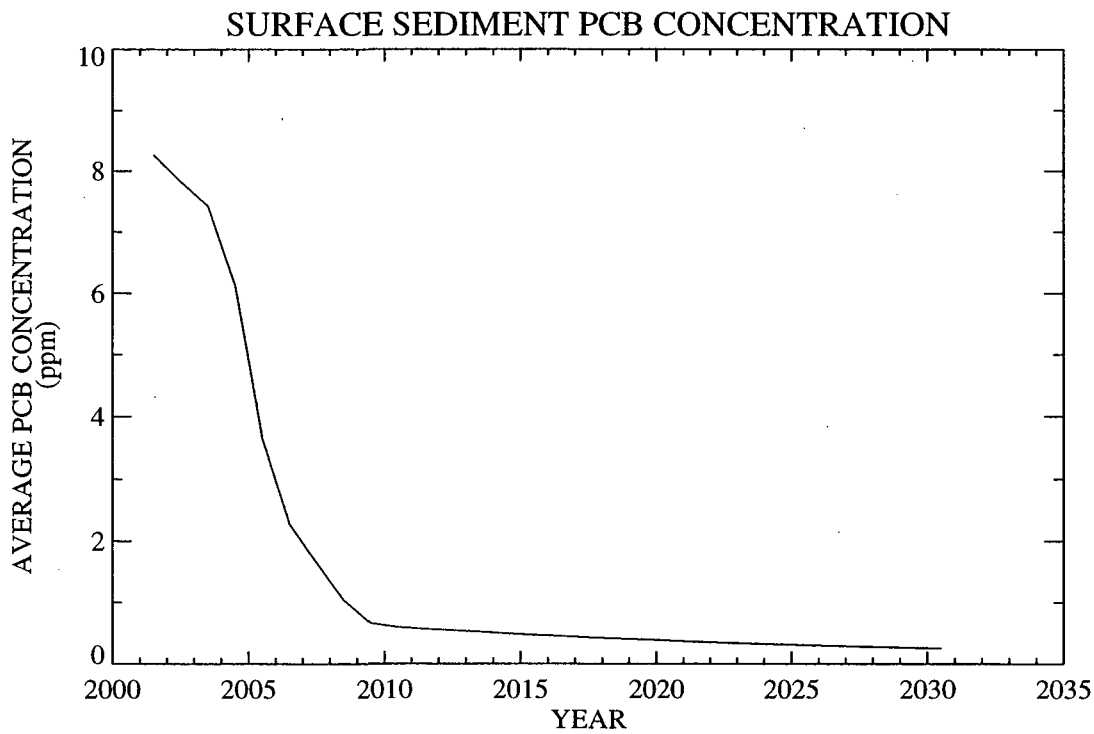

Figure B4-29. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 9 - Dredge ≥ 10 ppm; Cap ≥ 5 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm; Capping effectiveness = 90%.

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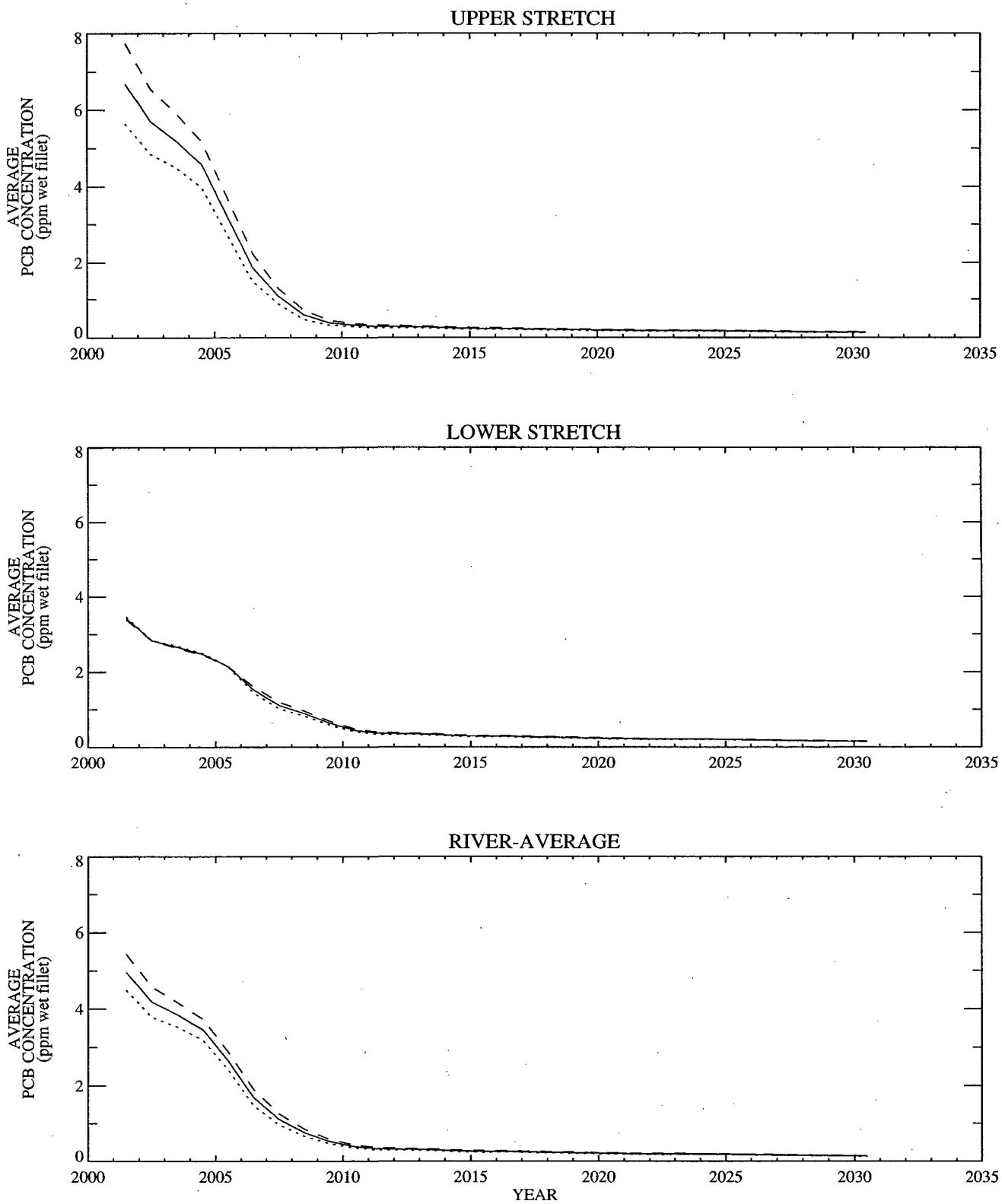

