HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY FOR
VOLUME 2C-A LOW RESOLUTION SEDIMENT CORING REPORT
ADDENDUM TO THE DATA EVALUATION AND INTERPRETATION REPORT

FEBRUARY 1999

For

U.S. Environmental Protection Agency
Region II
and
U.S. Army Corps of Engineers
Kansas City District

Book 1 of 2

TAMS Consultants, Inc.
TetraTech, Inc.

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

FEB 17 1999

To All Interested Parties:

The U.S. Environmental Protection Agency (EPA) is pleased to release this Responsiveness Summary to the Low Resolution Sediment Coring Report (LRC) for the Hudson River PCBs Superfund site. This document contains written comments from various reviewers of the LRC and the Agency's responses to significant comments. In addition, the appendices to the responsiveness summary include: a comparison of sediment PCB inventory between 1984 and 1994 on an area basis, rather than a point-to-point basis; a revised estimate of the Thompson Island Pool sediment PCB inventory; and, a revised estimate of the loads measured in EPA's 1993 water-column sampling based on corrections to the site database described in the December 1998 Responsiveness Summary for the Database Report, Preliminary Model Calibration Report, and Data Evaluation and Interpretation Report.

EPA's careful consideration of comments received on the LRC, and the additional analyses contained in the appendices to the responsiveness summary, support the overall conclusions of the LRC. The area-to-area analysis in Appendix A calculated a level of loss of PCB mass from highly contaminated sediments in the Thompson Island Pool that is similar to the loss estimated by a point-to-point comparison in the LRC. EPA acknowledges that there is considerable uncertainty surrounding the loss values in these estimates, but stresses that there is statistically significant loss of PCB mass despite this uncertainty. EPA therefore believes that it is appropriate to reaffirm the following general conclusions from the executive summary to the LRC:

> The decrease in PCB inventories in the more contaminated sediments of the Thompson Island Pool and from several of the studied *hot spots* below the Thompson Island Dam, along with the indication of an inventory gain in the coarse sediments of the Thompson Island Pool, indicate that PCBs are being redistributed within the Hudson River system. These results show that the stability of the sediment deposits cannot be assured.
>
> Burial of contaminated sediment by cleaner material is not occurring universally. Burial of more PCB-contaminated sediment by less contaminated sediment has occurred at limited locations, while significant portions of the PCB inventories at other *hot spots* have been re-released to the environment. It is likely that PCBs will continue to be released from Upper Hudson River sediments.

In other words, the PCB contamination in the Upper Hudson River continues to release PCBs to the water column, and it does not appear that burial by clean sediment is occurring significantly enough to resolve the problem.

The Data Evaluation and Interpretation Report (DEIR) and the LRC are currently being peer reviewed by a panel of independent experts. In addition to those reports, EPA is providing the peer reviewers copies of the responsiveness summaries to the DEIR and the LRC. The reviewers will discuss their findings at a meeting to be held on March 16, 17 and 18, 1999 at the Marriott Hotel in Albany, New York.

The technical concerns raised by both the peer review and the public comment processes are valuable to EPA's evaluation of the Hudson River system. We are pleased to provide you this response to public concerns on the LRC.

Sincerely yours,

William McCabe

William McCabe, Deputy Director
Emergency and Remedial Response Division

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FEBRUARY 1999

CONTENTS

BOOK 1 OF 2

Pages

TABLE OF CONTENTS

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY FOR
Volume 2C-A LOW RESOLUTION SEDIMENT CORING REPORT
Addendum to the Data Evaluation and Interpretation Report

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY FOR
Volume 2C-A LOW RESOLUTION SEDIMENT CORING REPORT
Addendum to the Data Evaluation and Interpretation Report

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2

Pages

APPENDICES

BOOK 2 OF 2

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY FOR
Volume 2C-A LOW RESOLUTION SEDIMENT CORING REPORT
Addendum to the Data Evaluation and Interpretation Report

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2 Pages

LIST OF CORRECTIONS

LIST OF APPENDICES

LIST OF TABLES

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2

LIST OF FIGURES

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY FOR
Volume 2C-A LOW RESOLUTION SEDIMENT CORING REPORT
Addendum to the Data Evaluation and Interpretation Report

FEBRUARY 1999

CONTENTS

BOOK 1 OF 2 Pages

CORRECTED LRC FIGURES

LIST OF ACRONYMS

ASTM	American Society for Testing and Materials
^{7}Be	Beryllium-7
^{7}Be'	^{7}Be Concentration Decay-corrected to September 1, 1994
cm	Centimeter
^{137}Cs	Cesium-137
DEIR	Data Evaluation and Interpretation Report
DN	Digital Number
ECD	Electron Capture Detector
GC	Gas Chromatograph
GE	General Electric
IQD	Interquartile Distance
ITD	Ion Trap Detector
kg	Kilogram
kHz	Kilohertz
LQ	Lower Quartile
LRC	Low Resolution Sediment Coring Report
LWA	Length-Weighted Average
MDPR	Molar Dechlorination Product Ratio Sum of BZ#1, 4, 8, 10, & 19 over Sum of All Congeners (molar basis)
MDPR*	Sum of BZ#1 ,4, 10 & 19 only over Sum of All Congeners (molar basis)
mg	Milligram
MPA	Mass Per Unit Area
MPI	Malcolm Pirnie, Inc.
MVUE	Minimum Variance Unbiased Estimator
MW	Molecular Weight
ng	Nanogram
NPDES	National Pollution Discharge Elimination System
NYSDEC	New York State Department of Environmental Conservation
PCB	Polychlorinated Biphenyl
ppb	Parts per Billion
ppm	Parts per Million
QA	Quality Assurance
QAPjP	Quality Assurance Project Plan
RPD	Relative Percent Difference
RRT	Relative Retention Time
RSD	Relative Standard Deviation
s	Standard Deviation (also as SD)
SAP	Sampling and Analysis Plan
SAS	Special Analytical Services
SOP	Standard Operating Procedure
SSW	Solid Specific Weight
TC	Total Carbon
TCL	Target Compound List (Organics)
TI	Thompson Island
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TOC	Total Organic Carbon
µg	Microgram
UQ	Upper Quartile
USGS	United States Geological Survey

Introduction

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY
VOLUME 2C-A: LOW RESOLUTION SEDIMENT CORING REPORT
ADDENDUM TO THE DATA EVALUATION AND INTERPRETATION REPORT
FEBRUARY 1999

I. INTRODUCTION AND COMMENT DIRECTORY

1. INTRODUCTION

The United States Environmental Protection Agency (USEPA) has prepared this Responsiveness Summary for Volume 2C-A: Low Resolution Sediment Coring Report (LRC) for the Hudson River PCBs Reassessment Remedial Investigation/Feasibility Study (Reassessment) which is an addendum to the Data Evaluation and Interpretation Report. It addresses significant comments received during the review of this Report.

For the Reassessment, USEPA has established a Community Interaction Program (CIP) to elicit feedback from the public through regular meetings and discussion and to facilitate review of and comment upon work plans and reports prepared during all phases.

The LRC is incorporated by reference and is not reproduced herein. No revised copy of the LRC will be published as such. The comment responses and revisions noted herein are considered to amend the Report. For complete coverage, the Report and this Responsiveness Summary must be used together.

The first part of this Responsiveness Summary is entitled "Introduction and Comment Directory." It describes the Report review and commenting process, explains the organization and format of comments and responses, and contains a comment index or directory.

The second part, entitled "Responses", contains the USEPA responses to significant comments. Responses are grouped according to the section number of the Report to which they refer, *e.g.*, responses to comments on Section 2.1 are found in the "Responses" Section 2.1 of the Responsiveness Summary. Additional information about how to locate responses to comments is contained in the Comment Directory. Tables and figures for the responses are found within the text of the responses in Book 1 of the Responsiveness Summary. Book 1 also contains the appendices prepared for the Responsiveness Summary. Note that each appendix begins with a table of contents, listing the figures and tables contained in the appendix. The respective tables and figures are contained at the end of each of the appendices

The third part, entitled "Comments on the Phase 2 Report", contains copies of the comments submitted to the USEPA on the LRC. The comments are identified by commentor and comment number, as further explained in the Comment Directory. These comments are found in Book 2.

1.1 Recent Developments

Since the issuance of the LRC, further review of the Report has revealed certain errors in the text and figures of the document. Corrections to these errors are provided under the "Responses" section of the Responsiveness Summary under section in which the error occurred.

In addition, an alternative analysis to the comparison of the Thompson Island Pool (TI Pool) sediment inventory in 1984 and 1994 is presented in Appendix A. This approach addresses a number of criticisms of the LRC analysis. The analysis is area-based, examines the change in trichloro and higher homologue inventories only, and uses a more normally-distributed function to assess the bulk change in inventory.

A revised estimate of the TI Pool sediment PCB inventory in 1984 is presented in Appendix B. This revised estimate incorporates texture information and results in inventory estimates for fine-grained and coarse-grained areas of the TI Pool.

Appendix C presents a revision of the water column PCB transport analysis originally presented in the Data Evaluation and Interpretation Report (DEIR) (USEPA, 1997). The revisions reflect the current understanding of flow and PCB transport conditions in the Upper Hudson. In particular, revised flow estimates for the Stillwater and Waterford monitoring stations as well as a potential bias in the TI Dam monitoring station precipitated these revisions. The need for these revisions was originally noted in the Responsiveness Summary forVolumes 2A, B, and 2C, USEPA (1998). Several figures from the DEIR were revised as a result of these developments. The revised figures are included in Appendix C.

2. Report Commenting Process

This section documents and explains the commenting process and the organization of comments and responses in this document. To find responses to particularly comments, the reader should go to the Comment Directory on page CD-13.

2.1 Report Distribution

The LRC was distributed to federal and state agencies and officials, participants in the Community Interaction Program (CIP), and General Electric, as shown in Table 1. Distribution was made to approximately 100 agencies, groups, and individuals. Copies of the Report were also made available for public review in 17 information repositories, as shown in Table 2.

2.2 Review Period and Informational Meetings

USEPA held a formal 30-day comment period on the LRC, although USEPA has welcomed comments on the Reassessment throughout the study. USEPA held a Joint Liaison Group meeting that was open to the public to present the Report. The meeting was held on July 23, 1998 in Albany, NY.

Minutes for the meeting will be contained in a binder entitled Project Documents Binder. This binder is part of the project information available for public review at 11 of the 17 information repositories (Table 2). Four of the six repositories that do not currently have a Project Documents Binder (Marist Library, R.I. Library, SUN Albany Library, and USA Library) are partial repositories maintained primarily for their CD-ROM capability. The other two, Sojourner Truth Library at SUN New Pails, and the Sea Grant office in Kingston, will have copies of Project Documents Binders in the near future .

As stated in USEPA's letter transmitting the Report, citizens are encouraged to participate in the Reassessment process and to join one of the Liaison Groups formed as part of the Community Interaction Program. USEPA requested that all comments, including those of Liaison Groups, be sent to USEPA.

2.3 Receipt of Comments

Comments on the Report were received in two ways: letters or other written submissions to USEPA; and written statements submitted as follow-up to oral statements made during the meetings.

2.3.1 Comments on the Low Resolution Sediment Coring Report

A total of 8 comment sets were received, submitted by one federal agency, one state agency, one local government; four Community Interaction Program participants; and General Electric.

Federal agency comments consisted of one set from the National Oceanic and Atmospheric Administration (NOAA) (LF-1, 8/28/98).

One set of comments was received from the New York State Department of Environmental Conservation (L.S.-1, 8/31/98).

Local government comments were submitted by the Saratoga Environmental Management Council (LL-1, 8/28/98).

Comments were submitted by four members of the Community Interaction Program including J. Sanders (member, Science and Technical Committee; LC-1, 8/31/98), George Pitman (member, Science and Technical Committee; LC-2, 8/29/98), T.Borden (chairperson, Agricultural Liaison Group; LC-3, 8/30/98), and M. Pulver (co-chair, Agricultural Liaison Group and Fort Edward Town Board; LC-4, 8/31/98).

General Electric (LG-1) comments constituted virtually a free-standing Report, with 54 pages of text plus 46 pages of tables and figures, as well as two additional appendices.

2.4 Distribution of the Responsiveness Summary

This Responsiveness Summary, like all other documents prepared for the Reassessment, has been distributed to the members of the Steering Committee, the Hudson River PCB Oversight Committee, the Scientific and Technical Committee, NYSDEC and General Electric. In addition, copies have been sent to the peer reviewers for the DEIR and LRC. This Responsiveness Summary has also been placed in the 17 Information Repositories and will be included in the Administrative Record.

TABLE 1

DISTRIBUTION OF REPORTS

HUDSON RIVER PCBs OVERSIGHT COMMITTEE MEMBERS

- USEPA ERRD Deputy Division Director (Chair)
- USEPA Project Manager
- USEPA Community Relations Coordinator, Chair of the Steering Committee
- NYSDEC Division of Hazardous Waste Management representative
- NYSDEC Division of Construction Management representative
- National Oceanic and Atmospheric Administration (NCAA) representative
- Agency for Toxic Substances and Disease Registry (ATSDR) representative
- US Army Corps of Engineers representative
- New York State Thruway Authority (Department of Canals) representative
- USDOI (USF&W) representative
- NYSDOH representative
- GE representative
- Liaison Group Chairpeople
- Scientific and Technical Committee representative

SCIENTIFIC AND TECHNICAL COMMITTEE MEMBERS

STEERING COMMITTEE MEMBERS

- USEPA Community Relations Coordinator (Chair)
- Governmental Liaison Group Chair and two Co-chairs
- Citizen Liaison Group Chair and two Co-chairs
- Agricultural Liaison Group Chair and two Co-chairs
- Environmental Liaison Group Chair and two Co-chairs
- USEPA Project Manager
- NYSDEC Technical representative
- NYSDEC Community Affairs representative

FEDERAL AND STATE REPRESENTATIVES

Copies of the Reports were sent to relevant federal and state representatives who have been involved with this project. These include, in part, the following:

- The Hon. Daniel P. Moynihan
- The Hon. Alfonse M. D'Amato
- The Hon. Gerald Solomon
- The Hon. Nita Lowey
- The Hon. Maurice Hinchey
- The Hon. Ronald B. Stafford
- The Hon. Michael McNulty
- The Hon. Sue Kelly
- The Hon. Benjamin Gilman
- The Hon. Richard Brodsky
- The Hon. Bobby D'Andrea

17 INFORMATION REPOSITORIES (*see* Table 2).

TABLE 2
INFORMATION REPOSITORIES

Adriance Memorial Library
93 Market Street
Poughkeepsie, NY 12601

Catskill Public Library
1 Franklin Street
Catskill, NY 12414

^ Cornell Cooperative Extension
Sea Grant Office
74 John Street
Kingston, NY 12401

Crandall Library
City Park
Glens Falls, NY 12801

County Clerk's Office
Washington County Office Building
Upper Broadway
Fort Edward, NY 12828

* ^ Marist College Library
Marist College
290 North Road
Poughkeepsie, NY 12601

* New York State Library
CEC Empire State Plaza
Albany, NY 12230

New York State Department
of Environmental Conservation
Division of Hazardous Waste Remediation
50 Wolf Road, Room 212
Albany, NY 12233

* ^ R. G. Folsom Library
Rensselaer Polytechnic Institute
Troy, NY 12180-3590

Saratoga County EMC
50 West High Street
Ballston Spa, NY 12020

* Saratoga Springs Public Library
49 Henry Street
Saratoga Springs, NY 12866

* ^ SUN at Albany Library
1400 Washington Avenue
Albany, NY 12222

* ^ Sojourner Truth Library
SUN at New Pails
New Pails, NY 12561

Troy Public Library
100 Second Street
Troy, NY 12180

United States Environmental Protection
Agency
290 Broadway
New York, NY 10007

* ^ United States Military Academy Library
Building 757
West Point, NY 10996

White Plains Public Library
100 Martine Avenue
White Plains, NY 12601

* ***Repositories with Database Report CD-ROM (as of 10/98)***

^ ***Repositories without Project Documents Binder (as of 10/98)***

3. ORGANIZATION OF COMMENTS AND RESPONSES TO COMMENTS

3.1 Identification of Comments

Each comment submitted for a Report was assigned a dual letter code. The first letter references the Report (L for LRC) for which the comment was addressed and the second letter was used to denote one of the following:

F - Federal agencies and officials;
S - State agencies and officials;
L - Local agencies and officials;
C - Community Interaction Program Committees and Liaison Groups; and,
G - General Electric.

The letter codes were assigned for the convenience of readers and to assist in the organization of this document; priority or special treatment was neither intended nor given in the responses to comments.

Once a letter code was assigned, each submission was then assigned a number, in the order that it was received and processed, such as LC-1, LC-2 and so on. Each different comment within a submission was assigned its separate sub-number. Thus, if a federal agency submitted three different comments under the same cover, these are designated LF-1.1, LF-1.2, LF-1.3.

The alphanumeric code associated with each reprinted written submission is marked at the top right corner of the first page of the comment letter; the sub-numbers designating individual comments are marked in the margin, as shown in the sample letter in Section 4 of this introduction. Comment submissions are reprinted in numerical order by letter code in the following order: F, S, L, C, and G.

3.2 Location of Responses to Comments

The Comment Directory, following this text, contains a complete listing of all commentors and comments. This directory allows readers to find responses to comments and provides several items of information. In several cases, the name of the agency or organization of the commentors has been abbreviated, as follows:

- NOAA	National Oceanic and Atmospheric Administration
- NYSDEC	New York State Department of Environmental Conservation
- SCEMC/GLC	Saratoga County Environmental Management Council/Governmental Liaison Committee
- GE	General Electric Company

The comment directory table is organized as follows:

- The first column lists the names of commentors. Comments are grouped first by: F (Federal), S (State), L (Local), C (CIP) or G (General Electric) preceded by a L for the LRC.

- The second column identifies the alphanumeric comment code, *e.g.*, LF.1-1, assigned to each comment.

- The third column identifies the location of the response by Report section number. For example, comments raised on Section 3.2 of the Report can be found in the corresponding Section 3.2 of the Responses section, following the third tab of this document.

- The fourth, fifth, and sixth columns list key words that describe the subject matter of each comment. Readers will find these key words helpful as a means to identify subjects of interest and related comments.

Responses are grouped and consolidated by section number in order that all responses to related comments appear together to help achieve consistency among the responses and for the convenience of the reader interested in responses to related or similar comments.

In a few instances, several commentors commented on the same or very similar items. These comments are answered by one common response that addresses the common issue being raised. Thus, a comment is not necessarily answered by an individualized response.

In other cases, different comments pertaining to the same Report section are made. Thus, a section number may contain more than one response.

3.3 Types of Responses

Responses to comments include the types described below.

- General Responses

  In some instances, comments were general and pertained to the Reassessment process or the Report overall rather than to a specific section of it. Responses to these comments are coded as General and appear at the very beginning of the Responses, under the heading General.

- Specific Responses to Comments

  These comments are answered in the Responses, grouped by the number of the section of the Report to which they refer. A common response is provided when commentors question the same or very similar items. In some cases, commentors voiced opposite opinions about the same point, typically a controversial one, but both comments took issue with the same part of the Report. The rationale for the Report's findings or resolution of the issue may be contained in a common response addressing the conflicting nature of the comments and the controversy surrounding the issue.

- Additional References

  Full citations are provided only for new references not identified previously in the References section of the LRC.

- Corrections

  Corrections to the text are noted in the appropriate Report section. No subsequent action will be taken since the Report will not be reissued. A list of corrections to the LRC is included in the Table of Contents. Revised figures for the DEIR can be found in Appendix C.

- Acronyms

  A table of acronyms originally provided with the LRC has been updated to reflect discussions in this Responsiveness Summary. The table immediately follows the Table of Contents.

4. COMMENT DIRECTORY

A Comment Guide, a sample comment letter, a diagram illustrating how to find responses to comments, and the Comment Directory follow.

As stated in the preface to this Responsiveness Summary, this document does not reproduce the LRC. Readers are urged to utilize this Responsiveness Summary in conjunction with the Report in order to fully understand the comments and responses.

4.1 GUIDE TO COMMENT DIRECTORY RESPONSIVENESS SUMMARY

Step 1	Step 2	Step 3
Find the commentor or the key words of interest in the Comment Directory. Comments are separated by commentor group.	Obtain Comment Codes and Report Section. Find coded comments following the tab in Book 2 of this Responsiveness Summary.	Find the responses following the Responses tab in Book 1. See the Table of Contents to locate the page of the Responsiveness Summary for the Report Section.

Key to Comment Codes:
Comment codes are in this format XY-a.b X=Report (L=LRC) Y=Commentor Group (F=Federal, S=State, L=Local, C=Community Interaction Program, G=General Electric) a=Letter or report containing comments b=Numbered comment

Example:

COMMENT RESPONSE ASSIGNMENT FOR THE DEIR

AGENCY/ Name	Comment CODE	REPORT SECTION	KEY WORDS		
			1	2	3
NOAA /Rosman	LF-1.1	4.4.3	Near Shore Sediment Concentration		

Find comment under tab "Federal (LF)".
Find response under tab "Response" on page LRC-88 where comments relating to Section 4.4.3 are discussed.

LF-1

SAMPLE LETTER

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Ocean Resources Conservation and Assessment
Hazardous Materials Response and Assessment Division
Coastal Resources Coordination Branch
290 Broadway, Rm 1831
New York, New York 10007

August 28 , 1998

Doug Tomchuk
U.S. EPA
Emergency and Remedial Response Division
Sediment Projects/Caribbean Team
290 Broadway
New York, NY 10007

Dear Doug:

Thank you for the opportunity to review the July 1998 Phase 2 Report-Review Copy, Further Site Characterization and Analysis, Volume 2C-A Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report, Hudson River PCBs Reassessment RI/FS. The following comments are submitted by the National Oceanic and Atmospheric Administration (NOAA).

Comments

The Executive Summary of the Low Resolution Sediment Coring Report highlighted four major findings. The results of the nearshore sediment investigation were reported as additional findings and the significance of these findings was downplayed. It was stated that the implications from the two to three times increase in the estimate of the exposure point concentration would be addressed in the Human Health Risk Assessment. Implications to the Ecological Risk Assessment (ERA) were not discussed. It was suggested that this increased estimate of PCB concentrations in nearshore sediments should not substantially change the human health risk estimate from wading and swimming (pg. 4-44); however, it may have serious implications for human health exposure from consumption of fish and for ultimate remedial decisions. Furthermore, the ERA risk to ecological receptors must consider the potential underestimate of PCBs in the nearshore environment. 1.1

Four nearshore areas were sampled in approximately 4 feet of water. The water depth was chosen since it posed a likely human exposure from wading and swimming. These shallow nearshore areas are also of particular importance to biota because they provide refuge, feeding and spawning habitat for fish and are an important source of contamination to prey species. In addition, PCBs in these sediments may be most affected by daily changes in water level associated with hydropower generation, as well as being vulnerable to scour from large debris (e.g., logs, root masses), ice scour, and other disturbances.

The Low Resolution Coring Report attempted to quantify the potential underestimation of PCB concentrations in nearshore sediments, but conceded that the results usefulness may be limited due to the small sample size (n=11). Using data from all nearshore fine-grained low resolution TIP cores within 50 feet of the shoreline yielded a somewhat larger dataset (n=19) and a higher 95 percent confidence limit (264 ppm PCBs compared to 151 ppm PCBs). Side-scan sonar nearshore samples that overlapped with the shoreline appeared to have been excluded from this analysis even though these are important areas to ecological receptors. The limited characterization of nearshore

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Comment Directory

4.2 COMMENT DIRECTORY FOR THE LRC

AGENCY/ NAME	COMMENT CODE	REPORT SECTION	KEYWORDS 1	2	3
NOAA/Rosman	LF-1.1	4.4.3	Near Shore		
NOAA/Rosman	LF-1.2	4.2.3	PCB Deposits	Fish	
NOAA/Rosman	LF-1.3	2.4.3	C/N Ratio		
NOAA/Rosman	LF-1.4	2.4.1	Homogeneity		
NYSDEC/Ports	LS-1.1	4.2.4	Burial		
NYSDEC/Ports	LS-1.2	4.1.2	PCB Mass Loss	Estimates	
NYSDEC/Ports	LS-1.3	4.2.3	PCB Inventories	Loss	
NYSDEC/Ports	LS-1.4	4.2.3	PCB Inventories	Underestimates	
NYSDEC/Ports	LS-1.5	4.1.4	Within TIP	PCB Inventory	
NYSDEC/Ports	LS-1.6	4.4.3	Near Shore	PCB Concentration	Sediment
NYSDEC/Ports	LS-1.7	general	Human Health	Risk Assesment	Scope of work
SCEMC/Balet	LL-1.1	4.1	PCB Inventories	1977-1984	1984-1994
SCEMC/Balet	LL-1.2	4.1	PCB Mass	Stat. Variance	Heterogeneity
SCEMC/Balet	LL-1.3	4.1	Sampling Design	Heterogeneity	
SCEMC/Balet	LL-1.4	2.1	Below TIP		
SCEMC/Balet	LL-1.5	2.3.1	Modeling	Redox	TC/TN
SCEMC/Balet	LL-1.6	2.4.1	Spatiality	PCB Inventories	
SCEMC/Balet	LL-1.7	2.4.1	PCB Burial		
SCEMC/Balet	LL-1.8	2.4.1	Fig 2.4 Ref Incorr.	Units Incorrect	
SCEMC/Balet	LL-1.9	4.2.3	36% PCB Conc.		
SCEMC/Balet	LL-1.10	2.4.1	Replicates	Heterogeneity	Analytical Uncert.
SCEMC/Balet	LL-1.11	3.2	Var. of Parameters	High Res. Cores	
SCEMC/Balet	LL-1.12	4.1/App. E	Analytical Methods	1984 v. 1994	Corr. Factors
SCEMC/Balet	LL-1.13	4.1.1/Fig4-2	Core Profile		
SCEMC/Balet	LL-1.14	4.1.1	Scour	Distant Between Cores	
SCEMC/Balet	LL-1.15	4.1.1/Fig 4-7	MPA3+	Tri+ Loss	
SCEMC/Balet	LL-1.16	4.1.3	Scour	Cohesive Seds.	Non-coh. Seds
SCEMC/Balet	LL-1.17	4.2.1	Grab Samples	Extrapolation	
SCEMC/Balet	LL-1.18	4.2.1	Two Data Sets	Difference	
SCEMC/Balet	LL-1.19	4.2.1	SSW, '76-'78	Correlation	Uncertainty
SCEMC/Balet	LL-1.20	4.2.2/Fig 4-18	Side Scan Sonar	Sed. Classification	
SCEMC/Balet	LL-1.21	4.2.2/Fig 3-28	Sed. Classification	Correlation	
SCEMC/Balet	LL-1.22	4.2.3	Hot Spot Bound.		
SCEMC/Balet	LL-1.23	Fig 4-19, 4-20, 4.2.3	Fig. Ref. Incorrect		
SCEMC/Balet	LL-1.24	4.2.3	PCB Loss	1994 v 1976-78	
SCEMC/Balet	LL-1.25	4.2.3	Burial	PCB Profile	
SCEMC/Balet	LL-1.26	4.2.3	Burial	Long-term Storage	Long-term Loss
Sanders, J.	LC-1.1	2.1	Sample Depth		
Putman, G.	LC-2.1	4.2	Consistency	Statistics	
Putman, G.	LC-2.1A	general	Variance Estimates		
Putman, G.	LC-2.1B	general	Model Calibration		

AGENCY/ NAME	COMMENT CODE	REPORT SECTION	KEYWORDS 1	2	3
Putman, G.	LC-2.2	general	PCB Mass Flux		
Putman, G.	LC-2.3	1.3	DNAPL		
Putman, G.	LC-2.4	4.2.3	PCB Mass Flux		
Putman, G.	LC-2.5	4.2.3	PCB Mass Loading		
Putman, G.	LC-2.6	4.2.3	Diffusional Loss		
Borden, T.	LC-3.1	general	Water Column	Fish	
Pulver, M.	LC-4.1	general	40% Loss		
Pulver, M.	LC-4.2	2.3.1	# of Samples	Heterogeneity	Areal Coverage
Pulver, M.	LC-4.3	general	Analytical Methodology	PCB3+	1994 Total PCBs
Pulver, M.	LC-4.4	4.1	84 PCB3+/'94 PCB3+	Mass Loss Estim.	
Pulver, M.	LC-4.5	4.1.2	9" Sample Inter.	Highest Conc.	
Pulver, M.	LC-4.6	4.1.2	73% PCB Loss	Hot Spot	
Pulver, M.	LC-4.7	general	Highest PCB Level	Top 9 Inches	
Pulver, M.	LC-4.8	general	Peer Review		
Pulver, M.	LC-4.9	general	Dredging		
GE	LG-1.1	Section 4	1984 PCB Inventory	Statistical Uncertainty	
GE	LG-1.2	Section 4.1	Matched pairs	PCB Mass Estimate	
GE	LG-1.2A	4.1.1	Sample Numbers		
GE	LG-1.3	Section 4.1	Consistency		
GE	LG-1.4A	4.1.2	Tri+ Inventory	PCB Mass Estimate	40% loss
GE	LG-1.4B	4.1.2	40 % Loss		
GE	LC-1.4C	4.1.2	Other PCB Meas.		
GE	LG-1.4D	4.1	Mechanisms		
GE	LG-1.4E	4.1.2	PCB Mass Est.	40% Loss	
GE	LG-1.5A	4.2.4	^{7}Be	Burial	
GE	LG-1.5B	4.2.3	Burial		
GE	LG-1.5C	3.1	Dechlorination		
GE	LG-1.5D	4.2.3	PCB Inventories		
GE	LG-1.5E	4.1.2	Implausible	Mass Loss	
GE	LG-1.5F	4.2.3	PCB Inventories		
GE	LG-1.6	4.2.3	PCB inventories		
GE	LG-1.7	4.2.3	^{137}Cs	PCB inventory	
GE	LG-1.8	4.1	1984 Grab samples	PCB depth profile	
GE	LG-1.9	Section 2.1	Sample Location	Heterogeneity	H-7 site
GE	LG-1.10	4.1, 4.2	% mass change	PCB mass	
GE	LG-1.11	4.1.2, Appendix E	PCB 3+(1984)	Total congeners	
GE	LG-1.12	4.2, 4.3	Geometric mean	Delta PCB	Arithmetic Mean
GE	LG-1.13	4.1.2	PCB mass loss		
GE	LG-1.14	4.1.2	Implausible	Mass Loss	
GE	LG-1.15	4.1.2	Fate and Transport	Mass Loss	

AGENCY/ NAME	COMMENT CODE	REPORT SECTION	KEYWORDS 1	2	3
GE	LG-1.16	4.1.2	Mass Loss	Water Column Data	
GE	LG-1.17	No relevant section (GE's 1998 data) 4.1.2	GE-1998 data		
GE	LG-1.17A	4.1.2	PCB_{3+}	GE-1998 Data	
GE	LG-1.17B	4.1.2	PCB_{3+}	Fish	
GE	LG-1.18	4.2.4	^{7}Be	Deposition	
GE	LG-1.18A	4.2.4	^{7}Be	Burial	
GE	LG-1.18B	4.2.4	^{7}Be		
GE	LG-1.18C	4.2.4	^{7}Be		
GE	LG-1.19A	4.1.2	Water column PCB Concentration	Areal Flux	
GE	LG-1.19B	4.1.2	Water Column PCB Concentration	Organic Carbon	
GE	LG-1.20	4.1	Surface Sediment	Sediment-Water Exchange Processes	
GE	LG-1.21	2.3.1	Fish Flesh Studies (NOAA)	PCB Congeners	Exposure ratio
GE	LG-1.22	4.1.2	January 1998 Flood	Water Column	
GE	LG-1.23	Sect. 3.2	^{137}Cs	Scour	
GE	LG-1.24	4.4.2	PCB mass	Below TIP	Parametric Statistics
GE	LG-1.25	3.1	Dechlorination		
GE	LG-1.26	3.1	Arochlor 1242	Mass loss	Dechlorination
GE	LG-1.27	3.1	Dechlorination	Log of the PCB Concentration	
GE	LG-1.28	4.1.2	Fate and Transport	Mass Balance Model	
GE	LG-1.29	Section 2.1	Sample Selection	Bias	"Purposive" Sampling
GE	LG-1.30	2.2.1	7 locations below TIP		
GE	LG-1.31	3.1	Cross-Contamination	Rejected Data	
GE	LG-1.32	2.4.1	Low Concentration Data	Log-normal Distribution	
GE	LG-1.33	3.1	Purposive Data Selection		
GE	LG-1.34	4.2.1, Figure 4-17, Table 4-3	SSW		
GE	LG-1.35	4.2.1	Measurement Methods		
GE	LG-1.36	4.2.1	Grab Samples	Extrapolation	
GE	LG-1.37	3.2	Regression		
GE	LG-1.38A	4	MVUE method	Statistics	
GE	LG-1.38B	2.4.1	Lognormal bias		
GE	LG-1.38C	4.2.3	PCB inventory	Statistics	
GE	LG-1.38D	4.2	Statistical methods		

AGENCY/ NAME	COMMENT CODE	REPORT SECTION	KEYWORDS 1	2	3
GE	LG-1.38E	4.1.2	Hot spots	Delta ratio	
GE	LG-1.38F	4.2	Statistics		
GE	LG-1.38G	4.2	Statistics		
GE	LG-1.38H	4.1.2	Statistics	PCB inventory	
GE	LG-1.38I	4.2.3	PCB inventory	Zonal areas	
GE	LG-1.38J	4.1.2	Uncertainty	PCB inventory	
GE	LG-1.39A	4.2.4	^{7}Be		
GE	LG-1.39B	4.2.3	PCB inventory	PCB change	
GE	LG-1.39C	3.1	Dechlorination		
GE	LG-1.40A	4.2.3	Burial		
GE	LG-1.40B	4.1.2	Loss vs gain		
GE	LG-1.40C	4.2	Statistics		
GE	LG-1.41	general	Modelling	Sediment Transport	PCBs

Responses

HUDSON RIVER PCBs REASSESSMENT RI/FS
RESPONSIVENESS SUMMARY
VOLUME 2C-A: LOW RESOLUTION SEDIMENT CORING REPORT
ADDENDUM TO THE DATA EVALUATION AND INTERPRETATION REPORT
FEBRUARY 1999

RESPONSES TO GENERAL COMMENTS

Response to LC-2.1A

The issue of variance was addressed in response to comment DC-4.6 in the Responsiveness Summary for Volumes 2A, 2B and 2C (USEPA, 1998b), which states as follows:

Each of the three sources of variance mentioned (variance shown in analyses from the site; variance caused by sampling methods; and known physical sources of variance including cross channel and vertical inhomogeneity in the PCB distribution in the river) are examined separately below. The Phase 2 data were generated in such a way as to minimize unwanted sources of variability so that the actual trends in the data would not be obscured.

For variability shown in analyses from Rogers Island, Phase 2 data are compared to General Electric data for the same period. Figure 3-105 of the DEIR shows monthly PCB loads from above Bakers Falls, Bakers Falls to Rogers Island, and Rogers Island to the TI Dam. The Phase 2 flow-averaged estimates agree well with the General Electric estimates in both total load and distribution for July through September 1993 (post construction at the Bakers Falls area).

The precision in the Phase 2 sampling methods is determined by comparing the split sample data. Figure DC-4.6 shows the relative fractional differences of the ten split samples analyzed for Total PCBs taken during the flow-averaged and transect events. Although the distributions are right skewed, the median values are low at 0.10, 0.13, and 0.13 for the dissolved, suspended and whole water samples, respectively. Each sample required a large volume of water in order to achieve the low quantitation limits for PCBs, which in turn necessitated a long sampling period. This may be the cause of the occasional high relative fractional difference.

The impact of physical sources of variance due to cross channel and vertical inhomogeneity in PCB distribution in the Hudson River is shown in Figure 4-22 of QEA's March 1998 report, Thompson Island Pool Sediment PCB Sources. General Electric's routine composite sample of east and west channels at Rogers Island is compared to shallow and deep samples taken at six stations in a river cross section just upstream of Rogers Island. This was performed on 2 separate occasions. While there are differences among the samples, it is clear that the routine sample provides a reasonable estimate of the Hudson River PCB concentration at this station. The routine sample is comparable to the Phase 2 sample at Rogers Island which was stationed before the river splits into east and west channels.

Response to LC-2.1B

Discharges from the Snook Hill and Moses Kill add only about five percent to the total flow at the TI Dam. Contrary to the writer's assertion, the discharges from the Snook Kill and Moses Kill are included in all flow and PCB load analyses presented in the DEIR. As far as their contributions

to suspended solid loads, this issue, including the HydroQual study, will be examined as part of the Baseline Modeling Report. These tributaries do not contribute significantly to the Upper Hudson's total PCB load. *See* also Appendix C of this Responsiveness Summary (Interpretation of the Revised Estimates in the Upper Hudson, Spring Flood); and response to comment DC-4.7 in the Responsiveness Summary for Volumes 2A, 2B and 2C.

Response to LC-2.2

See response to comment DC-4.6 in the Responsiveness Summary for Volumes 2A, 2B and 2C (USEPA, 1998b), which is reprinted in the Response to Comment LC-2.1A, above.

There has also been a careful examination of the loads at Rogers Island, as reported in Section 3.4.2 of the DEIR. This section examines the biweekly data collected by GE and finds a relatively consistent basis on which to estimate loads at Rogers Island. Note that the Phase 2 water column sampling was conducted in 1993.

Response to LC-3.1 and LC-4.1

EPA never described the loss of approximately 40% of the PCB inventory from areas of high concentration in the Thompson Island Pool as either a "crisis" or an "emergency." Nevertheless, the conclusions reached in the LRC, particularly the loss of PCBs from the Thompson Island Pool sediments coupled with the lack of widespread burial of contaminated sediments, are serious because they imply that PCB contamination in sediments is spreading from areas of high concentration into the rest of the river.

Although it is true, as suggested in Comment LC-3.1, that the Low Resolution Sediment Coring Report relies on previously collected data, the complex and time-consuming analysis of that data was completed only shortly before the LRC was issued.

Response to LC-4.3

After learning the results of the LRC analyses indicating the loss of approximately 40% of the PCB inventory from areas of high concentration in the Thompson Island Pool, and of the lack of widespread burial of contaminated sediments, it was entirely appropriate for the Agency to evaluate whether some action could be taken to prevent the spread of contamination before an overall remedy for the site is selected. In fact, it is a standard practice in the Superfund Program to examine site information as it is generated and analyzed to determine if some expedited action is necessary to contain or prevent the spread of contamination from a known and identified source, even before an overall remedy is chosen for the entire site. After carefully reviewing the available options for an early action, however, on December 17, 1998, EPA notified the public that the

Agency was not able to identify a feasible and appropriate interim action that would have a significant impact on the loss of PCBs from Upper Hudson River sediments.

Response to LC-4.7

The depth in the sediment to which fish and other organisms are potentially exposed to PCBs will be investigated further in the Baseline Modeling and Ecological Risk Assessment reports.

Response to LC-4.8

The LRC will undergo peer review between January and March, 1999.

Response to LC-4.9

Remedial action alternatives for the Hudson River PCBs site will be addressed in the Feasibility Study.

Response to LG-1.41

This comment is simply a status report of GE's sediment modeling efforts. The USEPA appreciates these contributions and will consider them under the comments to the Baseline Modeling Report. Note that the USEPA has constructed its own sediment transport model.

Response to LS-1.7

Comments on the Human Health Risk Assessment Scope of Work will be addressed in the responsiveness summary for that document.

RESPONSES TO SPECIFIC COMMENTS

EXECUTIVE SUMMARY

ACRONYMS

GLOSSARY

No significant comments were received on the Executive Summary, Acronyms or Glossary.

1. INTRODUCTION

1.1 Purpose of Report

1.2 Report Format and Organization

No significant comments were received on Sections 1 through 1.2.

1.3 Project Background

Response to LC-2.3

The USEPA agrees that the loads originating above Rogers Island have decreased markedly since the early 1990's. However, loads originating within the TI Pool have not. Additionally, while DNAPL was shown to be present at the release areas near the GE Hudson Falls facility, its presence has not been demonstrated at Rogers Island or at points downstream. *See* also the response to comment DG-1.3, third paragraph, in the DEIR Responsiveness Summary (USEPA, 1998b). Note that the USEPA Phase 2 water column sampling was conducted in 1993.

1.4 Background for the Low Resolution Sediment Coring Program

No significant comments were received on Section 1.4.

1.5 Low Resolution Sediment Coring Program Objectives

No significant comments were received on Section 1.5.

2. SAMPLING DESIGN AND METHODS

2.1 Technical Approach for the Low Resolution Sediment Coring Program

Response to LC-1.1

The USEPA acknowledges the suggestions made by the writer concerning sampling techniques and data interpretation. It should be noted that the primary purpose of the low resolution coring program was to examine inventory changes and not to establish release mechanisms, however.

Response to LG-1.9

In this comment the writer critiques the degree of certainty associated with each of the paired TI Pool sampling locations. However, the writer incorrectly assesses the degree of uncertainty in location. In both the NYSDEC and the USEPA studies, the uncertainty in location was estimated to be $\pm$ 3 ft. These uncertainties are properly combined as follows assuming the stated error to represent 2 standard deviations about an individual point:

$$Total\ uncertainty = 2 * \sqrt{3/2^2 + 3/2^2} = 4.2\ ft$$

Thus, the writer exaggerates the degree of uncertainty in the location differences. In addition, since this uncertainty is presumably random, some locations are undoubtedly closer and some further than estimated. Thus, the best estimate of the average distance between 1984 and 1994 sampling locations remains the mean distance of separation or 3.7 $\pm$ 4.2 feet, and not the 10 feet stated by the writer. It should be noted as well that 56 of the 60 paired locations (93 percent of the locations) were separated by less than 8 feet, which is within the mean plus its uncertainty.

The writer also contends that net changes with the clusters of samples are simply random. As shown in Plate 4-20 of the Report as well as by the area-based analysis included as Appendix A of this Responsiveness Summary, this is not true. The majority of the clusters show loss whether considered on an individual location basis or as whole clusters. This is also evident in Figure 4-5 of the Report which shows both the Total PCB as well as the Tri+ inventory to be lower in 1994 relative to 1984. Thus, the losses are not random within the clusters although there is some variability. The data as presented by the writer shows this quite clearly, with many of the plots showing mass loss for the entire cluster. That the absolute amount of mass loss is not constant is to be expected since mass loss is expected to be dependent upon the amount of mass originally present (as well as other factors). Thus, higher values have greater mass loss.