Figure B4-30. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 9: Dredge ≥ 10 ppm (0.1% release, 2.5% residual); Cap ≥ 5 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

mQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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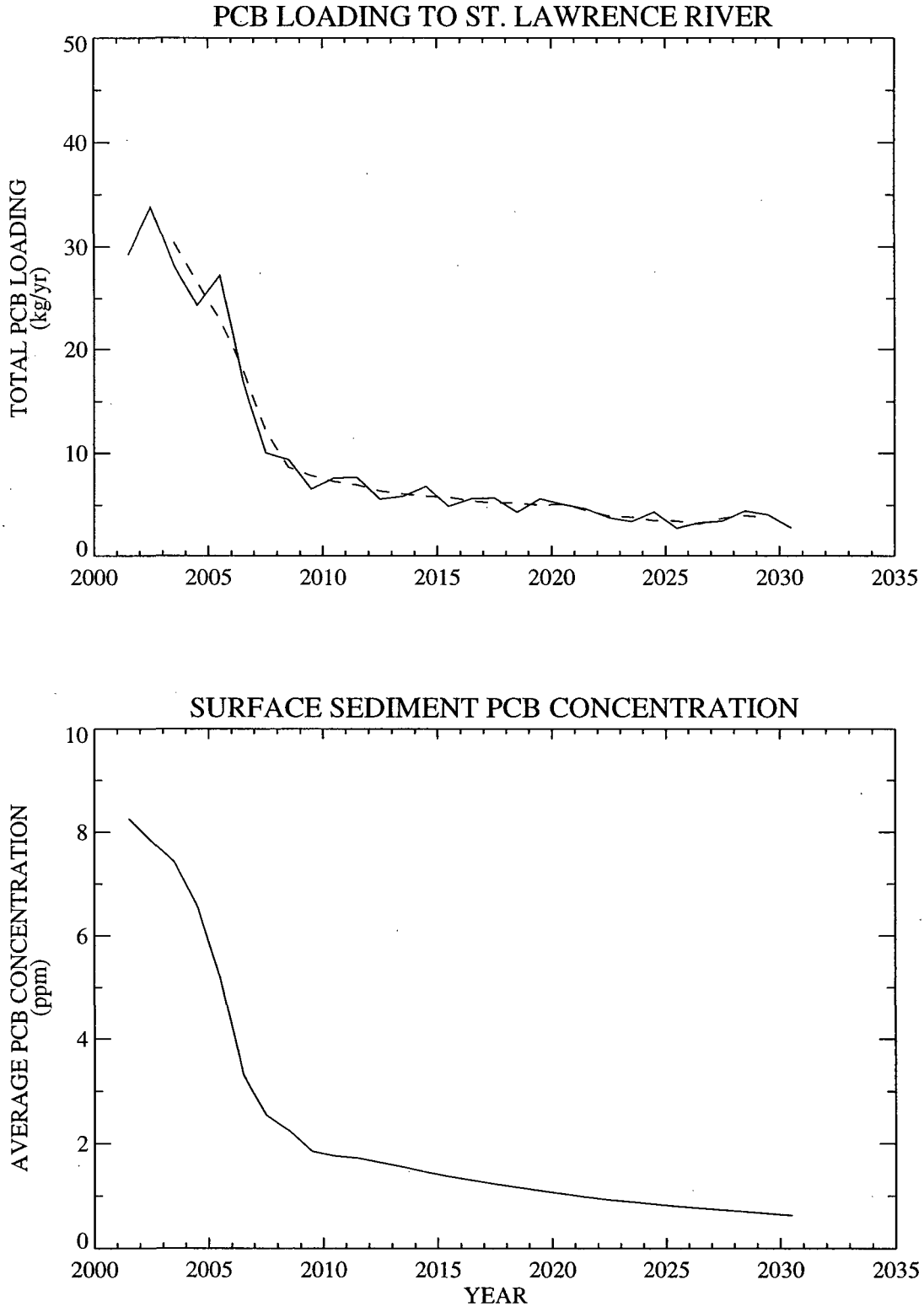

Figure B4-31. Predicted PCB Loading to the St. Lawrence River and Surface Sediment PCB Concentration. Alternative 10 - Dredge ≥ 1 ppm.

PCB loading to the St. Lawrence River computed by PCB fate model.

Surface (0-3") sediment PCB concentrations represent area-weighted averages (Power Canal - Mouth). Solid lines represent annual average; dashed line represents three-year moving average.

PCB releases = 0.1%; PCB residual = 2.5 ppm.

DN - D:\ALCgra\Model\PCBfate\Outputs\PLOTS\projection\base_plots\SLR_SED\plot_slr_sed_1.pro
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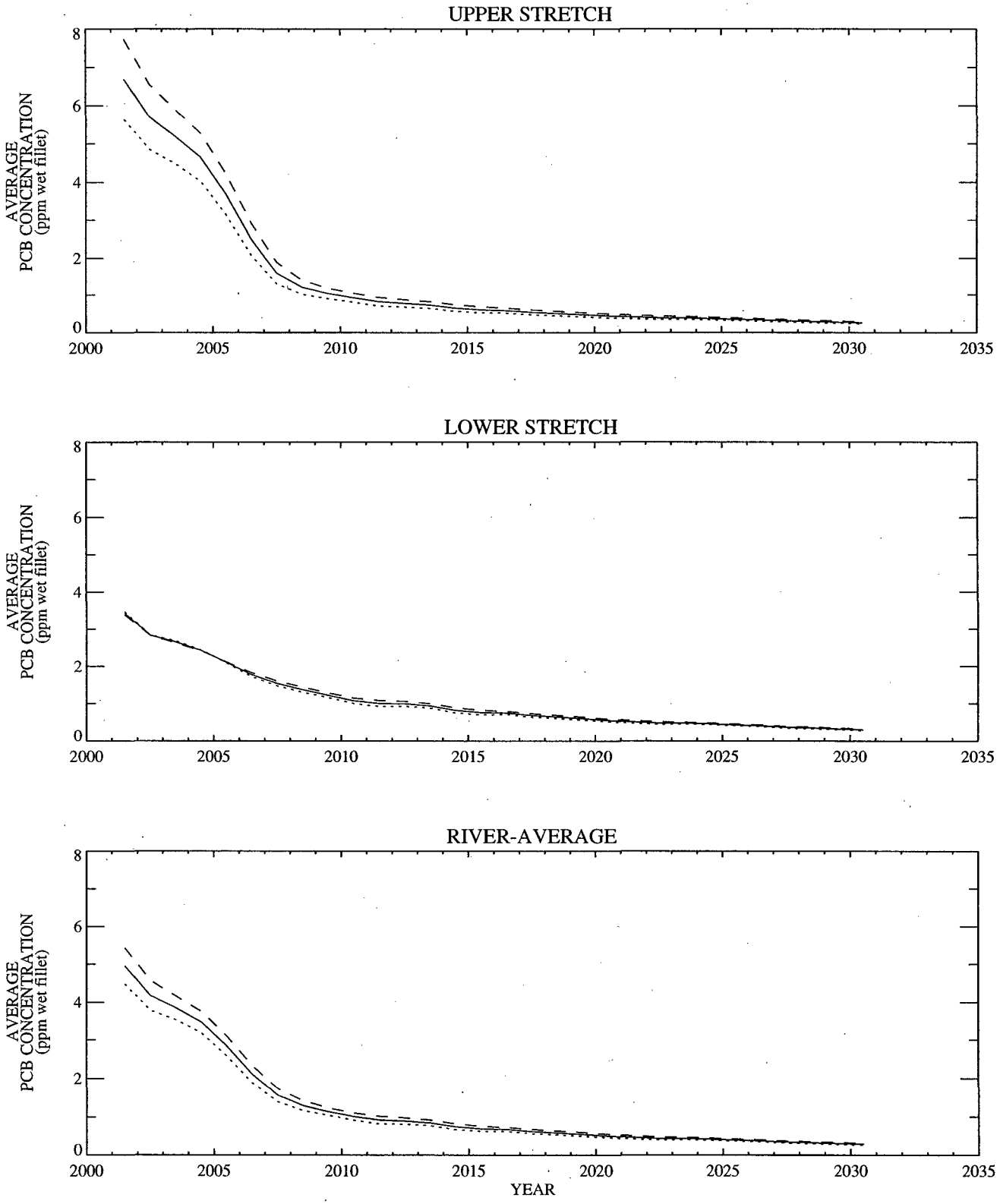

Figure B4-32. Predicted Average Fish Tissue PCB Concentrations in the Lower Grasse River.