Further, the writer also contends that the H-7 area represents the only data set useful for estimating close range variability. This is not true. The H7 site is located in the northern part of the Thompson Island Pool, where a high degree of heterogeneity and limited spatial correlation is expected based on the variogram analysis presented in the DEIR. *Hot spots* reoccupied for the Low Resolution Sediment Coring Study, however, were primarily from the more southerly portions of the Thompson Island Pool, where spatial correlation is much stronger (*see* Table LG-1.9, which is based on Table 4-4 of the DEIR). Specifically, only 4 of the 60 paired locations are found in the region near H-7.

Table LG-1.9

Subreach Variogram Models[a] for Natural Log of PCB Mass Concentration, 1984 Thompson Island Pool Sediment Survey

	Subreach 5 1163000 - 1170100 N	Subreach 4 1170100 - 1177000 N	Subreach 3 1177000 - 1181900 N	Subreaches 1 and 2 1181900 - 1191700 N
Observations	235	320	238	321
Nugget	0.750 (.284)	0.484 (.154)	0.0 (--)	1.54 (.108)
Sill-Nugget	1.520 (.282)	1.092 (.153)	1.733 (.060)	0.203 (.106)
Practical Range (ft)[b]	340 (75)	280 (68)	286 (49)	582 (521)
Anisotropy Ratio[c]	1.0	1.5	2.5	1.0
Major Axis[d]	-	N 10° W	N 35° W	-

Note:

a. Variograms are exponential models, showing fit along the major axis and anisotropy ratio. Standard errors of the coefficients from the least squares estimation are shown in parentheses.

b. A value of 2 times the practical range was used as the length of the major axis of the polygon associated with each 1994 location. This distance represents the distance of separation at which variance between point pairs approaches that of the population as a whole.

c. This ratio represents the ratio of the major axis over the minor axis of the ellipse associated with each sampling point.

d. This represents the orientation of the major axis. Essentially this orientation causes the ellipse to be oriented in the direction of river flow. This angle is not defined when the anisotropy ratio is unity (1).

Source: USEPA, 1997

TAMS/TetraTech

The variogram analysis in the DEIR addresses primarily long-range spatial correlation, with practical ranges of variograms extending up to 521 feet. This scale primarily addresses the coherency of *hot spot* areas, i.e., it confirms that high MPA values tend to be found together within discrete *hot spots*, as is appropriate to estimate total PCB mass. Small scale spatial correlation was not addressed in the DEIR, but evidence as to shorter scales is available in the 1984 sediment survey. While most samples in the 1984 survey were collected on a 125-foot sampling grid, NYSDEC also investigated finer-scale variability. This included 19 clusters of 5 samples each on 10 foot separations (four cardinal directions around a central point), and a 10-core east-west transect at 10 foot intervals. A total of 321 samples pairs are available at a separation distance of less than 30 feet within the 1984 Thompson Island Pool sediment data set.

Analysis of the variogram of closely spaced log-transformed MPA data suggests that the short range structure has a sill near 1.0 at a separation distance of 20 feet. Note that this sill (equivalent to the local variance estimate) is considerably less than the sill of larger scale structures on a subreach basis, which ranges from 1.73 to 2.27 (DEIR, Table 4-4). A Gaussian model was fit to the short-range variogram structure of 1984 log-transformed MPA (all samples), with the following characteristics:

Practical Range (a)	25 feet
Sill - Nugget (C_1)	0.778
Nugget (C_0)	0.254

The unstandardized Gaussian variogram model may be defined on separation distance h as

$$\gamma(h) = C_0 + (C_0 - C_1)\cdot\left[1 - \exp\left(-\frac{3h^2}{a^2}\right)\right]$$

in which the practical range, a, is the distance at which the variogram value is 95% of the sill. The correlogram (cross-correlation) function between points for h greater than zero is

$$\rho(h) = \frac{C_1\cdot\exp\left(\frac{-3h^2}{a^2}\right)}{C_0 + C_1}$$

Sixty five percent (39 out of 60) of the 1984-1994 pairs were collocated within 4 feet, at which distance the correlation coefficient is 0.70. Ninety five percent (57 out of 60) are collocated within 10 feet, at which distance the correlation coefficient is 0.47. This contrasts markedly with the comment that "*The semi-variogram showed that PCB levels were correlated only within a distance of 5 feet... Beyond 5 feet, the variance was near that of the population... even within the distance of 5 feet, the correlation was weak...*" The latter conclusions apply only to the very heterogeneous H7 site, and are clearly not applicable to other *hot spots* within the Thompson Island Pool.

The remaining contentions of the writer concerning the rejection of various sample pairs to yield a smaller set of paired coring locations are thus refuted by the discussion above. Nonetheless,

the suggestion by the writer that an area-based comparison be made for the various clusters of 1994 coring locations has merit. Appendix A of this Responsiveness Summary presents such an analysis. This analysis yields a similar degree of statistically significant mass loss as that presented in the original Low Resolution Sediment Coring Report.

Response to LG-1.29

In selecting its coring sites, the USEPA attempted to minimize sediment variability and focus on those areas best quantified by both USEPA and NYSDEC. In this regard, areas which were screened but otherwise unanalyzed were avoided. Additionally, since spatial correlation was clearly evident in the 1984 data, it was most prudent to take advantage of this fact by placing the samples relatively close together while matching the previous sampling locations. Since the chief goal of the sampling program was to establish the degree of change and not to re-establish sediment inventories, it was most important that the 1994 effort match the locations of the 1984 program as much as possible to reduce variability due to factors other than true inventory change. As stated in the Report, the main conclusions apply to fine-grained sediment and not to the entire Pool. More importantly, the document states that it is the occurrence of inventory loss itself and not the absolute magnitude of this loss which is the most important conclusion of the Report, thus refuting any scenario wherein sediment burial and PCB inventory gain in Upper Hudson sediments are assumed to represent the major fate-and-transport processes. The samples as collected and analyzed in the LRC and this Responsiveness Summary provide a sufficient basis for this conclusion.

Response to LL-1.4

The area represented by the cores below the Thompson Island Dam is approximately 526,000 m^2. A breakdown of these areas by *hot spot* is given in Table 4-8 of the LRC. The near-shore area of the TI Pool can be approximated as two six-mile-long strips of river bottom extending about 50 feet from shore. This area is approximately 300,000 m^2. These area can be compared to the *hot spot* areas of the TI Pool itself as estimated by Tofflemire and Quinn, 1979), which total approximately 520,000 m^2.

2.2 Field Sampling

2.2.1 Sample Locations

Response to LG-1.30

For the areas below the TI Dam, the *hot spot* boundaries formed the basis for the sampling design, not the dredge locations. The dredge boundaries were made available to USEPA after the sampling effort was completed and simply served as an alternate basis for comparison.

2.2.2 Sample Preparation

No significant comments were received on Sections 2.2 through 2.2.2.

2.3 Sample Analyses

2.3.1 PCB Congener Analysis

Response to LC-4.2.

The USEPA believes that some, if not all, of the fish body burdens are derived from PCBs associated with the sediments. The pathways for fish exposure may be direct, as in a benthic food pathway, or indirect via sediment release to the water column, with subsequent direct absorption across the gills, or via a water column (pelagic) food pathway. In either case, the PCB contamination in fish is at least partially derived from the sediments. The fact that the sediments are losing inventory over time does not require that fish levels increase over time. In fact, it is expected that since fish body burdens are related to the sediments, fish body burdens would decrease over time, paralleling the decline in the sediments. Fish data collected to date indicate some decline over time despite the recent releases from the GE facilities. It now appears that fish levels have returned to the conditions seen in the years just prior to the 1991 GE release event, a period where water column and fish levels were most likely governed by the sediment PCB inventory. Thus there is no inconsistency in the low resolution coring results and the historical trend in fish body burdens. The issue with the sediments is the length of time required for the remaining inventories to be either re-released and transported downstream or truly buried. To date, there is little evidence to suggest that the sediment releases are declining to any substantive degree despite the major reduction in the GE discharges from the Hudson Falls facility. The issue of the PCB congener fingerprint in fish will be discussed in the Ecological Risk Assessment. However, the ratios used by GE and referenced here by the writer do not provide a sufficient key to link the fish to recently released PCBs. *See* response LG-1.21 concerning the applicability of the fish ratios.

Response to LG-1.21

The writer suggests that proposed congener ratios can be used to directly link fish body burdens to their PCB source. GE's proposed use of several, specific congener ratios to determine the degree of dechlorination was addressed in detail in responses to comments DG-1.19 and DG-1.20 in the Responsiveness Summary for Volumes 2A, 2B and 2C. As explained in those responses, EPA does not believe that the suggested congener ratios are good predictors of the degree of dechlorination. Thus, EPA does not believe that these congener ratios are useful in determining the source of PCBs.

While the figure provided by the writer does show the trend of the mean ratios with chlorines per biphenyl, the graphs oversimplify the wide range of variability. This is illustrated in Figure LG-1.21 (a copy of Figure DG-19A from the DEIR responses). The very wide range in values suggests that these ratios may not have the predictive power assigned to them by the writer. Note for example that the 56:49 ratio can vary more than an order of magnitude at 3 Cl/BP. Additionally, the fish samples collected in 1993 in the TI Pool may have been directly influenced by the large, water-borne loads present from 1992-1993 relative to other food web-related pathways. Nonetheless, there may be some use for these and other congener ratios in the ecological investigation. These issues will be further explored later in the Ecological Risk Assessment.

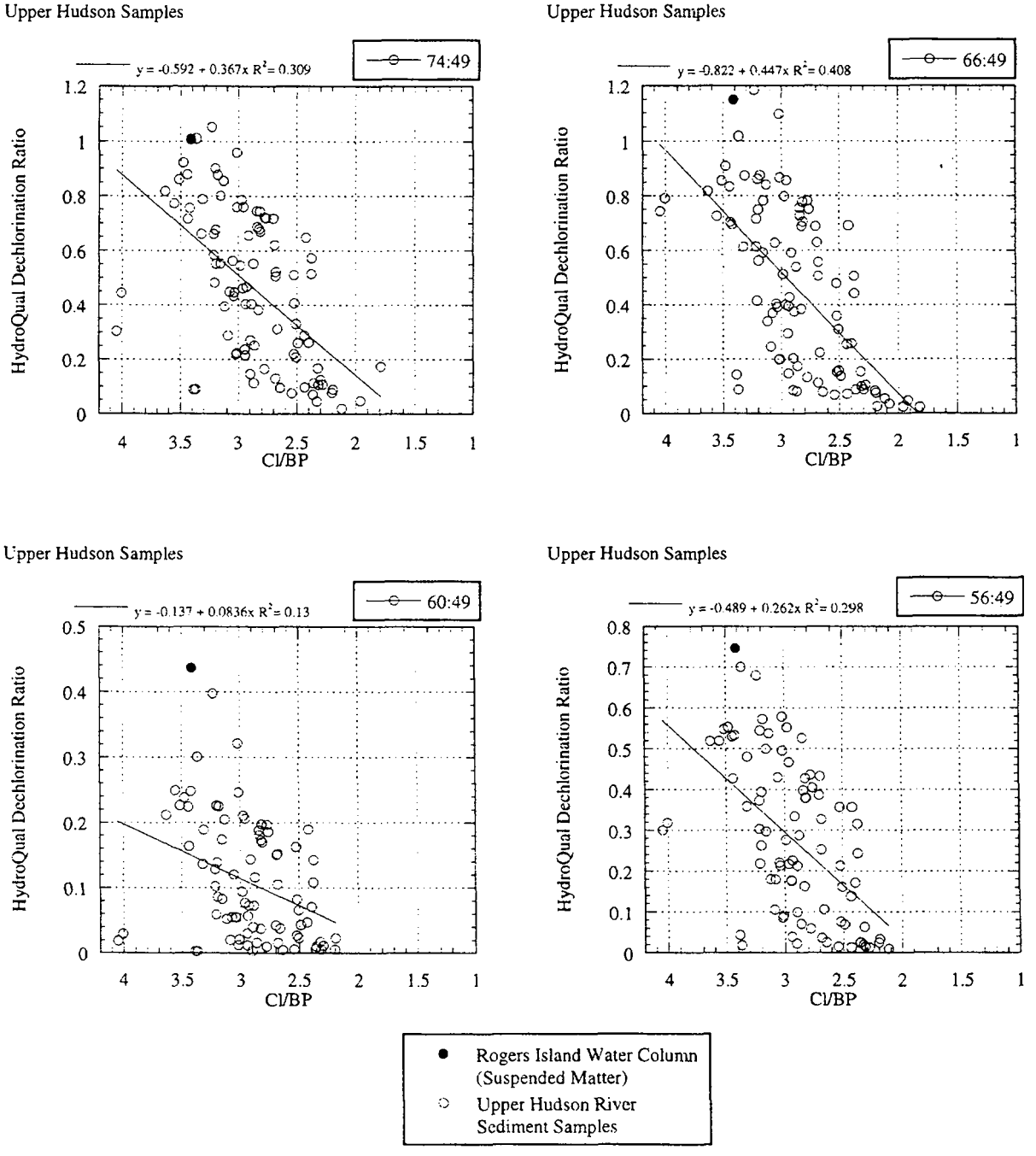


Figure LG-1.21
The Number of Chlorines per Biphenyl vs. the GE/HydroQual Dechlorination Ratios for the High Resolution Core Data

Response to LL-1.5

The reduction/oxidation potential data and the total carbon/total nitrogen data are not used directly in the model. Much of the data used for modeling comes from long term monitoring programs of the Hudson River. The reduction/oxidation potential data and the total carbon/total nitrogen data, like all of the data gathered from the low resolution cores, were to be used to gain an understanding of the processes affecting PCBs in the river. *See* response to LG-1.28.

2.3.2 Radionuclide Analysis

2.3.3 Total Organic Carbon and Total Kjeldahl Nitrogen

2.3.4 Physical Properties

No significant comments were received on Sections 2.3.2 through 2.3.4.

2.4 Summary of Analytical Results

2.4.1 PCB Congener Analysis

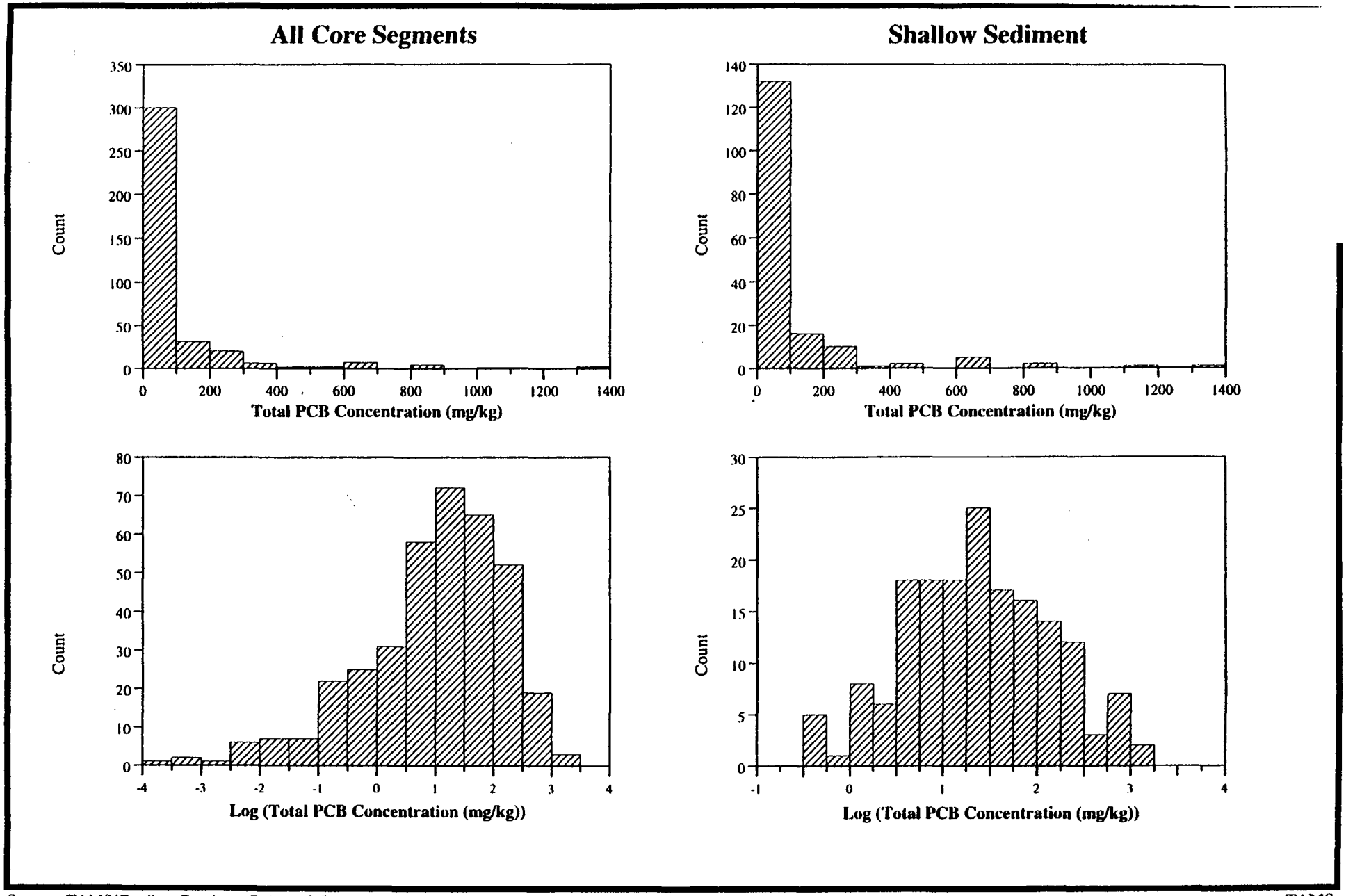
Correction to Section 2.4.1 - PCB Congener Analysis

Figure 2-6 is incorrectly referenced as Figure 2-4 on page 2-18. The text of the second full paragraph on page 2-18 should read:

> An RPD of zero is ideal, meaning the paired measurements are identical. An RPD of 50 percent represents a difference of 40 percent between the smaller and larger measurement based on the larger measurement. For example, a pair of measurements of 6 and 10 would have an RPD of 50 percent. Figure 2-6 shows the level of precision attained for field replicates. The average RPD was 36 percent, and the median RPD was 27 percent.

The units on Figure 2-4 were corrected to read mg/kg in the revised figure. The values of the abscisa of the upper figure in Figure 2-6 are corrected in the revised Figure 2-6, included in this Report.

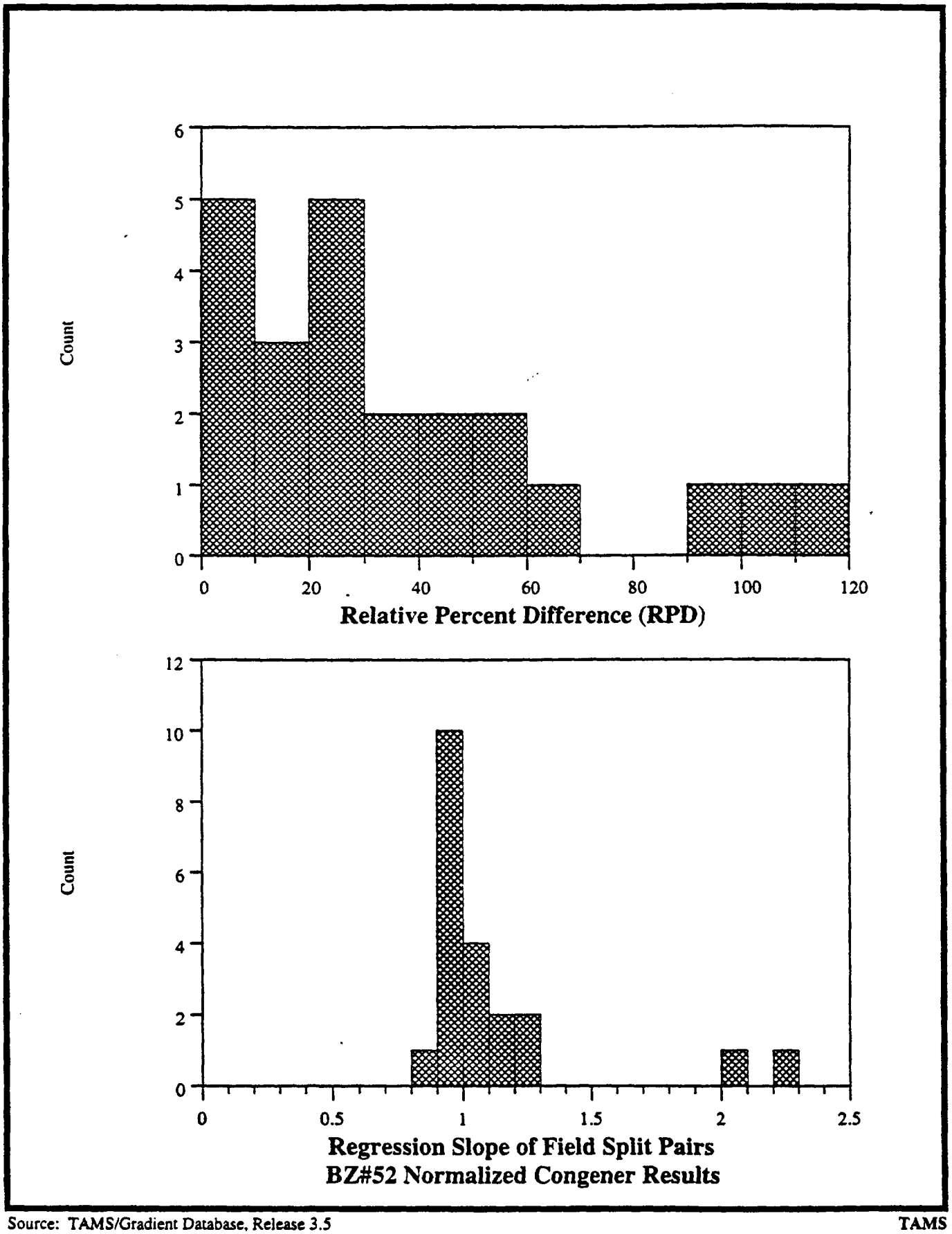
Based on the discussions at the peer review meeting in January of 1999 as well as those with the NYSDEC, the issue of the low resolution coring RPD and its potential correlation with other parameters was explored. The RPD can be considered an integrating measure of uncertainty and so the parameter is useful in estimating the uncertainty of the entire sampling and analysis process. Because the RPD is a relative measure of uncertainty, it tends to increase near the "edges" of the measurement range, that is, near the analytical detection limit and the analytical maximum quantitation level. In particular, the RPD tends to increase when the absolute measurement error becomes large relative to the amount being quantified. In any given data set, it is anticipated that the sample pairs with the highest RPD values represent samples with concentrations very close to the



Source: TAMS/Gradient Database, Release 3.5

TAMS

Figure 2-4 (corrected)
Distribution of Total PCB Concentrations in Low Resolution Sediment Core Samples



Source: TAMS/Gradient Database, Release 3.5

TAMS

Figure 2-6 (corrected)
Precision in Total PCB Concentration for Low Resolution Core Field Splits

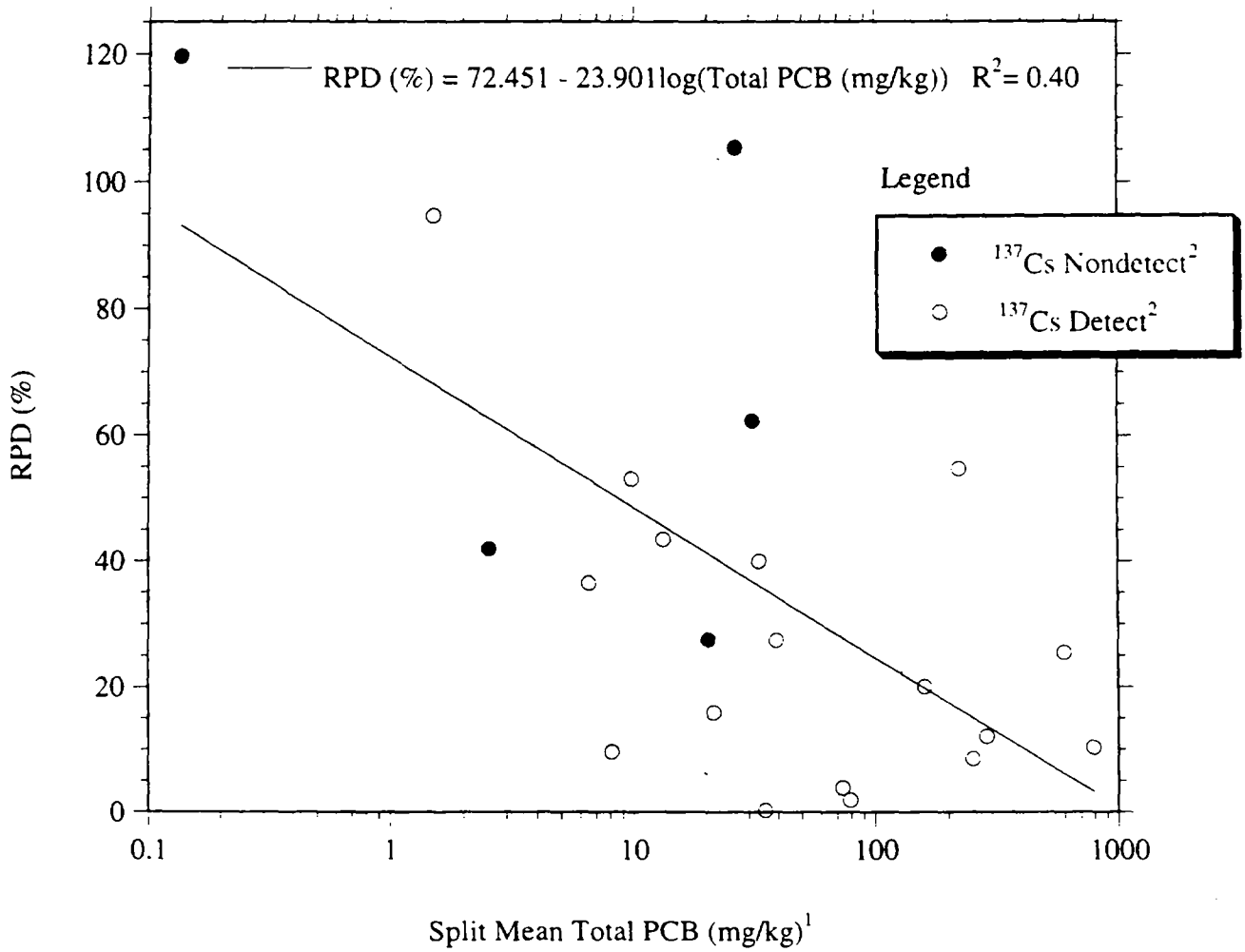
detection limit. Figure 2.4.1A shows the relationship between RPD and Total PCB concentration for the low resolution sediment coring program. The figure demonstrates the tendency of lower RPD levels corresponding to higher Total PCB concentrations. This trend, while statistically significant, is not a very strong one and much of the variation in the RPD is unrelated to concentration. The results indicate that PCB concentrations greater than 20,000 µg/kg (20 ppm) have a mean RPD of 28 percent while those higher than 50,000 µg/kg (50 ppm) have a mean RPD of 17 percent.

Given the issue of potential cross-contamination discussed in the LRC and its relationship to ^{137}Cs, the ^{137}Cs levels of the split pairs were examined. This is illustrated in Figure 2.4.1A as black and white symbols, with black symbols indicating the bottom core layers from cores lacking ^{137}Cs in the core bottom, much as was done in Figure 3-3 of the LRC. White symbols represent all top and middle segment split pairs plus the bottom core segments where ^{137}Cs was present in the core bottom. This figure and all subsequent figures in this discussion represent 22 of the 23 low resolution sediment core split pairs. One sample, LR-016-2436, was excluded from this analysis due to its lack of detected congeners. Only two congeners were detected in both of the split samples for this core segment. All of the remaining core split pairs had at least 23 congeners detected in both split samples. Sample LR-016-2436 apparently represented PCB-free sediments underlying the contaminated, recent deposition. Its Total PCB concentration was less than 1 µg/kg. The other split pair samples had concentrations in the range of 135 to 83,000 µg/kg.

In the LRC, the data analysis showed that bottom core segments from cores lacking 137Cs in the core bottom frequently had higher dechlorination ratios than would be predicted from the sediment PCB concentration. This was attributed to the occurrence of cross-contamination by overlying core segments or to the sample stratigraphy wherein a small layer of PCB-bearing sediments would have to be blended with a larger, uncontaminated region of the core segment. Both cross-contamination and incomplete mixing of a small quantity of PCB-bearing sediment would yield the divergence from the expected trend (*see* Section 3.1 of the LRC). Similar to the finding in the LRC for the entire low resolution coring data set, the bottom core segments in the low resolution coring split sample pairs which lack ^{137}Cs in the core bottom are the segments most likely to have a high RPD. This is consistent with the interpretation of these core segments as described above. The distinctly higher RPD levels are illustrated more clearly in Figure 2.4.1B which shows a set of "box and whisker" diagrams for the coring data grouped on ^{137}Cs absence or presence. Despite the small size of the group lacking ^{137}Cs, it is still significantly higher in RPD than the remaining samples. This difference is statistically significant and is summarized in Table 2.4.1.

The absence of ^{137}Cs marks the bottom core segment as a likely candidate for this concern. This is made clearer when the RPD is examined as a function of depth. In Figure 2.4.1C, the split pair data are grouped by position within the core. The diagram shows a clearly lower RPD value for the top core segments relative to the underlying ones. This difference, while not statistically significant, indicates that the top core segments, where the majority of PCB inventory was shown to occur, have the lowest RPD levels. The mean and median RPD levels for these samples are 22 and 20 percent, respectively. This represents a substantial improvement over the low resolution sediment core data set as a whole (37 percent mean RPD).

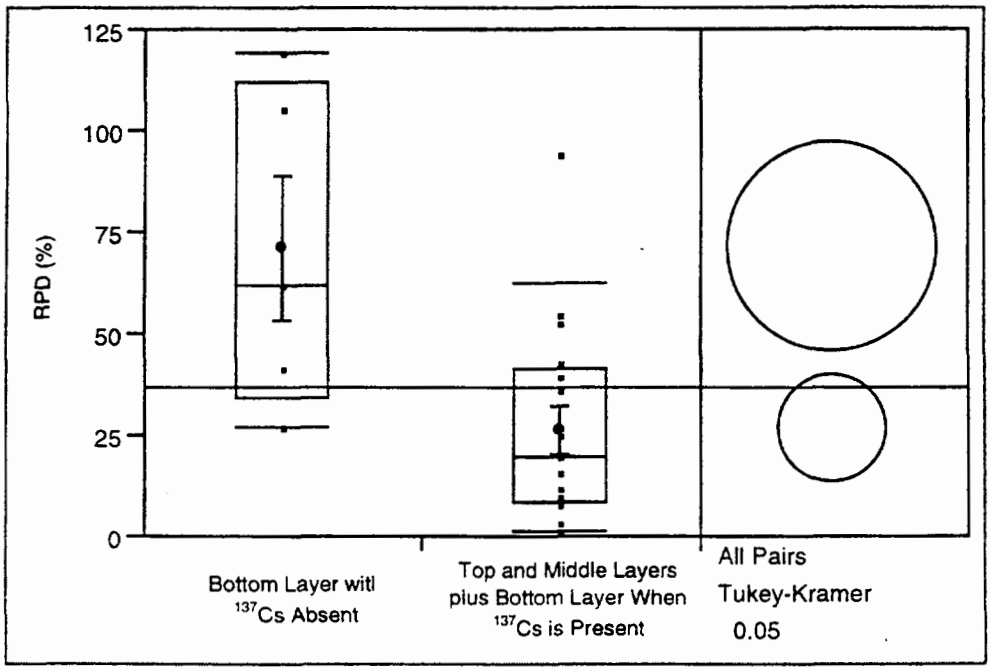
This consideration plus the general trend toward lower RPD at higher sediment concentrations indicate that the individual sediment inventory estimates presented in the LRC (which integrate the top and underlying core segments) have a much lower degree of uncertainty than was



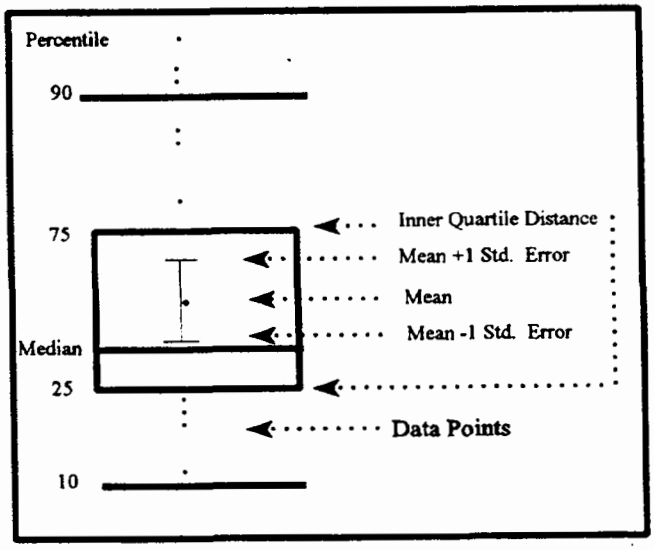
Notes:

1. Mean Total PCB concentration for field split pair.
2. Open symbols represent top and middle core segments as well as bottom core segments when ^{137}Cs was detected at the bottom of the core. Closed symbols represent bottom core segments when ^{137}Cs was not detected in the core bottom.

Figure 2.4.1A
Relationship Between RPD and Total PCB Concentration for Low Resolution Core Field Splits



Legend



Note: 1. Separation of circles indicates that the two groups are statistically different.

Figure 2.4.1B

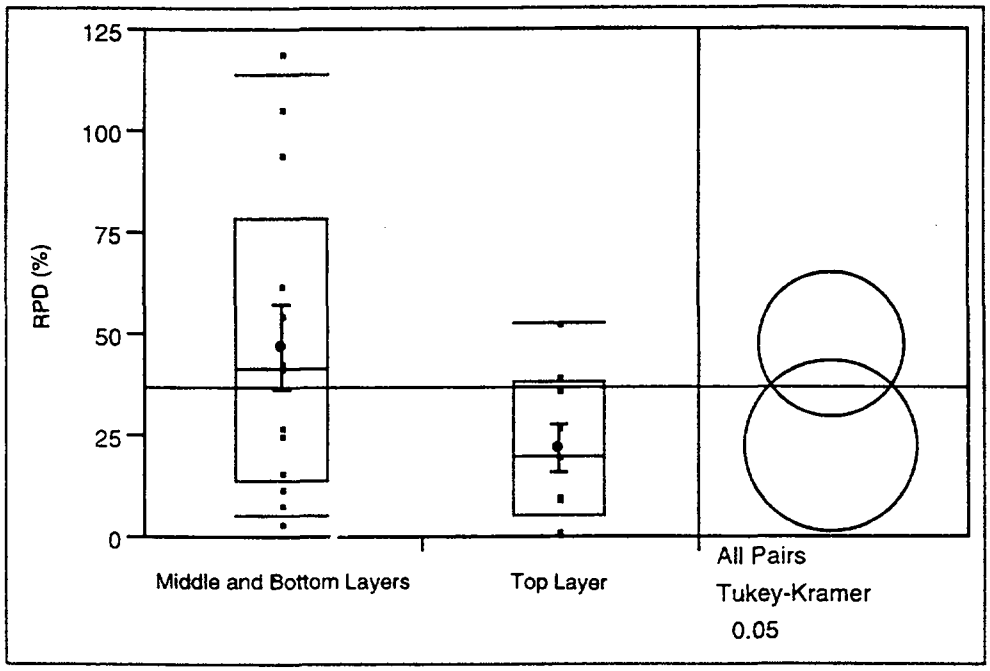
RPD Comparison for Low Resoution Core Split Samples Based on ^{137}Cs Presence

Table 2.4.1
Statistic Summary of RPD (%) as a Function of Depth and ^{137}Cs Presence in the Core Bottom

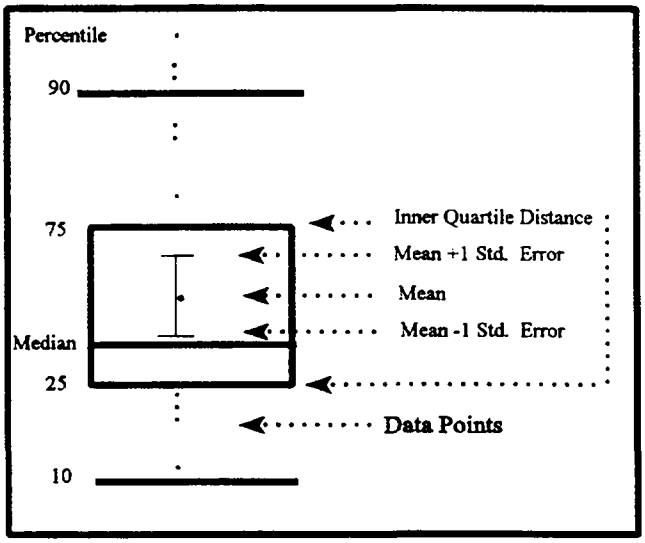
Events		No. of Samples	RPD[1] (%) Mean	Median	Std. Error
Depth	Top Layer	9	22.1	20	6.1
	Middle and Bottom Layers	14	45.8	34.7	10
^{137}Cs Present[2]	Top and Middle Layers plus Bottom Layer when ^{137}Cs is Present	17	26.9	20	6
	Bottom Layer, ^{137}Cs Absent	5	71.3	62.3	17.8

Note:

1. RPD is based on the Total PCB concentration in low resolution sediment core field split pairs.
2. Samples are grouped according to the presence or absence of ^{137}Cs in the core bottom. The first group includes all top and middle core segments plus the bottom core segments when ^{137}Cs was detected in the bottom core slice. The second group represents the the bottom core segments where ^{137}Cs was not detected in the bottom core segment.



Legend



Note: Lack of separation of circles indicates that the two groups are not statistically different

Hudson River Database Release 4.1

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Figure 2.4.1C

RPD Comparison for Low Resoution Core Split Samples Based on Sample Depth

suggested by the original RPD analysis presented in the LRC. Based on all above analysis, it can be concluded that poor homogenization or cross-contamination of deeper core segments characterized by lower PCB concentrations are the principal contributors to the relatively high RPD levels reported for the low concentration core samples. It is likely that the majority of the PCB mass estimates from the low resolution cores have uncertainties closer to 20 percent rather than the 37 percent originally presented in the LRC.

Response to LF-1.4

No response required.

Response to LG-1.32

The exclusion of low-level samples in order to find quantitative relationships among Total PCBs and other parameters is an attempt to exclude samples wherein the expected relationships are unlikely to apply. In these instances, issues of accurate quantitation, sample cross-contamination and related factors are likely to mask the true relationships of PCBs with other parameters. It may have been appropriate for USEPA to have used different criteria to select and exclude these data, but these exclusions have little impact since only one of the many relationships examined was converted to a quantitative basis. Specifically, only solid-specific-weight was evaluated quantitatively for use in estimating 1977-78 inventories. As such, it had a very limited impact since the density factor only varies about $\pm$30 percent about its average value.

Response to LG-1.38B

The writer correctly identifies an inconsistency between the formulas on page 4-28 and Table 4-13. Table 4-13 was mislabeled, and should have noted that the formula represents a simpler, approximate estimate of the mean as given by Gilbert (1987) and not the MVUE. It should be noted here that the estimator is applied consistently here and therefore sufficient for the comparisons made. Nonetheless, the USEPA acknowledges that the MVUE would have provided a more rigorous comparison.

Response to LL-1.6

The complete sentence to which the comment refers is, "Mean sediment concentrations obtained from the low resolution core results should not be directly compared between the two regions because the 76 cores analyzed in the TI Pool and 94 cores taken downstream of the TI Pool were intended to characterize local conditions in several areas and do not comprise a spatial coverage sufficient to calculate PCB inventories for these areas directly." These cores were selected to understand the change in PCB inventory in the hotter areas of the fine-grained sediments, i.e. local conditions. This study was not designed to or used to generate a 1994 Thompson Island Pool PCB inventory nor are the data used in that manner in the LRC. It is strictly used to surmise the direction and degree of change in a limited number of representative areas. In this context, the data set is sufficient.

Response to LL-1.7

The 28 Phase 2 high resolution cores were collected from areas of relatively continuous sedimentation of fine-grained material along the length of the Hudson River. Twelve historical sample collection sites which had previously produced high quality cores with readily interpretable analytical results were reoccupied. To select the remaining 16 locations, 55 preliminary cores were subjected to screening for radionuclide abundance to ascertain the capability of the sediment to produce an interpretable profile. This rigorous selection process was designed to collect datable cores; thus, the majority of the cores show a characteristic total PCB profile with a peak at depth. This does not mean that all cores collected from the fine-grained areas of the Hudson River have this profile.

The majority of the low resolution cores have the PCB maxima in the top-most core layer. Since these samples are homogenized from zero to nine inches below the surface, the exact location of the peak cannot be ascertained. The peak concentrations could occur anywhere within the ten inches, even at the surface. It cannot be inferred by the profiles of the selected high resolution cores that the peak concentrations are always buried by several inches of cleaner sediment. More importantly, the occurrence of the PCB maxima in the 0-9 inch interval directly refutes the GE contention that PCBs are being "deeply" buried since at most, the peak is only a few inches below the surface. Only occasionally was the peak overlain by nine or more inches of less contaminated but still not clean sediments.

In addition, PCBs within the top few inches of the surface in shallow near-shore areas are subject to disturbance by watercraft. Although scour by high-flow events may be an unlikely transport mechanism in these areas, this does not preclude the possibility of PCB transport to the water column through other currently less-well-defined mechanisms. For instance, since it is relatively clear that the current TI Pool load is not produced by a flow/scour process, other processes must work to create the water-column load in the TI Pool.