Alternative 10: Dredge ≥ 1 ppm

Solid lines represent species-averages computed from PCB levels in smallmouth bass and brown bullhead.

Dotted lines represent predicted PCB levels in smallmouth bass.

Dashed lines represent predicted PCB levels in brown bullhead.

mQ - \\Jimq\D_Drive\ALCgra\Models\Bioaccum\AAruns\Plots\Projections\projtemp_uppr_lowr_avg.pro
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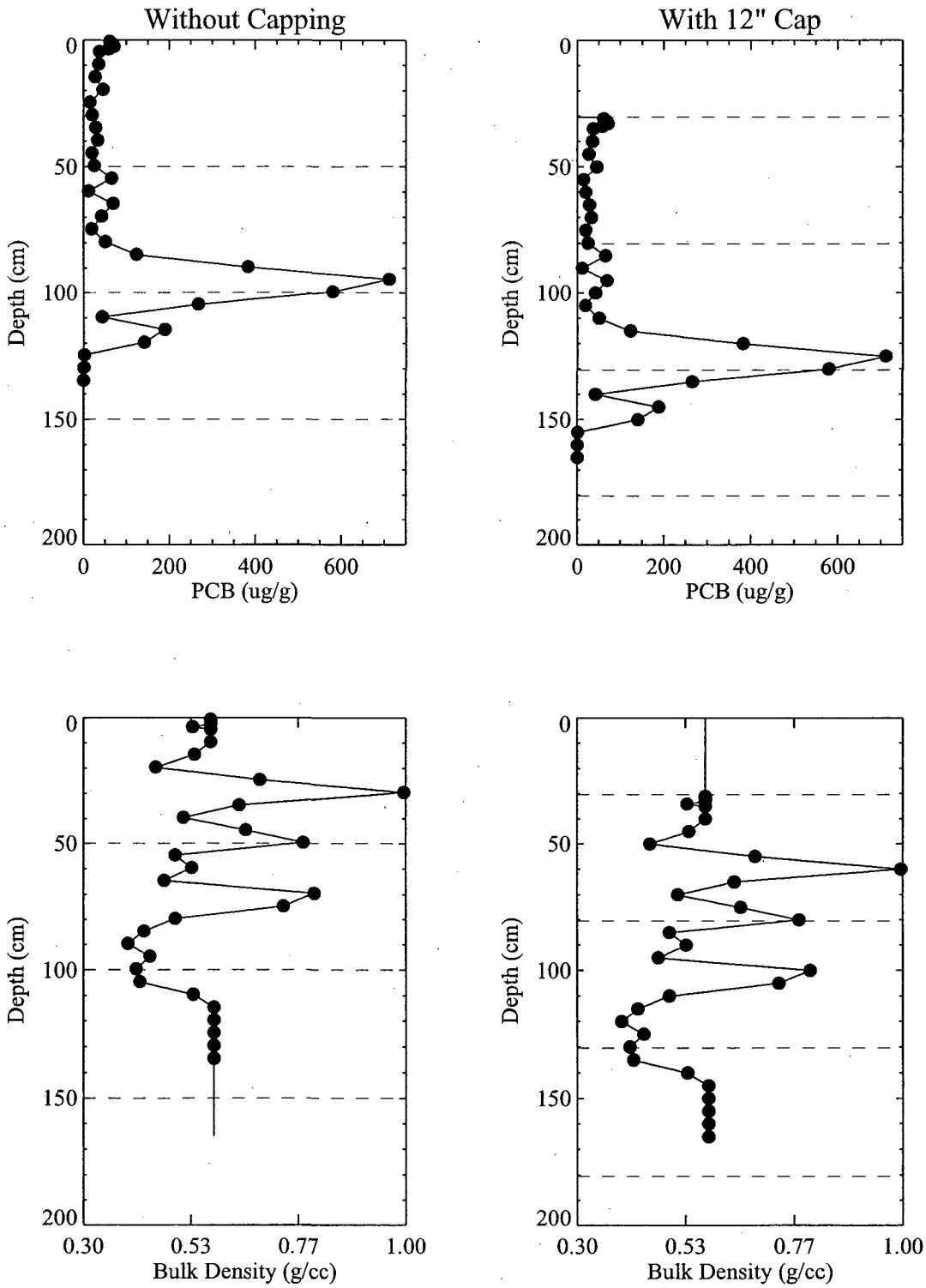

Figure B5-1. PCB and Bulk Density Profiles Used as Input to 1-D Cap/Sediment PCB Fate Model.

Symbols and lines represent data and model input, respectively.

EC - \\Emily\D_DRIVE\ALCgra\Documents\reports\AofA_202\model_app_C\figures\pcb_bdens_input_profiles_fig_C5_1.pro
Mon Feb 11 13:55:33 2002