Response to LL-1.8

USEPA acknowledges the error in the LRC figure. This correction has been noted in the Correction to Section 2.4.1 of the Low Resolution Sediment Coring Report.

Response to LL-1.10

See response to comment LG-1.6 for discussion of analytical uncertainty. See response to comment LG-1.1 for discussion of the validity of the 1984 versus 1994 inventory analysis given the number of sampling points.

2.4.2 Radionuclide Analysis

No significant comments were received on Section 2.4.2.

2.4.3 Total Organic Carbon and Total Kjeldahl Nitrogen

Response to LF-1.3

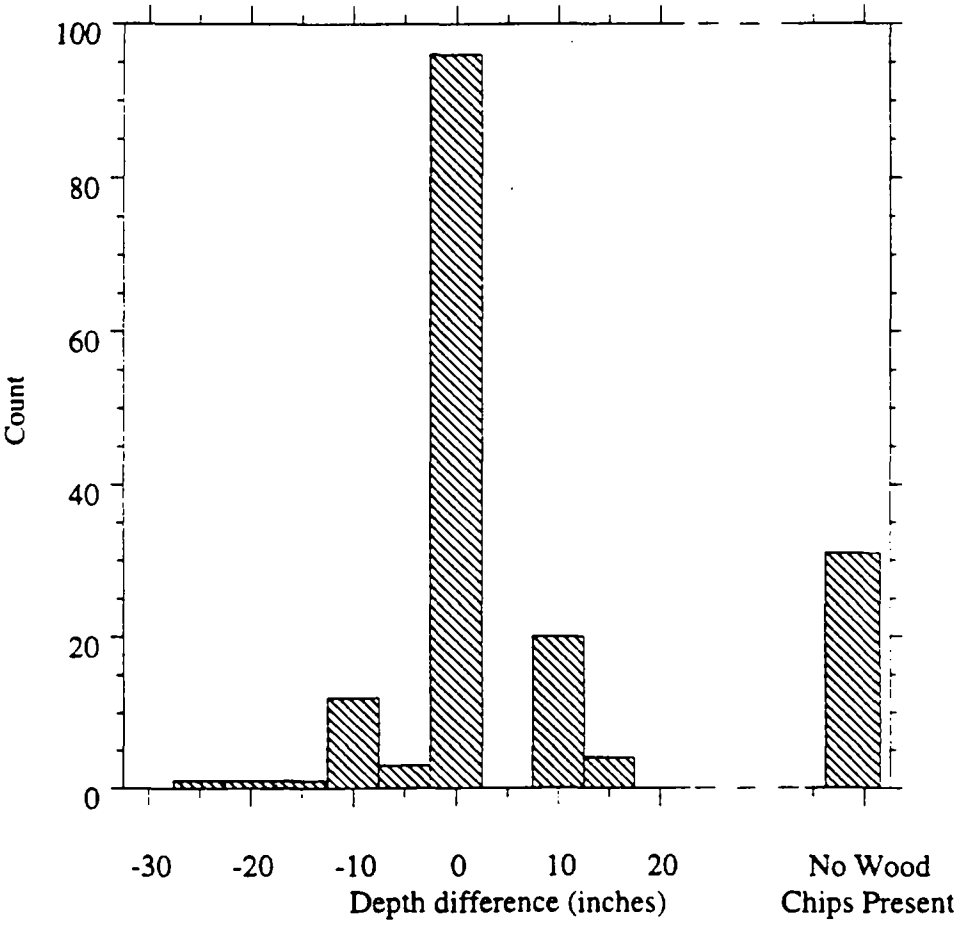
In response to this comment USEPA has prepared a further analysis of the wood chip and PCB data available for the low resolution cores. The field geologist's descriptions concerning the absence or presence of wood chips were retrieved from the database and correlated with the occurrence of the PCB maximum. This was accomplished by subtracting the upper depth of the core segment containing the PCB maximum from the upper depth of the first core segment found to contain wood chips. Thus core segments with coincident wood chips and PCB maxima were assigned a value of zero. If the PCB maximum overlay the wood chip occurrence, a negative value was obtained. If the converse was true, a positive value was obtained. The results for all low resolution cores are presented in Figure LF-1.3A. It is clear from this figure that the PCB maximum and the appearance of wood chips are coincident (difference equal to 0) in the majority of the low resolution cores, given their coarse resolution. The next largest group is those cores where wood chips were not reported. The next most important groups are those occurring at about 10 inches separation, close to the typical slice thickness. However, these non-zero difference cores scatter relatively equally about the value of 0, indicating no definitive trend. These results are consistent with the conclusion based on the C/N ratio in the LRC, that is, woody materials are present throughout Upper Hudson sediments and do not reliably predict the C/N ratio.

This issue was explored further by removing those cores which might affect the distribution due to their special conditions, *i.e.*, one segment cores (one PCB analysis) and incomplete core (cores where the PCB maximum depth is uncertain). These results are presented in Figure LF-1.3B. The relationships are the same as noted in Figure LF-1.3A.

As a last analysis, the C/N ratio was examined for the high resolution cores along with the total PCB levels. These results are shown for six cores in Figure LF-1.3C. These profiles show that the C/N maximum predates the PCB maximum in every case, indicating that the ratio is not a good predictor for Total PCBs. The results also show that major wood chip releases occurred prior to the onset of GE operations, probably commensurate with wood processing operations in the early part of this century.

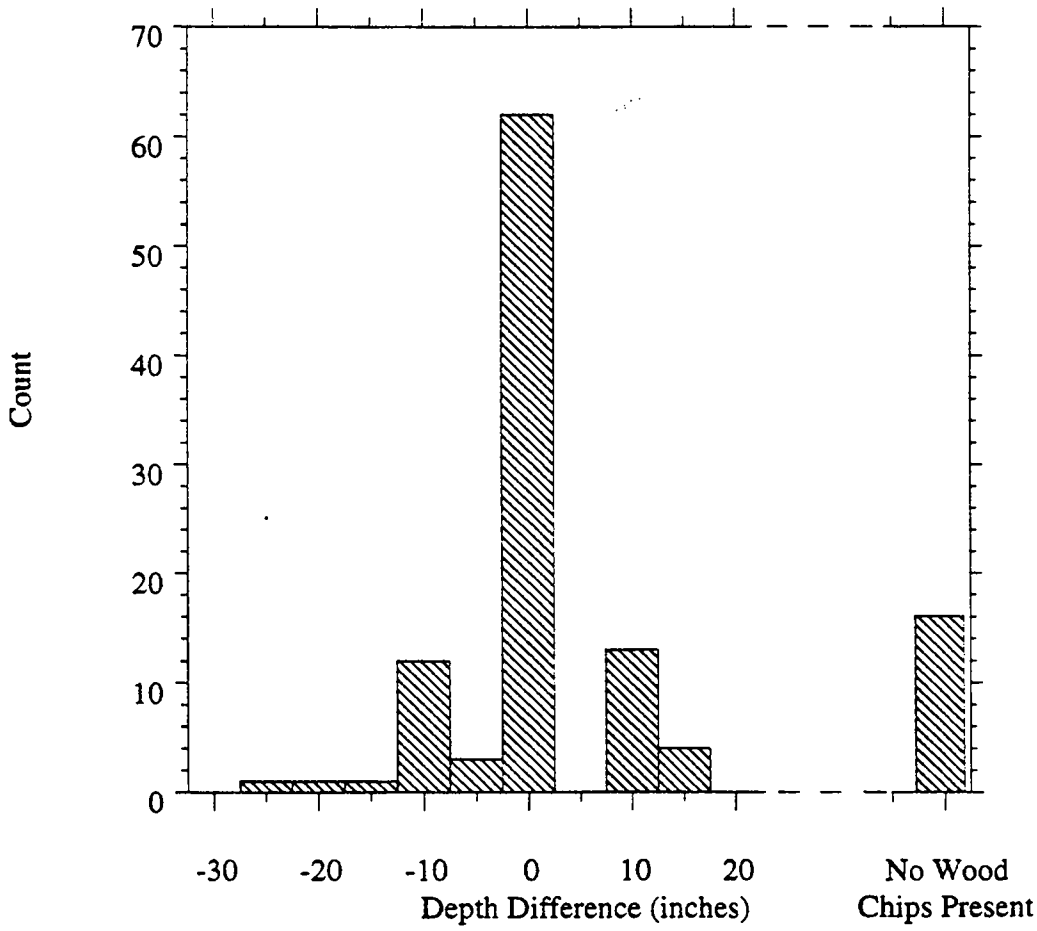
2.4.4 Physical Properties

No significant comments were received on Section 2.4.4.



Note:
1. Depth difference is defined as the top of the core segment with the PCB maximum minus the top of the first segment found to contain wood chips. Thus a core with a PCB maximum in the top layer (0-9 inches) and a first reported occurence of wood chip in the next layer (9-18 inches) would have a depth difference of (0-9) or -9.

Figure LF-1.3A
Depth Difference of PCB Maximum and the First Appearance of Wood Chips in All Low Resolution Core Samples



Note:
1. Depth difference is defined as the top of the core segment with the PCB maximum minus the top of the first segment found to contain wood chips. Thus a core with a PCB maximum in the top layer (0-9 inches) and a first reported occurence of wood chip in the next layer (9-18 inches) would have a depth difference of (0-9) or -9.

Figure LF-1.3B
Depth Difference of PCB Maximum and the First Appearance of Wood Chips in the Low Resolution Core Samples Excluding Incomplete and One-Segment Cores.

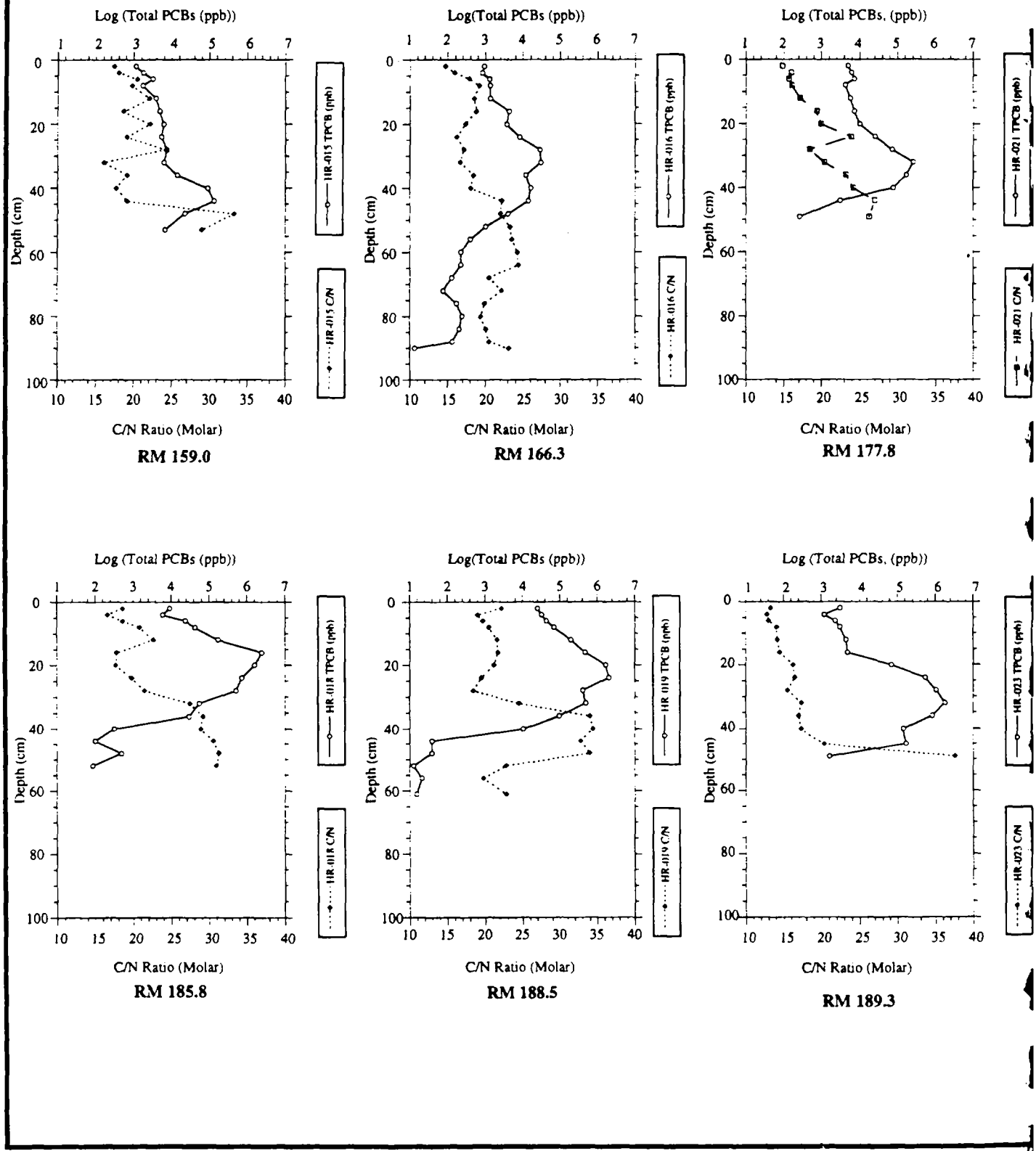


Figure LF-1.3C
Total PCBs and the C/N ratio in High Resolution Cores from the Upper Hudson

3. INTERPRETATION OF LOW RESOLUTION SEDIMENT CORING RESULTS

3.1 Comparison between the PCB Results for the Low Resolution Cores and the High Resolution Cores

Response to LG-1.5C

The USEPA does not dispute that recent release events from the Hudson Falls facility have added PCBs to the Pool inventory. If the GE data show that the April-September 1991 measurements at the TI Dam were more dechlorinated, this may be due to a number of factors including the addition of new material to the Pool sediments. More importantly however, as shown in the DEIR, the congener pattern of the net gain of congeners to the water column across the Pool has not changed in a consistent manner over the seven year period, suggesting that there has been no substantive change in the nature of the PCBs responsible for the Pool load gain.

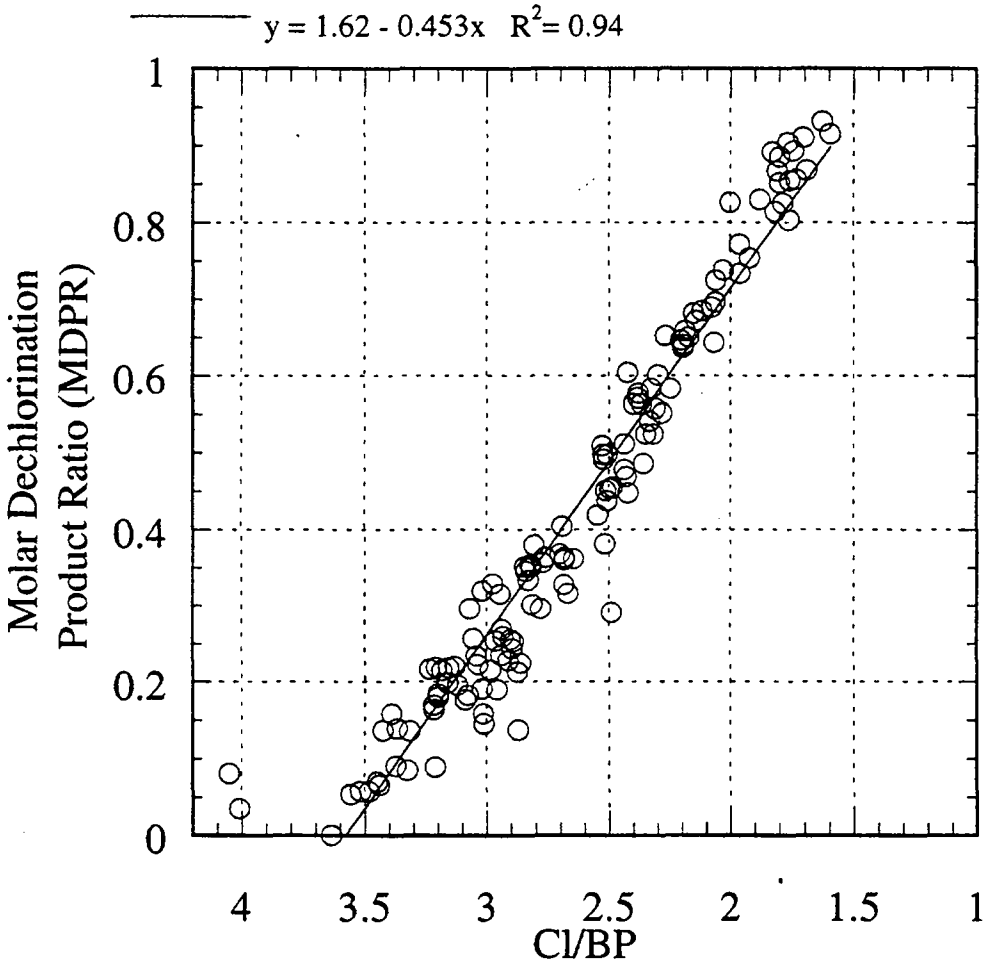
Response to LG-1.25

This Report was intended to examine changes in the PCB inventory of the sediments of the Upper Hudson. The issues raised by the writer will be examined and addressed in later Phase 2 Reports, in particular, the Ecological and Human Health Risk Assessment Reports. It should be noted, however, that the extent of dechlorination is found to be greatest in highly-contaminated sediment, while it is relatively minor in sediments with low levels of PCB contamination typical of most of the Hudson.

Response to LG-1.26

It has been demonstrated that the change in molecular weight (ΔMW) is algebraically related to the number of chlorines per biphenyl (Cl/BP) (*see* response DG-1.19 of the Responsiveness Summary for Volumes 2A, 2B and 2C). It has also been shown in both the DEIR and the LRC that the relationship between the ΔMW and the molar dechlorination product ratio (MDPR) is linear (R^2 = 0.90 or higher), meaning that the dechlorination products are produced in direct proportion to the degree of chlorine mass loss from a sediment mixture. Therefore, since these measures track each other and are directly related to Cl/BP, they directly reflect the degree of dechlorination in a sample. The quality of these measures can be contrasted with the relationship between Cl/BP and the ratios proposed by GE. This is illustrated by comparing Figure LG-1.21 and Figure LG-1.26A. The ratios proposed by the writer yield R^2 values of 0.4 or less, indicating the substantially greater scatter and therefore reduced sensitivity in these relationships. In particular note the broad ratio ranges seen around 2.5 to 3 Cl/BP, levels commonly found in the Hudson.

The discussion concerning the insensitivity of the MDPR to the conversion of BZ#8 (2,4'-dichlorobiphenyl) to BZ#1 is misleading. This conversion is only important at extremely high degrees of dechlorination. At levels more typical of Hudson sediments, BZ#8 forms an important intermediate whose inclusion in the MDPR enhances the usefulness of this ratio. This is illustrated in Figure LG-1.26B which compares the MDPR and MDPR*. MDPR* is defined as the sum of BZ#1, 4, 10 and 19 (excluding BZ#8) over the sum of all congeners on a molar basis. Figure LG-1.26B shows that the MDPR* also tracks the change in molecular weight although not as well as the orginal MDPR. However, both ratios are clearly superior to the ratios proposed by the writer.



Note:
Data from Phase 2 Upper Hudson samples shown.

Figure LG-1.26A
The Relationship Between the Number of Chlorines per Biphenyl
and the Molar Dechlorination Product Ratio for the High Resolution Core Data

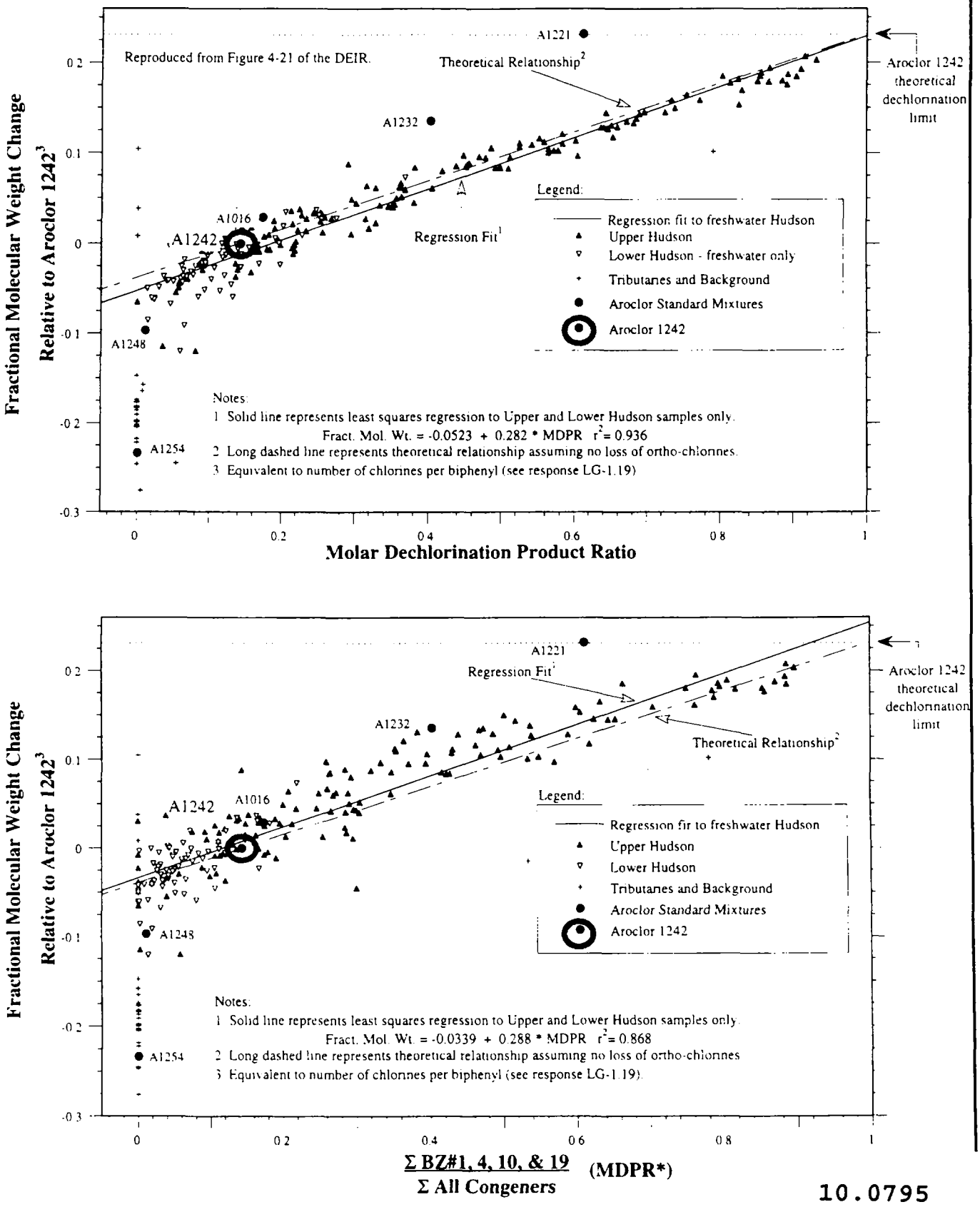


Figure LG-1.26B
Relationship Among MDPR, MDPR* and Fractional Change in Molecular Weight for All Post-1954 Freshwater High Resoution Core Sediment

Ultimately, it is the close correlation between the ΔMW and the MDPR which validates USEPA's methodology. The ΔMW expression, just as Cl/BP, integrates the entire sample for the degree of dechlorination. The strong linear relationship between the MDPR and ΔMW indicates that the MDPR also represents the degree of dechlorination in the sample and that the conversion of BZ#8 to BZ#1 does not substantively affect the usefulness and sensitivity of the MDPR to the dechlorination process.

Response to LG-1.27

The correlation between extent of dechlorination and PCB mass is well established by the analyses presented in the DEIR. In the discussion presented there, it was shown that below 30 mg/kg, the degree of dechlorination was not predictable and that many samples found below this level did not show substantive levels of dechlorination. These samples had low values for ΔMW, and high values for Cl/BP, indicating that the dechlorination process was unimportant for reducing sample mass or toxicity in these instances. This included nearly all of the Lower Hudson as well as locations from the Upper Hudson. The possibility that a few select congeners may be rapidly dechlorinated in the sediment at low concentrations does not change the fact that the majority of the heavier congeners remain intact in the sediments at low concentrations.

The removal of the "cross-contaminated samples" was predicated on the strong relationship developed from the high resolution cores. The arguments presented in the LRC are sufficient to justify the exclusion of these samples in the examination of the dechlorination ratios. Note, however, that these samples were not excluded from the sediment inventory calculations performed in Chapter 4 of the Report.

Response to LG-1.31

The criteria for selection of data to be rejected were presented in detail in the Report and provides a sufficient basis for their exclusion. The knowledge of the geochemical processes affecting PCBs and their relationships in the sediment is an essential foundation necessary before any statistical tests can be applied. This is an important precept, since relationships between PCBs and other parameters cannot be discerned if the data set contains many sediments deposited prior to appearance of PCBs in the Hudson.

Nonetheless, the most important conclusions of the Report stem from the analyses described in Chapter 4 of the LRC. In these analyses, no samples were excluded based on the rejection criteria, *i.e.*, all core sections were included in creating the mass-per-unit-area (MPA) values subsequently used in estimating the degree of change over time. Thus the comment does not apply to these analyses.

Response to LG-1.33

The data analysis presented in Figures 3-2 and 3-8 of the LRC does not represent data censoring. In fact the difference in the data sets represented in these figures is the result of a model used to predict those points which were likely candidates for cross-contamination. PCB concentration was not used as a criterion in selecting the points excluded from Figure 3-8. This is extensively discussed in the text and intervening figures. This analysis was done to confirm an

already proven relationship (*i.e.*, the relationship between total PCB mass and the degree of dechlorination). This was developed as a part of a prior study completed on Hudson River sediments for the USEPA. As such the data presented in Figure 3-8 were intended to check for consistency with the previous relationship and not prove the original premise.

Response to LG-1.39C

The USEPA disagrees with the writer's contention that the low resolution coring results do not confirm the findings of the DEIR that dechlorination is proportional to Total-PCB concentration. Specifically, both the 1994 low resolution coring and 1992 high resolution coring data sets provide nearly identical regressions between the change in molecular weight (ΔMW) and the dechlorination product content of the sample (MDPR) to that predicted by the simple dechlorination model. This relationship will only hold if the dechlorination process does not involve the inner chlorine atoms on the PCB molecule. The minor differences between the two regressions for the two data sets is probably attributable to minor changes in the analytical techniques and are not indicative of real differences between the two data sets. Thus the high resolution core finding in this regard is confirmed by the low resolution results.

Similarly, the low resolution cores results, when corrected for what is arguably a likely cross-contamination issue, yield a relationship between the degree of dechlorination and the total PCB mass of the sample which parallels that of the high resolution cores. This confirms the general high resolution core result finding, that dechlorination increases with total PCB mass. Subsequently, when the impact of the different sampling techniques are considered, it is clear that the parallel relationships converge to a single relationship. While this step does not constitute a confirmation, it does represent an interpretation of the data which is consistent with the original premise. Thus the low resolution coring data confirm both general findings and are consistent with the specific finding in the latter case.

3.2 Interpretation of the Relationships Among the Low Resolution Core Parameters

Response to LG-1.23

^{137}Cs cannot be directly applied in the manner suggested for the same reason that surface sediment PCB levels cannot be used to infer scour. Both ^{137}Cs and PCBs are particle-reactive agents whose distribution in the sediments is based upon deposition rates, deposition history, history of release and bioturbation. For this reason, the high resolution cores cannot be used to establish the ^{137}Cs level of sediments of comparable age throughout the Pool. This would be the same as using these cores to establish the sediment PCB levels throughout the Pool. As is well known, PCB levels (and presumably ^{137}Cs levels) vary widely in the Pool. Thus the use of surface ^{137}Cs levels as a measure of the depth of scour in a theoretical high resolution core does not establish the approximate depth (or time horizon) of scour since the initial level of ^{137}Cs in the coring location is not known. Based on the difficulty of finding suitable coring locations, it is unlikely that most areas experience the same levels of ^{137}Cs as seen in the high resolution cores. Indeed, even among the high resolution cores sediment ^{137}Cs levels can vary by nearly an order of magnitude. See the surface ^{137}Cs in the region between RM 185 and 195 on Figure 3-63 of the DEIR. An important compounding factor is the degree of bioturbation at a site. This process serves to homogenize ^{137}Cs levels and reduce and broaden the peak levels.

The net result is that surficial ^{137}Cs cannot be used *a priori* as a measure to determine the depth scour, or as suggested by the writer, to exclude the possibility of scour without knowing the detailed variation of ^{137}Cs in the core. The premise proposed by the writer would be useful in an ideal setting but must be rejected here as a basis to eliminate scour as an important mass loss process.

Response to LG-1.37

The commentor addresses the fact that, for any pair of measurements subject to uncertainty, initial high values will tend to decrease, and initial low values will tend to increase, on resampling. This "regression toward the mean" effect results because uncertainty, whether due to uncertainty in resampling location or to analytical uncertainty, results in a sample being more like the local mean value than the other member of the pair under comparison.

The USEPA acknowledges that the "regression toward the mean" effect exists, and should have been noted within the Report. This issue would be more significant if the split of the samples at an MPA of 10 g/m^2 was arbitrary and unsupported by geophysical evidence. In fact, the split point is logical, as "the greater-than-10-g/m^2 group corresponds to sediments typically found in *hot spot* areas (LRC, page ES-4)." Thus, the analysis which was performed is consistent with a geophysical hypothesis that mass loss has occurred from concentrated *hot spots*, with some of the mass being locally redistributed into less contaminated areas. If this mechanism is accepted as reasonable, it is not appropriate to perform statistical analysis of the data without stratifying on the basis of whether 1984 sediment samples were representative of *hot spot* or non-*hot spot* conditions.

The fact is clear that higher concentration sediment samples show a statistically significant decline in PCB inventory from 1984 to 1994 (Figures 4-12 through 4-14 of the LRC). A part of this sample change is due to actual mass loss, and a part may be due to the "regression toward the mean" effect. For the "regression toward the mean" effect to constitute a major portion of the difference, however, would require the presence of significant uncertainty due to either analytical uncertainty or location errors.

The effect of analytical uncertainty has first been minimized by examining multiple measures (MPA, $Delta_M$, $Delta_{PCB}$), where the latter two ratios are designed to diminish the importance of analytical variability, as described in the response to comment LG-1.39B. More importantly, it should be noted that the estimates of sediment inventory change in the Thompson Island Pool are based on comparison of 1994 Total PCB mass per unit area to 1984 estimates of Tri+ mass. Clearly, monochlorbiphenyl and dichlorobiphenyl mass was present in 1984, although not measured. The 1984 MPA estimates are thus known to be biased low, which will minimize resulting estimates of mass loss. Indeed, among the higher-concentration 1992 high resolution coring samples, Tri+ represented less than 50 percent of the total PCB mass present. The mass loss estimates presented in the Low Resolution Sediment Coring Report are conservative. In this manner, the USEPA has presented a strong test for mass loss from the more-contaminated sediment areas which should not be affected by the analytical uncertainty.

The commentor appears to attribute significance to the "regression toward the mean" effect primarily based on locational uncertainty, stating that "the geostatistical evidence from the 1984 survey shows that very short-scale spatial variability is often comparable to total variability." This statement is untrue within the areas sampled in 1994. Indeed, short-scale spatial variability was not

examined in the 1997 DEIR, and cannot be evaluated from the figures presented in that Report. The response to comment LG-1.9 shows that samples are highly correlated within the short range of locational uncertainty applicable to reoccupying the 1984 sample locations.

In sum, the commentor has correctly pointed out an additional source of uncertainty which could result in a slight high bias in the estimated amount of mass loss from highly contaminated sediments between 1984 and 1994. This uncertainty does not, however, invalidate the general finding of mass loss from higher concentration *hot spot* sediments.

Response to LL-1.11

The Phase 2 high resolution cores were selected from areas of relatively continuous sedimentation of fine-grained material. As a result, the bulk sediment properties, grain-size distribution and some chemical parameters, such as total organic carbon, show little variation. The correlation with Total PCBs is poor for these samples, because the material is all of one type. It is known that ^{137}Cs is correlated with Total PCBs due to the similar deposition histories of these parameters. This relationship is displayed in Figures 3-53 through 3-55 of the DEIR (USEPA, 1997) which show the concentration Total PCBs and ^{137}Cs plotted versus depth.

In contrast, the Phase 2 low resolution cores were selected to obtain new estimates of the sediment PCB inventories at a number of locations in the TI Pool and to refine the PCB mass estimates for a limited number of historic *hot spot* locations below the TI Pool. These objectives did not require the cores to be of only fine-grained sediment. The low resolution sediment core samples show a wider range of values for the bulk sediment and chemical properties. These value can be correlated with Total PCBs and measures of dechlorination.

3.3 Interpretation of the Low Resolution Core and the Side-Scan Sonar Results

No significant comments were received on Section 3.3.

3.4 Summary of Chapter 3

No significant comments were received on Section 3.4.

4. AN EXAMINATION OF HUDSON RIVER SEDIMENT PCB INVENTORIES: PAST AND PRESENT

Response to LG-1.1

The writer asserts that the various estimates created in the USEPA Reports for the inventory of PCBs in the TI Pool sediments are largely the result of the sediment heterogeneity. While the sediments are certainly heterogeneous in their PCB content, this is not the reason for the large differences between the estimates given in Brown *et al.*, 1988 and the Data Evaluation and Interpretation Report (USEPA, 1997). Rather, the wide differences are the result of the assumptions used to estimate the sediment inventory. The estimate by Brown *et al.* is largely based on subjective evaluation of the data, which while useful, may yield an overestimate of the actual inventory. As part of the DEIR, the sediment inventories were estimated at 14.5 and 19.3 metric tons, based on two separate statistical techniques, kriging analysis and Theissen polygonal declustering, respectively. Of these techniques, the kriging analysis is the more rigorous since it examines how contamination varies as a function of distance. These techniques are described in detail in the DEIR. Neither technique as applied in the DEIR was able to directly account for the sediment textures mapped by the side scan sonar. When this information is used in conjunction with the Theissen polygonal declustering, the inventory estimate obtained is 14.7 metric tons, essentially the same as that obtained via the kriging analysis. Appendix B of this Responsiveness Summary describes the new analysis.

The writer also asserts that the number of samples collected was too small to discern a difference between the 1984 and 1994 collection events. This again is incorrect. In the analysis of the low resolution coring data, various statistical techniques were applied to test for the statistical significance of the difference between the 1984 and 1994 data. These tests take into account the number of samples available. The Report only presents those differences which were shown to be statistically significant at the 95 percent confidence level. The 95 percent confidence level is the generally accepted significance level for most statistical tests.

Response to LG-1.38A

The writer is correct in noting that the Minimum Variance Unbiased Estimator (MVUE) method is based on an underlying log-normal distribution. Minor deviations from a true log-normal distribution introduce minor errors to the MVUE. However, the writer's concern over data censoring is unwarranted. As discussed in the text as well as in response LG-1.33, the data sets used in the mass inventory estimates did not exclude any sample data. Additionally, no inventory estimates were nondetect. It is important to note that underlying data distribution is not known except through the data collected. The fact that the sample distribution is not perfectly log-normal does not disprove the log-normality of the underlying population. Thus, the use of the MVUE is justified in light of the greater probability that the underlying population is log-normal. This is evident in LRC Table 4–6, which illustrates the high probability that the sediment PCB data are log-normally distributed.

The writer's contention that the simple arithmetic mean is preferable to the MVUE due to the uncertainties in the population's shape is untrue. Specifically, if the underlying population is log-normal, as has been suggested by many different studies of PCB contamination in Hudson River sediments, then the use of the MVUE provides a minimum variance estimate (which the arithmetic

mean is not, (Gilbert, 1987)) and is preferred, particularly when the sample set is small and likely to be log-normal. Small data sets typically do not sufficiently capture the complete population distribution and tend to under represent the values far from the mean. As a result, the simple arithmetic mean may not provide the best estimate of the true mean. Further evidence for an underlying log-normal distribution is found in LRC Table 4-6 which shows all of the *hot spots* to have a rather high probability of a log-normal distribution. In each case, the test for normal distribution yielded lower probabilities. Lastly, as is evident in LRC Table 4-7, there is little difference between the two estimators and thus, the writer's concern makes little difference in the ultimate result. The statistical analysis only yielded significant differences when the mass values varied more than a factor of 2 so that the small (roughly 5 percent) difference between the estimators is unimportant.

4.1 Sediment Inventories of the Thompson Island Pool

Response to LG-1.2

The writer asserts that a list of conditions must be met in order for the USEPA Report to provide "credible and persuasive results." While the USEPA agrees that meeting the conditions posed would be useful in assessing differences between the 1984 and 1994 surveys, the list is not an essential list of criteria for the evaluation. Each of the conditions adds to the uncertainty of the analysis. However, the statistical tests used in the USEPA's evaluation account for this uncertainty by examining the variability of the data collected. In reply to each of the conditions listed, the USEPA offers the following:

1. This condition is incorrect. Since the USEPA's evaluation is based on the average difference between the sixty 1984-1994 sample pairs, the true requirement is that the two data sets represent unbiased estimates of the sediment PCB inventory at the sampling location at the time of collection. Therefore, the differences represent unbiased estimates of the actual difference. By examining the average difference and testing for its statistical difference from zero, the analysis is not dependent upon the absolute accuracy of any individual pair. Rather, by taking the average, the analysis accounts for the fact that some pairs may overestimate or underestimate the actual difference, but on average, since the data are unbiased, the mean difference will indicate the direction and magnitude of change. The uncertainty calculations performed as part of this analysis indicated that the reported degree of change was statistically different from zero and therefore that the direction of change (*i.e.*, inventory loss) was discernable from the data. The relatively large uncertainty in the actual magnitude of the change was accounted for in part by the creation of a lower bound (minimum) estimate of the mass loss. In this manner, since the minimum estimate of mass loss was shown to be statistically different from zero, it is likely that the magnitude of mass loss was at least comparable or perhaps greater than that estimated. This analysis is described in detail in Section 4.1 of the Report.

2. This condition was only truly necessary for the 1994 data set. To this end, the cores were analyzed for ^{137}Cs in the bottom-most slice. As discussed in the text, most (46 / 60) of the sediment cores had no ^{137}Cs in this slice. The remaining 14 of the 60 cores did have detectable levels in the bottom-most slice but 5 of these were shown to have falling ^{137}Cs, indicating that the vast majority of the PCB inventory had been captured. Thus the 1994 data set represents the entire PCB inventory in nearly all TI Pool cores. This is summarized in Table LG-1.2. If the 1984 coring work did not

Table LG-1.2
Review of 1994 Low Resolution Sediment Core Completeness

Core Characterization	Total Thompson Island Pool Locations	Matched 1984 to 1994 Locations	Change in Sum of Tri+ and Dechlorination Products (BZ# 1,4,8,10,19)[4]		Change in Sum of Tri+ Homologues Only[4]		Original 1984 Inventory[4]	
			Number of cores with loss	Number of cores with gain	Number of cores with loss	Number of cores with gain	Cores less than 10 g/m^2	Cores greater than 10 g/m^2
Complete[1]	61	46	27	19	42	4	15	31
Nearly Complete[2]	5	5	3	2	5	0	0	5
Incomplete[3]	10	9	5	4	8	1	4	5
Total	76	60	35	25	55	5	19	41
% Nearly Complete or Better	87	85	86	84	85	80	79	88

TAMS/Tetra Tech

1. No cesium-137 present in bottom slice of core.
2. Cesium-137 levels decline from surface to bottom core slice.
   PCB maximum evident, i.e. maximum concentration occurs above deepest slice in core.
3. Rising or steady cesium-137 with no PCB maximum evident.
4. Based on 60 matched 1984 to 1994 locations only.

capture the entire sediment inventory, then these estimates represent lower bounds on the actual PCB inventory present in 1984. If, in this case, the 1994 inventory is lower than the 1984 based on the measured values, the difference represents the minimum mass loss. Again the data analysis has been performed in a manner to conservatively estimate the actual mass loss, thus assuring the absolute direction of change in the inventory.

3. The comparability of the 1984 grab samples to core samples was closely examined by NYSDEC (Brown *et al.*, 1988). While the grabs have greater uncertainty associated with the sediment depth they represent relative to the cores, this does not preclude their use in the analysis, since, again, the statistical tests used account for uncertainty. The similarity of the '84 grab - '94 core pairs to that of the core-core pairs is shown in Figure 4-15 of the Report. For both the >10 g/m^2 and the <10 g/m^2 groupings, the '84 grab - '94 core pairs were not found to be statistically different from the core-core pairs. Indeed, the match between the core-core pairs and the '84 grab - '94 core pairs was quite close for the >10 g/m^2 group (the more contaminated sediments).

4. Strictly speaking, the same sediment cannot be sampled in both 1984 and 1994 since the 1984 sampling effort removed and did not replace the sediments that were collected. However for the purposes of the low resolution coring analyses, it is only necessary that the 1994 samples be collected from the same area as that of 1984 samples. In this manner, on average, the difference between the 1984 and 1994 results will represent the average change in the sediment inventory. The semivariogram analysis performed on area H-7 by GE demonstrates the heterogeneity of the sediments in the upper reach of the TI Pool, an area characterized by coarse-grained sediments. This analysis does not apply to most of the 1994 sample collection sites which are located further downstream. Only four 1994 locations were placed in this area of the Pool.

As shown in Figure 4-9 of the DEIR, semivariogram analysis of 1984 samples collected in the upper portions of the Pool yield the same level of variability seen by GE at H-7. However, semivariogram analysis of the lower two-thirds of the Pool shows significant spatial correlation, also shown in Figures 4-10 to 4-12 of the DEIR. Thus it is clear that the remaining 56 paired sampling locations occupied in 1994, with a median separation of 3 feet from the 1984 location, can expect to represent the same sediment as collected in 1984. (A discussion of the semivariogram analysis is presented in Section 4.2.4 of the DEIR.)

5. The objective of the 1994 effort was not to completely reestablish a new inventory for the TI Pool. Rather it was to assess changes in the inventory documented in 1984. The writer misconstrues the information in his calculation of sampling density for the 1994 survey. In fact, 16 areas of the TI Pool were examined at exactly the same sampling density as originally performed by NYSDEC, since they are collected from precisely the same locations as those occupied by NYSDEC in the areas studied. These 16 areas were selected from throughout the TI Pool and represent a range of contamination and sediment textures, although they focus principally on fine-grained sediments. As such, these areas are subject to the same processes affecting all sediments of the Pool and can be considered representative of 1994 sediment conditions in the Pool. The analysis of the 60 coring locations in the TI Pool as well as the 80+ locations below the TI Dam all support the conclusion of substantive sediment PCB loss from the sediments. The data set is sufficient for the purpose for which it was intended, *i.e.*, the assessment of the direction and approximate magnitude of the change in sediment PCB inventory between 1984 and 1994.

Response to LG-1.3

The USEPA disagrees with the premise posed by the writer that either the 1984 or 1994 data sets are insufficient to characterize the PCB inventories in the areas examined. Both data sets were subject to extensive quality assurance and quality control procedures and represent valid estimates of the sediment concentrations at the time of sampling. While both data sets (as well as those collected by GE) contain some degree of uncertainty, the data were compared by employing statistical tests which account for the uncertainties in the data.

With regard to quantitation, the USEPA asserts that more reliable quantitation for the 1984 and 1994 data sets has not been demonstrated. In fact, both the USEPA and NYSDEC analytical programs employed near state-of-the-art techniques at the time of implementation. In both cases, sufficient data were obtained to assess uncertainties in the sampling and analytical procedures. Ultimately, it is the construction of an average degree of change in the sediment PCB inventories which yields the most powerful statistical tests to confirm the direction and magnitude of change.

The USEPA acknowledges that a better understanding of the mechanisms responsible for the mass losses estimated in the Low Resolution Sediment Coring Report would be useful. However, it is not necessary that these mechanisms be understood in order for the measured difference to be considered valid. More importantly, it is essential to integrate the net change in sediment inventory caused by the assortment of mechanisms so that the nature and scale of these mechanisms can be constrained. The mechanisms discussed by the writer are not known in sufficient detail or magnitude to provide their own constraints in the absence of data on sediment losses or gains.

Response to LG-1.4D

The purpose of the LRC was not to study PCB release mechanisms but rather to identify changes in PCB inventories in the TIP and in *hot spots* below the Thompson Island Dam, essentially integrating the net effect of these mechanisms. Comments on GE mechanism estimates have been provided in the DEIR Responsiveness Summary. USEPA does not believe that these estimates themselves provide sufficient independent constraints on the actual amount of mass loss. Additionally, the USEPA provided a critique in Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C of the GE/QEA model which forms the baasis for the writer's assertions in this comment. In this critique, several of the underlying assumptions made by GE/QEA are shown to be of questionable validity (*see* Sections 2 and 3 of the critique in particular), thereby rendering the flux estimates attributed to the various mechanisms very uncertain. As such the GE/QEA model cannot be used to refute the findings of the LRC with regard to mass loss.

Response to LG-1.8

Inclusion of grab samples from the 1984 data set was necessary since about two-thirds of the 1984 NYSDEC locations were represented by grab samples. Thus exclusion of these from the low resolution coring analysis data set is unjustified. NYSDEC assessed the data from paired cores and grabs to determine the depth to assign to the grab samples (Brown *et al.*, 1988).While the USEPA acknowledges that the use of grab-to-core comparisons introduces some uncertainty into the analyses presented in the LRC, this uncertainty is again incorporated in the statistical tests which still yielded

statistical significance for the differences found despite all the uncertainties present. As further evidence in support of the use of the grab-core pairs, the LRC presented an analysis of the Delta values derived for core-core and grab-core pairs in Figure 4-15 of the Report. This analysis as illustrated by the figure demonstrates that the grab-core pairs are not statistically different from the core-core pairs and in fact yield very similar results for the sediments with PCB inventories greater than $10g/m^2$.

Response to LG-1.10

The writer's contention that spatial heterogeneity is so great that the TI Pool inventory cannot be determined precisely is inaccurate as discussed in detail in the response to LG-1.1. The writer also contends that the 1994 sampling density was too low for the comparisons made. This is incorrect since, within the clusters, the sampling density matched that of the NYSDEC study. Finally, with regard to the number of samples, the writer contends that the USEPA acknowledges that its sample set is too small but then uses it anyway. The USEPA acknowledges that the data set is too small to constrict an overall sediment inventory estimate, not that it cannot be used to study the changes in inventory within the areas studied.

In implementing the 1994 low resolution sediment coring program, the USEPA sampling program focused on several concerns dealing with sediment homogeneity. Specifically, the low resolution core clusters were selected so as to minimize local sediment heterogeneity by selecting areas where sediment PCB inventories did not vary greatly (roughly a factor of 2% range). Additionally, the USEPA sampled at the high end of the sediment distribution to characterize the changes in the most contaminated sediments. These sediments represent the sediments most likely to release PCBs to the water column since their high concentrations yield the strongest gradients to drive this release. Lastly, due to their higher concentrations, accurate quantitation of PCB levels by both 1984 and 1994 could be expected since detection limit thresholds were avoided. Figure 5 presented by the writer confirms that the 1994 locations represent the more contaminated sediments of the TI Pool.

Figure 6 presented by the writer is used to contend that the selected 1994 locations are not representative of the *hot spots* in general. However, this comparison should be made on the basis of the *hot spots* studied only. In addition, Brown *et al.*, 1988 noted that many of the 1977 delineations did not appear valid based on the 1984 sampling locations. It is the USEPA's intention to apply the loss calculations to the fine-grained sediment PCB inventories defined by the 1984 sampling and the 1992 side-scan sonar survey. It is clearly stated that the mass loss calculations apply to sediments of 10 g/m^2 or higher, which are typical of *hot spots*. The writer has incorrectly inferred this statement to mean that all *hot spot* sediments have greater than 10 g/m^2. By focusing on the actual inventory, the low resolution coring results can be used to estimate changes in the more contaminated, fine-grained sediments (*i.e.*, sediments greater than 10 g/m^2). Figure 6 confirms that the 1994 survey sampled among the more contaminated sediments and thus can be considered representative of these sediments.

The writer incorrectly states that the mass loss calculations of the LRC apply to all sediments of the TI Pool. There is in fact no inference that the mass loss seen for sediments greater than 10 g/m^2 applies to all sediments. Indeed, the Report suggests that there may be PCB gains in the

coarse-grained sediments of the Pool, perhaps in part due to the redistribution of PCBs from the higher inventory areas.

See also LG-1.2, part 5 for additional discussion of these issues.

Response to LG-1.20

The issues raised here are addressed at length in USEPA's critique of the GE Model Report prepared by QEA. This is included as Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C. As noted in the executive summary of the critique, the USEPA finds the following:

> The congener signature of the TIP load is consistent with a weathered, partially-dechlorinated PCB source although not as fully dechlorinated as some buried *hot spot* sediments. The assumption that pore water flux is the only summer loading pathway appears to be incorrect. Instead, new analyses conducted for this review suggest that the summer TIP load is a mixture of pore water flux and bulk loading of fine sediment, perhaps driven by bioturbation.

Additionally, the USEPA notes that the match shown on the writer's Figure 19 is a comparison of measured data with the model construct, essentially a regression exercise and does not constitute proof of the model assumptions. The partition coefficients for the dissolved organic carbon-bound PCB congeners are not well known and those estimated by applying a simple, constant correction factor do not agree with those reported by USEPA in the DEIR. The concentration of dissolved organic carbon (DOC) is also not a well-known parameter since the values used by GE are based on frozen samples. Freezing will likely cause precipitation of DOC, thereby potentially introducing both variability and bias to the reported values. The issue of the compositing process is also important here since it may mask relationships between concentration and congener ratios in the sediments.

Response LG-1.19B also discusses some issues related to this comment.

Response to LL-1.1

The 1984 estimate of the TI Pool (Brown, *et al.* 1988) of 23 metric tons of PCBs is substantially lower than the 1978 estimate of 61 metric tons (MPI, 1978). As discussed in Brown, *et al* (1988) there are several differences in calculation methods, assumptions and quantitation that result in this apparent 62 percent loss. These differences are listed on Table LL-1.1. From this listing it is clear that the 1984 analysis has more precision than the 1978 analysis, because:

- The 1984 study of the TI Pool included more than three times the number of samples in the TI Pool than in 1978,
- 40% of the 1984 locations are cores versus 33% in 1978,
- The 1984 grab depth is assigned by sediment texture and these depths were estimated through statistical analysis of sediment cores of similar texture, and
- Specific weight was analyzed for most of the 1984 samples, but none of the 1978 samples

Table LL-1.1
Parameter Comparison for Brown *et al.*, 1988, and LRC Inventory Analyses

	No. Sample Locations Used in Analysis						
	1978	1984	1984	1994	1984	1994
	Inventory to Inventory		Point to Point		Sample Area	
Total Number of Locations	313	1014	60	60	197	70
No. Grabs	209	607	15	0	85	0
No. Cores	104	407	45	60	112	70
Quantitation	1221, 1016, 1254	1242, 1254, 1260	Trichloro and Higher Homologues		Trichloro and Higher Homologues	
Specific Weight Analysis	None 1.042 g/cc	Yes, except for gravel 1.3 g/cc for gravel	Yes, except for gravel 1.3 g/cc for gravel	Yes	Yes, except for gravel 1.3 g/cc for gravel	Yes
Grab Depth Estimate						
Coarse-Grained Sediments	24"	12"	12"	Not	12"	Not
Fine-Grained Sediments	24"	17"	17"	Required	17"	Required

Sources: Hudson River Database Release 4.1 and Brown, 1988 TAMS/TetraTech

The conservative grab depth of contamination and constant specific weight serve to bias the 1978 inventory estimate high. The quantitation in 1978 included Aroclors 1221 and 1016 and captured the monochloro- and dichlorohomologue fractions. As discussed in LRC Appendix E, the 1984 quantitation did not capture these fractions. By 1984, a significant amount of dechlorination could have occurred, but this mass is not accounted for in the 1984 inventory estimate. The 1984 inventory estimate is underestimated, because this portion of the inventory is not included.

The LRC point-to-point analysis used the same number of sample locations in 1984 inventory estimates and 1994. Only 25 percent of the 1984 sample locations utilized for the point-to-point analysis were grabs (*see* response to comment LG-1.8 for the justification for using grab samples). Specific weight was analyzed in the laboratory for both the 1984 and 1994 samples. The comparison is made on a constant quantitation basis using trichloro and higher homologues only. A second sample area comparison is provided in Appendix A of this Responsiveness Summary which yields a 43% molar loss of trichloro and higher homologues (with upper and lower 95 percent confidence limits of 2 percent and 59 percent loss) from local areas of fine-grained sediment in the TI Pool.

The LRC analysis recognized and accounted for the differences between the 1984 and 1994 sampling events, whereas no attempt was made to reconcile the differences between the 1978 and 1984 estimates. Because the 1978 to 1984 comparison was without a common basis, but the 1984 to 1994 has a common basis, it is reasonable to reject the 1978 to 1984 mass difference of 62%, but accept the 43% (on average) molar loss from local areas of fine-grained sediment in the TI Pool between 1984 and 1994.

The decision by Brown *et al.* not to assess the difference between the 1978 and 1984 inventory estimates inventory estimates was most likely limited by the issues discussed above. Nonetheless, it is clear that the river was not working in a different manner during the period 1978 to 1984 than in the period 1984 to 1994. This is evident in the water column transport analysis performed in the DEIR (*see* DEIR Figures 3-100 and 3-101). In both figures the mass loss from the TI Pool from 1978 to 1985 is so great that it is readily discerned from the sporadic USGS monitoring data. The inability of the USGS to track the lighter congeners limits the usefulness of this data as the trichloro- and higher homologue decreases over time after 1985. This limitation is subsequently superceded by the GE data which begin in 1991 and continue to demonstrate the mass loss from the TI Pool. The writer's contention that Brown *et al.*'s perspective was somehow better than the current understanding and should therefore be used as a benchmark for deciding the impact of sediment PCBs is not accepted by the USEPA.

Response to LL-1.2

The comparison in the LRC between the 1984 and 1994 inventories was designed to characterize local areas of finer sediment. The study was not designed to create a 1994 inventory, but to determine the direction of change and an estimate of the degree of change in these local areas. A subsequent analysis based on area-to-area averages is presented in Appendix A of this Report. This analysis confirms the results presented in the LRC. The statistical techniques utilized take into

account the number of samples available and account for the uncertainty as discussed in the response to comment LG-1.1.

Response to LL-1.3

The analysis presented in the LRC for the TI Pool inventory is a point-to-point comparison between sixty 1984 cores or grabs and sixty 1994 cores, not a Thompson Island Pool inventory estimate comparison. Not all 1984 cores were used in the analysis, only the sixty locations reoccupied in 1994. These sixty locations can be considered representative of the most contaminated areas of the TI Pool. The analysis shows that these locations have lost inventory. By inference, it is likely that similar sediments throughout the TI Pool have also lost inventory. A similar conclusion was found based on area comparisons. (*See* Appendix A of this Responsiveness Summary.)

The issue of spatial heterogeneity is addressed in the responses to comments LG-1.9 and LG-1.10.

Response to LL-1.12

The analysis of 1984 sediment PCB Aroclor-based quantitation in Appendix E of the LRC provides a translation scheme to make the 1984 data consistent with the Phase 2 congener-based quantitation. The method is quite successful, yielding a linear relationship between the trichloro- and higher homologues and the 1984 method sum of Aroclors with a correlation coefficient (r^2) of 0.983. It should be noted that this relationship is based solely on the 1994 data. Nonetheless, it is still the best approach currently available to establish a consistent analytical basis between the 1984 and 1994 sediment data sets. By applying the correction factor developed in Appendix E, a reasonable basis of comparison between 1984 and 1994 sediment samples is achieved.

At the time of the preparation of this Report, a more direct analysis of the 1984 and 1994 methods was being prepared by Dr. R. Bopp of Rensselaer Polytechnic Institute for NYSDEC. This analysis will be reviewed by the USEPA in the near future.

4.1.1 A Comparison of 1984 and 1994 Conditions

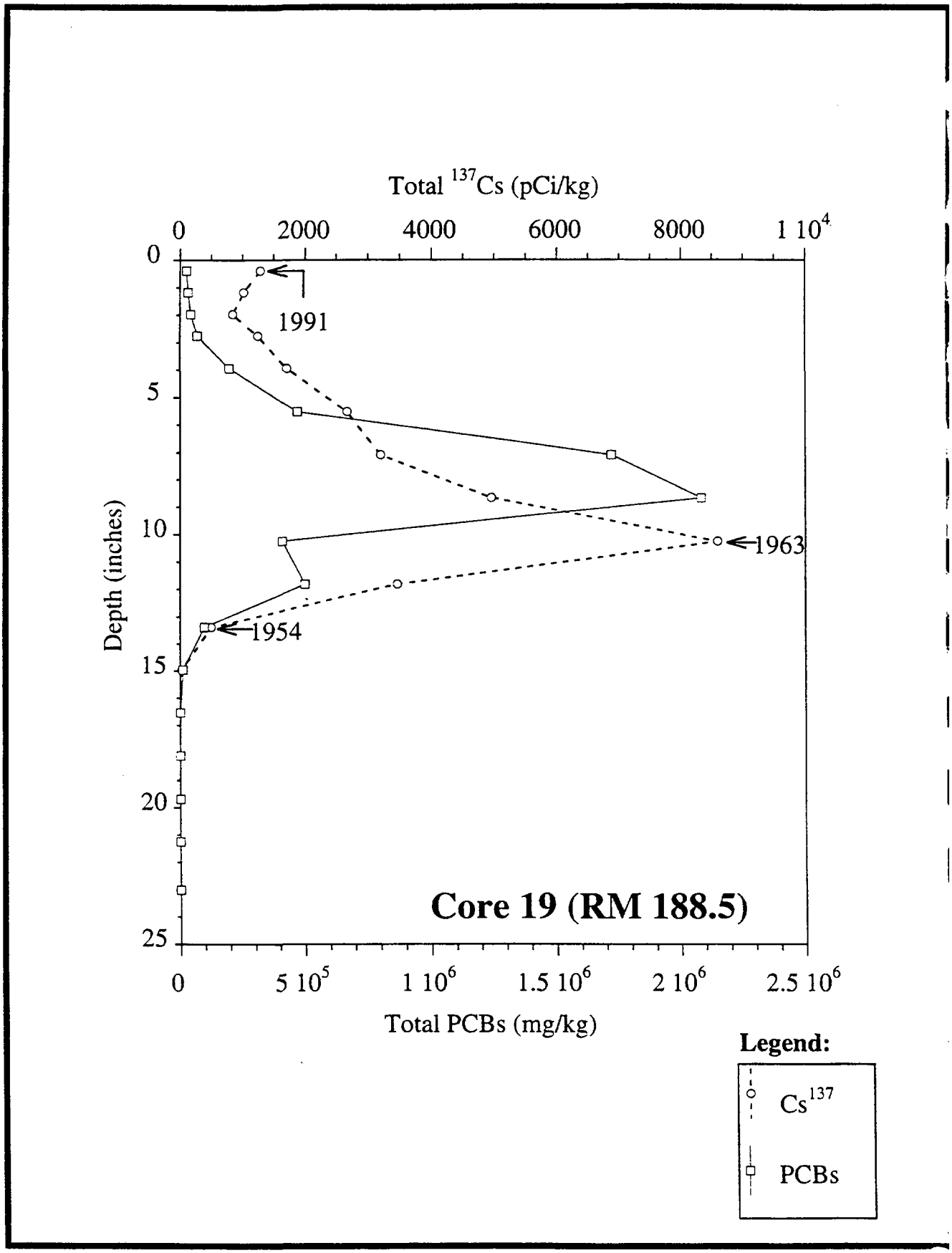
Corrections to Section 4.1.1 - A Comparison of 1984 and 1994 Conditions

Figure 4-2 has been revised to show the correct units of depth.

Figure 4-7 has been revised. The graphs are reversed to match the discussion in the text and the units have been corrected.

Response to LC-4.4

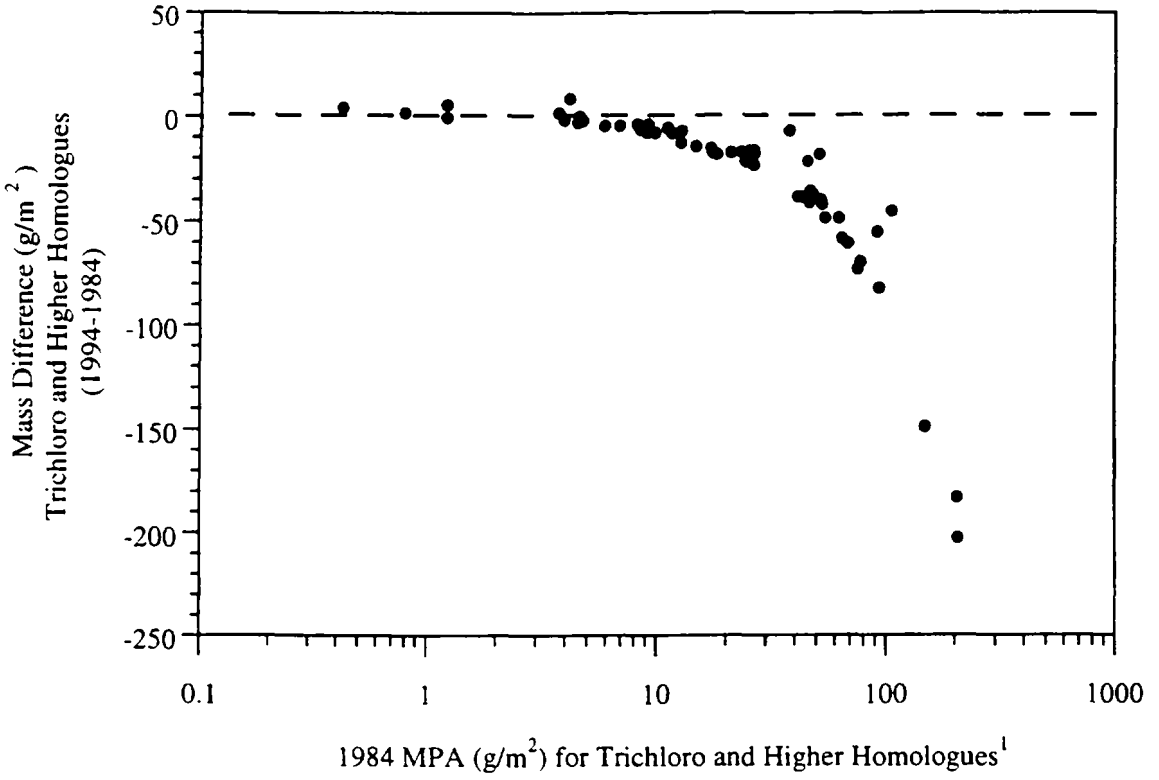
See response to comment LG-1.2, part 5 and LG-1.10.

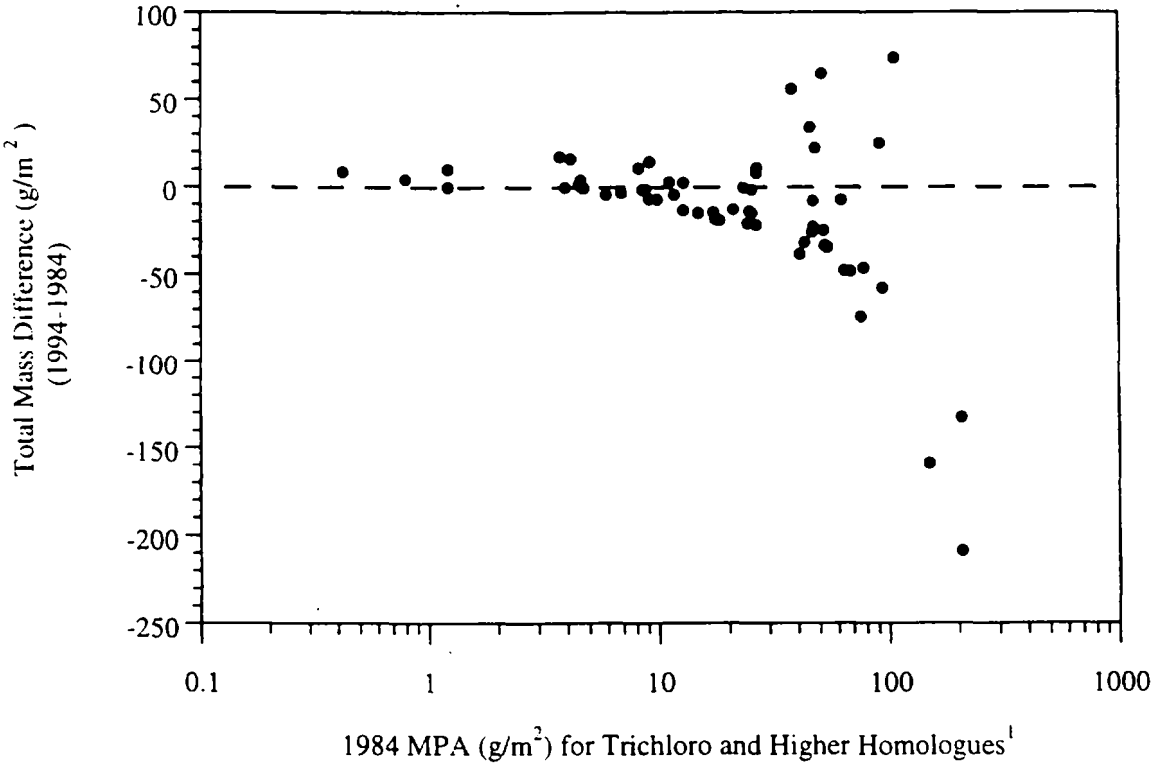


Source: TAMS/Gradient Database, Release 3.5

TA

Figure 4-2 (corrected)
High Resolution Core 19 from the TI Pool





Note:
1. See text for definition.

Source: TAMS/Gradient Database, Release 3.5

TAMS

Figure 4-7 (corrected)
1984 Trichloro and Higher Homologues as MPA vs Mass Difference Relative to 1994 - Log Scale

Response to LG-1.2A

As discussed in the Response to LG-1.2, the USEPA investigation focused on areas of local homogeneity in PCB contamination to establish the degree of change during the period 1984 to 1994. It is clear from the semivariogram analysis presented in the DEIR (*see* Section 4.2.4 of the DEIR and part 4 of response LG-1.2) that GE selected an unsuitable area (area H7) of the TI Pool to study the spatial relationship in sediment PCB contamination, as documented by both their study and the NYSDEC 1984 survey. In addition to largely avoiding this area of the Pool in the 1994, the USEPA low resolution coring program also took care to select clusters of coring sites with relatively minor variation in total PCB mass per unit area and sediment texture based on the NYSDEC 1984 survey. Lastly, the statistical tests employed confirm the significance of the changes measured. If the data set was insufficient or its uncertainty too great, the statistical tests would have yielded no statistical significance to the differences calculated.

Response to LL-1.13

USEPA acknowledges the error in the LRC figure. This correction has been noted in the Corrections to Section 4.1.1 of the Low Resolution Sediment Coring Report. *See* Response LL-1.6 and LL-1.7.

Response to LL-1.14

See responses to comments LG-1.9 and LG-1.10. Since only four sampling locations pairs were separated by more than eight feet, the table requested is not necessary, and will not provide a useful comparison and is not included here.

Response to LL-1.15

USEPA acknowledges the error in this LRC figure. This correction has been noted in the Corrections to Section 4.1.1 of the Low Resolution Sediment Coring Report.

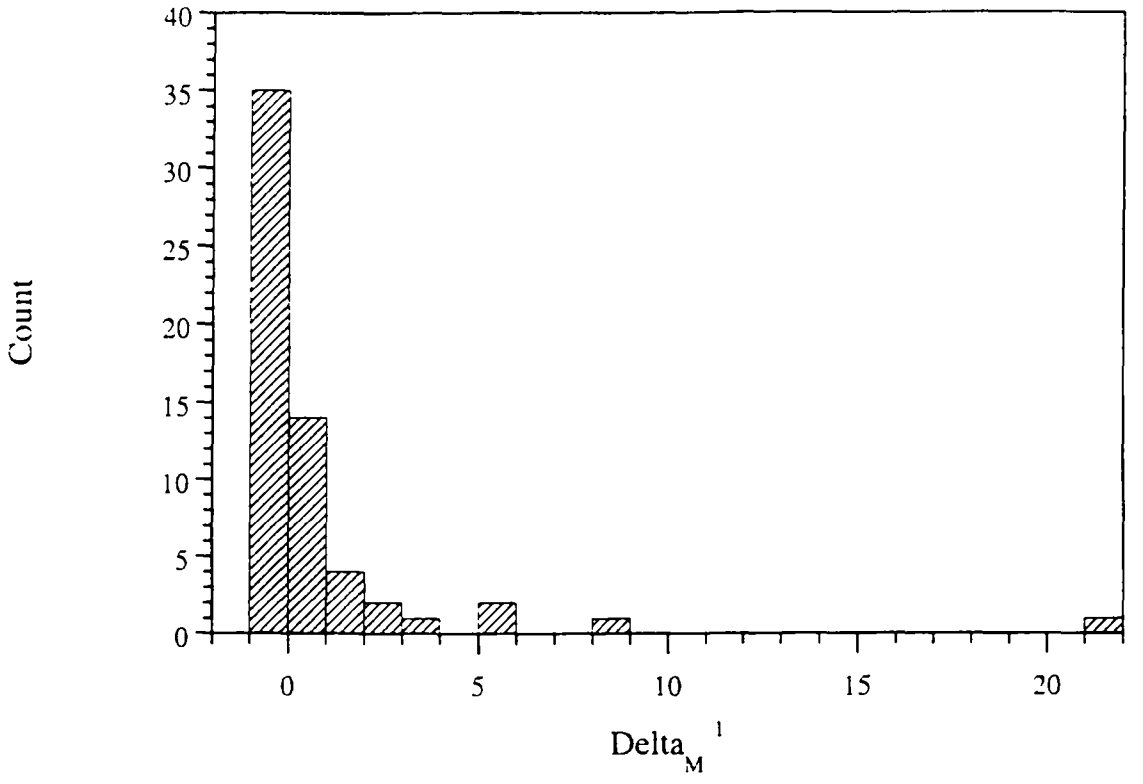
4.1.2 Assessment of Sediment Inventory Change Based on the Original 1984 ∑Tri+ Sediment Inventory

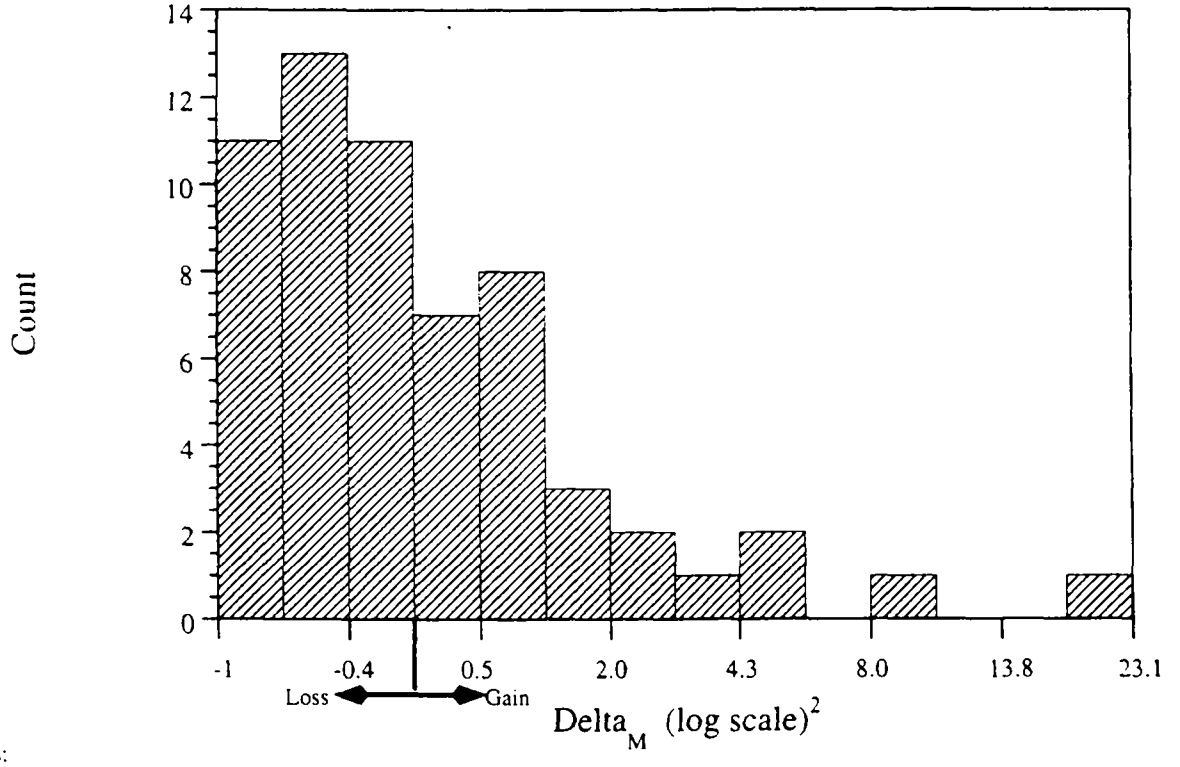
Correction to Section 4.1.2

The x axis on the lower diagram in Figure 4-10 was corrected to show the correct values and units. It is included in this report.

Response to LC-4.5

The 1984 to 1994 TI Pool inventory comparison used a common quantitation basis of trichloro and higher homologues. *See* Appendix E of the LRC for a discussion of the 1984 quantitation and translation scheme implemented in the LRC analysis. *See* also Response LG-1.11.





Notes:

1. See text for definition of Delta$_M$
2. The value of 2 is added to Delta$_M$ prior to taking the logarithm of the value in order to translate the distribution away from zero and negative numbers which do not have defined logarithm values. The scale is the actual Delta value and not the log.

Source: TAMS/Gradient Database, Release 3.5

TAMS/Tetra Tech

Figure 4-10 (corrected)
Distribution of the Percent Change in PCB Molar Inventory (Delta$_M$)

Response to LC-4.6

The value of 73 percent loss of Tri+ PCBs is based on GE's calculation and not the USEPA's. It is based on the assumption of a log normal distribution of the parameter $Delta_M$. The use of the $Delta_M$ function to estimate the mean degree of inventory change in this manner is not appropriate since the function is highly skewed and neither normally nor log-normally distributed. Its use in the LRC is appropriate since the analysis there was focused on detecting real change. However, the average degree of change predicted by the $Delta_M$ function is not considered accurate and was not reported in the LRC. To better address this issue, a ratio estimator whose statistical properties are much better defined was used to estimate the average mass loss for the fine-grained sediments of the Pool. This is presented in Appendix A of this Responsiveness Summary.

Response to LG-1.4A

The Executive Summary of the LRC should have noted that the loss estimate represents the median mass loss from the sediments. The intention of the program was to test whether the sediment loss or gain was occurring and whether this change was statistically significant. The writer should note that there has been much made of the scenario wherein "dirty," contaminated sediments are being overlain and "buried" by "clean" sediments. In light of the revelations concerning the leaking GE facilities at Hudson Falls, it is unlikely that any "clean" sediments have been deposited in the Upper Hudson in the last 20 years. Indeed this is verified by the high resolution cores which show the continued contamination of recently deposited sediments. Nonetheless it is still possible that "cleaner" sediments still serve to sequester more contaminated ones if the more contaminated areas are being overlain with these materials. However, in this instance, sediment inventories (*i.e.,* PCB mass-per-unit-area) should increase since additional sediment, even if it is less contaminated than sediments that were deposited earlier, will add additional PCB mass. At the same time, previously deposited sediments would be isolated from the water column, thus isolating and securing their PCB inventory. In the low resolution coring analysis, the loss of PCB inventory was found to be statistically different from zero, thereby rejecting the premise that the sediments had either gained PCBs or had simply stayed the same. The results showed a statistically significant loss, effectively discrediting the burial scenario and demonstrating the absence of TI Pool-wide sediment burial and sequestering.

Response to LG-1.4B

In the discussions contained in the LRC, comparisons were made among several different interpretations of the analytical results. Total PCBs estimates, the sum of trichlorinated and higher homologues, and the sum of trichlorinated and higher homologues plus the five dechlorination product congeners (BZ#1, 4, 8, 10 and 19), were compared in various ways. The purpose of the various comparisons was to simply demonstrate that regardless of which assumption was used concerning the quantitation of the 1984 data set, the same major conclusion was obtained, *i.e.,* there has been a significant net loss of PCB inventory from the sediments despite the evidence for continual input from GE sources upstream. Presumably this loss has released PCBs to the overlying water column and sediments elsewhere in the river. In fact, the Report focuses on the sum of trichlorinated and higher homologues plus the five dechlorination product congeners (BZ#1, 4, 8, 10 and 19), which provides a minimum PCB mass loss estimate. The writer is referred to pages 4-10 to 4-12 of the LRC which discuss in detail the construction of the PCB inventory estimates. As

stated in the Report, the comparison of this sum for the 1994 samples to the sum of trichlorinated and higher homologues in 1984 conservatively assumes that all dechlorination occurred post-1984. A recent study performed by at Rensselaer Polytechnic Institute (McNulty, 1997) developed an *in situ* dechlorination rate for sediments deposited prior to 1984. A revised calculation is included in Appendix A of this Responsiveness Summary, which includes a dechlorination rate derived from McNulty's work.

With regard to the estimation of the actual PCB mass represented by the 1984 measurements, the USEPA believes that the discussion presented in Appendix E of the LRC is the best current basis for these data. Nonetheless, the analysis in LRC Appendix E is based on GE's attempt to reproduce the NYSDEC 1984 technique and as such does not represent proof that this interpretation is correct. Thus, it was important to examine other possible interpretations to show that regardless of the basis used, the 1984 inventory has substantively declined.

Response to LG-1.4C

The writer's contention that 10.8 metric tons have left the TI Pool is incorrect. Specifically, the mass loss calculated for the TI Pool is attributed to the fine-grained sediments, which represent about 8.7 metric tons of PCBs, or about 60 percent of the TI Pool inventory. This estimate is discussed in detail in Appendix A of this Responsiveness Summary. More importantly, the USEPA does not contend that all PCBs lost from the fine-grained sediments have left the TI Pool but simply that they have left the fine-grained sediments. As noted in the LRC, the area of the Pool characterized by coarser sediments appears to have seen an apparent gain in PCB inventory, probably in part due to the redistribution of PCBs from the more contaminated fine-grained sediments.

The writer's contention also assumes that no dechlorination occurs between 1984 and 1994. This is the opposite assumption from that used in the LRC (*i.e.*, the LRC assumes that no dechlorination occurs prior to 1984 and that all dechlorinated congeners present in 1994 were produced between 1984 and 1994). The writer's assumption yields an upper bound on the amount of PCBs lost from the sediment (rather than the lower bound estimated by the USEPA's calculation). While the USEPA believes that dechlorination largely ceases a few years after deposition, there is some evidence to suggest that it does continue at a slow rate after PCB-contaminated sediments have been in place for about one year (McNulty, 1997). *See* also the discussion in Appendix A of this Responsiveness Summary.

Response to LG-1.4E

The 80 percent mass loss is a number constructed by the writer and does not represent the USEPA's estimate of the true mass loss from either the Pool or even from the fine-grained sediments. The data set referenced by the writer (consisting of only 12 points) is probably too small to make the comparison concerning the rate of mass loss over time between 1994 and 1998. However, as is evident from Figure 13 in the writer's commentary, both the 1994 and 1998 inventory estimates are substantially lower than the 1984 inventory, again confirming the finding that the fine-grained sediments have lost substantial mass since 1984. The writer is also referred to response LG-1.14 for further discussion.

Response to LG-1.5E

The USEPA acknowledges that a better understanding of the mechanisms responsible for the mass losses estimated in the Low Resolution Sediment Coring Report would be useful. The writer's contention that modeled mechanisms can only yield an 18 percent mass loss does not provide a constraint on the actual mass loss since it is not known whether all mechanisms are represented or correctly modeled. However, it is not necessary that these mechanisms be understood in order for the measured difference to be considered valid. More importantly, it is essential to integrate the net change in sediment inventory caused by the assortment of mechanisms, so that the nature and scale of these mechanisms can be constrained. The mechanisms discussed by the writer are not known in sufficient detail or magnitude to provide their own constraints in the absence of data on sediment losses or gains. The suggestion of erosion as the sole source of these mass losses is strictly the writer's conclusion and not the position of the USEPA. It is the USEPA's contention that there are probably several mechanisms, working separately or in conjunction with each other, which are responsible for the measured mass loss. Finally, the limited number of cores presented by GE is too small a set to provide useful constraints on the USEPA data set. Additionally, as noted in Response LG-1.7, both the GE and USEPA data show a marked decline in the PCB inventory relative to the 1984 study.

Response to LG-1.11

Several comparisons were made between the 1984 and 1994 measurements based on different assumptions about the reported values in 1984 and the likely processes affecting the sediment PCB inventory. These include the following:

1. Total PCBs in 1994 *vs.* Total PCBs in 1984
2. Total PCBs in 1994 *vs.* sum of trichlorinated and higher homologues (Tri+) in 1984
3. Sum of trichlorinated and higher homologues (Tri+) in 1994 *vs.* sum of trichlorinated and higher homologues (Tri+) in 1984
4. Sum of trichlorinated and higher homologues (Tri+) plus 5 specific dechlorination congeners (BZ#1, 4, 8, 10 and 19) in 1994 *vs.* sum of trichlorinated and higher homologues (Tri+) in 1984

The detailed discussion of these choices and how they were developed is discussed in Section 4.1 of the LRC. Only comparisons 2 and 4 were used to quantitate the change in sediment inventory. With regard to comparison 2 (the writer's issue) this comparison demonstrates that a mass loss is evident even when all PCBs present in 1994 are considered. Ultimately, these choices were made to demonstrate that no matter what assumptions are made about the 1984 data set, the direction of change in the TI Pool sediment PCB inventory is found to be the same, *i.e.*, loss. By focusing on the fourth comparison listed above, the analysis presents a minimum estimate of PCB loss from the sediments. By showing that this comparison yields a statistically significant loss, it can be assured that an actual, substantive loss has taken place and that the hypothesized sediment burial scenario proposed by GE can be rejected. This loss combined with that obtained from examining the degree of dechlorination yielded the 40 percent mass loss discussed in the Report.

The USEPA agrees with the writer that the Tri+ estimate is probably the best representation of the 1984 data, which is why it was used for the most rigorous comparisons in the Report.

Nonetheless, the analyses presented in the LRC demonstrate that the direction of change in the TI Pool inventory is the same regardless of the interpretation of the 1984 results as Tri+ or Total PCBs.

See also responses LG-1.4B and LG-1.12 as well as Appendix A of this Responsiveness Summary for related discussions of this issue.

Response to LG-1.13

The USEPA uses all points to evaluate change. The data were simply separated into two groups based on the original 1984 inventory. The group less than 10 g/m^2 yielded mass gain while the groups greater than 10 g/m^2 yielded mass loss. The mass loss estimated by the point-to-point comparison was confirmed by an area-based analysis. This is presented in Appendix A of this Responsiveness Summary. This analysis yielded a net mass loss of 43 percent excluding dechlorination losses. The purpose of the comparisons made in the LRC was to examine 1994 conditions relative to 1984 conditions and not the validity of the 1978 *hot spot* designations. Therefore the probability plots developed by the writer are not appropriate to define the sample groups for comparison, *i.e.* the type of sediments characterized.

The USEPA indicated that locations greater than 10 g/m^2 were typical of *hot spots*. However, our classification was not based on this designation and yielded, more directly, that more contaminated sediments lost mass while less contaminated sedimentary have gained mass. The issue of *hot spot* boundaries is immaterial to this calculation since *hot spot* boundaries were not used. Nonetheless, if the criteria is decreased to 5 g/m^2, a statistically significant loss for sediments greater than 5 g/m^2 is still obtained. As discussed elsewhere in the responses, the USEPA rejects the premise that some of the sample pairs should be rejected because of separation distance (*See* LG-1.9). The calculation of the Tri+ difference alone as suggested by the writer assumes no dechlorination loss and so represents a kind of upper bound on the degree of mass loss. This mass loss calculation is presented in LG-1.12.