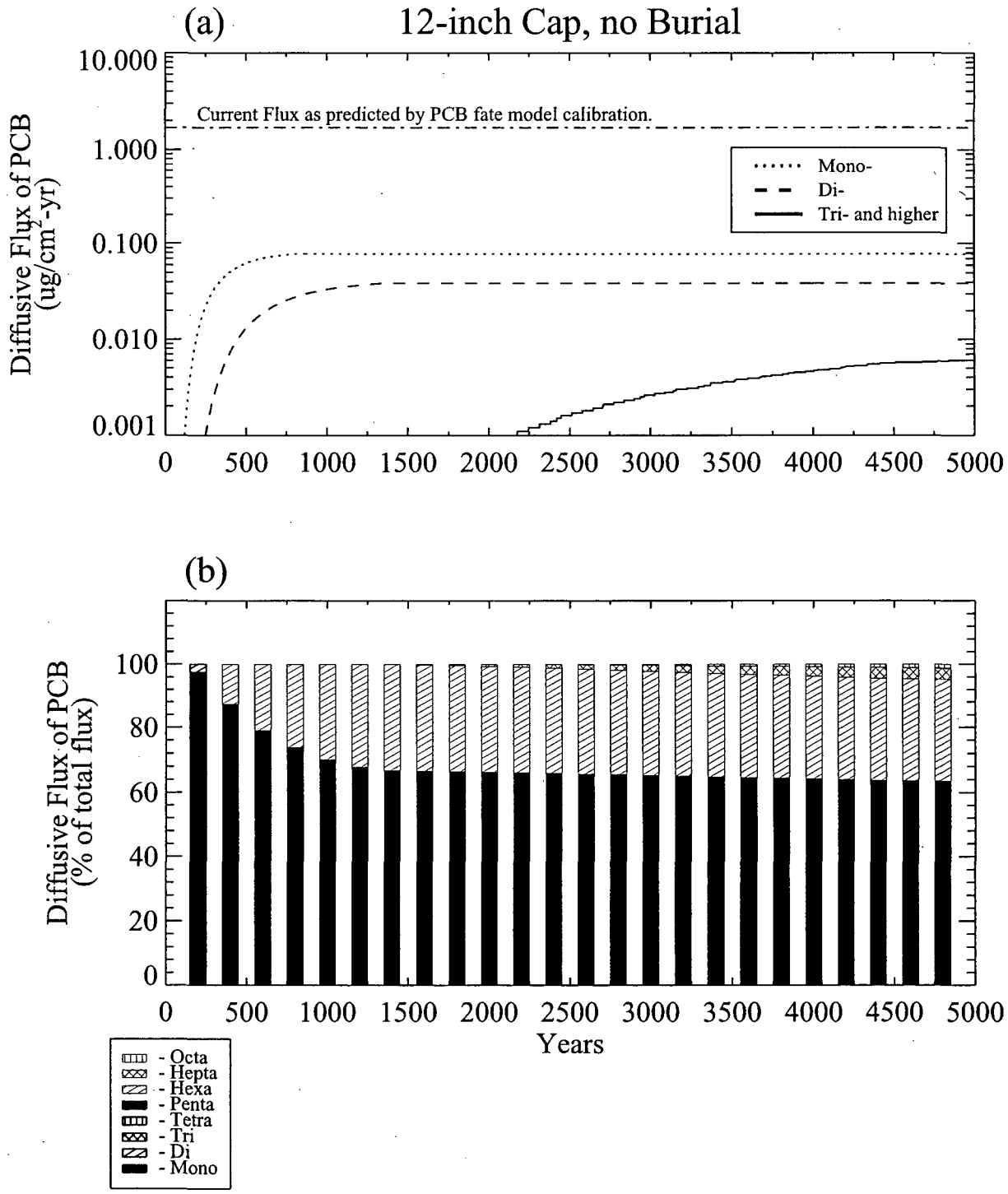

Figure B5-2. Predicted Diffusive Flux of PCB Through 12-inch Cap to the Overlying Water Column.

EC - \\Emily\D_DRIVE\ALCgra\Documents\reports\AofA_202\model_app_C\figures\plot_vs_fatemodel_fig_C5_2.pro
Mon Feb 11 13:57:53 2002

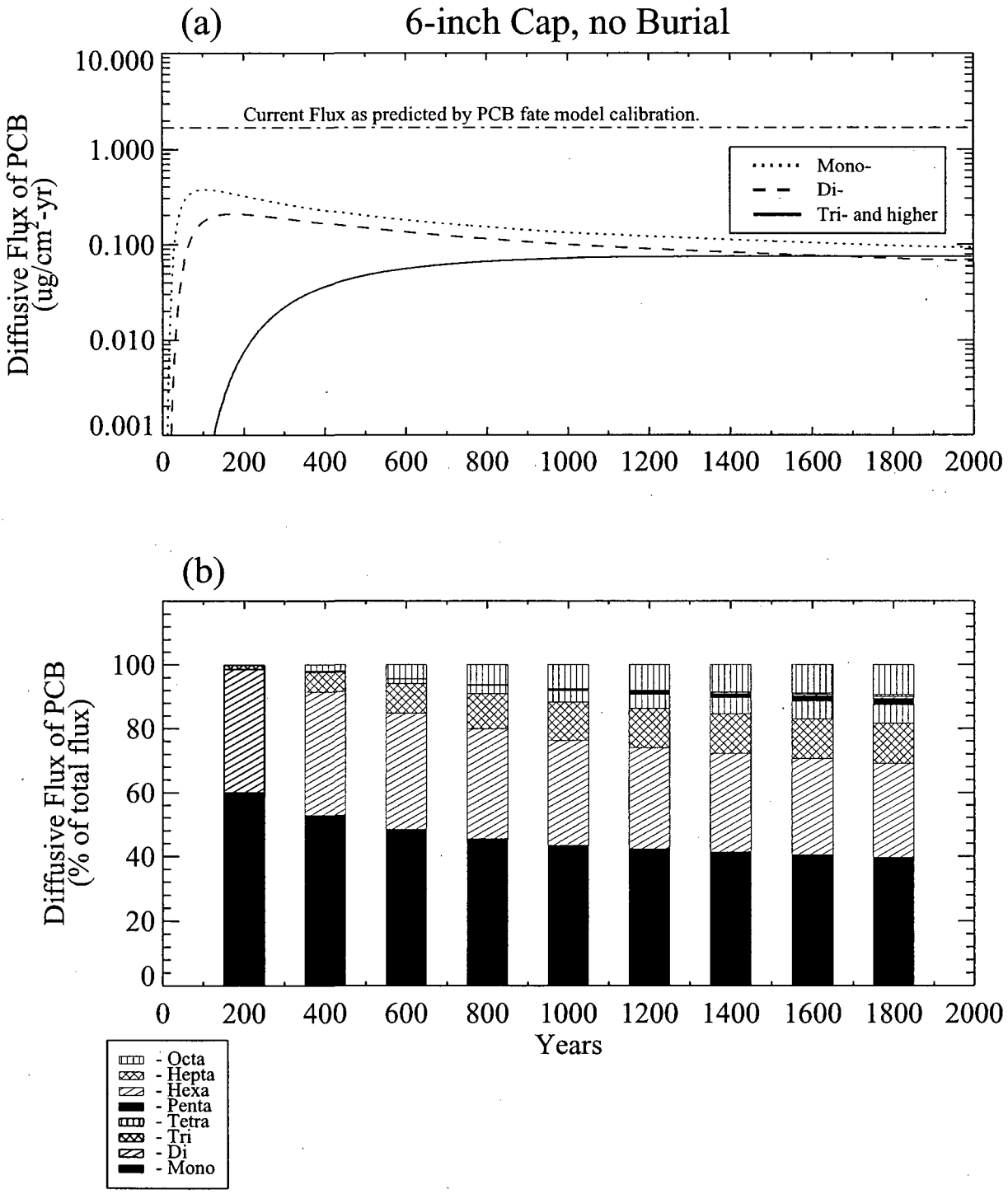

Figure B5-3. Predicted Diffusive Flux of PCB Through 6-inch Cap to the Overlying Water Column.

EC - \\Emily\D_DRIVE\ALCgra\Model\DepMod_AofA202\Outputs\Plots\plot_vs_fatemodel_6.pro
Mon Feb 11 14:00:00 2002

Table C-1
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Summary of Preliminary Costs Estimates for Alternatives 1 through 10

Alternative	Description	Estimated Cost
1	No Further Action	$0
2	Monitored Natural Recovery	$2,700,000
3	Cap T11 to T38	$30,900,000
4	Dredge PCBs ≥50 ppm; Cap T11 to T38	$51,400,000
5	Dredge PCBs ≥25 ppm; Cap PCBs ≥10 ppm	$64,900,000
6	Cap PCBs ≥5 ppm	$54,800,000
7	Dredge PCBs ≥50 ppm; Cap PCBs ≥5 ppm	$75,100,000
8	Dredge PCBs ≥25 ppm; Cap PCBs ≥5 ppm	$89,500,000
9	Dredge PCBs ≥10 ppm; Cap PCBs ≥5 ppm	$196,300,000
10	Dredge PCBs ≥1 ppm	$525,400,000

Notes:
1. Additional detail included on Tables C-2 through C-10.
2. Alternative descriptions provided above are the "abbreviated descriptions". Further detail for each alternative is provided in Section 5.
3. Site-wide natural recovery (i.e., sedimentation and biodegradation) is a component of Alternatives 3 through 10.
4. The term "cap" is used to indicate a 12-inch sand/topsoil cap.
5. Alternatives 3 through 9 include the placement of an engineered cap in the vicinity of Outfalls 001/004. The term "engineered cap" is used to indicate an 18-inch unwashed run-of-bank (ROB) cap with an additional 6-inch layer of gravel.
6. Target PCB concentrations identified in Alternatives 4 through 10 refer to PCB levels in the surface (0 to 3 inches) sediment.

Table C-2
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimate for Alternative 2:
Monitored Natural Recovery
Within the Lower Grasse River

Construction Total:	$0
Long-Term Monitoring/O&M Program (Present Worth):	$2,700,000
Total (2004 $):	$2,700,000

See assumptions on page 3 of 19.

Table C-2
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimate for Alternative 2:
Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that no active remediation would be performed on the lower Grasse River. A 30-year monitoring program will be implemented to assess the natural recovery processes of the River.
2. The long-term monitoring program would include annual water column, sediment, and fish monitoring in the lower Grasse River for a period of 30 years. A 5-year review of the long-term monitoring program, including a summary and trend analysis, would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified. In addition, one fish and water column sampling event would be conducted in the Power Canal. The estimated cost for the long-term monitoring program was calculated using the present worth analysis process outlined in the "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" (USEPA, July 2000). A discount rate of 7% was used for the present worth calculation. All costs are provided in 2004 dollars.
3. 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.

Table C-3
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimate for Alternative 3:
Cap Between Sediment Probing Transects T11 and T38, Engineered Cap at Outfalls 001/004,
and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$1,200,000	$1,200,000	$1,311,272
2	Access Area Development/Restoration	LS	1	$300,000	$300,000	$327,818
3	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup	LF	7,800	$75	$585,000	$639,245
4	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
5	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
6	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
7	Cap - Material Purchase, Delivery, and Mixing	CY	226,350	$30	$6,790,500	$7,420,163
8	Cap - Material Placement	CY	196,830	$25	$4,920,750	$5,377,036
9	Construction Monitoring/Oversight	MO	14	$125,000	$1,750,000	$1,912,272
					Construction Total:	$17,962,399
					Engineering Design (15%):	$2,694,360
					Contingency (25%):	$4,490,600
					Long-Term Monitoring/O&M Program (Present Worth):	$5,800,000
					Total (2004 $):	$30,947,359
					Rounded Total (2004 $):	$30,900,000

See assumptions on page 5 of 19.

Table C-3
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimate for Alternative 3:
Cap Between Sediment Probing Transects T11 and T38, Engineered Cap at Outfalls 001/004,
and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that an engineered cap would be placed over sediments adjacent to Alcoa's Outfalls 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed from sediment probing Transect T11 to T38 covering approximately 122 acres.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 2 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Each mobilization/demobilization for capping has been estimated at $600,000 per season.
5. Two distinct areas (each located along the northern shore on Alcoa's property) would be used for access purposes. The cost to construct/prepare each access area has been estimated at $150,000 per area.
6. Work to be conducted 6 days per week.
7. Single silt curtain (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
8. No more than one-half of the River would be cordoned off with silt curtains at one time. 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.
9. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
10. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
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, capping, etc.). For purposes of this estimate, it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
12. 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.
13. 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.
14. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.
15. 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.

Table C-4
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 4:
Dredge River Areas With Surface Sediment PCB Concentrations ≥50 ppm,
Cap Between Sediment Probing Transects T11 and T38,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$2,200,000	$2,200,000	$2,403,999
2	Access Area Development/Restoration	LS	1	$500,000	$500,000	$546,364
3a	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Dredging Activities	LF	5,000	$130	$650,000	$710,273
3b	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Capping Activities	LF	7,800	$75	$585,000	$639,245
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	48,000	$125	$6,000,000	$6,556,362
5	Water Treatment	1k Gals	67,000	$10	$670,000	$732,127
6	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	48,000	$90	$4,320,000	$4,720,581
7	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
8	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
9	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
10	Cap - Material Purchase, Delivery, and Mixing	CY	226,350	$30	$6,790,500	$7,420,163
11	Cap - Material Placement	CY	196,830	$25	$4,920,750	$5,377,036
12	Construction Monitoring/Oversight	MO	18	$125,000	$2,250,000	$2,458,636
					Construction Total:	$32,539,378
					Engineering Design (15%):	$4,880,907
					Contingency (25%):	$8,134,844
					Long-Term Monitoring/O&M Program (Present Worth):	$5,800,000
					Total (2004 $):	$51,355,129
					Rounded Total (2004 $):	$51,400,000

See assumptions on page 7 of 19.

Table C-4
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 4:
Dredge River Areas With Surface Sediment PCB Concentrations ≥50 ppm,
Cap Between Sediment Probing Transects T11 and T38,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 50 ppm would be removed (total of approximately 48,000 in-situ cy of soft sediments) using a hydraulic dredge. During the last month of dredging, an engineered cap would be placed over sediments adjacent to Alcoa's Outfalls 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed from sediment probing Transect T11 to T38 covering approximately 122 acres. It should be noted that one isolated area (approximately 1 acre) with surface PCB concentrations greater than or equal to 50 ppm located downstream of the area targeted for capping would not be remediated due to the significant implementation inefficiencies associated with such an effort.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 3 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging has been estimated $1,000,000 per season (one season required) and $600,000 per season for capping (two seasons required). Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging, and the cost provided for dredging would include costs associated with mobilization/demobilization of capping during the first season.
5. Two distinct areas (each located along the northern shore on Alcoa's property) would be used for access purposes. The cost to construct/ prepare one access area in preparation of dredging has been estimated at $350,000 and the cost to construct/prepare an additional area for capping alone is estimated at $150,000.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. Capping work would require a single silt curtain system (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
9. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
10. The production rate for dredging is estimated to be 1,250 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
11. Include dredge passes necessary to reach a target cleanup level with a total of five passes.
12. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
13. In-situ sediments are assumed to contain 44% solids.
14. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
15. Water treatment would consist of sand and carbon filters.
16. Disposal costs assume that all materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill.
17. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
18. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
19. 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, capping, etc.). For purposes of this estimate, it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
20. 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.
21. 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.
22. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified. The long-term monitoring program will be conducted for a period of 30 years. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.
23. 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.