Response to LG-1.14

The comparison of the Tri+ values for 1984 and 1994 as promoted by the writer assumes no dechlorination loss occurs over the 10 year period, resulting in an overestimate of the Tri+ mass loss. Dechlorination rates for PCB-contaminated sediments have been documented by McNulty (1997) and shown to be low though not negligible. In addition, as calculated in response LG-1.12, the mass loss of Tri+ based on the molar change would be 70 percent, not 80 percent as suggested by the writer. However, as recommended by the writer, an area-based mass loss estimate was completed as well. The analysis is summarized in Appendix A of this Responsiveness Summary. The result of the analysis yielded a mass loss of 43 percent, excluding dechlorination losses, and is again applicable only to the fine-grained sediment areas. The mass loss estimate would not apply to the entire TI Pool inventory as incorrectly inferred by the writer. USEPA integration of the fine-grained sediments indicates that about 8.7 metric tons are found in these areas assuming the 1984 values to represent Total PCBs (8.2 metric tons are obtained if the Tri+ assumption is applied; *see* Appendix B). The writer has incorrectly applied the mass loss to the 14.5 metric ton estimate given in the DEIR, representing the entire Pool inventory. The mass loss rate of 43 percent would yield a PCB inventory loss of 3.5 tons, but as stated elsewhere in these responses, not all of these PCBs would

necessarily leave the Pool. Some would be deposited elsewhere, presumably among the less contaminated sediments of the Pool. Thus the calculation as presented by the writer does not present an independent constraint on the degree of PCB loss and cannot be used to dismiss the USEPA mass loss estimates.

Response to LG-1.15

Fate and transport mechanisms do not provide sufficient independent constraints to disprove the mass loss estimates developed in the LRC. The need for an independent mass loss estimate for the purpose of fate and transport modeling was one of the main reasons for the low resolution coring program.

The estimation of dechlorination losses based on McNulty (1997) is presented in Appendix A of this Report. These results are summarized here. Essentially, McNulty shows that changes in the congener patterns of matched sediment layers between cores collected 8 years apart suggest dechlorination loss continues at a slow rate, after PCB-contaminated sediments have been in place for about one year. Dechlorination loss as indicated by the shift from trichloro and higher homologues to mono and dichlorinated homologues ranges from + 8.4 to -19.3 percent. The fact that some layers actually show positive shifts toward higher homologues is probably the result of analytical uncertainty. Nonetheless, the results can be used to estimate a net rate of 4.7 percent mass loss for the 8 year period. This is much lower than the estimate put forth by the writer. The writer has chosen a single layer (representing ~1968), the layer exhibiting the highest rate of dechlorination and clearly an outlying estimate for dechlorination throughout the core as a whole. Thus the writer's contention that dechlorination loss from 1984 to 1994 amounts to 12 percent is clearly an overestimate. This value is similar to that used in the LRC, in which the 11 percent dechlorination value was clearly identified as an overestimate but was used to construct the lower bound estimate of the actual molar loss from the sediments. In light the data presented by McNulty (1997), it is clear that this value is much too high and that the conclusions of the DEIR concerning dechlorination are correct, *i.e.,* the vast majority of dechlorination occurs soon after deposition with little modification after the first year. The writer's assertion that a 10 percent mass loss occurred over the ten-year period is also inconsistent with their assumptions regarding a Tri+ to Tri+ comparison. It should also be noted that the mass loss calculated by the writer is incorrectly applied to the entire Pool inventory instead of to the inventory of the fine-gained sediments only.

The writer also presents estimates of other mechanisms which are proposed to provide further constraint on the degree of mass loss. These other mechanisms are much more poorly constrained than dechlorination and are contingent upon knowing surficial conditions in all areas of the TI Pool, conditions which are not well defined. In addition, the processes of diffusion and groundwater transport are not well documented in the Upper Hudson. Modeling results suggest that flow-induced shear may not be sufficient to yield the PCB loss but little *in situ* data on the vertical mixing of sediments is available to constrain these models. Lastly, other potentially important mechanisms probably exist which are not addressed in the GE model. In particular, bioturbation, a process well documented in other systems, is not addressed and is capable of enhancing both resuspension and porewater exchange. Comments on the March, 1998 GE Report discuss these issues in greater detail.

These comments are provided as Book 3 of the Responsiveness Summary for Volumes A, B and C of the Phase 2 Report.

The writer also cites the water-column monitoring data collected by the USGS and GE as an additional constraint on the mass loss from the fine-grained sediments. It is emphasized here that the loss from these sediments is not inherently loss from the TI Pool. Re-deposition of some portion of the fine-grained sediment PCB losses are likely elsewhere in the Pool. Evidence to support this comes from the results of the less contaminated sediments (less than 10 g/m^2) as discussed in the LRC, which were indicated to have seen an inventory gain. Secondly, as acknowledged in Chapter 4 of the LRC, the magnitude of the change in inventory is relatively uncertain although definitely different from zero and so cannot be used as a criterion for dismissal of the conclusion of mass loss from Pool sediments.

Finally, model mechanisms as currently understood do not provide a basis for the dismissal of the measured estimate of PCB mass loss because of the uncertainties involved. Failure of the model to match the estimated loss may be because the GE model simply does not accurately depict the system.

Response to LG-1.16

The USEPA did not estimate a 10.8 metric ton PCB loss from the TI Pool, as asserted by the writer. Even assuming that the entire mass loss from the fine-grained sediments left the Pool (an unlikely prospect as discussed in LG-1.15) at the rate calculated in the LRC (30 percent mass loss) or as revised in LRC Appendix A and in response LG-1.12 (43 percent mass loss), the mass transport rate would be much smaller. Using the 8.2 metric ton estimate for the trichlorinated and higher homologue inventory of the fine-grained sediments as provided in Appendix B of this Responsiveness Summary, the mass loss from these sediments would be 3.5 metric tons as trichlorinated and higher homologues. Even if this entire loss were to leave the Pool (unlikely as described above), the average transport rate would be 2.1 lb/day (1 kg/day), which is well within the range of values obtained by the USGS and GE.

It should also be noted that the USEPA does not accept the GE estimates for PCB mass transport, which are developed on the basis of a rating curve. The calculation techniques and load estimates developed in the DEIR (USEPA, 1997) should be applied instead.

The comment also makes several other statements or inferences which require correction. Specifically, the USGS used a packed column procedure to measure PCB concentrations only until 1987 after which the procedure was switched to a capillary column procedure. Also, the USGS record at Schuylerville (sometimes used as a surrogate for the TI Dam concentration) only extends to 1989 and not 1991 as indicated by the writer. USGS stations further downstream are quite distant (at least 13 miles) and cannot be directly used in place of this monitoring station as a measure of the TI Pool load due to the potential occurrence of PCB loss or gain in the intervening river section.

Response to LG-1.17

The comparison made between the USEPA and GE sediment inventories is based on an assumption of a constant (linear) rate of mass loss between 1984 and 1994. This is an unlikely

prospect since mass loss is typically driven by concentration gradients, which would have been much higher in the earlier portion of the 10 year period. An exponentially declining release rate is much more likely. It should also be noted that the GE data set described in this comment was not available for USEPA review at the time of the preparation of these responses, thereby limiting the ability of the USEPA to respond to these comments.

Response to LG-1.17A

The data set used by GE for this comparison was clearly quite small (12 locations) and insufficient to estimate differences between 1994 and 1998. No data are provided to assess GE sample reproducibility nor is any other uncertainty analysis presented. It should be noted, however, that both data sets show a substantial loss relative to the 1984 inventory, as shown in Figure 13 of the GE comments. The contention that mass loss should occur continuously between 1984 to the present from all areas of the Pool is simply incorrect and represents a significant oversimplification of the issue. The LRC demonstrated that some areas gain while others lose but that the overall trend was downward.

Response to LG-1.17B

The contention of low fish body burdens in 1997 is based on a limited sample set collected by GE and not by NYSDEC. This data set may not be directly comparable to earlier NYSDEC data. The USEPA will evaluate the 1997 NYSDEC fish data when it becomes available.

With regard to the other issues raised by the writer, the PCB loss rate is unlikely to be linear, as discussed in LG-1.17A, therefore extrapolating a linear decline scenario to present conditions is largely a useless exercise. The declines in fish body burdens are consistent with a sediment loss scenario which is non-linear, such as an exponential decline. Both the measured fish body burden decline seen from the 1984 to 1996 and the measured sediment inventory decline are consistent with the major losses from the sediments occurring in the early 1980's and a subsequent decline in the sediment PCB loss rate, yielding proportionately lower levels in fish. Fish body burdens, although they have responded to the recent release events from the Hudson Falls facility, still suggest an underlying source since they have declined only slightly relative to the late 1980's. These results indicate that food chain derived PCBs as well as PCBs from on-going sediment release will serve to sustain fish body burdens for the foreseeable future.

The limited GE data also represent a different time of year than most of the previous NYSDEC sampling and therefore may not be directly comparable. Thus it is inappropriate to speculate on the nature of the 1997 fish body burdens until they are released by the State. The GE data do not represent an extensive survey nor have they been shown to match the NYSDEC data on a quantitative basis. With regard to the recent decline in fish body burdens, it is important to note that as of 1996, fish body burdens were at or just slightly below the fish levels measured in 1989, two years prior to the major release event. Thus the fish body burden "recovery" alleged by GE largely represents a return to the river conditions which prompted the initiation of the Hudson River Reassessment in 1990.

The USEPA also notes in the few diagrams provided by GE concerning their 1998 sediment collection (the data were not received in sufficient time for review prior to the preparation of these responses) that the surface sediment layers show no substantive decline in the top 5 cm despite the controls put in place at the Hudson Falls facility during the last few years. These preliminary results indicate either the absence of recent deposition at these sites or else the deposition of re-released PCBs originating from other sediments.

Response to LG-1.19A

The figure presented does not suggest a linear increase in water column load across the TI Pool and in fact suggests several points where PCB load increases markedly (*e.g.*, RM 192.5 and 190). Nonetheless, the distribution of *hot spots* and fine-grained sediments is such that if these areas were the main sources, then the river PCB load might increase somewhat linearly as well. In fact, float survey data not presented by the writer shows substantially higher concentrations (some greater than 200 ng/L) in the near-shore environments relative to the main channel, suggesting enhanced PCB transfer in these areas. These areas have substantial levels of biological activity which may enhance PCB transfer and help to create the strong seasonal variation seen in the more recent monitoring data. It is entirely possible that water column loads from the TI Pool are produced from near-shore fine-grained sediments and simply mixed into the main channel flow. This would potentially explain the discontinuities in the main channel loads as the River's passage through the Pool is directed by river bends and narrows which force horizontal mixing. Even under low flow conditions, water within the Pool is in motion, serving to homogenize concentrations. Thus the contention that the float survey data indicate that the TI Pool load is produced in a uniform areal manner is not inherently supported by the data. Additional evidence for enhanced release in the near-shore environment comes from the TI Dam monitoring station maintained by GE which sometimes shows substantially higher PCB concentrations relative to the main channel, indicative of incomplete mixing of loads produced in the near-shore area with the main channel. These loads also show enhanced concentrations of lighter congeners as might be expected from more concentrated and subsequently more dechlorinated PCB inventories. Much of the writer's contention in this comment is based on assumptions made in the construction of GE's PCB transport model which likely has significant flaws. (*See* Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C).

Response to LG-1.19B

This comment is addressed as part of the critique of the GE Model Report contained in Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C of the Phase 2 Report. A portion of the USEPA critique (Section 5) is repeated here.

> ...(GE)/QEA implicitly sets up the hypothesis that known mechanisms of flux from "old" *hot spot* sediments in the TIP (considered to be hydrodynamic erosion, diffusion, and pore water advection) are not sufficient to account for the "anomalous" TIP load. Therefore, additional mechanisms are needed to provide a newer, enhanced PCB load to surficial sediments in the TIP. Three additional mechanisms are postulated:

1. PCB DNAPL loading in bedload along the sediment-water interface
2. Pulse loading of PCBs due to periodic flooding of the Baker Falls plunge pool
3. Transport of oil-soaked sediment into the TIP at the time of the Allen Mill collapse.

As an implied result of these "additional mechanisms", GE/QEA claims that organic-carbon normalized PCB surface sediment concentrations are similar across the TIP, and that these active sediment concentrations are disconnected from buried *hot spots*...

...QEA (1998, Table 4-6) presents information showing that mean PCB concentration in surface sediments, when normalized to organic carbon concentration, is similar in the *hot spot* and non-*hot spot* areas, and is similar for fine and coarse sediment. They then state (p. 48): "The flux of PCBs from surface sediments to the water column depends on the organic carbon normalized PCB concentration... Regions of the river with equal surface sediment organic carbon normalized PCB concentrations and composition contribute equally to the water column PCB load."

This argument is flawed. Suppose PCB concentrations on organic carbon are everywhere the same, but location A has a high weight percent of organic carbon, while location B has almost no organic carbon. Obviously, location A has a much greater mass of PCBs per volume of sediment and is likely to contribute more PCB load to the water column, even if similar pore water concentrations are calculated for each location under equilibrium conditions. What QEA's argument primarily reflects is that *hot spot* areas are "hot" because they have more fine-grained sediment with high organic carbon concentrations.

QEA's argument is invalid for any source mechanisms that involve bulk sediment movement (scour, bioturbation, etc.), and only partly valid for consideration of a purely pore water source from sediments. It is true that equilibrium partitioning assumptions imply that the observed apparent pore water concentration, $C_{PW,a}$, (including both dissolved and colloidally-sorbed PCBs) should be proportional to the organic-carbon normalized PCB concentration, but this is not the only factor. Rearranging Equation (3-29; USEPA, 1997) yields:

$$C_{PW,a} = \left(\frac{C_P}{f_{OC}} \right) \frac{\theta(1 + m_{DOC} K_{DOC})}{K_{OC}}$$

where C_P is the particulate concentration,
θ is the saturated porosity,
m_{DOC} is the mass of DOC per volume of pore water,
K_{DOC} is the partition coefficient to dissolved organic carbon, and
K_{OC} is the partition coefficient to sediment organic carbon.

Inspection of this equation shows that the apparent pore water concentration depends not just on the organic-carbon normalized sediment concentration but also on θ and m_{DOC}. As both porosity and the concentration of dissolved organic carbon tend to increase in fine-grained, organic sediments, the pore water concentration should also be higher in *hot spot* areas.

Analysis of the 1991 GE data from the 0-5 cm layer in the TIP reveals wide ranges in TOC concentration (from 4,961 to 69,474 ppm) and in porosity (from 16 to 70 percent). With a few exceptions, TOC concentration increases with porosity (*see* Figure LG-1.19B). This correlation indicates that inferences of pore water source strength cannot be based on organic carbon normalized PCB concentrations alone.

In Phase 2 results (USEPA, 1997, p. 4-20) it was noted that "locations with...finer-grained sediments have consistently higher median and mean PCB levels." The 1984 NYSDEC data also show a strong relationship between sediment texture class and total PCB concentration, with the highest concentrations in the finest grained sediments. Table [LG-1.19B] shows the averages of NYSDEC top core section and grab sample results for the near-surface layer. These results show a clear increase in average PCB concentration for sediments with finer texture and higher organic content. Results are similar for sample medians, except in the case of sediments classified as clay. A portion of these samples are believed to include intact, uncontaminated glacial clays. In any case, it appears clear that it is inappropriate to compare sediment concentrations as a source of pore water flux unless both organic carbon fraction and porosity are taken into account.

It should be noted that it is reasonable to expect a smoothing out of surface concentrations relative to buried *hot spot* concentrations. However, such a general smoothing of surface sediment concentrations does not indicate that the surface PCB inventory is unconnected to buried *hot spots*. PCBs introduced into the water column by erosion or other disturbance of bulk sediment would be subject to local-scale settling, spreading concentrations. Some settling may also occur of PCBs loaded to the water column via pore water advection, following partitioning to solids in the water column, while lateral interflow could also "smear" the pore water signal.

Response to LG-1.22

USEPA cannot comment fully on these data, having only just received them prior to the completion of this Responsiveness Summary. However, the approach used by the writer is inherently flawed. Specifically, the approach assumes that the sediments responsible for the PCB load across the TI Pool during this event have a single congener pattern. This is highly unlikely given the broad range of mixtures present in the Pool. Instead, the PCB load generated by the river's passage through the Pool represents the integration of what is undoubtedly a broad range of sediment congener patterns whose net result is to produce the patterns seen at the TI Dam. It is likely that this mixture represents both recently deposited, fresh Aroclor-1242 like mixtures as well as recently exposed, older and more altered mixtures and recently re-released and redeposited older PCB mixtures. Various combinations of these mixtures are capable of yielding the mixture seen at the TI Dam. Nonetheless, the ratios selected by the writer do demonstrate that the passage through the Pool does

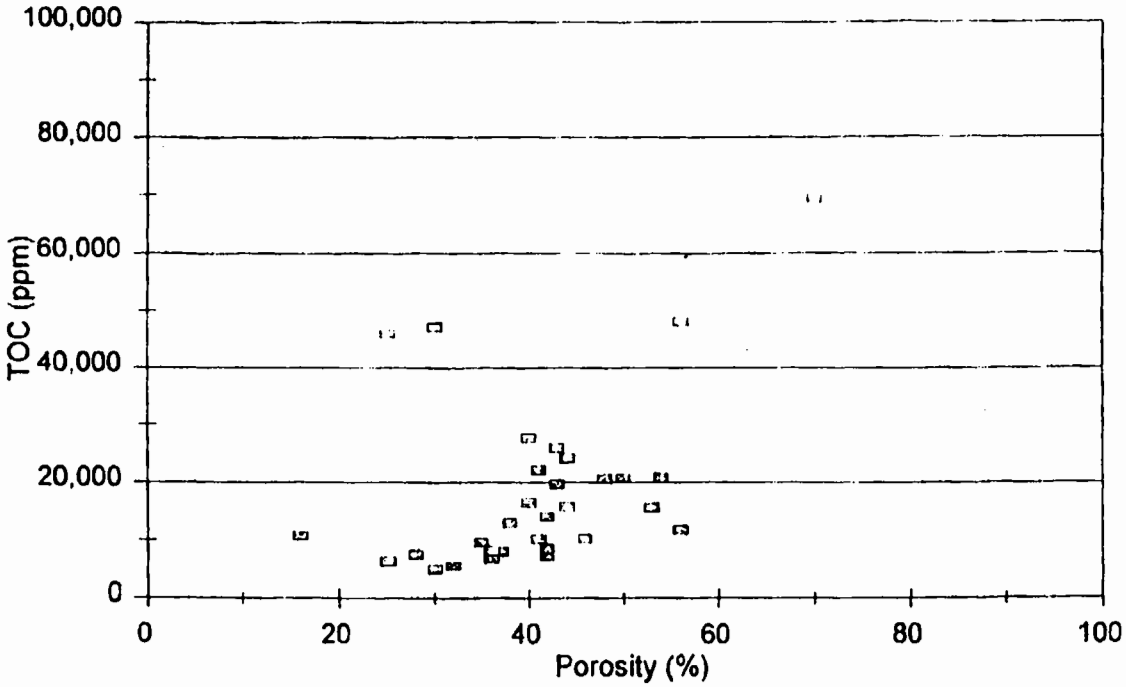


Figure LG-1.19B
Correlation of TOC Concentration and Porosity in TI Pool Surface Sediments

Table LG-1.19B
Surface PCB Concentrations in NYSDEC 1984 Data Compared to Texture Class

Texture Class	Interpretation	Average Total PCBs (mg/kg)	Median Total PCBs (mg/kg)	Median Specific Weight (g/cc)	Sample Count
FS-GRV	Fine sand and gravel	14.7	9.1	0.9	7
CS-WC	Coarse sand, wood chips	16.9	10.7	1.1	9
GRAVEL	Gravel	19.8	14.1	--	127
CS-SND	Coarse sand	25.0	13.8	1.25	22
GR-WC	Gravel, wood chips	29.9	29.3	--	19
FS-WC	Fine sand, wood chips	47.3	25.7	0.9	79
CLAY	Clay	54.9	6.7	1.0	10
FN-SND	Fine Sand	80.8	31.1	0.8	290
MUCK	Muck	121.1	103.8	0.5	14

markedly shift the congener spectrum to a more altered mixture as illustrated by a brief examination of the GE samples collected on Jan. 9, 1998.

Three samples collected on Jan. 9, 1998 were examined in terms of their molecular weight and Cl/BP to note the impact of the passage through the Pool as well as to Schuylerville. This information is summarized in Table LG-1.22. The data show a marked decline in the molecular weight from Rogers Island to points downstream.

The load at Rogers Island is particularly interesting since its ΔMW is negative (-0.06) relative to Aroclor 1242. This sample is notable as well in the near complete absence of monochloro- and dichloro-homologues. As EPA learned, GE was performing remedial work at the GE Hudson Falls Plant Site in the river near the pumphouse in January 1998. This work involved the removal of debris and sediment which contained high concentrations of PCBs. At the time GE performed sampling in the river, there was a high flow event occurring which could have mobilized PCBs from this area. Therefore it is highly likely that GE has captured a truly recent sediment deposit undergoing resuspension. In this scenario, nearly all of the lighter congeners have been lost in the deposition process, presumably via partitioning to the water column. It is likely that this sample represents the unaltered surface sediment GE has been attempting to find. It is interesting to note that this evidence has occurred upstream and <u>not</u> within the TI Pool.

The total load at the TI Dam has a ΔMW value of 0.08, representing about a 9 % mass loss by dechlorination. However, this represents the molecular weight of the total load. The change in this value from Rogers Island to the TI Dam is quite large, at 0.14. This indicates that the molecular weight of the net load is substantially lower than that of the total load. This in turn suggests that the net additional PCB load from the Pool to the water column during this high flow event was produced from sediments with an average ΔMW in the range of 0.1 to 0.2, since the ΔMW value rose so much during the passage through the Pool. Only if the entire PCB load entering the TI Pool from above Rogers Island is deposited within the TI Pool (an unlikely scenario based on the 1993 spring transect event), does the ΔMW of the sediment source approach that of the TI Dam load.

The transit from TI Dam to Schuylerville serves to raise the molecular weight somewhat and decrease the apparent level of dechlorination to a 5.8 percent mass loss. This may be accomplished in several ways, such as loss of the lightest congeners by gas exchange or resuspension of sediments less dechlorinated than those typical of the TI Pool. However, when examined with respect to the Rogers Island load, both the TI Dam and Schuylerville stations show major reductions in the molecular weight of the water column load, presumably by the scouring of sediments at 10 percent or higher dechlorination mass loss.

Based on this initial analysis, the data suggest that sediments dechlorinated to at least 9 percent mass loss (ΔMW greater than 0.08) are responsible for the changes seen. In reality the level of dechlorination may be much higher.

<u>Response to LG-1.28</u>

The USEPA is currently undertaking development of PCB fate-and-transport models to better understand the processes affecting PCBs. Nonetheless, it is data sets such as the one obtained for the LRC which provide the necessary constraints on the model and not the other way around. Simply

Table LG-1.22
An Examination of GE Monitoring Results for Jan. 9, 1998
Ft. Edward Flow at 34,300 cfs

Station	PCB Concentration ng/L	Flux at 34,300 cfs lb/day	Molar Concentration nmol/L	Mol. Weight g/mole	AMW Relative to A1242	Cl/BP	Theoretical Mass Loss by Dechlorination (%)
Rt. 197 Bridge (Rogers Island)	71	13	0.252	281.7	-0.06	3.70	
TI Dam West	142	26	0.581	244.6	0.08	2.63	9.2%
Schuylerville	253		1.001	252.4	0.05	2.85	5.8%
Aroclor 1242				265.7	0.00	3.24	

TAMS/Tetra Tech

being unable to explain a phenomenon does not inherently make the measurement of the phenomenon wrong or inaccurate. The LRC presents analyses which show statistically lower median inventories in the sediments of the Upper Hudson. Further analyses provided as part of this Responsiveness Summary improve on the calculations provided in the LRC and yield similar degrees of change for both median and mean mass loss from TI Pool sediments (56 and 43 percent loss, respectively). As stated elsewhere, the writer has incorrectly applied the original mass loss estimates to the entire Pool, as well as assumed that all lost PCBs have left the TI Pool instead of being at least partially redistributed elsewhere in the Pool. Ultimately, the major conclusion from the LRC is not the degree of absolute mass loss but rather that the fine-grained sediments of the Upper Hudson have only served as temporary storage for PCB contamination and that they have re-released much of their burden to the river.

See also LRC Appendix A which presents the statistical analysis described above.

Response to LG-1.38E

The statement referenced by the writer could have been more well written. This statement was not intended to represent an ad hoc basis for assigning significant differences but rather represents the end result of the statistical analyses performed earlier in the LRC. Specifically, the statistical analysis used in the *hot spot* comparisons completed earlier in the Report did not yield statistically significant differences, unless the 1976-1978 and the 1994 inventory estimates differed by a factor of 2. This is simply an observation based on the fact that the when the 1984 and 1994 geometric means were found to be statistically different, the arithmetic means differed by a factor of 2 or more. That is, the inventory had to be at least halved or doubled in order for the statistics to confirm the difference as significant. This can be seen in LRC Table 4-8. *Hot spot* areas whose arithmetic means differed less than a factor of 2 relative to the 1976-1978 inventory did not yield statistically significant differences. The minimum statistically significant difference relative to the 1976-1978 data was seen for *Hot Spot* 34, where the difference was almost exactly a factor of 2 (1976/950 = 2.1). Since all of the subsequent estimates for these *hot spots* were based on the same 1976-1978 data set, this observation provided a useful basis for evaluating the important differences between estimates.

Response to LG-1.38H

The value of 2 added to each of the $Delta_M$ values represents the minimum value required to permit the calculation of log values for all points. This addition does not modify the distribution but only shifts its center. Specifically, the addition creates a three-parameter log-normal distribution function, wherein the distribution is shifted but no change is made in its actual shape, i.e., there is no effect on the lower end characteristics nor on the distribution parameters. Only the log-transform affects the shape of the distribution, but this is a standard statistical practice when an underlying log-normal distribution is suspected. This is further discussed in Chapter 12 of Gilbert (1987). Although the USEPA believes that the $Delta_M$ function to be a useful one, there has been sufficient concern over its use that the USEPA has prepared an alternate approach. This approach is described Appendix A and utilizes a ratio estimate rather than a Delta estimate. *See* Appendix A for the ratio-based estimates of the sediment inventory changes.

Response to LG-1.38J

The USEPA agrees that it is useful to provide measures of uncertainty when presenting information, but it is not possible to display this information everywhere. Table 4-8 is already quite complicated as it is presented, and inclusion of further data would only worsen this problem. Instead the uncertainties are presented prior to the introduction of this table in Table 4-7. Previous estimates of sediment inventory did not provide rigorous measures of uncertainty which is why this information was reconstructed for the 1976-1978 data set in this Report.

Response to LG-1.40B

The sign test applied by the writer was performed on the most conservative estimates of mass loss. When such a comparison is made solely on the basis of the Tri+ inventory, such a test is likely to prove a statistical significance. More importantly, however, is the additional area-based analysis presented in Appendix A. This comparison is based on area-based means for the cluster areas of the 1994 sampling event, wherein the ratio of 1994 to 1984 inventories in mole/area is used as the regression variable. This provides a parameter which is well described by parametric statistics and is found to have statistically significant differences with respect to zero (no change) for both the median and mean estimates.

Response to LS-1.2

See response to comment LG-1.4A. *See* also Appendix A which provides a mean mass loss estimate and its associated uncertainty.

4.1.3 Assessment of Other Potentially Important Characteristics

Response to LL-1.16

From the last paragraph of Section 4.1.3 on p. 4-18:

> The data were also grouped based on a cohesive/noncohesive sediment classification developed by Limno-Tech and reported in the Preliminary Model Calibration Report (LTI, 1996). This classification was largely based on the side-scan sonar results. In this analysis, a general trend toward higher inventory losses was seen for cohesive relative to noncohesive sediment but it was only significant at the 90 percent confidence level.

This states that the 1994 cores show PCB loss relative to the 1984 samples which is greater in the fine-grained sampling areas than the coarse-grained sampling areas. No mechanism is proposed to account for this loss, because the USEPA program was not designed to unequivocally determine the means of PCB transport. The mechanisms need not be defined in order for the measured difference to be considered valid.

4.1.4 Implications of the Inventory Assessment

Response to LS-1.5

No response required.

4.2 Sediment Inventories of the Upper Hudson Below the Thompson Island Dam

Response to LC-2.1

See response to comment LG-1.38G.

Response to LG-1.12

The USEPA agrees with the writer that the arithmetic mean should be used to calculate the net changes when integrating over the entire Pool. Nonetheless, the 40 percent mass loss presented in the LCR does represent a useful value for comparison since it represents the median change in the sediments, *i.e.*, any individual location is likely to see a mass loss comparable to this level. However, the estimation of the mean mass loss from the function $Delta_M$ is not straight forward since the function is neither normally nor log-normally distributed. While the use of this function is appropriate for the testing of the direction and statistical significance of change, it is not the best function for the estimate of the scale of the mean loss. For this reason, the USEPA has prepared a separate analysis to estimate the magnitude of the mean change in inventory. This analysis is described in detail in Appendix A of this Responsiveness Summary. The approach and results are summarized below.

Based on the suggestions of several of the reviewers (including the writer), the USEPA has prepared a revised mass loss estimate, implementing four important changes. First, the estimate of mass loss is now based on an area-based comparison. This comparison reduced the number of data pairs available but also reduced some of the variability since the comparisons are now based on area averages and not point estimates. Second, the USEPA used an estimate of the dechlorination rate based on the work of McNulty (1997) rather than the upper bound (maximum possible) rate originally applied in the LRC. Third, no distinction was made based on the original 1984 inventory, *i.e.*, all sampling areas were considered in the examination without regard to the greater-than 10 g/m^2, less-than 10 g/m^2 classification previously used. Nonetheless, the results are still considered indicative of fine-grained sediments and not the entire Pool due to their locations along the sides of the river channel.

Lastly, the USEPA used a ratio rather than a Delta statistic to estimate the change in mass. Specifically, the ratio of the 1994 to 1984 sediment inventories is used as the variable in the statistics rather than the Delta function. This yields a statistically better "behaved" log-normal function as shown in Figure A-8 in Appendix A. In this instance, the ratio can be converted to a Delta value after the statistical calculations are applied by simply subtracting one from the ratio as shown below:

$$\Delta_M = \frac{1994\ MPA_{3.} - 1984\ MPA_{3.}}{1984\ MPA_{3.}}$$
$$= \frac{1994\ MPA_{3.}}{1984\ MPA_{3.}} - 1$$

In this manner, the ratio is tested for statistical significance relative to 1 (*i.e.*, log (0)) since this represents the absence of change (*i.e.*, 1984 =1994). The result is then converted to the Delta function afterwards. This avoids the creation of negative values prior to the log conversion. In the original analysis presented in the LRC, the creation of negative Delta values necessitated the addition of 2 prior to taking the log of the delta values in order that a log value could be defined for all delta values. This approach also avoids the creation of the asymmetric distribution characteristic of the delta function.

The end result of the revised calculation was to yield a mean mass loss of -45 percent including dechlorination. The 95 percent confidence interval about this value was -4 to -59 percent, thus excluding 0 and indicating that the change was statistically significant. The median mass loss as estimated by the geometric mean was -57 percent with a 95 percent confidence interval of -33 to -72 percent. These values represent the total mass losses from the sediment. Correcting for dechlorination loss yields only a minor decrease in the mean mass loss estimate, to -43 percent. The range about this estimate is +1 to -58 percent. (The fact that this uncertainty now includes zero is not considered important since the median mass loss is still statistically different from zero at -56 percent (range of -31 to -72 percent).) Thus the mean mass loss of -43 percent represents the mass loss from the sediment which is not the result of *in situ* dechlorination but rather represents the mass loss from the sediment to the water column of the TI Pool. Presumably some portion of this loss passes over the TI Dam while another portion is deposited at lower concentrations elsewhere in the Pool. The lower concentrations result from the mixing with less contaminated sediments in the water column and river bottom.

The results obtained in the analysis presented in Appendix A are comparable to the results originally reported in the LRC. Specifically, the median value of -56 percent (range of -31 to -72 percent) is within error of the value obtained for the molar loss of the trichlorinated and higher homologues of -28 percent (range of -2.9 to -50 percent). These values both represent the median losses from the sediment to the overlying water column. More importantly, both estimates show the statistical significance of the net sediment loss. On this basis, the hypothesis of simple burial and sequestering of contaminated sediments must be rejected, as discussed in the LRC.

Response to LG-1.38D

The USEPA agrees that a multivariate model would be interesting to complete, but it is largely peripheral to the main topic of mass loss. It has been demonstrated elsewhere (USEPA, 1997) that dechlorination is proportional to sediment PCB concentration. Therefore, the statement listed by the writer is not based on the analysis of the low resolution coring results and does not constitute a misinterpretation of the data. Other statements concerning the correlations of PCBs and ^{137}Cs are

based on the LRC analysis but have been demonstrated elsewhere as well. (Bopp and Simpson, 1989; USEPA, 1997).

Response to LG-1.38F

The purpose of the discussion in Section 4.3 of the LRC was simply to show that the estimate based on 1984 data could represent a significant underestimate if applied in a risk assessment. This 95 percent confidence limit value was all that was reported in the 1991 USEPA Phase 1 Report and so establishes the basis for comparison. The writer is correct in noting that the 95 percent confidence limit value is subject to a number of influences related to sampling. Nonetheless, the 95 percent confidence limit value provided in the Phase 1 Report still appears low, even with respect to the mean estimates reported on the line above in LRC Table 4-13. This table summarizes the results for shallow, near-shore sediments based on the 1984 and 1994 surveys. Based on this, the comparison is still appropriate and not misleading.

Response to LG-1.38G

A more detailed analysis of variance, while probably interesting, was not necessary to support the basic conclusions of the Report. Additionally, it is unlikely that sufficient information is available to accurately and completely represent all components of variance in each of the surveys utilized. This deficiency would then return the analysis to the original approach used here. That is, by the use of mean and standard error estimates, the analysis presented simply assumes that the various sources of variance are unbiased and that the total variance is reflected in the standard error estimates.

It should be noted, however, that the discussion of the semivariogram analysis in this comment is inaccurate. The upper portion of the TI Pool, *i.e.*, the area studied extensively by GE (H-7), is subject to very short-scale spatial variability. This is confirmed by analysis of both the NYSDEC 1984 and GE 1991 data sets from this region. However, in the areas of the TI Pool principally sampled during the low resolution sediment coring program, the short-scale spatial variability is substantially lower than the total variability observed between widely-separated locations. Thus, the writer over-states the actual uncertainty of the data. This is further discussed in response LG-1.9.

Response to LG-1.40C

The analyses presented in the LRC were never intended to be exclusively statistical analyses. Indeed, statistics are simply tools with which to test hypotheses and do not represent an end in themselves. Knowledge of the geochemical processes which can affect PCB inventories, as well as the history of PCB release and transport, is essential before undertaking any statistical tests. These tests simply provide numerical support for the apparent geochemical changes which have occurred over time. The examples listed by the writer represent the geochemical processes which form the hypotheses for subsequent statistical testing and analysis. Without the prior geochemical knowledge to propose these hypotheses, there would be little purpose to perform any statistical analyses. Ultimately, it is the knowledge of PCB geochemical fate and transport, supported by the data collected and subsequently tested with appropriate statistics, which provide the basis for the

conclusions drawn in the Report. It is the combination of these components which make the conclusions of the LRC most defensible.

4.2.1 Calculation of the Length-Weighted Average Concentration (LWA) and Mass Per Unit Area (MPA) for Sediment Samples Below the TI Dam

Response to LG-1.34

The criticism raised by the writer is a valid one but given the data available, there was no other basis to establish the sediment density. The USEPA was aware of this issue at the time of the preparation of the Report. As a result, the length-weighted average concentrations were also compared between the 1976-1978 and the 1994 surveys. These values do not require solid-specific weight and provide an alternate basis for comparison. The comparisons of the 1976-1978 to 1994 length-weighted averages yielded similar results to those obtained for the mass-per-unit-area comparisons.

Response to LG-1.35

The issue of various analytical techniques was discussed at length in Appendix E of the LRC. It certainly would have been preferable to be able to run the techniques on identical samples, but the descriptions of the historical techniques are less than complete so that reconstruction of the original techniques is difficult. Reconciliation was addressed to some degree by a series of samples collected by GE in 1991 and 1992 which form part of the discussion in Appendix E.

Response to LG-1.36

This issue was addressed in the previous Reports dealing with the 1976-1978 data sets. The analysis in the Report relies on the relationships developed in Malcolm-Pirnie, 1992. Figure 4-23 of the LRC is derived from the Malcolm-Pirnie Report and shows the relationship to be unbiased although the extrapolation of grab samples to depth adds additional uncertainty relative to the core-based inventory estimates. This issue, as well as that discussed in LG-1.35, add uncertainty to the individual *hot spot* PCB inventory estimates. Nonetheless, given the magnitude of change found for several of the *hot spots*, it is unlikely that main conclusion for Section 4.2 will be directly affected. That is, the sediment PCB inventories of the Upper Hudson below the TI Dam are not static zones simply undergoing burial but are instead subject to various processes which serve to re-release the PCB contamination originally stored there.

Response to LL-1.17

As stated on p. 4-21 of the LRC, the 1994 length-weighted average concentrations for the 0-12" interval were calculated, "For the 1994 data when the top-most segment ended above the 12-inch mark (*e.g.*, a nine-inch top segment), the remaining inches were included in an LWA by using the concentration of the next deepest layer for just the needed inches. When the top-most segment was greater than or equal to 12-inches, the reported concentration for the segment was used without modification." A last condition, which was not mentioned in the text, is that if the concentration of the second layer dropped below 10% of the top layer, the LWA was set equal to the top layer concentration. A review of the 1977-76 LWA concentrations indicates that the second layer was

nearly always used if the top-most layer was less than 12-inches thick. Both data sets are subject to the same affect of dilution if the inventory is unchanged. It is unlikely that this approach badly underestimates the LWA since the PCB maxima were typically found in the uppermost core segment.

See response to comment LG-1.8 for a discussion of the inclusion of the 1984 grab samples.

Response to LL-1.18

The data for the NYSDEC 1976-78 Sediment Survey was taken from a Malcolm Pirnie (MPI) draft report written in 1994 for NYSDEC (MPI, 1994). Upon comparison between the data in the MPI report and the data in the Hudson River Database Release 3.5, it was evident that numerous cores shown in the report drawings were absent from the database. There were also instances where core or grab concentrations did not match between the report and the database. Because there was no means of checking the data included in the database which had been provided by NYSDEC, the data in the MPI report was used. The hard copy of data in the report was manually converted into electronic files and then checked. Coordinates were digitized from the report drawings. The conversion to an electronic media was both time consuming and painstaking, but performed to provide the highest quality analysis possible. In this manner, the USEPA chose the better, not the more convenient, data set.

Response to LL-1.19

The statement made on page 3-18 of the LRC regarding the strength of the correlation between solid-specific weight and Total PCBs is too strongly worded and essentially incorrect. The trend in the data was obscured by binning the data finely in the box and whisker plot (LRC Figure 3-15). In fact, as shown on LRC Table 3-7, solid-specific weight has a regression coefficient of -54 percent, second only to percent solids for the bulk sediment properties. Solid-specific weight is one of the better predictors for Total PCBs.

In addition to a mass basis, the *hot spots* below the TI Dam were compared on a length-weighted basis which is independent of the solid-specific weight of the samples. From the graphs shown in LRC Figure 4-22, both the length-weighted and mass bases give similar results. Only *Hot Spot* 39 is different, with a statistically significant different loss between 1976-78 and 1994 for the length-weighted average and no change on a mass basis. But as discussed in the text, because the PCB mass at *Hot Spot* 39 appears to have been poorly captured in both sampling events, conclusions drawn for this area are uncertain.

4.2.2 Comparison of 1976-1978 Sediment Classifications and the Side-Scan Sonar Interpretation

Correction to Section 4.2.2 -Comparison of 1976-1978 Sediment Classifications and the Side-Scan Sonar Interpretation

Figure 3-27 incorrectly referenced as Figure 3-28 on page 4-25. The text should read,

Fine-sands yielded the greatest number of samples in the NYSDEC data set. The results map out as approximately 55 percent coarse-grained sediment and 45 percent fine-grained sediment based on the side-scan sonar, when rocky locations and the other minor areas are excluded. This split in area type is very consistent with the results obtained for the low resolution cores, as shown in Figure 3-27. Note that Figure 3-27 uses bins based on the side-scan sonar assignments and maps the grain-size classification whereas Figure 4-18 uses bins based on the NYSDEC classifications and maps the side-scan sonar assignments. Fine-sand samples are approximately evenly split (52 percent coarse-grained and 48 percent fine-grained) using the side-scan sonar classification and the NYSDEC results (upper diagram of Figure 3-27). These results are consistent with the resolution afforded by the side-scan sonar images, in that the acoustic signal (DN50) value used to separate fine-grained and coarse-grained sediments (55 to 60) roughly corresponds to the middle of the range of DN50 values obtained for fine-sands, as shown in Figure 3-30. Thus an even split of fine-sand samples among fine-grained and coarse-grained sediment areas would be expected for both the low resolution core sites and the NYSDEC sampling locations.

Response to LL-1.20

The side scan sonar can distinguish between fine-grained and coarse-grained sediments, although fine sand which is on the boundary of fine and coarse-grained material cannot be distinguished. This issue is addressed in the quoted passage from the LRC referenced in the peceding correction to Section 4.2.2. The agreement is good between the NYSDEC visual sediment classification and the side scan sonar, with the knowledge that the side scan sonar cannot resolve the fine sands.

Response to LL-1.21

USEPA acknowledges the error in the LRC text. This correction has been noted in the Correction to Section 4.2.2 of the Low Resolution Sediment Coring Report.

As discussed in the response to LL-1.20, the side scan sonar analysis is not sensitive in the range of fine sands. The result is that fine sands can be characterized as either fine-grained or coarse-grained sediments with equal probability. For the USEPA data approximately two-thirds of the fine sands samples were located in fine-grained areas, but nearly half of the NYDEC fine sand samples were located in fine-grained areas. Both data sets show a significant split for the samples characterized as fine sand, but the higher percentage of fine sands located in fine-grained areas for the USEPA is most likely due to the selection of sample location. The USEPA samples were intentionally placed in fine-grained areas while the NYSDEC sampling locations were selected by overlaying the TI Pool with a sampling grid. NYSDEC sample locations are roughly evenly split between fine and coarse-grained sediments, while the USEPA samples are predominantly fine-grained.

4.2.3 Comparison of Sediment PCB Inventories: NYSDEC 1976-1978 Estimates versus 1994 Low Resolution Core Estimates

Correction to Section 4.2.3 - Comparison of Sediment PCB Inventories: NYSDEC 1976-1978 Estimates versus 1994 Low Resolution Core Estimates

Figures 4-19 and 4-20 are incorrectly referenced as Figure 4.2-3 and 4.2-4, respectively, on page 4-27. The text should read,

> To compare the PCB levels within these areas, arithmetic and geometric means were calculated. Because of the log-normal nature of the data distribution for both data sets, the geometric mean and its standard error provide the best statistical basis to assess change in the sediment inventories over time. The log-normal nature of the entire 1976-1978 data set was originally established by Tofflemire and Quinn (1979). The subset of 113 NYSDEC samples was also log-normally distributed, as seen in Figures 4-19 and 4-20. These figures show that both the one-foot length-weighted averages (LWA) and the SSW-corrected PCB mass per unit area estimates (MPA) are log-normally distributed. Similarly, Figures 4-19 and 4-20 show the LWA and MPA distributions for the subset of 64 low resolution cores from the seven study areas below the TI Dam as well as for all low resolution core results below the TI Dam. These results were determined to be log-normally distributed using the Shapiro-Wilk W test for normality (Table 4-6).

Response to LC-2.4

This comment will be taken under consideration during the preparation of the Baseline Modeling Report.

Response to LC-2.5

The USEPA disagrees with the writer's contention that water column loads provide a critical constraint on PCB mass loss estimates derived from the low resolution coring analysis. The mass loss estimates apply only to the fine-grained sediments. The net change in the coarse-grained sediment inventories is unclear. Therefore, the load gain across the TI Pool is not directly linked to the mass loss estimates derived in the LRC and Appendix A of this Responsiveness Summary. While discerning the exact nature of the source mechanisms is useful, the fact remains that the fine-grained sediments of the Upper Hudson River have lost a substantive portion of their prior inventories despite the continued released from the GE facilities. With regard to high-flow releases from the TI Pool, GE has recently (January 1998) obtained data from a one-in-15-year flow event which should provide input on TI Pool resuspension loads driven by flow. As discussed in Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C, (USEPA, 1998b), however, it appears that much of the TI Pool load is not derived by flow-driven shear stress. This issue will be more closely examined in the Baseline Modeling Report.

Response to LC-2.6

This comment will be taken under consideration during the preparation of the Baseline Modeling Report.

The USEPA agrees that recent trends more clearly exhibit the load originating from the TI Pool. However, the earlier years of data (1991-1996) also clearly illustrate the TI Pool load in both magnitude and congener pattern. The USEPA disagrees with the contention that TI Dam loads for 1991-1995 are not partially derived from TI Pool sediment inventories which were primarily deposited prior to 1977 and does not see any inconsistency in its perspective in this regard. The water column loads leaving the TI Pool are quite distinct from those entering the Pool and represent what is clearly a spatially altered source. The USEPA does not state that the TI Pool was responsible for the majority of the total load of PCBs during the period 1991 to 1995, but rather that the TI Pool is responsible for the majority of the load during low flow conditions. In particular, conditions prior to June 1993 were dominated by loads originating upstream of Rogers Island, as noted in the DEIR. Nonetheless, the importance of the TI Pool load should not be dismissed, since low flow conditions are particularly important to biological uptake because they represent the water column exposure concentrations during the period of maximum biological activity. Additionally, the conditions post-1995 are probably similar to those which existed prior to September 1991 (the Allen Mills structure failure), thus returning the Upper Hudson River to the condition wherein sediments probably played a more important role in governing water column and fish PCB concentrations. These were the conditions which existed prior to the USEPA Reassessment study.

Response to LF-1.2

An independent assessment of the PCBs lost to the water column from the sediments of the TI Pool can be made by comparison with the estimated load at the TI Dam. Comparison with the fish body burdens is complicated by fish exposure to sources other than the TI Pool sediments. In particular, the load from above Rogers Island was a significant source to the water column between 1984 and 1994.

Note that the mass loss fraction given in the LRC (28 percent) represents a median and not a mean loss, as incorrectly stated in the Report. The loss of trichloro and higher homologues from the predominantly finer areas of the TI Pool is estimated at -43 percent with upper and lower 95 percent confidence limits of 1 and -58 percent, respectively (*See* the revised calculations in Appendix A). The amount of trichloro- and higher PCBs estimated to be present in the finer-grained areas of the TI Pool in 1984 is 8,200 kg (*See* Appendix B). Using these values, the trichloro- and higher homologue loss to the water column between 1984 and 1994 (assuming 10 years and 365 days/year) is 0.97 kg/day on average with bounds of 0 kg/day and 1.3 kg/day. A net gain is not calculated here since the estimated median mass loss is clearly negative, precluding any net mass gain by the fine grained sediments of the Pool.

The load at the TI Dam generated by the sediments of the TI Pool can be estimated using the data in Figures 3-86 and 3-87 of the DEIR. Figures 3-86 and 3-87 show the cumulative load of trichloro- and tetrachloro homologues at Rogers Island and the TI Dam over nearly five years (1991-1995) to be 422 kg or approximately 0.23 kg/day. Tri- and tetrachloro homologues are the greatest contributors to the trichloro- and higher homologue load, making this value a slight underestimate.

This trichloro- and higher homologue load at the TI Pool is four times smaller than the expected value of 0.97, but falls well within the 95 percent confidence limits. Also note that the 43% loss of trichloro- and higher homologues represents all forms of loss excluding dechlorination. Note that the 43 percent mass loss also incorporates redistribution within the TI Pool, which may represent a significant fraction of the total. The point-to-point comparison of 1984 to 1994 cores suggests that the noncohesive sediments may be gaining inventory while the cohesive sediments have lost PCB mass.

Response to LG-1.5B

See Response to Comment LG-1.7.

Response to LG-1.5D

The writer's premise in this comment is that a single pattern can be developed which represents the sole source of PCBs to the water column. Any "match" achieved is strictly dependent on the mechanisms assumed to produce it. In this instance, the writer is almost certainly incorrect in assuming a single mechanism when almost certainly more than one is involved. This issue is discussed in detail in Book 3 of the Responsiveness Summary for the Database Report, PMCR and DEIR. Specifically, it is unlikely that the partition coefficient data is sufficiently precise to uniquely constrain any congener pattern and preclude a specific mechanism.

The use of PCB fish tissue data alone is inappropriate to isolate the nature of the sediment source since fish do not bioaccumulate less chlorinated congeners as efficiently as heavier ones and, therefore, fractionate the congener distribution. This process serves to partially obscure the fingerprint of the source material. Greater depth of analysis is required before any single source can be removed from further consideration in this regard.

A discussion of the January 1998 high flow sampling data collected by GE is found under response LG-1.22.

Response to LG-1.5F

In the *hot spots* below the TI Dam, the samples were distributed throughout the *hot spot* areas and were comparable to the sampling densities applied by NYSDEC in 1977-1978. As noted in the LRC, the premise for loss is simply dependent on complete recovery of the contaminated sediment interval in 1994 and not in the earlier survey. This is because an incomplete core in 1977-1978 versus a complete core in 1994 will show a mass gain, as long as there has been no true PCB loss. Thus, for those *hot spots* below the TI Dam exhibiting statistically significant mass loss, there is no doubt that these areas must have truly lost PCB mass. The measured gain at *Hot Spot* 28 appears to be, in fact, the result of the hypothesized example given above, *i.e.*, the collection of incomplete cores in the earlier study followed by complete cores in the latter study. Only in this case, the earlier study missed so much of the inventory that it is unclear whether any actual mass loss had occurred as well.

Response to LG-1.6

The use of averages and confidence limits to compare the 1984 and 1994 conditions intrinsically incorporates the uncertainties in the data. The USEPA does not assume no error; but, in fact, explicitly tests to see if the uncertainties in the estimates of the means render the differences in the means statistically meaningless (Note: the estimates were found to be statistically different). The data were not analyzed assuming no error in the measurements but simply that the data represent unbiased estimates of the true values.

The USEPA does not suggest or state that the Delta functions reduce analytical uncertainty. The USEPA agrees with the writer's statement that no mathematical transformation can reduce analytical uncertainty. However, the use of a Delta function or other similar ratio is to convert the analytical uncertainty to an approximately constant value. That is, analytical uncertainty is typically a small percentage of the absolute value reported, regardless of it magnitude (*i.e.*, analytical error is often given as a percentage of the value reported). Thus, by dividing by the 1984 concentration, the differences between 1994 and 1984 are normalized to account for analytical uncertainty as an approximately constant percentage of the reported value.

For example, assume that an analytical precision of 20 percent is attained for a set of samples and two measurement sites are examined, one at 300 g/m^2 and one at 5 g/m^2 based on 1984 measurements. Subsequent sampling in 1994 yields 250 and 12 g/m^2 for these locations. It is clear that the absolute change at the 300 g/m^2 site is much greater than that for the 5 g/m^2 site (-50 *vs.* +7). However, as a percentage of the original value, the relative change at the 300 g/m^2 site is much smaller ((250-300)/300 or -17 percent) *vs.* that at the 5 g/m^2 site ((12-5)/5 or +140 percent). In this context, it is clear that the inventory change at the 5 g/m^2 site is relatively more important and exceeds its analytical precision of 20%. The change at this 300 g/m^2 site, although large in absolute value, does not represent a large fraction of the site inventory and, in fact, falls below the level of analytical precision, suggesting the change is not significant. Thus by the use of the Delta function, the importance of any 1984 to 1994 change in PCB inventory can be assessed relative to the likely analytical uncertainty.

Analytical uncertainty was estimated to average 36 percent for individual 1994 samples. (The median uncertainty was 27 percent, meaning half of all replicate pairs agreed to within 27 percent or less.) However, it should be noted that the uncertainty of the average concentration difference from 1984 to 1994 will be substantially less since the error on the average will decrease with the number of samples utilized in the average. Although the tests used in the LRC are more rigorous and incorporate the uncertainty of both the 1984 and 1994 data sets, an example of how the uncertainty of the average decreases relative to the individual uncertainty is given as follows:

$$\text{Error on Average} = \frac{\text{Individual Uncertainty}}{\sqrt{\text{No. Of Samples In Average}}}$$

$$\text{Error on Average} = \frac{36\%}{\sqrt{45}} = \frac{36\%}{6.71}$$

$$= 5.4\%$$

Forty-five represents the number of samples in the locations greater than 10 g/m^2. Based on this calculation, the uncertainty on the average is about 7 times less than the individual uncertainty.

Lastly, it should be noted that the use of averages and confidence limits to test for statistical significance intrinsically incorporate the analytical as well as all other uncertainties inherent in the data.

Response to LG-1.7

See Response LG-1.2 and Table LG-1.2, with regard to the number of complete and incomplete cores. USEPA acknowledges that the truly incomplete cores of the TI Pool add some additional uncertainty since they are potentially biased low with respect to the mass estimate. However, this would have excluded only 9 of the 60 1994 matched core sites or 15 percent. Only 10 of the 76 cores placed in the TI Pool were considered incomplete, representing only 13 percent of the total number of cores. Of the 9 paired cores, 5 represent sites with greater than 10 g/m^2. The remainder represent sites with less than 10 g/m^2. Thus, the effect of excluding these cores would be spread across both 1984 inventory core groups (*i.e.*, <10 g/m^2 and <10 g/m^2). Only 5 of the 9 show mass loss when considering the dechlorination products while 8 of the 9 show loss based on the Tri+ sum. Based on the roughly equal distribution of these cores among the main groups in two of the three cases just mentioned and the relatively small number of incomplete cores out of the total, it is unlikely that these cores serve to greatly bias the statistical outcome.

This assertion is verified in the calculations presented in Appendix A which compare the area-based mean inventories for 1984 and 1994 both with and without the incomplete cores. In all comparisons, the results show that the estimate of the mean mass loss changes less than 5 percent based on the exclusion or inclusion of the incomplete cores. Thus the inclusion of these cores, while potentially adding some uncertainty, does not affect the major conclusions of the LRC. .

The direct comparison between the USEPA 1994 data and the GE 1998 data is restricted by the small sample size of the GE data set, as it is probably insufficient to conduct the proper statistical analyses to support their conclusions. GE did not occupy any incomplete coring sites as defined by the USEPA criteria (described in Chapter 2 and pages 4-32 to 4-33 of the LRC) so it is not possible to test these sites to see the extent of contamination missed. Nonetheless, as discussed previously, the few new GE data confirm the findings of the LRC, showing major loss of PCB inventory from the sediments between 1984 and 1998, as depicted in GE's Figure 13 of their comments.

Response to LG-1.38C

The analysis of PCBs and related ancillary parameters was presented for interest and completeness. The USEPA does not believe that the data set is sufficiently detailed to develop a covariate model for PCB mass loss, since these ancillary parameters are not consistently measured between the older and newer data sets and some potentially important parameters are not available for the portions of the various data sets.

Response to LG-1.38I

The 1984 survey does not provide specific information on the spatial distribution of sediment contamination in the areas of *Hot Spots* 25 through 39, since these areas are located downstream of the areas studied in 1984. As shown in the DEIR, the spatial relationships vary from reach to reach and are not readily extrapolated. It should be noted that the 1984 and 1994 means are estimated in the same fashion, thereby providing a consistent basis for comparison. To a large extent, the spatial variation is already accounted for, in that the areas were previously surveyed and selected as areas of high contamination. Side-scan sonar images showed *Hot Spots* 25, 28, 34 and 35 to consist primarily, though not exclusively, of fine-grained sediments (*see* LRC Plates 4-21 to 4-24), thus much of the spatial relationships are effectively included by the averaging process. It should be noted as well that all of the *hot spots* studied, except *Hot Spot* 34, represent areas similar in shape and design to the semivariogram results obtained for the 1984 survey of the TI Pool. Specifically, each *hot spot* area represents an elongated or elliptic zone whose major axis parallels the direction of river flow and whose minor axis is perpendicular to this flow. Essentially, the original layout of the *hot spots* inherently incorporated the spatial relationships anticipated in each area.

Lastly, it should be noted that samples collected in 1994 demonstrate that areas outside *hot spots* are typically much less contaminated than those within the *hot spots*, supporting the original area designations.

Response to LG-1.39B

The text notes that there is a need to differentiate analytical variability from real change. The writer is correct in noting that the text is technically wrong in suggesting that analytical uncertainty can be diminished. However, while there is no means to reduce the degree of uncertainty attributable to analytical variability, it is possible to isolate it in a fashion so that real change can be more readily discerned. Analytical variability is such that it typically represents a percentage of the reported value, and it occurs such that measured values are equally likely to overpredict and underpredict the true value, (i.e., the errors are unbiased). Analytical techniques are generally applied so that this variability is a small percentage of the expected range of concentrations to be measured. Otherwise little information can be obtained from the analysis. For example, little confidence is placed in a reported value if its associated uncertainty is close to its absolute value (i.e., 100 percent uncertainty). On the other hand, a value with a 10 percent level of uncertainty is frequently considered "good" when estimating sediment contamination. In either case, the absolute value of the uncertainty of the reported value is dependent upon the magnitude of the value itself. These percentages essentially represent the absolute uncertainty divided by the reported value. By dividing by the measured value, the uncertainty is converted to a constant (e.g., 10 percent). Thus, examining the differences between 1984 and 1994 on a delta or ratio basis, it is possible to effectively isolate the analytical uncertainty by assuming it to represent a constant, unbiased percentage of the reported value. True analytical uncertainty will express itself as both positive and negative changes within a small range of zero, yielding a delta function that is not statistically different from zero. On the other hand, if real change has occurred, the deltas will be typically one-sided, with a mean statistically different from zero.

It is useful to illustrate this point in an example. Two coring sites are originally occupied and found to contain 15 and 300 g/m^2 of PCB contamination, respectively. Analytical uncertainty is

estimated at 10 percent. Upon a subsequent resampling, the values obtained for these sites are 5 and 270 g/m^2, respectively. This yields absolute differences of -10 and -30 g/m^2. Based on absolute values, it appears that the sediment has lost more mass from the 300 g/m^2 site and that this is the more important mass loss. However, when these differences are viewed in the context of the absolute inventory of the site, the relative importance of these losses relative to the ability to measure them becomes evident. Specifically, the 10 g/m^2 represents a loss of 66 percent of the original inventory from the 15 g/m^2 site, while the 30 g/m^2 loss represents only a 10 percent loss from the 300 g/m^2 site and is probably within the measurement error. Thus, the smaller 10 g/m^2 loss would be expected to represent a true decline in the sediment inventory while the greater 30 g/m^2 loss is within measurement error and may in fact represent no real change. Because of the wide range of concentrations obtained from both the 1984 and 1994 sediment samples (over several orders of magnitude), it is necessary to put the measured differences in context of the original inventory so that real change can be assessed relative to the likely analytical uncertainty.

In the case of no real change, delta values such as that for 300 g/m^2 site would be expected to occur as both positive and negative differences with a mean value close to zero. The range of values obtained for delta would reflect the total variability in the measurements, including the analytical variability. It is for this reason that the delta function was tested for its statistical difference with respect to zero. The results obtained for the LRC yielded a delta value for sediments greater than 10 g/m^2 which was negative and statistically different from zero, indicating that real change had occurred.

The finding of net PCB loss from the sediment is not a result of regression toward the mean, as contended by the writer. As noted elsewhere in these responses and in the LRC, the net loss was found for the minimum loss estimate, (that is, loss of Tri+ homologues plus the five dechlorination product congeners). It is even more evident when the Tri+ sums alone are compared or when a minor correction for dechlorination is included. In this case, most sites show loss, regardless of inventory. This is further borne out by the analysis presented in Appendix A of the Responsiveness Summary.

In this presentation, area-based averages are compared for 1994 and 1984. Again, statistically significant losses are found, comparable to those estimated from the delta function analysis presented in the LRC.

Response to LG-1.40A

Statistical evidence for the change in PCB inventory was extensively developed in the Report. Inherent in this finding is the fact that if the PCB inventory is declining and there is no evidence for its *in situ* destruction, then the inventory cannot be undergoing burial. Supporting evidence for the lack of wide-spread burial is multifold. Thus, this conclusion does not hinge on any single result or analysis. The differences in both the depth and concentration of PCB contamination between 1984 and 1994 are direct evidence of the lack of burial since the sediment inventory has decreased and the depth of contamination has largely decreased or remained the same. The premise put forth by GE that the most contaminated areas of the river were being rapidly sequestered by burial is clearly inconsistent with this evidence. This is because the inventories are principally still within the top 9 inches of sediment, just as they were in 1984. Hence, rapid, "deep" burial (*i.e.*, on the scale of 9 to 12 inches) is not occurring. Thus, if burial has occurred, in most instances it is

limited to a few inches, certainly not deep and probably not beyond the reach of sediment resuspension or biological activity in many cases.

If sediments were experiencing burial, sediment PCB inventories would be expected to increase, since, as has been well documented by GE as well as other monitoring efforts, the area above Rogers Island continues to contribute fresh PCBs to the Upper Hudson (at least up to 1996; the cores were collected in 1994). Thus, additional sediment would also add PCB inventory. Yet all evidence suggests PCB loss from the sediment.

The fact that the very unique environments of the high resolution cores show burial of the PCB maximum does not, in fact, mean that this phenomenon is wide-spread, or even common. These cores are not considered representative of sedimentation patterns throughout the Pool since in fact, such environments are difficult to find. Note that several of the high resolution cores collected from the Pool could not be dated due to their apparent variations in sediment deposition. In fact, potential application of the cores as representative of Pool-wide conditions was strongly assailed by GE on several occasions. The high resolution cores, in reality, provide information on the nature of annual transport and on the nature of the type of material which is actually deposited in the river, but they do not provide any information on the pervasiveness of this phenomenon. The only direct evidence for real change in the sediment inventories comes from the low resolution cores themselves.

Evidence for the absence of extensive burial is consistently seen in both the TI Pool and in the areas downstream, since many sediment areas show loss over time. There is also the direct water column evidence exhibited in Figures 3-100 and 101 of the DEIR, which show extensive loading of the water column with PCBs between Ft Edward and Schuylerville throughout much of the early 1980s, despite the USGS' inability to track the lighter congeners. The loss from this region of the river can be inferred, despite the somewhat random timing of the USGS sampling events at the various stations. Presumably, the same mechanisms responsible for these losses are in part responsible for the continued losses since 1984. Indeed, it is difficult to understand how the areas originally responsible for the early 1980s loads could convert from source areas to storage areas. It is far more likely that these areas continue to lose inventory in the same manner as before but simply at a lower rate, since much of the inventory has already been depleted.

Lastly, additional evidence is provided by the ^{7}Be data which show that burial is not in evidence in many places, based on its absence. As noted in response LG-1.18, the ^{7}Be results do not prove the absence of burial as originally asserted in the LRC. However, neither does its presence prove long term burial since episodic depositional events followed by periodic resuspension events will yield ^{7}Be bearing sediment, if sampled at the right time. At a minimum, in those areas lacking ^{7}Be, the results suggest the deposition rate to be quite slow in these areas, amounting to no more than a few tenths of a centimeter per year. Over a period of 20 years, a deposition rate of 0.5 cm per year would accumulate roughly 10 cm (4 inches). This would leave the sediment PCB maximum associated with the early 1970's well within the biologically active region of the sediments, despite the passage of two decades.

The USEPA agrees that the lack of change in the sediment inventory depth does not prove the absence of burial, but it does preclude the "deep" burial inferred by GE. Indeed, there was at least one major depositional event in the Upper Hudson, since PCBs are found throughout the Pool. The Ft. Edward dam removal in 1973 and the subsequent 100 year flood in 1976 are, of course, the most

likely culprits. However, as is evidenced by the USGS records of the early 1980s, the GE records of the 1990s and the USEPA studies of 1992-1994, the sediments continue to release PCBs to the water column, as seen in the water column gains across the Pool as well as in the sediment losses reported in the LRC.

Response to LL-1.9

See response to comment LG-1.6.

Response to LL-1.22

Because the *hot spot* locations are uncertain, these boundaries were not used in the analysis. Rather the dredge location areas (which approximate the *hot spot* boundaries) were digitized from the MPI, 1994 Report and used. In addition, the sample locations for the 1976-78 had been surveyed and the coordinates known at the time of the 1994 sampling. The 1994 USEPA cores were located to assess the same areas delineated in 1976-78. It is evident from LRC Plates 4-21 through 4-28 that the areas delineated in 1976-78 by NYSDEC were resampled in 1994 with a similar sample density.

Response to LL-1.23

USEPA acknowledges the error in the LRC text. This correction has been noted in the Correction to Section 4.2.3 of the Low Resolution Sediment Coring Report.

Response to LL-1.24

See the responses to comments pertaining to the 1976-78 versus 1994 PCB inventory comparison below the Thompson Island Dam (LL-1.17, LL-1.18 ,LL-1.19, LL-1.22, and LL-1.26). The USEPA disagrees with the writer's contention. The areas sampled in both surveys were covered at similar sampling densities and yielded statistically significant differences while directly or indirectly accounting for the uncertainties. For example both the LWA and the MPA results show statistically significant differences but only MPA incorporates sediment density and its uncertainty.

Response to LL-1.25

See response to comment LL-1.7. The USEPA disagrees with the writer's contention. As discussed in response LG-1.40A, high resolution cores cannot be used to infer burial on a wide spatial scale. They are not typical of the rate of sediment deposition throughout the river.

Response to LL-1.26

Of the 13 low resolution cores taken from *Hot Spot* 28, six have the PCB concentration maximum in the top core segment and four have the PCB concentration maximum in the second segment. The remaining three cores contain only one segment for PCB analysis (*see* the core profiles in Appendix D of the LRC). Long-term storage of PCBs is not assured, because six of the cores or 46 percent have profiles indicative of scour or at a minimum no change in inventory. This is based on the occurrence of the PCB maximum in the top core segment as well as the presence of a smaller but still substantial PCB inventory at depth.

The inventory estimate for *Hot Spot* 28 was 1,850 kg in 1976-78 and 20,382 kg in 1994. At face value this suggests that between 1977 and 1994, 18,532 kg of PCBs were deposited at *Hot Spot* 28. This is more than the 1984 Thompson Island Pool inventory estimate of 14,900 kg (*see* Appendix B of this Responsiveness Summary). But, as discussed on page 4-35, only a small fraction of the PCBs downstream was transported after 1977:

> The percent mass deposited between 1977 and 1994 can be estimated using the dated high resolution cores shown in Figure 4-24. These cores are considered recorders of river PCB loads, as described in the DEIR (TAMS, *et al.* 1997). In these and essentially all other dated sediment cores from the Hudson, the sediment record shows a substantial decline over time in the PCB loads carried by the river. Based on these core profiles, only 2 to 5 percent of the cumulative PCB load was transported in the period after 1977. Thus the river was not carrying the volume of PCBs which would be required to substantially raise sediment inventories between 1977 and 1994. Since at the time of the 1976-1978 surveys the river had already transported at least 95 percent of its total PCB load, it is highly unlikely that the remaining 2 to 5 percent to be transported in the post-1978 period could yield the eleven-fold increase in inventory found in *Hot Spot* 28. Thus, it is unlikely that a true substantive increase in PCB inventory has occurred at *Hot Spot* 28 since 1976-1978. Rather, it is likely that the 1976-1978 inventory was badly underestimated.

See response to comment LG-1.24 for more discussion.

The writer inappropriately separates the results into "good" and "bad" data. The 1976-1978 data collected for *Hot Spot* 28 were not "bad" but simply did not capture the entire inventory. The values themselves were probably accurate for the sediments measured. The reason that losses can be assured is related to this. Since in most instances, the 1994 cores captured all of the recent deposition as documented by the ^{137}Cs analysis, they represent all of the PCB contamination at the location. Conversely, the earlier data do not have this assurance and so there is the possibility that further contamination lay below the core or grab. As a result, the earlier estimate can be thought of as a minimum inventory estimate. Any differences between the 1976-1978 and 1994 surveys must then represent a minimum difference since the 1976-1978 inventory estimate may be low. Thus any comparison indicating PCB loss can be assured since in reality the actual loss may be bigger than estimated. Additionally there are water column data to suggest that sediment losses are occurring, thus substantiating these results as well. In the case of gains, the opposite is true. Since the 1976-1978 inventory estimate is a minimum, any gain estimate represents the maximum gain since the actual difference between the current measurments and the 1976-1978 inventory is probably less than estimated. In the case of *Hot Spot* 28, this is precisely the issue, *i.e.*, the earlier study failed to capture the deeper, more contaminated sediments and thus underestimated the 1976-1978 inventory. Hence the apparent gain is not real.

Response to LS-1.3

No response required.

Response to LS-1.4

No response required.

4.2.4 ^{7}Be in Surface Sediments

Response to LG-1.5A

See Response to Comment LG-1.18

Response to LG-1.18

The writer proposes several issues in this comment with regard to the use of the ^{7}Be results. In particular, the writer attempts to use the ^{7}Be data to determine a deposition rate for the sediments and then state that the USEPA has potentially misclassified some low deposition rate sites as nondepositional. While the USEPA agrees that there may be some low level of deposition which is not detected by the sampling technique, it is probably lower than that suggested by the writer. The entire approach proposed by the writer presupposes a knowledge of the geochemistry of ^{7}Be which is currently not available. Specifically, the temporal variability of ^{7}Be deposition is not well known, nor are there much data on the ^{7}Be levels in depositing sediment. The approach used by the writer to estimate the maximum undetectable deposition rate is not supported by the USEPA since it requires this currently unavailable information. The writer's premise is also based on the assumption that ^{7}Be levels in depositing sediment are the same everywhere. This is also probably not true. These issues are discussed in greater detail below. Essentially, the USEPA believes that it is important to be cognizant of the limitations of the current understanding of ^{7}Be geochemistry and to avoid "over interpreting" the ^{7}Be data.

As stated in the LRC, the presence of ^{7}Be was used to discern those areas where recent deposition had occurred. Due to its short half life, ^{7}Be presence in the surfical layer specifically indicates the presence of sediments deposited within the last 6 months to a year. However, ^{7}Be presence only proves recent deposition, not long term deposition. Sporadic events of deposition and resuspension will yield ^{7}Be-bearing sediments even though there is no long term burial. Alternatively, mixing of sediment layers by biological activity ("bioturbation") can serve to mask the presence of recent deposition by diluting the surface material with underlying, ^{7}Be-free sediments. Ultimately, it is only the presence and depth of more persistent tracers, such as ^{137}Cs or PCBs themselves which can provide a true measure of the deposition rate at a given location.

Part of the writer's premise is predicated on the delivery of ^{7}Be during a single event in the spring of 1994. This argument would also imply that ^{7}Be levels are homogeneous throughout the study area. Alternatively, this hypothesis would hold that the ^{7}Be-to-^{137}Cs ratio would be constant, since both constituents are to be delivered by the same event. Evidence for the delivery of ^{137}Cs suggests that at least this radioisotope is principally delivered during the spring runoff event since it currently has no atmospheric deposition component, unlike ^{7}Be. ^{7}Be input, while potentially dominated by spring deposition, is not exclusively tied to this event since atmospheric production and fallout are relatively continuous throughout the year. Thus surface sediment ^{7}Be levels can be partially replenished after the major depositional event of the year. This additional input of ^{7}Be

undermines the assumption of a single ^{7}Be depositional event occurring around April 17, 1994 as proposed by the writer. The occurrence of additional ^{7}Be input, also noted by the writer but not discussed, would serve to increase ^{7}Be levels and yield an overestimate of the actual deposition rate using the model promoted by the writer.

The likelihood that the sediment deposition of ^{7}Be and ^{137}Cs are not linked is supported by the ^{7}Be/^{137}Cs ratio results for the 0-1 inch layer (surficial sediment). This ratio provides additional evidence that the deposition rate of ^{7}Be is not a well-known phenomenon and cannot be used in the manner suggested by the writer. The data for the ratio of ^{7}Be/^{137}Cs are shown in Figure LG-1.18A. This figure represents all of the low resolution coring results. Note that the ^{7}Be results are all decay-corrected to a single date, Sept. 1, 1994 as follows:

$$C_{\text{Date of Interest}} = C_{\text{Count Date}} * e^{-\log(2)*(\text{Date of Interest} - \text{Count Date})/53.28\ \text{days}}$$

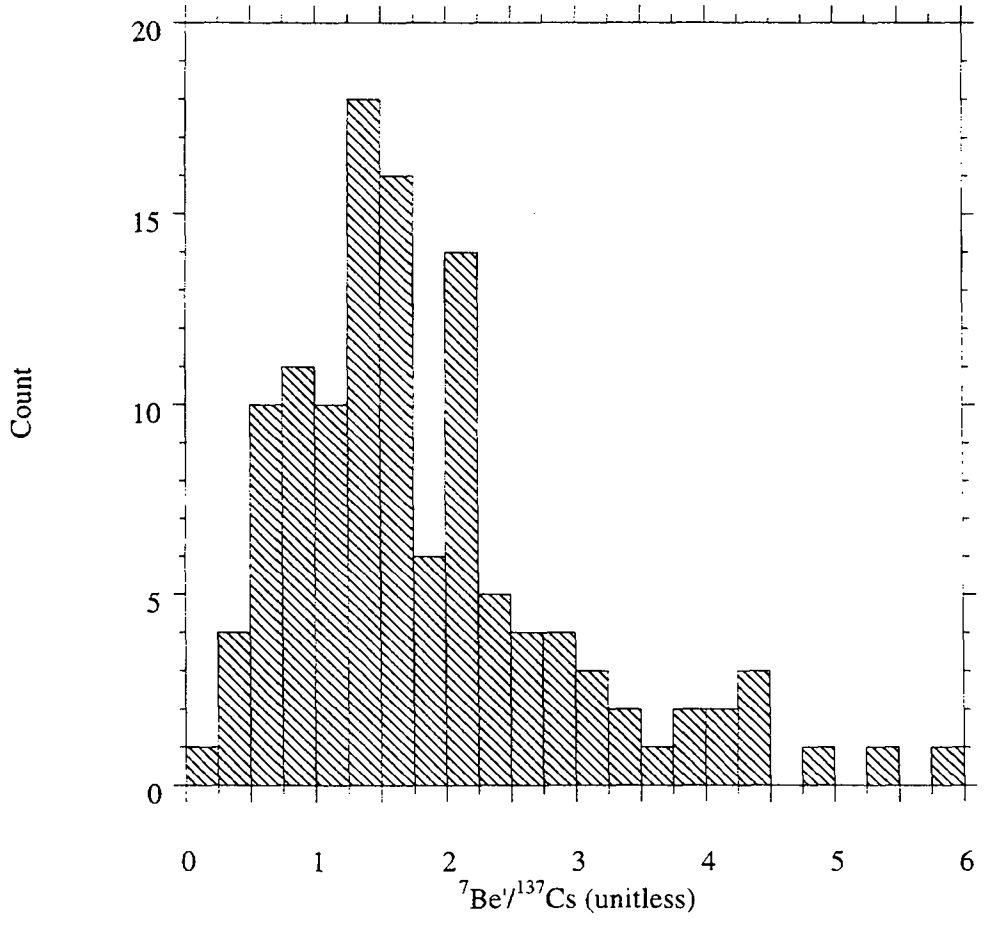
where C_{date} = ^{7}Be concentration on date specified in pCi/kg.

This date is approximately midpoint in the sample counting period. Correcting to this date eliminates decay concerns when examining the results while also avoiding the uncertainties associated with decay correction over a long period of time (such as to April 17). This diagram shows that this ratio varies over an order of magnitude (less than 0.25 to 6). Given that ^{137}Cs is principally delivered during the spring high flow event, these results suggest that ^{7}Be and ^{137}Cs are not linked to the same pathways and, in particular, that ^{7}Be input is not simply governed by a spring high flow depositional event. Figure LG-1.18B illustrates the absence of correlation between the two isotopes as well as shown by the poor regression line drawn in the figure. As described above, ^{137}Cs is derived almost exclusively from soil erosion since there is no direct atmospheric input. Thus if ^{7}Be were simply related to spring deposition, its ratio to ^{137}Cs would remain relatively constant since both would be delivered in essentially the same manner from the same source materials.

The detection limit for ^{7}Be is an important component of the writer's analysis. ^{7}Be measurements decay-corrected to September 1, 1994 suggest a detection limit of 400 pCi/kg decay (*see* Figure LG-1.18C). The value of 400 pCi/kg is a lower value than that obtained by examining the detection limits but is probably more accurate since it is based on the levels detected and not an estimation of the detection limit. This result suggests a lower threshold for ^{7}Be detection than suggested by the writer.

The purpose of the analyses presented above, is not to present an alternate estimate of the actual deposition rate "detection limit" achieved by the sampling but rather to simply show the uncertainties in the writer's approach. It is USEPA's opinion that ^{7}Be cannot be used for the purpose suggested by the writer since its geochemical input is too poorly known.

Ultimately, the ^{7}Be data provide some information of the occurrence of very recent deposition at the sampling site. These data cannot be used to infer a deposition rate at the resolution suggested by the writer since the initial conditions as well as the input function are not well known. Additionally, these data cannot be used to infer long-term or continuous deposition since episodic deposition and scour will also yield measurable levels of ^{7}Be if sampled at the appropriate time.



Notes:

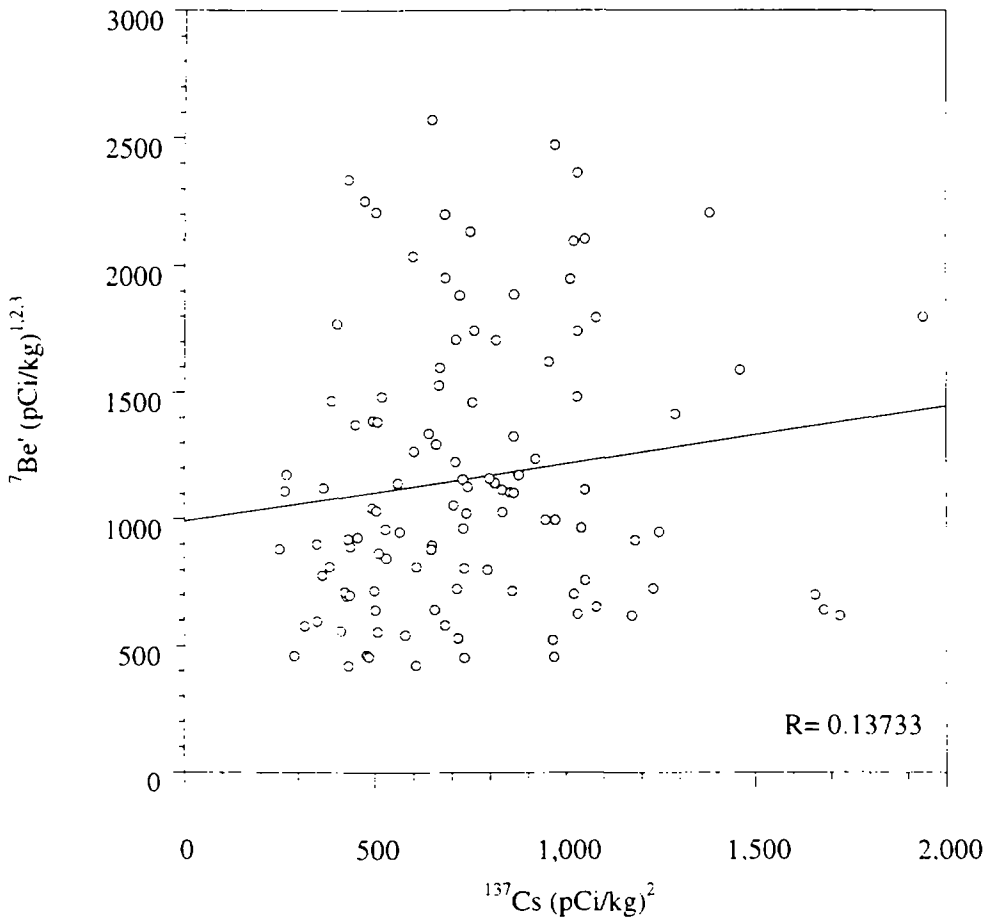
1. ^{7}Be' represents sample ^{7}Be activity decay-corrected to September 1st, 1994 (see text for discussion).

2. 50 samples were not detected for ^{7}Be. ^{137}Cs was found in all low resolution core tops.

3. ^{7}Be' and ^{137}Cs are reported for 0-1 inch of sediment from each core.

Figure LG-1.18A

Distributions of the ^{7}Be'/^{137}Cs Ratio in Low Resolution Cores Tops

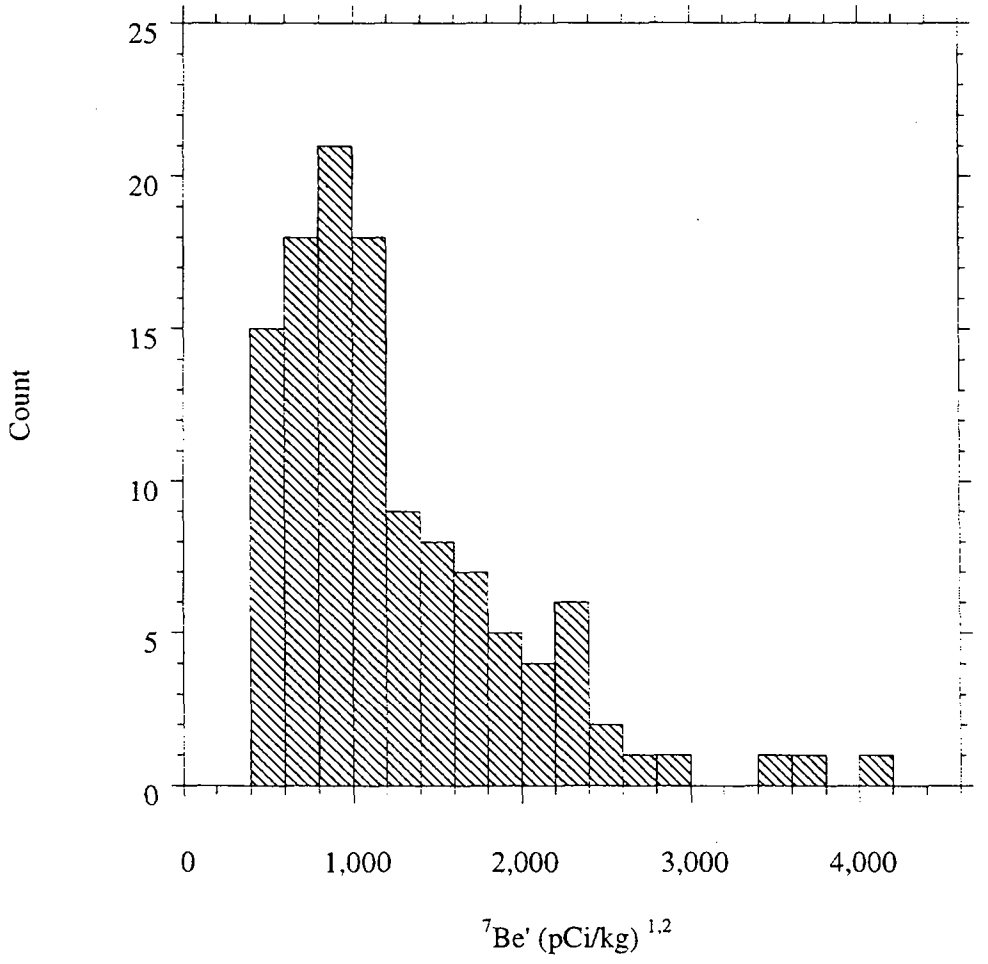


Notes:

1. ^{7}Be' is decay-corrected concentration to September 1st, 1994 (see text for discussion).
2. ^{7}Be' and ^{137}Cs are reported for 0-1 inch of sediment for each core.
3. Plot represents results for 112 low resolution cores. Six values were excluded as outliers based on Mahalanobis analysis. Plot also excluded the 50 samples which were non-detected for ^{7}Be.