Table C-5
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 5:
Dredge River Areas With Surface Sediment PCB Concentrations ≥25 ppm,
Cap Sediments With Surface PCB Concentrations ≥10 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$2,200,000	$2,200,000	$2,403,999
2	Access Area Development/Restoration	LS	1	$500,000	$500,000	$546,364
3a	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Dredging Activities	LF	6,200	$130	$806,000	$880,738
3b	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Capping Activities	LF	7,800	$75	$585,000	$639,245
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	101,000	$95	$9,595,000	$10,484,716
5	Water Treatment	1k Gals	135,000	$10	$1,350,000	$1,475,181
6	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	101,000	$90	$9,090,000	$9,932,888
7	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
8	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
9	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
10	Cap - Material Purchase, Delivery, and Mixing	CY	215,220	$30	$6,456,600	$7,055,301
11	Cap - Material Placement	CY	187,150	$25	$4,678,750	$5,112,596
12	Construction Monitoring/Oversight	MO	20	$125,000	$2,500,000	$2,731,818
					Construction Total:	$42,237,439
					Engineering Design (15%):	$6,335,616
					Contingency (25%):	$10,559,360
					Long-Term Monitoring/O&M Program (Present Worth):	$5,800,000
					Total (2004 $):	$64,932,415
					Rounded Total (2004 $):	$64,900,000

See assumptions on page 9 of 19.

Table C-5
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 5:
Dredge River Areas With Surface Sediment PCB Concentrations ≥25 ppm,
Cap Sediments With Surface PCB Concentrations ≥10 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 25 ppm would be removed (total of approximately 101,000 cy of soft sediments) using a hydraulic dredge. During the last month of dredging, an engineered cap would be placed over sediments adjacent to Alcoa's Outfall 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed over areas with surface sediments greater than or equal to 10 ppm covering approximately 116 acres.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 3 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging has been estimated $1,000,000 per season (1 season required) and $600,000 per season for capping (2 seasons required). Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging, and the cost provided for dredging would include costs associated with mobilization/demobilization of capping during the first season.
5. Two distinct areas (each located along the northern shore on Alcoa's property) would be used for access purposes. The cost to construct/prepare one access area in preparation of dredging has been estimated at $350,000 and the cost to construct/prepare an additional area for capping alone is estimated at $150,000.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. Capping work would require a single silt curtain system (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
9. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
10. The production rate for dredging is estimated to be 1,250 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
11. Includes dredge passes necessary to reach a target cleanup level with a total of five passes.
12. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
13. In-situ sediments are assumed to contain 44% solids.
14. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
15. Water treatment would consist of sand and carbon filters.
16. Disposal costs assume that all materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill.
17. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
18. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
19. 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, capping, etc.). For purposes of this estimate, it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
20. 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.
21. 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.
22. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.
23. 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.

Table C-6
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 6:
Cap Sediments With Surface PCB Concentrations ≥5 ppm, Engineered Cap at Outfalls 001/004,
and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$2,400,000	$2,400,000	$2,622,545
2	Access Area Development/Restoration	LS	1	$600,000	$600,000	$655,636
3	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup	LF	13,950	$90	$1,255,500	$1,371,919
4	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
5	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
6	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
7	Cap - Material Purchase, Delivery, and Mixing	CY	436,000	$30	$13,080,000	$14,292,869
8	Cap - Material Placement	CY	379,130	$25	$9,478,250	$10,357,140
9	Construction Monitoring/Oversight	MO	28	$125,000	$3,500,000	$3,824,545
					Construction Total:	$34,099,245
					Engineering Design (15%):	$5,114,887
					Contingency (25%):	$8,524,811
					Long-Term Monitoring/O&M Program (Present Worth):	$7,100,000
					Total (2004 $):	$54,838,944
					Rounded Total (2004 $):	$54,800,000

See assumptions on page 11 of 19.

Table C-6
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 6: Cap Sediments With Surface PCB Concentrations ≥5 ppm, Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that an engineered cap would be placed over sediments adjacent to Alcoa's Outfall 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed over areas with surface sediment PCB concentrations greater than or equal to 5 ppm covering approximately 235 acres.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 4 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Each mobilization/demobilization for capping has been estimated at $600,000 per season.
5. Four distinct areas would be used for access purposes (two areas likely to be located on Alcoa's property while the other two areas would not - property/access costs not included in estimate). The cost to construct/prepare each access area has been estimated at $150,000 per area.
6. Work to be conducted 6 days per week.
7. Single silt curtain (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
8. No more than one-half of the River would be cordoned off with silt curtains at one time. 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.
9. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
10. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
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, capping, etc.). For purposes of this estimate, it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
12. 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.
13. 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.
14. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.

    Note that the long-term monitoring program assumed for this alternative has a greater cost associated with it than that used for Alternatives 3 through 5 as it has a much larger capping area.
15. 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.

Table C-7
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 7:
Dredge River Areas With Surface Sediment PCB Concentrations ≥50 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$3,400,000	$3,400,000	$3,715,272
2	Access Area Development/Restoration	LS	1	$800,000	$800,000	$874,182
3a	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Dredging Activities	LF	5,000	$130	$650,000	$710,273
3b	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Capping Activities	LF	13,950	$90	$1,255,500	$1,371,919
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	48,000	$125	$6,000,000	$6,556,362
5	Water Treatment	1k Gals	67,000	$10	$670,000	$732,127
6	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	48,000	$90	$4,320,000	$4,720,581
7	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
8	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
9	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
10	Cap - Material Purchase, Delivery, and Mixing	CY	436,000	$30	$13,080,000	$14,292,869
11	Cap - Material Placement	CY	379,130	$25	$9,478,250	$10,357,140
12	Construction Monitoring/Oversight	MO	31	$125,000	$3,875,000	$4,234,317
					Construction Total:	$48,539,633
					Engineering Design (15%):	$7,280,945
					Contingency (25%):	$12,134,908
					Long-Term Monitoring/O&M Program (Present Worth):	$7,100,000
					Total (2004 $):	$75,055,486
					Rounded Total (2004 $):	$75,100,000

See assumptions on page 13 of 19.

Table C-7
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 7:
Dredge River Areas With Surface Sediment PCB Concentrations ≥50 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 50 ppm would be removed (total of approximately 48,000 cy of soft sediments) using a hydraulic dredge. During the last month of dredging, an engineered cap would be placed over sediments adjacent to Alcoa's Outfall 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed over areas with surface sediment PCB concentrations greater than or equal to 5 ppm covering approximately 235 acres. It should be noted that one isolated area (approximately 1 acre) with surface PCB concentrations greater than or equal to 50 ppm located adjacent sediment probing Transect T55 would not be dredged due to the significant implementation inefficiencies associated with the distance between targeted dredging areas.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 5 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging has been estimated $1,000,000 per season (one season required) and $600,000 per season for capping (4 seasons required). Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging, and the cost provided for dredging would include costs associated with mobilization/demobilization of capping during the first season.
5. Four distinct areas would be used for access purposes (two areas likely to be located on Alcoa's property while the other two areas would not - property/access costs not included in estimate). The cost to construct/prepare one access area in preparation of dredging has been estimated at $350,000 and the cost to construct/prepare three additional areas for capping alone are estimated at $150,000 per area.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. Capping work would require a single silt curtain system (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
9. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
10. The production rate for dredging is estimated to be 1,250 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
11. Includes dredge passes necessary to reach a target cleanup level with a total of five passes.
12. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
13. In-situ sediments are assumed to contain 44% solids.
14. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
15. Water treatment would consist of sand and carbon filters.
16. Disposal costs assume that all materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill.
17. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
18. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
19. 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, capping, etc.). For purposes of this estimate, it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
20. 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.
21. 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.
22. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.

    Note that the long-term monitoring program assumed for this alternative has a greater cost associated with it than that used for Alternatives 3 through 5 as it has a much larger capping area.
23. 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.

Table C-8
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 8:
Dredge River Areas With Surface Sediment PCB Concentrations ≥25 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$3,400,000	$3,400,000	$3,715,272
2	Access Area Development/Restoration	LS	1	$800,000	$800,000	$874,182
3a	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Dredging Activities	LF	6,200	$130	$806,000	$880,738
3b	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Capping Activities	LF	13,950	$90	$1,255,500	$1,371,919
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	101,000	$95	$9,595,000	$10,484,716
5	Water Treatment	1k Gals	135,000	$10	$1,350,000	$1,475,181
6	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	101,000	$90	$9,090,000	$9,932,888
7	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
8	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
9	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
10	Cap - Material Purchase, Delivery, and Mixing	CY	436,000	$30	$13,080,000	$14,292,869
11	Cap - Material Placement	CY	379,130	$25	$9,478,250	$10,357,140
12	Construction Monitoring/Oversight	MO	33	$125,000	$4,125,000	$4,507,499
					Construction Total:	$58,866,996
					Engineering Design (15%):	$8,830,049
					Contingency (25%):	$14,716,749
					Long-Term Monitoring/O&M Program (Present Worth):	$7,100,000
					Total (2004 $):	$89,513,794
					Rounded Total (2004 $):	$89,500,000

See assumptions on page 15 of 19.

Table C-8
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 8:
Dredge River Areas With Surface Sediment PCB Concentrations ≥25 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 25 ppm would be removed (total of approximately 101,000 cy of soft sediments) using a hydraulic dredge. During the last month of dredging, an engineered cap would be placed over sediments adjacent to Alcoa's Outfall 001/004 covering approximately 5 acres. Following engineered capping, a cap would be placed over areas with surface sediments greater than or equal to 5 ppm covering approximately 235 acres.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 5 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging has been estimated $1,000,000 per season (one season required) and $600,000 per season for capping (4 seasons required). Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging, and the cost provided for dredging would include costs associated with mobilization/demobilization of capping during the first season.
5. Four distinct areas would be used for access purposes (two areas likely to be located on Alcoa's property while the other two areas would not - property/access costs not included in estimate). The cost to construct/prepare one access area in preparation of dredging has been estimated at $350,000 and the cost to construct/prepare three additional areas for capping alone are estimated at $150,000 per area.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. Capping work would require a single silt curtain system (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
9. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
10. The production rate for dredging is estimated to be 1,250 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
11. Includes dredge passes necessary to reach a target cleanup level with a total of five passes.
12. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
13. In-situ sediments are assumed to contain 44% solids.
14. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
15. Water treatment would consist of sand and carbon filters.
16. Disposal costs assume that all materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill.
17. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
18. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
19. Construction monitoring/oversight includes daily oversight of construction activities is assumed to be conducted during all in-River activities (i.e., silt curtain installation/removal, capping, etc.). For purposes of this estimate it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
20. 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.
21. 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.
22. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.

    Note that the long-term monitoring program assumed for this alternative has a greater cost associated with it than that used for Alternatives 3 through 5 as it has a much larger capping area.
23. 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.

Table C-9
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 9:
Dredge River Areas With Surface Sediment PCB Concentrations ≥10 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$4,200,000	$4,200,000	$4,589,453
2	Access Area Development/Restoration	LS	1	$1,000,000	$1,000,000	$1,092,727
3a	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Dredging Activities	LF	10,000	$135	$1,350,000	$1,475,181
3b	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup for Capping Activities	LF	13,950	$90	$1,255,500	$1,371,919
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	515,000	$70	$36,050,000	$39,392,808
5	Water Treatment	1k Gals	800,000	$5	$4,000,000	$4,370,908
6	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	515,000	$90	$46,350,000	$50,647,896
7	Engineered Cap - Soil Material Purchase, Delivery, and Mixing	CY	13,920	$30	$417,600	$456,323
8	Engineered Cap - Gravel Material Purchase and Delivery	CY	4,440	$16	$71,040	$77,627
9	Engineered Cap - Soil/Gravel Material Placement	CY	16,130	$25	$403,250	$440,642
10	Cap - Material Purchase, Mixing, and Delivery	CY	436,000	$30	$13,080,000	$14,292,869
11	Cap - Material Placement	CY	379,130	$25	$9,478,250	$10,357,140
12	Construction Monitoring/Oversight	MO	48	$125,000	$6,000,000	$6,556,362
					Construction Total:	$135,121,857
					Engineering Design (15%):	$20,268,278
					Contingency (25%):	$33,780,464
					Long-Term Monitoring/O&M Program (Present Worth):	$7,100,000
					Total (2004 $):	$196,270,599
					Rounded Total (2004 $):	$196,300,000

See assumptions on page 17 of 19.