Figure LG-1.18B

Relationship Between ^{137}Cs and ^{7}Be' in Low Resolution Core Tops



Notes:

1. ^{7}Be' is decay-corrected concentration to September 1st, 1994 (see text for discussion).
2. ^{7}Be' reported for 0-1 inch of sediment cores.

Figure LG-1.18C

Distributions of Decay-Corrected ^{7}Be' in Surface Sediments from Low Resolution Cores

USEPA does acknowledge that there are inherent limitations in the ^{7}Be data but it is unlikely that deposition rates as high as 0.5 cm/yr have been missed. However, as noted in Response LG-1.40A, a deposition rate of 0.5 cm/yr will only yield 4 inches of sediment in 20 years, leaving the peak sediment PCB concentrations near the surface and within the biological active zone. Lower deposition rates would of course leave the layers even closer to the sediment surface. The writer's model is too simple to explain the ^{7}Be results, especially given the lack of knowledge concerning the temporal ^{7}Be input to the river. The USEPA still considers the interpretation of non-detect ^{7}Be levels as indicative of sites with little or no very recent deposition and as sites potentially undergoing scour.

Response to LG-1.18A

This comment has a large number of issues which are discussed separately below. Much of the comment is based on a data set obtained by GE during June through August of 1998. This data set had not been submitted to USEPA in time for complete review prior to the preparation of this Responsiveness Summary and as such the USEPA comments on the diagrams provided by GE should be considered preliminary.

The ability to discern statistically significant trends with the limited data set that GE collected in 1998 is highly unlikely based on the results presented by GE as of the time this report was being prepared.

GE presents the results of only 12 cores and attempts to use this much smaller data set as a basis to discredit the much larger USEPA effort (76 cores from the TI Pool and 94 cores from TIDam to Lock 2). Nonetheless, some useful information can be obtained from the GE cores as presented. According to GE's contentions, deposition rates in the TI Pool are about 1 cm per year so that these layers would represent 5 years of deposition. USEPA does not accept this deposition rate and believes that it is too high and certainly not applicable throughout the Pool. In nearly all cores presented, there was no apparent PCB decline in the upper 5 cm despite the major load reductions in PCBs entering the TI Pool over the past 5 years. These trends suggest that sediment-derived PCBs may be contaminating any recently deposited sediment as it is deposited. This would be consistent with sediment PCB loss as documented in the LRC.

This contention is also supported by the variability in the surface ratios of the sediments. For both the MDPR and Peak 46/32, surface (0 - 1 cm) sediments exhibit a wide range (MDPR of 0.3 to 0.8; Peak 46/32 ratio of 0.25 to 0.6, based on the graphs provided since USEPA does not have the actual data) which is inconsistent with a single source such as that of the Hudson Falls facility. These ratios are also substantially displaced toward greater degrees of dechlorination relative to Aroclor 1242. For the MDPR, initial ratios should be less than 0.14 (the ratio in Aroclor 1242) since water-column transport yields a suspended matter mixture that is fractionated toward the heavier congeners. Thus these ratios suggest that the material being deposited is not recently released Hudson Falls contamination but rather represents material which has been re-released from the sediments or perhaps a mixture of both recent and re-released contamination. Variations in these ratios may result from the degree of PCB dechlorination in nearby sediments, the ratio of recently released to re-released PCBs, and the period of time spent in the water column prior to redeposition. The level of dechlorination would presumably be related to the local concentrations since, as shown in the DEIR (USEPA, 1997), the degree of dechlorination varies with PCB mass. As to the ratios

found in deeper sediments (1 - 5 cm), it is interesting to note the reversals present in several of the profiles from more dechlorinated ratios to less dechlorinated to more dechlorinated in this very short distance. Perhaps in these instances, the 1991 event is evident as the ratio reversal. In these instances this would place the 1991-1992 horizon around 3 cm deep, yielding a deposition rate of 3 cm/6 years or a 0.5 cm/year deposition rate, placing at maximum 11 cm or 4.5 inches of sediment over the peak concentrations associated with the 1970-1975 period, hardly an example of "deep" burial. Profiles lacking this reversal suggest even slower rates of deposition since they lack sufficient sediment thicknesses to resolve this event. The presence of a few centimeters of sediment also does not necessarily represent long term deposition and sequestering of sediment PCBs since deposition may be transient, present for a few years only to be removed by a one-in-three or one-in-five year flow event.

In addition to the issues raised above, there are also analytical differences to be considered. Although USEPA and GE analytical data have been shown to indicate generally similar trends in water column loads, there has not been a direct reconciliation of the two analytical techniques for sediment. Of particular note is the use of only one analytical column by the GE investigators while the USEPA technique is based on a two column technique with 10 percent of samples confirmed by a third column. The GE data are also based on Aroclor standards and not the congener-specific standards utilized by USEPA. The USEPA technique is designed to be more conservative in its approach with more internal checks as well as a formal data validation program to certify data quality. These analytical differences may serve to create systematic differences between the two data sets.

Regardless of the most recent depositional trends and potential analytical differences, the most useful comparison is provided in Figure 13 of the GE comments. Specifically, this diagram shows that both the USEPA and GE data yield substantially lower sediment inventories relative to those obtained in 1984. The limited GE data set is probably too small to be shown statistically different from either prior set of efforts but the trend to lower inventories relative to 1984 is clearly suggested by the 1998 data.

The clear trend presented in Figure 13 should be contrasted with the Figures 11 and 12 presented by the writer. Specifically these figures attempt to suggest that the large difference between the 1984 and 1994 data sets is comparable to that between the 1994 and 1998 GE data sets. This is simply untrue and misconstrues the measurement uncertainty. As presented in the diagrams, the average difference between 1984 and 1994 is -80 percent. This is larger than the estimate obtained by USEPA (Appendix A) but is used here for the purposes of this discussion. Applying this difference to a 100 g/m^2 1984 Tri+ inventory would leave 20 g/m^2 in 1994. The writer contends that a similar scale "gain" occurs from 1994 to 1998. This is not true. If the 89 percent rise as Delta is applied to the 1994 inventory of 20 g/m^2, this yields a 1998 inventory of 38 g/m^2, representing a Delta of -62 percent relative to 1984. This is well within the uncertainties associated with the estimates of the 1984 to 1994 differences but nonetheless indicates a major loss of inventory from 1984 to the present. Thus the differences between the 1994 and 1998 data sets are substantially smaller than the 1984 to 1994 differences. This is shown quite clearly in Figure 13 which shows the 1984 Tri+ inventory levels relative to the 1994 and 1998 data. Apparently the error bars on the diagram represent the individual points and not the uncertainties about the mean values. It should be noted as well that the data have been "filtered" to include only those pairs separated by 5 feet.

USEPA does not believe it is appropriate to "filter" the data as suggested by the writer, as discussed in response LG-1.9.

Response to LG-1.18B

The USEPA agrees that erosion cannot be inferred for specific areas under specific flow events, however, neither can long term deposition. The distribution of sediment resuspension and settling asserted by the writer is principally based on modeling assumptions and not on measurements. Other processes may affect the sediment transport rate besides simple resuspension and settling within the normal river boundaries. Among some important processes which occur only during high flow events is the deposition of sediments in backwater areas and near-shore areas which are normally found above water. These areas are subject to both deposition and erosion during the high flow events while subject to surface runoff erosion during the period between major flood events. These special processes may affect both sediment and PCB transport during these events, making it difficult to characterize the system as a whole.

The model mentioned by the writer is described in an attachment to their comments as Appendix B. As attached, this information is not sufficient for a thorough review. It is unclear at this time as to whether the assumptions made in assembling this model are appropriate or well constrained by the available data. The USEPA has not received sufficient information so as to review the GE models. The USEPA intends to rely on its own modeling efforts to examine deposition phenomena.

Response to LG-1.18C

As mentioned in response LG-1.18B, the USEPA has not yet received sufficient information so as to review GE's sediment transport model. While the contentions put forth by the writer sound interesting, it is unclear whether the model is sufficiently constrained by available data to make its output meaningful. With regard to *Hot Spot* 14, it should be noted that the absence of berylium-7 in several sites is not the only evidence for lack of burial and possibly scour in this area. A large area of fine-grained sediments was found along the western side of *Hot Spot* 14 in which lineated sediment structures were found indicative of sediment scouring by flow. *See* response LG-1.18 for a discussion of berylium-7 and its relationship to long-term deposition. Lastly, it should be noted that the degree of variability in sediment PCB inventories is in part an indication of the degree of heterogeneity in sediment deposition and resuspension. The writer is reminded that assigning an average deposition rate to an area largely ignores this fact and may mask important local rates of sediment resuspension.

Response to LG-1.39A

The USEPA acknowledges that the text could have been written more clearly to explain the relationship between ^{7}Be and PCB inventory. In both the TI Pool and the areas below the TI Dam, the absence of ^{7}Be was shown to coincide with lower PCB inventories (median inventory at 4 g/m^2). Areas with ^{7}Be present had higher PCB inventories (median inventory of 10 g/m^2). In the case of the TI Pool, the coincidence was shown to be statistically significant. For the areas below the TI Dam, the data set was considered too small to provide a useful statistical test but still yielded the expected relationship. Individual comparisons did not prove as useful, since not all sites with lower

PCB levels relative to previous studies were nondetect for ^{7}Be. As discussed in the Report, however, this was considered to be evidence of temporary, very recent deposition in an environment which had clearly undergone PCB loss, possibly via scour. Nonetheless, when considered as a whole, the ^{7}Be results when examined on an absence/presence basis were consistent with the anticipated trend. Thus the text of the Report is not inconsistent.

The issue of the ^{7}Be data is discussed in the response to LG-1.18 as well and the writer is referred to that section.

Response to LS-1.1

No response required.

4.2.5 *Hot Spot* Boundaries

4.2.6 Comparison of the 1994 *Hot Spot* Inventories with Other 1977 Estimates

4.3 Sediment Contamination in the Near-Shore Environment

4.4 Summary and Conclusions

4.4.1 Sediment and PCB Inventories in the TI Pool

No significant comments were received on Sections 4.2.5 through 4.4.1.

4.4.2 Sediment and PCB Inventories Below the TI Dam

Response to LG-1.24

GE implies that the available evidence has too high a level of uncertainty to draw any conclusions regarding change of PCB mass over time in *hot spots* located below the Thompson Island Dam. While there is considerable uncertainty in the LRC estimates, as described in detail in the Low Resolution Sediment Coring Report, the USEPA contends that the data are sufficiently precise to draw firm conclusions regarding loss of PCB mass from several of the downstream *hot spots*.

This comment first presents an argument based on the sampling distribution of differences, and notes that the 95% confidence interval on the difference between 1976-1978 and 1994 arithmetic mean MPA includes zero for each *hot spot* analyzed below Thompson Island Dam. The standard error of the mean difference is calculated from the standard error of the mean for the individual samples as

$$\sigma_{\bar{x}_1 - \bar{x}_2} = \sqrt{\sigma^2_{\bar{x}_1} + \sigma^2_{\bar{x}_2}}$$

This standard error is then used to create a confidence interval about the difference in arithmetic means based on a spread of two standard errors, as presented in GE's Table 11.

In fact, the Low Resolution Sediment Coring Report (*see* p. 4-30) does not contend that the arithmetic differences are significantly different from zero or that the 1994 arithmetic means are significantly different from 1976-1978 means at the 95% confidence level (although the differences in MPA for *Hot Spots* 28, 31, and 37 are significantly different at the 90% confidence level). Rather, the Report demonstrates that the geometric means (means of the log-transformed data) are significantly different for four of the downstream *hot spots* in terms of MPA and five of eight in terms of LWA at the 95% confidence level. The geometric mean is an estimate of the median (50th percentile) of an arithmetic distribution. A significant decrease in median MPA can reasonably be concluded to represent a decrease in total mass. Differences in arithmetic means are not statistically significant at the 95% confidence level because the uncertainty in estimating arithmetic means from small samples of skewed distributions is taken into account in the MVUE estimator of the standard error. Essentially, the MVUE-based confidence limit addresses the small but finite statistical possibility that a small number of unobserved very high values might be present but not sampled, thus lending uncertainty to the arithmetic mean estimate.

Accounting for geophysical evidence in addition to statistics leads to the conclusion that inventories have indeed declined. Consider the alternative hypothesis that the median has indeed decreased, but the arithmetic mean has not. For this to occur, the decline in the median would need to be compensated for in the average by an increase in the high MPA values in the right-hand tail of the distribution. In other words, PCB mass would either need to be concentrated in a smaller volume, or new high-concentration PCB mass would need to be implaced in a few isolated pockets. There is no evidence for physical mechanisms which would account for either possibility in the upper Hudson below Thompson Island Dam. Therefore, a statistically significant decrease in the geometric mean can indeed be interpreted as representing a significant decrease in PCB mass.

USEPA agrees with the comment that uncertainty in mass change calculations is, in part, due to the small number of samples. The 1994 effort was not designed to be an exhaustive resurvey of PCB mass in downstream *hot spots*, and, in any case, the density of samples available from 1976-78 is also low. As noted, uncertainty is also introduced by the necessity of extrapolating grab samples and interpreting sediment density in the 1976-78 samples. The presence of these sources of uncertainty does not invalidate the basic findings of the discussion, that mean PCB mass appears to have declined since 1976-78 in most of the *hot spots* below Thompson Island Dam; rather it effects the degree of statistical certainty which can be applied to conclusions regarding the magnitude of change.

Finally, GE states that "the best indication of the overall uncertainty of the approach TAMS used is the result obtained for *Hot Spot* 28. The implausibly large increase of mass in this *hot spot* is dismissed." This argument addresses the statistics, but once again fails to consider the physical evidence present. In fact, there is good evidence to indicate that the 1976-78 sampling did not core below 12 inches in this *hot spot*, whereas later sampling suggests a significant amount of the PCB mass is present at depth. As stated on page 4-35 of the Report, "It is most likely that the apparent increase in total inventory is the result of an underestimate of PCB inventory in 1976-1978 derived from cores of insufficient length and incorrect assumptions about the total depth of PCB contamination."

4.4.3 Sediment Contamination in the Near-Shore Environment

Response to LF-1.1

No response required.

Response to LS-1.6

No response required.

4.4.4 Summary

No significant comments were received on the Summary.

Appendices A, B, C, D, E, F

No significant comments were received on the Appendices.

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Appendix A

APPENDIX A

A Comparison of PCB Sediment Inventories

in the Thompson Island Pool, 1984 to 1994

Low Resolution Sediment Coring Study

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APPENDIX A

A COMPARISON OF PCB SEDIMENT INVENTORIES IN THE THOMPSON ISLAND POOL, 1984 TO 1994

LOW RESOLUTION SEDIMENT CORING STUDY

TABLE OF CONTENTS

List of Tables

List of Figures

APPENDIX A

A COMPARISON OF PCB SEDIMENT INVENTORIES IN THE THOMPSON ISLAND POOL, 1984 TO 1994

LOW RESOLUTION SEDIMENT CORING STUDY

TABLE OF CONTENTS

Appendix A

A Comparison of PCB Sediment Inventories in the Thompson Island Pool, 1984 to 1994

This Appendix describes an alternate statistical analysis for the estimation of the direction and degree of change in the PCB inventory in the sediments of the TI Pool. The original statistical analysis presented in the Low Resolution Sediment Coring Report was based on a comparison of the results of the extensive 1984 NYSDEC survey of the PCB inventory at the TI Pool and a series of matched sediment cores collected by the USEPA in 1994. Specifically, the PCB inventories from a set of sixty sampling locations in the TI Pool were compared on a point-to-point basis to provide a quantitative understanding in the direction and extent of change of the PCB inventory of the Thompson Island Pool. The LRC concluded that the sediment PCB inventory has substantially declined, presumably by re-release to the river. Additionally, the report concluded that there is no evidence of extensive burial.

The statistical analysis presented in this Appendix examines the 1984 and 1994 data from an area-based perspective, as opposed to the point-to-point comparison used in the LRC. This analysis simply presents an alternate basis to examine the change in the PCB sediment inventory between 1984 and 1994. In part, this analysis is to address the concerns expressed by some reviewers that the point-to-point comparisons presented in the LRC may be biased due to a "regression toward the mean" effect or by the distance of separation between the 1984 and 1994 sampling locations. Although the USEPA does not accept these criticisms as wholly valid, the statistical analysis presented here was designed to avoid these issues.

Outline of Analysis

The area-based examination required the construction of area-based estimates for the areas to be compared. The examination presented in this Appendix is based on the procedure outlined below. A detailed discussion of the individual steps follows this outline:

1. As described in the LRC, the 1994 sampling locations were arranged in clusters and placed in areas of apparent local homogeneity in the PCB inventory and texture, based on the 1984 sampling results. These groups form the basis for the area-based comparison of PCB inventory between 1984 and 1994.

2. The semivariogram analysis presented in the DEIR was used to establish the "area of influence" around each of the 1994 sampling locations. Essentially, either a circle or an ellipse of "influence" was defined for each 1994 sampling location. The shape, size and orientation of each "area of influence" was dependent on the section of the TI Pool in which it was located. All seventy-six 1994 TI Pool locations were considered in this manner and not simply the ones specifically matched to the 1984 locations.

3. The clusters of 1994 sampling locations were grouped into larger areas based on the overlap of the individual "areas of influence." These areas essentially corresponded to the

original clusters developed in the sampling plan for the low resolution coring program. The shape and orientation of the larger areas was again defined by the section of the TI Pool in which it was located, following the proportions defined from the semivariogram analysis. The size was defined as the minimum area which would encompass the individual "areas of influence" for the cluster of 1994 sampling points. Clusters with extensive overlap were combined into a single large area.

4. All 1994 cores in a given cluster area were used to establish a mean PCB inventory for the cluster for 1994. Similarly, all 1984 cores and grabs in the cluster area were used to establish the mean PCB inventory for the cluster for 1984. Additionally, the 1984 sampling points were separated based on sampling method (*i.e.*, core or grab), and used to establish cluster area means based on the specific sampling technique. Similarly, the incomplete cores from the 1994 sampling program were excluded and an alternate inventory estimate for the cluster areas was obtained and contrasted with the 1984 cluster means. The calculations were based on the trichloro- and higher homologue sums for 1984 and 1994. The 1984 trichloro- and higher sum was based on the calculation technique described in Appendix E of the LRC. As part of this construction of means for each cluster area for each of the sampling programs, the best basis for estimating the mean was examined. For each cluster mean estimate, either the arithmetic (*i.e.*, simple) mean or the minimum-variance-unbiased-estimator of the mean (MVUE) was selected as the cluster mean. Like the point-to-point comparison presented in the LRC, the area-based comparisons are considered to be representative of the fine-grained sediments of the TI Pool.

5. The cluster means for the 1984 and 1994 sample data were then compared and used to estimate the net change for the entire set of clusters. The estimate of net change was based on two separate statistical approaches. In the first approach, a linear regression on the 1984 and 1994 cluster means was used to estimate the mean inventory change. In the second approach, the ratio of the mean 1994 inventory over the mean 1984 inventory for each cluster was the variable used in the statistical analysis since this ratio was found to be statistically better "behaved" than the Delta function used in the LRC. Specifically, when the 1994/1984 ratios were examined, the distribution of ratios was found to be log-normally distributed. By comparison, the Delta functions of the LRC were neither normally nor log-normally distributed, although they were closer to log-normal than to normal distributions. All of the individual cluster ratios were then examined as a whole to establish the direction and degree of change for the fine-grained sediments of the entire TI Pool.

6. The comparisons were based on the entire cluster set for both 1984 and 1994 as well as subsets of the 1984 and 1994 data sets, based on sampling technique (*i.e.*, 1984 core or grab) and on 1994 core completeness. These comparisons demonstrated the robustness of the mass loss regardless of the assumptions concerning the underlying data sets.

7. Lastly, a correction for *in situ* dechlorination from 1984 to 1994 was obtained from the data collected by McNulty, 1997 and applied to the 1984 PCB data. This permitted the calculation of the trichloro- and higher homologue mass loss from the sediments exclusive of any dechlorination loss.

Establishing a Basis for Comparison

In this comparison, the samples are grouped by the cluster locations developed for the low resolution sediment coring program instead of comparing the 1984 samples to the 1994 cores

on a point-to-point basis. The shape, orientation and dimension of the area associated with each of the 1994 sampling points are determined by the results of the geostatistical analysis of the Total PCB mass in the TI Pool using the 1984 data, as discussed in Section 4.2.4 of the DEIR. Results of this analysis are listed in Table A-1, which is based on Table 4-4 of the DEIR.

In order to establish the "areas of influence" which were spatially correlated with the 1994 cores, circles or ellipses were drawn centered on each 1994 sampling point. The dimensions of these circles or ellipses were based on the appropriate practical range, anisotropic ratio and orientation of the major axis given in Table A-1. Figure A-1 is a map illustrating the "areas of influence" defined for each 1994 sampling location in the TI Pool. For subreaches 1, 2, and 5 as defined in the DEIR, the "area of influence" was defined as a circle about the sampling point whose radius was given by the practical range developed from the semivariogram analysis. The practical range can be thought of as the distance from a sampling point where the sediment inventory would be expected to correlate with the original sampling point. Beyond this distance, no correlation between the original sampling point and other sampling points is evident. In these three subreaches, no directional component (*i.e.*, downstream or cross-stream) to the spatial correlation was evident. Hence, the spatial correlation is considered isotropic (equal in all directions) and a "circle of influence" was defined.

For subreaches 3 and 4, a directional component to the spatial correlation was evident. In these subreaches, the "areas of influence" were defined as ellipses whose major axes were oriented parallel to river flow. The degree of anisotropy was used to determine the ratio of the major axis to the minor (cross-stream) axis for the ellipses. The degree of anisotropy is essentially a measure of the ability to estimate river PCB inventory conditions upstream and downstream of a sampling point relative to conditions cross-stream.

After establishing the "areas of influence" about each sampling point, overlapping areas were combined to form a single, larger area for the entire cluster. The larger area was defined with the same proportions as the smaller areas it encompassed. The area was defined as the smallest area sufficient to encompass all of the smaller polygons (*see* Figure A-1). Note that these cluster areas were defined solely on the basis of the 1994 sampling locations. This procedure yielded 14 cluster areas for comparison.

Utilizing these cluster areas as overlays in a geographical information system, the 1984 and 1994 sampling locations contained within these areas were identified. This approach expanded the sample basis for estimating the 1984 and 1994 sediment inventories, yielding 243 locations for 1984 and 70 locations for 1994. This should be compared to the 60 paired locations used for both 1984 and 1994 in the point-to-point comparison presented in the LRC. Because overlapping areas of influence were combined into larger cluster areas, none of the 1994 sample locations and only one out of 243 of the 1984 sample locations were contained in more than one cluster area. Figure A-2 presents a map of the TI Pool, illustrating the locations of the 1984 and 1994 sampling locations considered in this analysis. The bounds of each cluster area along with associated 1984 and 1994 locations contained within each cluster area are shown.

Processing of the Data

On the previous section, a set of samples for 1984 and 1994 was established as a basis for the creation of area-based mean sediment PCB inventories. In this section, the basis for

calculating these means is presented. The original calculations presented in the LRC examined the sum of trichloro- and higher homologues in 1984 against the sum of tri-chloro- and higher homologues plus the congeners BZ#1, 4, 8, 10 and 19 for 1994 on a molar basis. This calculation was presented as a minimum estimate of the loss of trichloro- and higher homologues to the water column since it assumed the absence of dechlorination products in 1984. Subsequent discussions and review suggest this may have been too conservative an approach since evidence for the occurrence of dechlorination in 1984 was reported by several authors (*e.g.*, Bopp *et al.*, 1985).

In light of this, the PCB inventory as moles of trichloro- and higher homologues per unit area (abbreviated as Tri+ MPA) was selected as the initial basis for comparison in this calculation. A correction based on an estimate of the actual rate of dechlorination developed from McNulty, 1997 will be applied later in the analysis. The individual Tri+ MPA estimates for each sampling location (*i.e.*, core or grab) were calculated using the equations provided in Chapter 4 of the DEIR, with the exception that the corrected factor of 0.944 was applied to the 1984 data as described in Appendix E of the LRC.

The data treatment applied to the grab samples was the same as that used for the kriging analysis as discussed in the DEIR. Specifically, sample depth for grab samples was assigned based on sediment texture: 12" for coarse-grained samples and 17" for fine-grained samples, as originally defined by NYSDEC.

Co-located 1984 sample pairs (*i.e.*, field duplicates) were treated in the manner described in the DEIR for the kriging analysis: for core pairs or grab pairs the values are averaged, for core-grab pairs the core value is used, and for pairs in which one sample was analyzed with GC/ECD and the other screened with mass spectrometry, the GC/ECD value is used. Treatment of field duplicates in this manner reduced the number of sampling locations for 1984 from 243 to 197.

Representativeness of the Data

Several comments on the LRC raised the issue of the representativeness of the low resolution core sampling locations and their associated 1984 sample result. The following discussion addresses this concern in the context of the cluster area means. While the USEPA does not accept all the commentors' claims as correct in this regard, the following approach demonstrates that issues do not pertain to the area-based cluster estimates used in this Appendix.

Table A-2 presents several sets of arithmetic means for the cluster areas. The first column of data lists the cluster area Tri+ MPA arithmetic means for all 1984 samples (197 in total, excluding duplicates) contained within the clusters. The second column represents the arithmetic means of the 1984 sample locations reoccupied in the Phase 2 sampling event, grouped by cluster area. Notably, the cluster area mean values for all 1984 points are less than the mean values of the reoccupied sample location results in 10 of the 13 cluster areas containing matched 1984 to 1994 sample locations. (One cluster area, LR-13, had no matched 1984-1994 sampling locations as presented in the LRC.)

When all of the 1984 samples contained in the cluster areas are considered together, the mean for all 197 points is less than half of the value for the 59 re-occupied locations (0.061 moles/m^2 for all points in the sample areas and 0.134 moles/m^2 for the re-occupied locations). These means are considered significantly different, assuming an uncertainty of two standard

errors around the mean. This is indicative of the fact that the low resolution coring program attempted to sample among the more contaminated sediments of the TI Pool, anticipating that any sediment mass loss would be most easily discernible in these areas.

For all fine-grained areas in the Thompson Island Pool, the average Tri+ MPA is 0.050 moles/m^2 (based on the revised 1984 inventory analysis presented in Appendix B), which is within the uncertainty of the mean for the one hundred and ninety-seven 1984 samples. This comparison demonstrates that the 14 cluster areas studied as part of the low resolution coring program and defined based on the semivariogram analysis can be considered representative of all fine-grained sediments in the TI Pool when estimating change in the PCB inventory.

The last column in Table A-2 presents the arithmetic means for the 14 cluster areas based on the 1994 coring locations. The 1984 inventory estimates are higher than the 1994 estimates in nearly every case, regardless of whether the matched points or the entire cluster areas are considered. These differences will be shown to be statistically significant later in this Appendix.

In addition to examining the representativeness of the PCB concentrations themselves, the physical nature of the cluster areas was also reviewed. Specifically, both the reported sediment sample textures and the side-scan sonar results were examined in this context. The number of sampling locations assigned to each cluster area is listed in Table A-3. The sampling locations are further divided by sediment classifications based on side-scan sonar for both 1984 and 1994 locations, visual texture classification for 1984 samples and principal fraction based on laser-grain-size distribution for 1994 samples. For the majority of cluster areas (11 of 14), the fine-grained samples represent the majority of sampling points in the cluster, based on all four measures, thus supporting their classification as fine-grained areas. In two instances, the areas were dominated by coarse-grained samples and locations and were classified accordingly.

The general classification for the remaining cluster area (LR-06&07) was not as easily resolved. Figure A-2 shows the cluster areas and sampling locations superimposed on the side-scan sonar sediment classifications. In most instances, the cluster areas captured a majority of fine-grained sediment with some coarse-grained samples. This pattern is also evident in cluster area LR-06&07, in which a band of fine-grain sediments runs down the center. According to the side-scan sonar analysis, 17 of the 24 1984 sample locations fall into the coarse-grained region, but 14 of the 24 samples are fine-grained by visual texture classification. Similarly, the 1994 samples were exclusively classified as fine-grained based on laser-grain-size distribution analysis but 4 of the 7 were classified as coarse-grained based on the side-scan sonar classifications. On the basis of the specific samples, cluster area LR-06&07 was classified as fine-grained.

The original low resolution sampling program was principally designed to focus on fine-grained sediments so as to examine the change in PCB inventory in the more contaminated regions of the TI Pool. As shown above, the selected 1994 sampling locations and the associated 1984 locations were principally classified as fine-grained and as such can be considered representative of fine-grained sediment regions. This assessment is also supported by the agreement of the mean Tri+ inventory of the cluster areas with the mean Tri+ inventory for the entire domain of fine-grained sediments from the TI Pool.

Calculation of the Cluster Area Mean Inventories

The assessment of the mean mass loss from the sediments of the TI Pool is derived from the mass estimates for each cluster to be compared. Thus these estimates need to accurately represent the data available for each cluster. To this end, the data distributions for each of the cluster areas for each of the sampling programs was examined to assess the degree of normality and log-normality. The arithmetic mean for truly normal data distributions can be estimated by calculating the arithmetic average of the sample population. Alternatively, when an underlying distribution is log-normal, the MVUE may represent the best estimate of the arithmetic mean. Guidance on the basis for selecting the arithmetic mean or the MVUE was obtained from Gilbert, 1987.

The general log-normal nature of the groups of samples which comprise the individual cluster areas is illustrated by the statistics provided in Table A-4. This table lists the results of the Shapiro-Wilks W Test for normality for cluster area by year. The W statistic plus the probability that the underlying distribution is normal is given for the original Tri+ MPA values plus the log-transform of these values. The closer the W statistic is to a value of one, the more normal the underlying distribution. Most cluster areas have W values closer to one for the log transform. The majority of cluster areas have probability values greater than 0.05 (5 percent) indicating that the distributions could be log-normal. Since 71 percent of the 1984 cluster areas and 64 percent of 1994 cluster areas appeared more log-normal than normal for 1984 and 1994, respectively, all areas were assumed to be log-normal. The W test results are also listed for the 1994 cores that completely capture the PCB inventory at the sample location (i.e., complete or nearly complete cores only). Nine cores were excluded from the 1994 cluster area analysis because they were considered possibly incomplete representations of the sediment PCB inventory at their respective locations as discussed in the LRC and response LG-1.2. The majority of sample area distributions for the 1994 complete cores also have greater W values and probabilities for the log-transformed data relative to the untransformed values. It should be noted as well that the entire set of 1994 and 1984 values also indicate underlying log-normal distributions, consistent with the individual cluster areas.

Because the W test suggests that the underlying distribution of the data may be log-normal, the minimum variance unbiased estimator of the mean (MVUE) may be a better predictor of the true population mean than the sample arithmetic mean. Guidance obtained from Gilbert, 1987 states that if the coefficient of variation is greater than 1.2, the MVUE is a better predictor of the mean, otherwise the arithmetic mean can be used to estimate the population mean. The coefficient of variation is defined as the ratio of the standard deviation to the arithmetic mean for the sample group (*i.e.*, the individual cluster areas). This ratio is listed for each sample area on Table A-4. The 5 of the 13 individual cluster areas in 1984 plus the entire 1984 data set (*i.e.*, 197 points) have values greater than 1.2 indicating that the MVUE should be used to estimate the mean in these instances. Only two of the cluster areas in 1994 utilizing all cores as well as complete cores only have values greater than 1.2. The MVUE will be used in these instances as well. Calculation of the MVUE is based on Gilbert, 1987.

Table A-5 summarizes both the arithmetic mean and MVUE estimates for all cluster areas for the Tri+ MPA in mole/m^2. The last column in the table represents the best estimate of the mean based on the coefficient of variation criterion described above. The best estimate values are used throughout the remaining discussion in this Appendix.

Regression-Based Estimates of Mass Loss

Two approaches were used to estimate sediment PCB mass loss based on the Tri+ MPA data. The first of these uses a regression analysis between the 1984 and 1994 best-estimate-of-the-mean values from each of the cluster areas. Essentially, a regression of the form:

$$1994\ MPA = a * 1984\ MPA + b$$

was examined for the set of cluster area means. An initial examination of these regressions indicated that the intercept term "b" was not statistically different from zero. As a result, the regression was forced through zero, yielding the form:

$$1994\ MPA = a * 1984\ MPA$$

The advantage of this form is that the slope term "a" can be directly interpreted as a mass loss estimate. The nature of this form of estimate is such that the cluster areas farthest from the overall average 1984 and 1994 MPA values (*i.e.*, the average of all cluster areas) weigh more heavily in the determination of the slope "a." The other approach to be used to estimate the mass loss will weigh all clusters equally, regardless of their MPA value.

The results of the single coefficient linear regression directly comparing the Tri+ sediment inventories (MPA) for 1984 and 1994 are shown in Figure A-3. A diagram of the regression as well as some summary statistics are provided. The diagram shows the regression line along with the estimated uncertainty. The fact that the uncertainty about the regression does not include the line with a slope of unity (*i.e.*, 1994 = 1984) indicates that the slope is statistically different from unity and therefore indicates a statistically significant mass loss. The slope of the regression can be converted to the $Delta_M$ expression used throughout the LRC as follows:

$$Delta_M = \frac{1994\ MPA - 1984\ MPA}{1984\ MPA} = \frac{1994\ MPA}{1984\ MPA} - 1$$

$$= Slope - 1$$

Thus the $Delta_M$ estimated from Figure A-3 is (0.41 - 1) or -59 percent $\pm$ 19 percent. This represents an estimate of the mean mass loss of trichloro- and higher homologues from the sediments, including any dechlorination loss.

It should be noted that although care was taken to select the best estimate of the mean cluster inventories, similar results are obtained if the arithmetic means or the MVUE values are used exclusively. This results are presented in Figure A-4. The slopes obtained from these values (0.39 for the arithmetic means and 0.37 for the MVUE values) agree quite well and deviate less than one standard error from with the value of 0.41 obtained from the set of best estimates.

Figure A-5 represents a similar analysis utilizing only the complete 1994 cores for the 1994 cluster area MPA estimates. The values presented are based on the best estimates of the mean, as was done in Figure A-3. This analysis addresses the concern that the incomplete cores may substantively underestimate the 1994 sediment inventory and thereby overestimate the

1984 to 1994 mass loss. The results of this analysis show that this concern is unwarranted since the regression on the 1994 complete cores yields a $Delta_M$ value quite close and well within error of the value obtained for the entire 1994 data set.

Similar concerns were raised over the comparability of the 1994 cores to the set of 1984 cores and grabs. Two additional analyses were completed to address this concern. Figures A-6 and A-7 summarize these analyses. In Figure A-6, the 1994 cluster area MPA values are matched to the 1984 cluster area MPA values based on 1984 cores only. This analysis yields a slope of 0.31 or a mass loss estimate of -69 percent $\pm$ 16 percent. This agrees well with the mass loss estimate obtained using all 197 of the 1984 sampling points. In Figure A-7, the 1984 mean estimates were constructed based solely on the grab samples. This analysis also yielded a mass loss estimate within error of the original estimate presented in Figure A-3. On the basis of these sample subsets, it is clear that a statistically significant mass loss between 1984 and 1994 has occurred for fine-grained sediments, regardless of the basis used to estimate the loss.

In preparing the regression-based mass loss estimates, it is noted that the regressions do not consider the uncertainties in the individual cluster area means. An initial investigation of these uncertainties suggests that they will not impact the conclusion of significant PCB mass loss from the Upper Hudson sediments.

Ratio-Based Estimates of the Mean Mass Loss

An alternate basis of mass loss was developed from the 1984 and 1994 cluster area best-estimate-of-the-mean values. In this instance the ratio of the 1994 MPA to 1984 MPA was examined rather than the absolute values as was done in the regression analysis. This parameter is related to the $Delta_M$ function used in the LRC as follows:

$$Delta_M = \frac{1994\ MPA - 1984\ MPA}{1984\ MPA} = \frac{1994\ MPA}{1984\ MPA} - 1$$

Thus the value for $Delta_M$ can be obtained after the mean ratio is obtained. The $Delta_M$ function is a measure of the percent change in the sampling areas between 1984 and 1994. This parameter was originally used directly to characterize the degree of change between 1984 and 1994. The parameter was also shown to be skewed even under a log transform, making estimation of a mean value for $Delta_M$ difficult. After further analysis, it was found that the ratio of the 1994 and 1984 inventories was a statistically "better behaved" function whose central tendency was easily defined and whose distribution appeared normal under a log transform. This is clearly evident in Figure A-8.

The distribution of 1994 MPA/1984 MPA is shown in Figure A-8 and can be better described as log-normal (vs normal). Table A-8 provides the summary calculation for this estimate of the mass change. On a ratio basis, the cluster area median mass loss, $Delta_M$, was estimated to be -57 percent with a range of -33 to -72 percent, larger but still within the uncertainty of the original LRC median estimate of -40 percent. This is summarized on Figure A-8. Note that the median $Delta_M$ estimate is based on the mean of the log-transformed data (*i.e.*, the geometric mean) which is presented in Figure A-8.

Before the mean mass loss could be calculated, the coefficient of variation had to be examined. The coefficient of variation for the cluster area mean ratios based on all 1994 points as well as for the ratios using complete 1994 cores only are provided in the table. In both cases, the coefficient is less than 1.2, indicating the arithmetic mean as the best estimate of the men ratio. Nonetheless, the underlying log-normal distributions as shown by the W statistic also provided on Table A-6, indicate that the uncertainty estimates should be derived based on this consideration. The calculation of the uncertainty of the arithmetic mean given an underlying log-normal distribution is described in Gilbert, 1987 and was utilized in providing the estimates the table. These confidence limits for the ratio were converted to delta by subtracting one from the values. Based on the ratio, the mean $Delta_M$ is -45 percent, with a 95 percent confidence range between -59 percent and -4 percent. On this basis, the loss of trichloro- and higher homologues between 1984 and 1994 is estimated to be -45 percent including any dechlorination loss. This value is similar to the median mass loss of -40 percent originally estimated in the LRC . Both loss estimates are found to be statistically significant since the 95 percent confidence limits do not contain zero. Note that the arithmetic confidence limits are also provided in Table A-6. These limits also exclude zero and are provided simply for comparison.

The $Delta_M$ value was recalculated using only the 1994 cores which were complete or nearly complete by the cesium-137 and total PCB profiles. Based on the ratio, the mean $Delta_M$ is -50 percent, with a 95 percent confidence range of -63 percent to -13 percent. This result is quite similar to the $Delta_M$ values calculated using all 1994 cores. Because the incomplete cores should under represent the true amount of PCBs in the location, the $Delta_M$ excluding the incomplete cores was expected to increase. This is not the case because incomplete cores frequently yielded higher molar inventories relative to other 1994 cores from the cluster areas.

Based on this analysis, the mean mass loss including any *in situ* dechlorination losses is estimated to be -45 percent with a range of -59 to -4 percent. This agrees well with the regression-based estimate of -59 percent with a range of -78 to -40 percent.

Correction for Dechlorination

The degree to which the loss of tri- and higher homologues is due to dechlorination cannot be directly assessed using the 1984 data, because the amount of mono- and dihomologues present was not measured. A rough approximation of the degree of dechlorination between 1984 and 1994 can be calculated using the data found in McNulty, 1997. In this thesis, preserved cores from 1983 and 1991 were analyzed for PCBs on a congener-specific basis and dated using cesium-137. As shown in Figure A-9, the cores represent areas of near-continuous deposition in the Thompson Island Pool (RM 188.5 and 188.6) and exhibit the profiles typical of high-resolution cores. The homologue distributions and the $Delta_M$'s for trichloro- and higher homologues are shown in Table A-7. The average percent change in the trichloro- and higher homologue fraction is -4.7 percent. If the 1984 Tri+ MPA is multiplied by 0.953 (1-0.047), this approximates the amount of trichloro- and higher homologues that would have been present in 1984, but were lost to dechlorination. The factor of 0.953 was applied to all of the 1984 samples as an estimate of the dechlorination loss. The recalculated cluster mean values for the 1984 results are listed in Table A-8.

Using the revised cluster mean estimates, the 1984-1994 mass loss was recalculated to estimate loss exclusive of dechlorination (*i.e.*, loss from the sediments). The ratio calculation

followed the same process as described for the total Tri- mass loss and is summarized in Table A-9 and Figure A-10. Based on this calculation the median mass loss as estimated from the geometric mean is -56 percent with an uncertainty range of -72 to -31 percent. This is within the uncertainty of the median (as compared to the mean) mass loss estimate of -28 percent (range of -48 to -5 percent) originally estimated in the LRC. The mean change in Tri- inventory expressed as $Delta_M$ is -43 percent (*i.e.*, 43 percent molar loss) with an uncertainty range (or 95 percent confidence interval) of -58 percent to -1 percent (*see* Figure A-10). The inclusion of a positive upper limit in this instance is not taken as significant since the median mass loss is so large, the mass loss was statistically different from zero for the 1994 complete cores (discussed below) and the total Tri+ mass loss was shown to be statistically different from zero. The mean mass loss excluding dechlorination is statistically different from zero at the 90 percent confidence level.

Table A-9 also presents the results for the mean mass loss excluding dechlorination based on the 1994 complete cores and the 1984 cluster means. These results are statistically different from zero as well, and support the conclusion of mass loss for the sediments of the TI Pool.

Conclusions

Loss of trichloro- and higher homologues has been demonstrated with statistical certainty in the TI Pool between 1984 and 1994. This degree of loss cannot be explained by dechlorination alone and is estimated to be -43 percent, excluding dechlorination losses. This estimate is interpreted as a loss of 43 percent of the sediment inventory to the overlying water column. Following its release, some of this PCB mass would be transported downstream while some would be redeposited in other areas of the TI Pool.

Direct evidence for dechlorination loss suggests a loss of about five percent over the period 1984 to 1994. Combining loss from the sediments with dechlorination mass loss yields a mean mass loss of -45 percent with an uncertainty of -4 to -59 percent. (Note that the five percent dechlorination loss does not add directly to the 43 percent sediment loss since the 1984 inventory appears in both the numerator and denominator of the $Delta_M$ function.)