Table C-9
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 9:
Dredge River Areas With Surface Sediment PCB Concentrations ≥10 ppm,
Cap Sediments With Surface PCB Concentrations ≥5 ppm,
Engineered Cap at Outfalls 001/004, and Site-Wide Monitored Natural Recovery
Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 10 ppm would be removed (total of approximately 515,000 cy of soft sediments) using a hydraulic dredge. During the last month of dredging in the first construction season, an engineered cap would be placed over sediments adjacent to Alcoa's Outfall 001/004 covering approximately 5 acres. Following engineered capping and concurrent with hydraulic dredging, a cap would be placed over areas with surface sediments greater than or equal to 5 ppm covering approximately 235 acres until both activities are completed.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 5 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging has been estimated $1,000,000 per season (3 seasons required) and $600,000 per season for capping (2 seasons required). Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging, and the cost provided for dredging would include costs associated with mobilization/demobilization of capping during seasons both activities would occur concurrently.
5. Four distinct areas would be used for access purposes (two areas likely to be located on Alcoa's property while the other two areas would not - property/access costs not included in estimate). The cost to construct/prepare two access areas in preparation of dredging has been estimated at $350,000 and the cost to construct/prepare two additional areas for capping alone are estimated at $150,000 per area.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. Capping work would require a single silt curtain system (with a maximum curtain length in the River of 1,500 LF) to be placed around the area to be capped. The unit price includes purchase of material and cost to install/remove each setup.
9. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
10. The production rate for dredging is estimated to be 1,300 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
11. Includes dredge passes necessary to reach a target cleanup level with a total of five passes.
12. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
13. In-situ sediments are assumed to contain 44% solids.
14. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
15. Water treatment would consist of sand and carbon filters.
16. Disposal costs assume that materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill.
17. Costs assume that the engineered cap would consist of 18 inches of soil material placed atop the sediment and 6 inches of 1 to 1.5 inch diameter gravel would be placed on the cap material. Engineered cap would be composed of materials which can be obtained from local borrow pits. Assumes 15% of the sand/topsoil and 10% of the gravel material would be lost during transport to, from, and at stockpile area. Engineered cap placement rate has been estimated at approximately 420,000 sf/mo.
18. Cap would be composed of a sand/topsoil mix which can be obtained from local borrow pits. Assumes 15% of the cap material would be lost during transport to, from, and at stockpile area. It is assumed that a total of 12-inches of material would be placed in two 6-inch lifts. Assumes material placement rate of 225,000 sf/mo per crew with 2 crews working simultaneously (total of 450,000 sf/mo).
19. Construction monitoring/oversight includes daily oversight of construction activities is assumed to be conducted during all in-River activities (i.e., silt curtain installation/removal, capping, etc.). For purposes of this estimate it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, cap thickness monitoring, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study. Note that while dredging and capping activities would be performed at the same time, the number of months required for monitoring/oversight was calculated assuming no overlap so that the unit costs used for all other alternatives could be applied.
20. 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.
21. 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.
22. The long-term monitoring/operation and maintenance program is assumed to include annual water column, sediment, fish, and benthic monitoring, diver observation and observation by boat for new construction. The program also includes cap maintenance activities (assumed to be performed once every 3 years), an additional diver observation following a high energy event, and lower Grasse River bathymetry (assumed to be performed once every 5 years). A 5-year review of the long-term monitoring program, including a summary and trend analysis, 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. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.

    Note that the long-term monitoring program assumed for this alternative has a greater cost associated with it than that used for Alternatives 3 through 5 as it has a much larger capping area.
23. 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.

Table C-10
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 10:
Dredge River Areas With Surface Sediment PCB Concentrations ≥1 ppm and Site-Wide Monitored Natural Recovery Within the Lower Grasse River

ITEM NO.	DESCRIPTION	UNIT	NO. OF UNITS	UNIT COST	ESTIMATED COST (2001 $)	ESTIMATED COST (2004 $)
1	Mobilization/Demobilization	LS	1	$9,000,000	$9,000,000	$9,834,543
2	Access Area Development/Restoration	LS	1	$700,000	$700,000	$764,909
3	Silt Curtain System Materials/Installation/Removal/ Additional Silt Curtain Setup	LF	25,000	$145	$3,625,000	$3,961,135
4	Hydraulic Dredging/Boulder Removal/ Dewatering/Stabilization	CY	1,650,000	$70	$115,500,000	$126,209,969
5	Water Treatment	1k Gals	2,200,000	$5	$11,000,000	$12,019,997
6a	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill	CY	515,000	$90	$46,350,000	$50,647,896
6b	Transportation and Disposal of Sediments at Alcoa's On-Site Landfill with Design of Additional Cells	CY	1,135,000	$130	$147,550,000	$161,231,869
7	Construction Monitoring/Oversight	MO	62	$125,000	$7,750,000	$8,468,634
					Construction Total:	$373,138,952
					Engineering Design (15%):	$55,970,843
					Contingency (25%):	$93,284,738
					Long-Term Monitoring/O&M Program (Present Worth):	$3,000,000
					Total (2004 $):	$525,394,533
					Rounded Total (2004 $):	$525,400,000

See assumptions on page 19 of 19.

Table C-10
Grasse River Study Area
Massena, New York
Analysis of Alternatives Report

Preliminary Cost Estimates for Alternative 10: Dredge River Areas With Surface Sediment PCB Concentrations ≥1 ppm and Site-Wide Monitored Natural Recovery Within the Lower Grasse River

Assumptions:

1. This cost estimate assumes that areas with surface sediment PCB concentrations greater than or equal to 1 ppm would be removed (total of approximately 1,650,000 cy of soft sediments) using a hydraulic dredge.
2. A yearly increase of 3% was applied to adjust the cost from 2001 to 2004 dollars. The 3% increase was obtained by taking the average of the percent increases reported in the construction cost index (Engineering News Record) for 1999-2000 and 2000-2001.
3. All costs are provided in 2004 dollars and all capital cost expenditures are assumed to occur in 2004.
4. Work is estimated to take 9 construction seasons to complete (typical construction season includes 6 months of actual construction and 2 months for mobilization/demobilization). Mobilization/demobilization for dredging/engineered capping has been estimated $1,000,000 per season. Note that during the first construction season it is assumed that 2 months of mobilization would be required to prepare for dredging.
5. Two distinct areas (each located along the northern shore on Alcoa's property) would be used for access purposes. The cost to construct/prepare two access areas in preparation of dredging has been estimated at $350,000 per area.
6. Work to be conducted 6 days per week.
7. Dredging work would require a double or triple tiered silt curtain held in place through the placement of H-beams on the curtain. The unit price includes purchase of material and cost to install/remove each setup. A maximum curtain length in the River of 1,500 LF is assumed.
8. No more than one-half of the River would be cordoned off with silt curtains at one time. After capping/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 moved to the second area.
9. The production rate for dredging is estimated to be 1,300 cy/day using two dredges simultaneously. Boulder removal to occur concurrently with hydraulic dredging activity.
10. Includes dredge passes necessary to reach a target cleanup level with a total of five passes.
11. Any rocks or debris removed from the River by mechanical means or separated from dredged sediments via shaker screens would be hauled directly to Alcoa's property without any decontamination.
12. In-situ sediments are assumed to contain 44% solids.
13. It is assumed that materials taken directly off the filter press would be suitable for direct landfilling without further treatment.
14. Water treatment would consist of sand and carbon filters.
15. Disposal costs assume that a portion of the materials would be disposed in a new on-site cell constructed at Alcoa's Secure Landfill with current capacity of 515,000 cy at a unit cost of $90/cy which includes transportation/disposal. Additional cells to accommodate the remaining volume of 1,135,000 cy would be designed (including a siting study) and constructed at a unit cost of $130/cy which includes transport and disposal.
16. Construction monitoring/oversight includes daily oversight of construction activities is assumed to be conducted during all in-River activities (i.e., silt curtain installation/removal, capping, etc.). For purposes of this estimate it is assumed that there would be an additional month of monitoring per construction season to account for all in-River activities. The construction monitoring/oversight includes water column and sediment sampling, and operation of WINOPS system. Monitoring program included has been assumed to be less intensive than that performed for the Capping Pilot Study.
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.
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 is assumed to include annual water column, sediment, fish, and benthic monitoring for a period of 30 years. A 5-year review of the long-term monitoring program, including a summary and trend analysis, would be completed throughout the program to determine if the long-term monitoring and maintenance program should be modified. In addition, one fish and water column sampling event would be conducted in the Power Canal. 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 in 2005.
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.