The median mass loss estimate excluding dechlorination was -56 percent or -57 percent when dechlorination was included. These values are based on a statistically well-behaved ratio function and local area-based averages.

Regression analysis of the sediment PCB inventory data (*i.e.*, Tri+ MPA) yielded slightly higher estimates of mass loss with an average mass loss as $Delta_M$ of -59 percent and an uncertainty range -40 to -78 percent. The mean mass loss estimates obtained by regression were shown to be rigorous, regardless of the exclusion of various data types due to concerns over their representativeness or comparability. The mean mass loss by regression agrees well with the mass loss estimated by the ratio of the 1994 to 1984 Tri- MPA.

These results compare favorably with the original 40 percent median mass loss estimated in the LRC. This original value included a maximum dechlorination mass loss of 12 percent and a median loss from the sediments of 28 percent. The original results are based on point-to-point comparisons using a less-well-defined statistic ($Delta_M$). In view of this, the revised estimates presented in this Appendix are to be used in subsequent analysis of PCB contamination in the Hudson River.

APPENDIX A
TABLES

Table A-1

Subreach Variogram Models[a] for Natural Log of PCB Mass Concentration, 1984 Thompson Island Pool Sediment Survey

	Subreach 5 1163000 - 1170100 N	Subreach 4 1170100 - 1177000 N	Subreach 3 1177000 - 1181900 N	Subreaches 1 and 2 1181900 - 1191700 N
Observations	235	320	238	321
Nugget	0.750 (.284)	0.484 (.154)	0.0 (--)	1.54 (.108)
Sill-Nugget	1.520 (.282)	1.092 (.153)	1.733 (.060)	0.203 (.106)
Practical Range (ft)[b]	340 (75)	280 (68)	286 (49)	582 (521)
Anisotropy Ratio[c]	1.0	1.5	2.5	1.0
Major Axis[d]	-	N 10° W	N 35° W	-

Note:

a. Variograms are exponential models, showing fit along the major axis and anisotropy ratio. Standard errors of the coefficients from the least squares estimation are shown in parentheses.

b. A value of 2 times the practical range was used as the length of the major axis of the polygon associated with each 1994 location. This distance represents the distance of separation at which variance between point pairs approaches that of the population as a whole.

c. This ratio represents the ratio of the major axis over the minor axis of the ellipse associated with each sampling point.

d. This represents the orientation of the major axis. Essentially this orientation causes the ellipse to be oriented in the direction of river flow. This angle is not defined when the anisotropy ratio is unity (1).

Source: USEPA, 1997

Table A-2

Comparison of Tri+ MPA Arithmetic Means for All NYSDEC 1984 Sample Points in the Sample Areas and Co-Located 1984 to 1994 Sample Points

	1984 Results				1994 Results	
	All 1984 Sample Locations in Cluster Areas		1984 Sample Locations with matching 1994 Locations, grouped by Cluster area		All 1994 Sample Locations in the Cluster Areas	
Cluster Area[1]	No. of Locations	Mean Tri+ MPA (moles/m^2)	No. of Locations	Mean Tri+ MPA (moles/m^2)	No. Of Locations	Mean Tri+ MPA (moles/m^2)
LR-01	14	0.053	4	0.086	4	0.013
LR-02&03	12	0.166	6	0.281	6	0.011
LR-04&18	24	0.093	5	0.336	9	0.074
LR-05	14	0.070	4	0.143	5	0.067
LR-06&07	24	0.058	7	0.099	7	0.029
LR-08	9	0.021	5	0.025	5	0.011
LR-09	14	0.057	6	0.106	6	0.013
LR-10	8	0.139	4	0.244	4	0.036
LR-11	9	0.117	3	0.259	3	0.103
LR-12	8	0.018	5	0.019	5	0.018
LR-13[2]	6	0.033			3	0.015
LR-14	23	0.028	4	0.026	4	0.007
LR-15	30	0.013	4	0.006	4	0.016
LR-17	2	0.091	2	0.091	5	0.021
Total Locations	197		59		70	
Arithmetic Mean		0.061		0.134		
Standard Error		0.007		0.020		
All Fine Grained Areas of the TI Pool[3]		0.050				

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Notes:

1. The LR-16 cluster is not included in this analysis, because there is only one reoccupied 1984 sample location in the cluster. This is the sixtieth matched 1984 to 1994 sample location.
2. Three sample points in Sampling Area LR-13 were reoccupied in 1994, but were excluded from the pairwise analysis because the samples were only screened by mass spectrometry.
3. Tri+ MPA in the fine-grained areas of the TI Pool is calculated from the Total PCB Inventory Estimate described in Appendix B.

Table A-3

Number of Locations in Sample Areas for 1984 and 1994

Sampling Area Clusters	No. of Locations[1] in Sampling Area		Sediment Classification by Side Scan Sonar (No. of locations)					Visual Texture Principle Fraction Classification (No. of locations)		Laser Principle Fraction Analysis (No. of locations)		Principal Side Scan Sonar
			1984			1994		1984		1994		
	1984	1994	Fine	Coarse	Rocky	Fine	Coarse	Clay, Silt or Fine Sand	Coarse Sand or Gravel	Silt or Fine Sand	Medium Sand or Gravel	Texture of Region
LR-01	14	4	11	3		4		11	3	4		Fine
LR-02&03	12	6	9	2	1	5	1	10	2	5	1	Fine
LR-04&18	24	9	18	6		9		22	2	9		Fine
LR-05	14	5	14			5		12	2	5		Fine
LR-06&07	24	7	7	17		4	3	14	10	7		Fine[2]
LR-08	9	5	7	2		4	1	8	1	5		Fine
LR-09	14	6	7	7		4	2	10	4	6		Fine
LR-10	8	4	4	4		1	3	8		4		Fine
LR-11	9	3	2	7			3	6	3	2	1	Fine
LR-12	8	5	2	6			5	5	3	5		Fine
LR-13	6	3		6			3	1	5	1	2	Coarse
LR-14	23	4	14	9		3	1	14	9	4		Fine
LR-15	30	4	8	22		1	3	6	24	1	3	Coarse
LR-17	2	5	2			5		2		5		Fine
Total	197	70	105	91	1	45	25	129	68	63	7	

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Notes:

1 1984 field co-locates count as one point and were handled as described in USEPA, 1997

a. Core-core or grab-grab pairs were averaged

b For core-grab , the core value was used

c. If one sample in a pair was screened with mass spectroscopy and the other sample analysed with GC-ECD, the GC-ECD value was used.

2 This area was considered fine-grained based on the 1984 and 1994 sampling data only

Table A-4

Shapiro Wilks Test and Ratio of Arithmetic Mean to Standard Deviation for Sample Points in Cluster Areas for 1984 and 1994

	1984					1994					1994 Complete Cores Only					1984	1994	1994 Complete Cores
		Untransformed		Log10 Transform			Untransformed		Log10 Transform			Untransformed		Log10 Transform		Coefficient of		
Cluster Area	N	W	Prob<W[1]	W	Prob<W[1]	N	W	Prob<W[1]	W	Prob<W[1]	N	W	Prob<W[1]	W	Prob<W[1]	Variation[3]		
LR-01	14	0.831	0.012	0.969	0.845	4	0.863	0.267	0.873	0.305	4	0.863	0.267	0.873	0.305	1.1	0.3	0.3
LR-02&03	12	0.680	0.000	0.929	0.346	6	0.807	0.063	0.890	0.314	5	0.774	0.050	0.876	0.288	1.4	1.3	1.5
LR-04&18	24	0.594	< 0001	0.922	0.071	9	0.903	0.266	0.937	0.543	9	0.903	0.266	0.937	0.543	1.8	0.7	0.7
LR-05	14	0.872	0.045	0.888	0.089	5	0.786	0.062	0.867	0.254	5	0.786	0.062	0.867	0.254	1.0	0.8	0.8
LR-06&07	24	0.733	< 0001	0.941	0.176	7	0.724	0.007	0.983	0.968	5	0.700	0.011	0.987	0.957	1.21	1.4	1.5
LR-08	9	0.949	0.672	0.905	0.279	5	0.834	0.147	0.857	0.216	3	0.863	0.276	0.932	0.497	0.5	0.6	0.7
LR 09	14	0.697	0.000	0.931	0.309	6	0.960	0.826	0.700	0.006	5	0.991	0.973	0.758	0.037	1.3	0.6	0.7
LR 10	8	0.901	0.301	0.836	0.071	4	0.839	0.186	0.849	0.216	4	0.839	0.186	0.849	0.216	0.9	0.2	0.2
LR-11	7	0.814	0.030	0.972	0.906	3	0.790	0.090	0.844	0.226	2	Insufficient Number of Points				1.0	1.0	..[2]
LR 12	8	0.896	0.269	0.918	0.417	5	0.680	0.007	0.818	0.111	4	0.731	0.026	0.838	0.183	0.4	0.9	1.0
LR 13	6	0.906	0.396	0.712	0.008	3	0.991	0.823	0.988	0.792	3	0.991	0.823	0.988	0.792	0.5	0.6	0.6
LR 14	23	0.714	< 0001	0.984	0.957	4	0.938	0.618	0.882	0.341	4	0.938	0.618	0.882	0.341	1.3	0.3	0.3
LR 15	30	0.701	< 0001	0.944	0.134	4	0.905	0.448	0.754	0.042	3	0.814	0.329	0.807	0.132	1.1	0.6	0.7
LR-17	2	Insufficient Number of Points				5	0.949	0.738	0.779	0.055	5	0.949	0.738	0.779	0.055	..[2]	0.7	0.7
All Points	195	0.5718	0	0.9646	0.003	70	0.6780	0	0.9291	0.001	56	0.7308	< 0001	0.9188	0.000	1.7	1.3	1.19

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Notes

1 The probability that the data set for the cluster area is normal or log-normal. The W statistic is a measure ofthe degree of normality in the data. The premise of normality (or log-normality) is rejected when this value is less than 0.05. The log-transformed data i.e. log(Sample Value) can also be tested in this fashion, signifying the possibility of a log normal distribution when the probability is greater than 0.05.

2 Insufficient number of points

3 The coefficient of variation is the ratio of the standard deviation to the arithmetic mean. Values greater than 1.2 suggest that the minimum variance unbiased estimator of the mean is preferred to the arithmetic mean as an estimate of the mean for a lognormal distribution.

Table A-5

Selection of Cluster Area Best-Estimate-of-Mean for 1984 and 1994 Each Sample Area

1984	Arithmetic Mean	MVUE	Coefficient of Variation	Number of Sample Locations	Best Estimate of the Mean
LR-01	0.053	0.080	1.11	14	0.053
LR-02&03	0.166	0.155	1.40	12	0.155
LR-04&18	0.093	0.098	1.75	24	0.098
LR-05	0.070	0.107	0.98	14	0.070
LR-06&07	0.058	0.058	1.21	24	0.058
LR-08	0.021	0.021	0.47	9	0.021
LR-09	0.057	0.057	1.29	14	0.057
LR-10	0.139	0.177	0.91	8	0.139
LR-11	0.117	0.119	1.03	9	0.117
LR-12	0.018	0.018	0.45	8	0.018
LR-13	0.033	0.037	0.51	6	0.033
LR-14	0.028	0.030	1.27	23	0.030
LR-15	0.013	0.012	1.08	30	0.013
LR-17	0.091	0.091	--	2	0.091

1994	Arithmetic Mean	MVUE	Coefficient of Variation	Number of Sample Locations	Best Estimate of the Mean
LR-01	0.013	0.013	0.335	4	0.013
LR-02&03	0.011	0.014	1.313	6	0.014
LR-04&18	0.074	0.075	0.711	9	0.074
LR-05	0.067	0.067	0.767	5	0.067
LR-06&07	0.029	0.031	1.353	7	0.031
LR-08	0.011	0.011	0.628	5	0.011
LR-09	0.013	0.021	0.631	6	0.013
LR-10	0.036	0.036	0.212	4	0.036
LR-11	0.103	0.099	1.003	3	0.103
LR-12	0.018	0.017	0.913	5	0.018
LR-13	0.015	0.015	0.643	3	0.015
LR-14	0.007	0.007	0.315	4	0.007
LR-15	0.016	0.018	0.621	4	0.016
LR-17	0.021	0.027	0.686	5	0.021

1994 Complete Cores	Arithmetic Mean	MVUE	Coefficient of Variation	Number of Sample Locations	Best Estimate of the Mean
LR-01	0.013	0.013	0.337	4	0.013
LR-02&03	0.011	0.012	1.464	5	0.012
LR-04&18	0.074	0.075	0.711	9	0.074
LR-05	0.067	0.067	0.767	5	0.067
LR-06&07	0.031	0.031	1.503	5	0.031
LR-08	0.011	0.011	0.710	3	0.011
LR-09	0.011	0.017	0.715	5	0.011
LR-10	0.036	0.036	0.212	4	0.036
LR-11	0.043	0.043	0.158	2	0.043
LR-12	0.019	0.018	0.969	4	0.019
LR-13	0.015	0.015	0.645	3	0.015
LR-14	0.007	0.007	0.314	4	0.007
LR-15	0.013	0.014	0.749	3	0.013
LR-17	0.021	0.027	0.685	5	0.021

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Notes:

1. The best predictor of the mean is the arithmetic mean if the coefficient of variation is less than 1.2, otherwise it is the MVUE.

Table A-6
Estimate of the Average Molar Change in the Sediment PCB Inventory (MPA)
Trichloro- and Higher Homologues

Cluster Area	Ratio of 1994 to 1984 Sediment PCB Inventory (Tri+ MPA) (Best Estimate of the Mean) unitless	
	All 1994 and 1984 Samples	Complete 1994 Cores Only and All 1984 Samples[1]
LR-01	0.247	0.247
LR-02&03	0.091	0.075
LR-04&18	0.754	0.754
LR-05	0.956	0.956
LR-06&07	0.527	0.538
LR-08	0.522	0.524
LR-09	0.226	0.202
LR-10	0.261	0.261
LR-11	0.879	0.370
LR-12	1.011	1.084
LR-13	0.450	0.449
LR-14	0.231	0.231
LR-15	1.267	1.029
LR-17	0.228	0.228
Coefficient of Variation[2]	0.67	0.67
Estimate of the Mean Ratio (Arithmetic)	0.55	0.50
Delta$_M$	**-45%**	-50%
Shapiro-Wilks Test		
Untransformed		
W	0.91	0.89
Prob<W	0.14	0.08
Log-Transformed Data		
W	0.94	0.94
Prob<W	0.35	0.43
Delta$_M$ 95% Confidence Limits (Log-Transform Basis)[3]		
Upper	**-4%**	-13%
Lower	**-59%**	-63%
Delta$_M$ 95% Confidence Limits (Untransformed Basis)[4]		
Upper	-24%	-31%
Lower	-67%	-70%

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Notes:

1. The inventory estimates for 1994 were calculated excluding incomplete cores (*See* text for discussion).
2. If the coefficient of variation is less than 1.2, the arithmetic mean may be a better estimator of the average value than the MVUE even though the underlying distribution appears to be lognormal.
3. 95% Confidence interval's calculated assuming underlying log-normal distribution, as described in Gilbert, 1987.
4. 95% Confidence interval's calculated assuming underlying normal distribution, using standard error and Student's t.

Table A-7

Shift in Homologue Group Distributions (Mole Percent) for Matched Cores in the Thompson Island Pool

	1960 Sediment		1963 Sediment		1968 Sediment		1973 Sediment		1975 Sediment	
Homolog Group	1983	1991	1983	1991	1983	1991	1983	1991	1983	1991
Mono	11.29	15.52	10.13	23.80	13.24	30.26	13.14	23.72	15.54	24.71
Di	37.78	36.34	32.64	29.11	37.24	29.51	39.65	32.01	38.31	29.30
Tri	34.82	33.71	35.93	29.67	31.14	24.41	31.43	28.98	30.34	29.56
Tetra	11.52	10.07	14.31	10.80	12.27	9.84	11.56	9.55	10.36	10.56
Penta	2.49	2.30	4.28	3.60	3.68	3.22	2.00	3.22	3.12	3.29
Hexa-Deca	1.91	1.95	2.28	2.39	1.70	1.91	1.89	1.53	1.34	1.63
Tri+	50.74	48.03	56.80	46.46	48.79	39.38	46.88	43.28	45.16	45.04
Delta Tri+		-5.3%		-18.2%		-19.3%		-7.7%		-0.3%

	1976 Sediment		1979 Sediment		1980 Sediment		1982 Sediment	
Homolog Group	1983	1991	1983	1991	1983	1991	1983	1991
Mono	14.94	17.77	14.17	20.03	17.26	25.86	14.00	17.68
Di	37.81	31.94	35.95	31.70	36.64	31.15	37.20	29.98
Tri	30.66	32.53	32.15	31.04	32.01	31.09	34.84	36.34
Tetra	10.91	12.43	11.58	11.82	9.37	9.33	10.00	10.91
Penta	3.30	3.61	3.84	3.58	2.95	1.69	2.86	2.88
Hexa-Deca	1.39	1.59	1.41	1.68	1.14	0.83	1.02	2.07
Tri+	46.26	50.16	48.98	48.12	45.47	42.94	48.72	52.20
Delta Tri+		8.4%		-1.8%		-5.6%		7.1%
Average Delta Tri+	-4.7%							

Source: McNulty, 1997 (Table 8)

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Table A-8

Selection of Best-Estimate-of-Mean for 1984 Results After Correcting For Dechlorination Loss

Cluster Area	Arithmetic Mean	MVUE	Coefficient of Variation	Number of Sample Locations	Best Predictor of the Mean
LR-01	0.050	0.080	1.11	14	0.050
LR-02&03	0.158	0.155	1.40	12	0.155
LR-04&18	0.089	0.098	1.75	24	0.098
LR-05	0.067	0.107	0.98	14	0.067
LR-06&07	0.056	0.058	1.21	24	0.058
LR-08	0.020	0.021	0.47	9	0.020
LR-09	0.054	0.057	1.29	14	0.057
LR-10	0.133	0.177	0.91	8	0.133
LR-11	0.112	0.018	1.03	9	0.112
LR-12	0.017	0.119	0.45	8	0.017
LR-13	0.031	0.037	0.51	6	0.031
LR-14	0.027	0.030	1.27	23	0.030
LR-15	0.012	0.012	1.08	30	0.012
LR-17	0.087	0.091	--	2	0.087 [2]

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Notes:

1. The best predictor of the mean is the arithmetic mean if the coefficient of variation is less than 1.2, otherwise it is the MVUE.
2. The arithmetic mean was selected for LR-17 due to the small number of samples available.

Table A-9

Estimate of the Average Molar Change in the Sediment PCB Inventory Excluding Dechlorination (Trichloro- and Higher Homologues)

Cluster Area	Ratio of 1994 to 1984 Sediment PCB Inventory (Tri+ MPA) (Best Predictor of the Mean) unitless	
	All 1994 and 1984 Samples	Complete 1994 Cores Only and All 1984 Samples[1]
LR-01	0.261	0.261
LR-02&03	0.090	0.077
LR-04&18	0.752	0.752
LR-05	1.002	1.002
LR-06&07	0.534	0.533
LR-08	0.550	0.538
LR-09	0.225	0.201
LR-10	0.274	0.273
LR-11	0.921	0.388
LR-12	1.050	1.125
LR-13	0.478	0.477
LR-14	0.234	0.234
LR-15	1.321	1.072
LR-17	0.241	0.241
Coefficient of Variation[2]	0.67	0.67
Estimate of the Mean Ratio (Arithmetic)	0.57	0.51
$Delta_M$	**-43%**	-49%
Shapiro-Wilks Test		
Untransformed		
W	0.91	0.89
Prob<W	0.16	0.07
Log-Transformed Data		
W	0.94	0.95
Prob<W	0.41	0.47
$Delta_M$ 95% Confidence Limits (Log-Transform Basis)[3]		
Upper	**1%**	-10%
Lower	**-58%**	-62%
$Delta_M$ 95% Confidence Limits (Untransformed Basis)[4]		
Upper	-21%	-29%
Lower	-65%	-69%

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Notes:

1. The inventory estimates for 1994 were calculated excluding incomplete cores (See text for discussion)
2. If the coefficient of variation is less than 1.2, the arithmetic mean is considered a better estimator of the average value than the MVUE even though the underlying distribution appears to be lognormal.
3. 95% Confidence interval's calculated assuming underlying log-normal distribution, as described in Gilbert, 1987.
4. 95% Confidence interval's calculated assuming underlying normal distribution, using Standard error and Student's t.

APPENDIX A
FIGURES

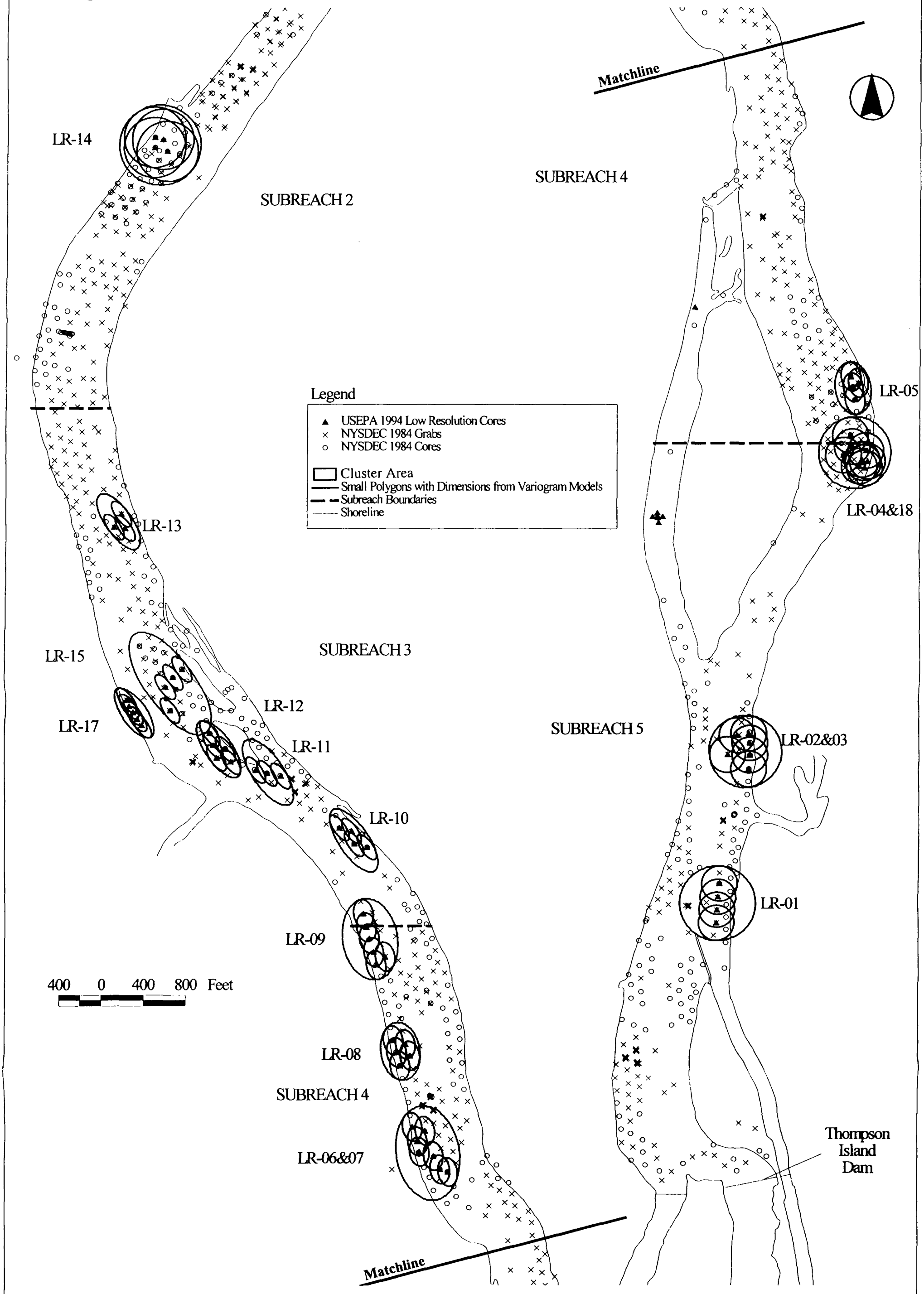

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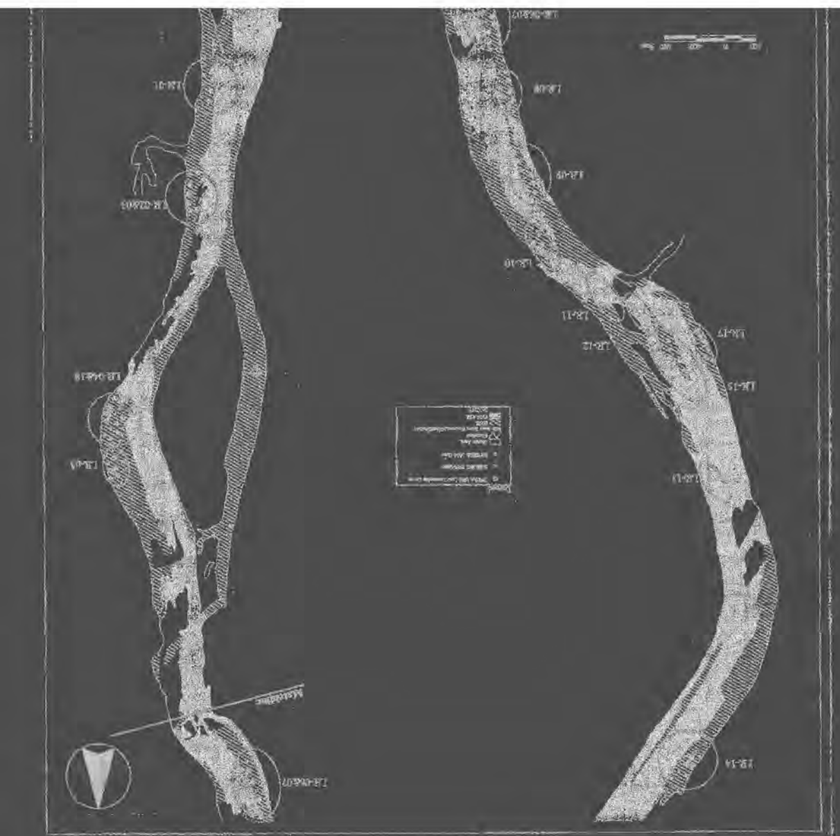
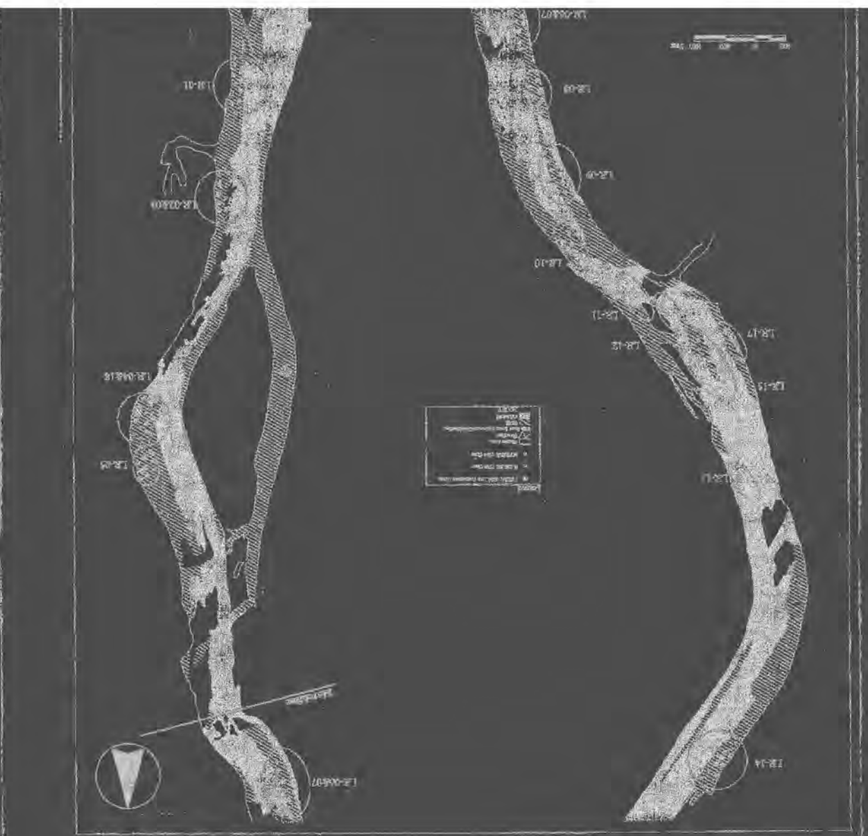
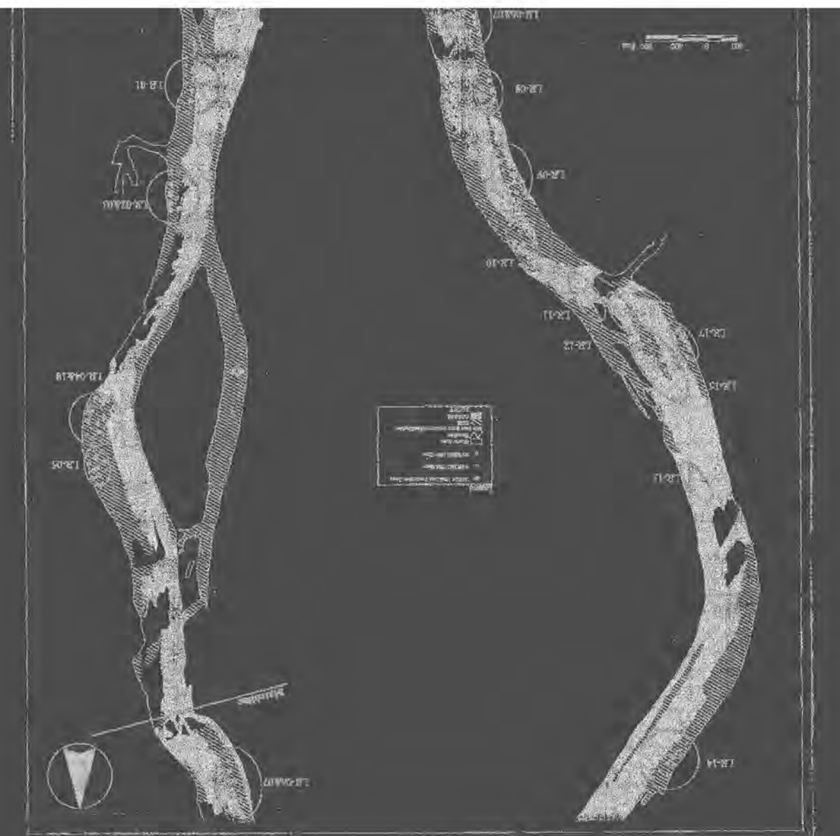
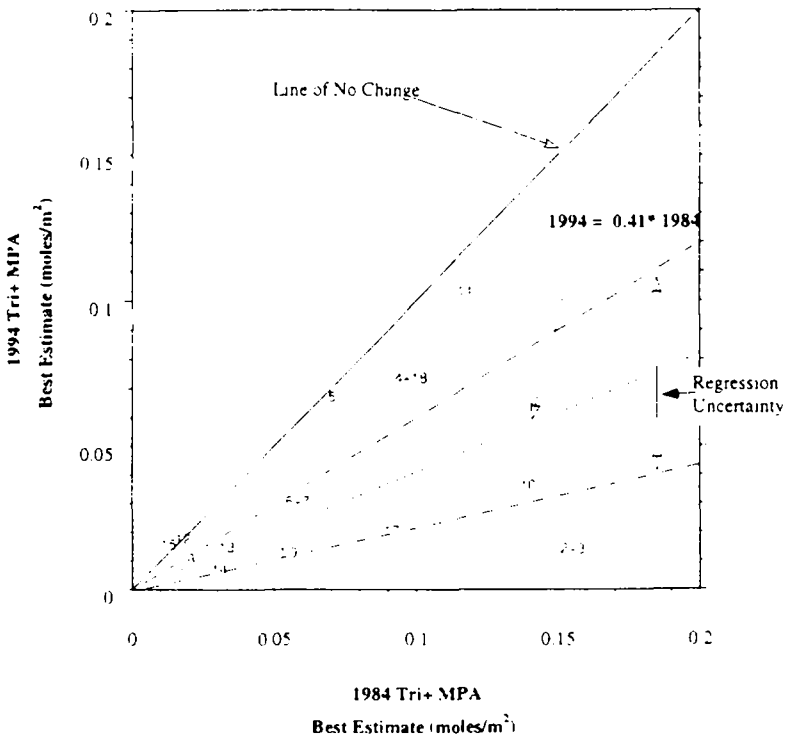
Figure A-1
Construction of the Cluster Areas Using the Subreach Semivariogram Models









Summary of Fit

RSquare	•
RSquare Adj	•
Root Mean Square Error	0.026711
Mean of Response	0.03129
Observations (or Sum Wgts)	14

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	Zeroed	0	0	•	•	0	0
Best Predictor		0.4095612	0.087919	4.66	0.0004	0.2196236	0.5994989

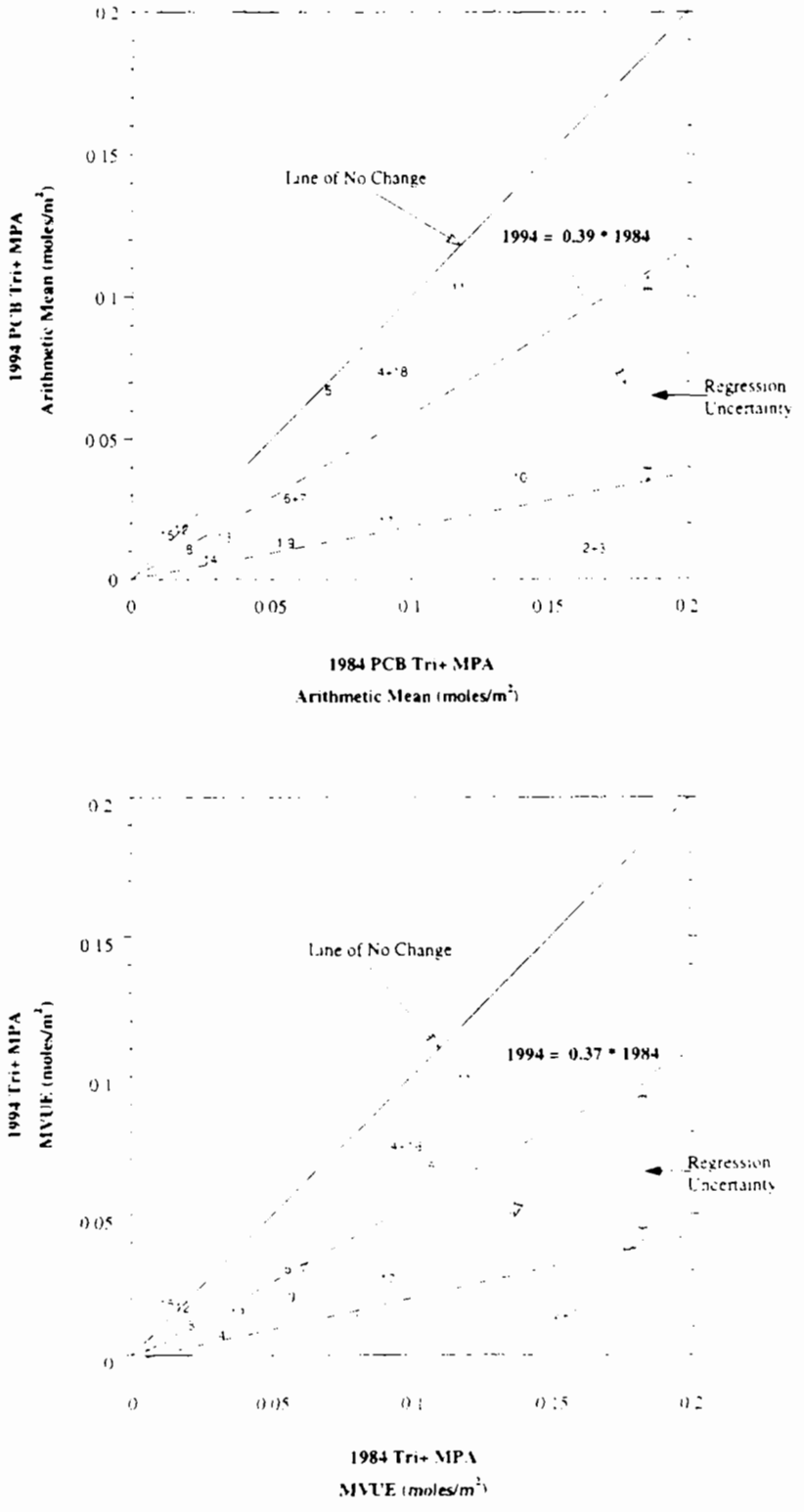
Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Best Predictor	1	1	0.01548296	21.7005	0.0004

Notes:

Numbers on diagram represent cluster numbers.
Dashed lines represents regression through 0 and its uncertainty.
Regression has a slope statistically different from unity (1).

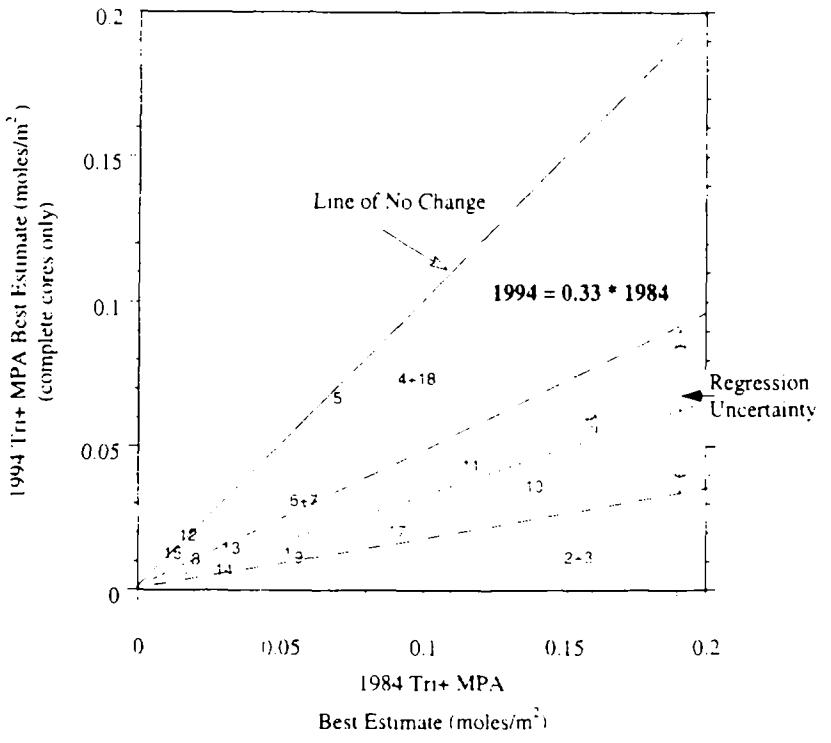
Figure A-3
1984 vs. 1994 Sediment Tri+ MPA
Best-Estimate-of-Mean Basis



Notes:

Numbers on diagram represent cluster numbers.
Dashed lines represents regression through 0 and its uncertainty.
Regressions have slopes statistically different from unity (1).

Figure A-4
1984 vs. 1994 Sediment Tri+ MPA
Based on Arithmetic Mean and MVUE



Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	0.021344
Mean of Response	0.026672
Observations (or Sum Wgts)	14

Parameter Estimates

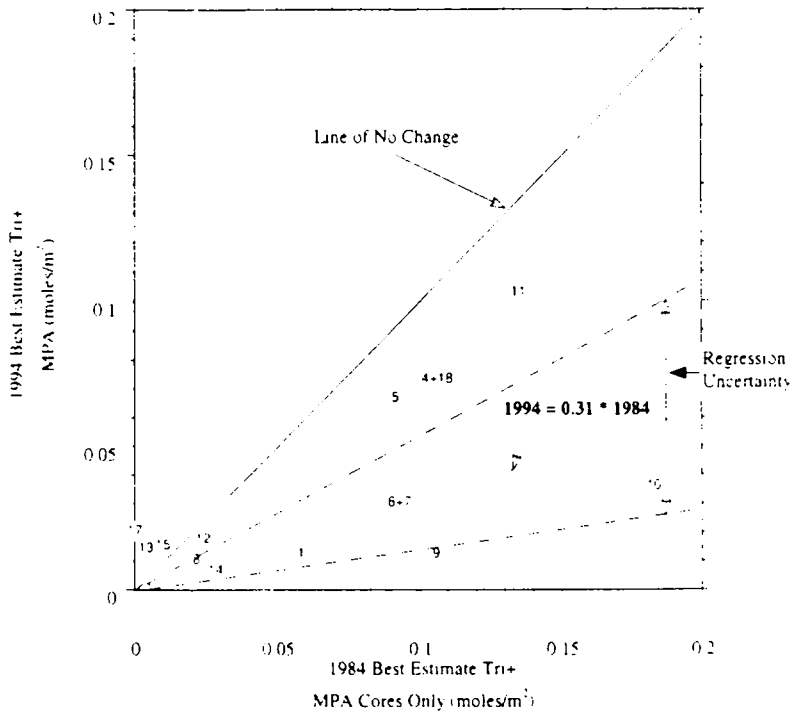
Term		Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	Zeroed	0	0	?	?	0	0
Best Predictor		0.3289175	0.070252	4.68	0.0004	0.177147	0.480688

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Best Predictor	1	1	0.00998597	21.9207	0.0004

Notes:
Numbers on diagram represent cluster numbers.
Dashed lines represents regression through 0 and its uncertainty.
Regression has a slope statistically different from unity (1).

Figure A-5
1984 vs. 1994 Sediment Tri+ MPA
Best-Estimate-of-Mean Basis (1994 Complete Cores Only)



Summary of Fit	
RSquare	?
RSquare Adj	?
Root Mean Square Error	0.029858
Mean of Response	0.032102
Observations (or Sum Wgts)	13

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	Zeroed	0	0	?	?	0	0
1984 Cores only		0.3134883	0.080171	3.91	0.0021	0.1388105	0.488166

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
1984 Cores only	1	1	0.01363086	15.2900	0.0021

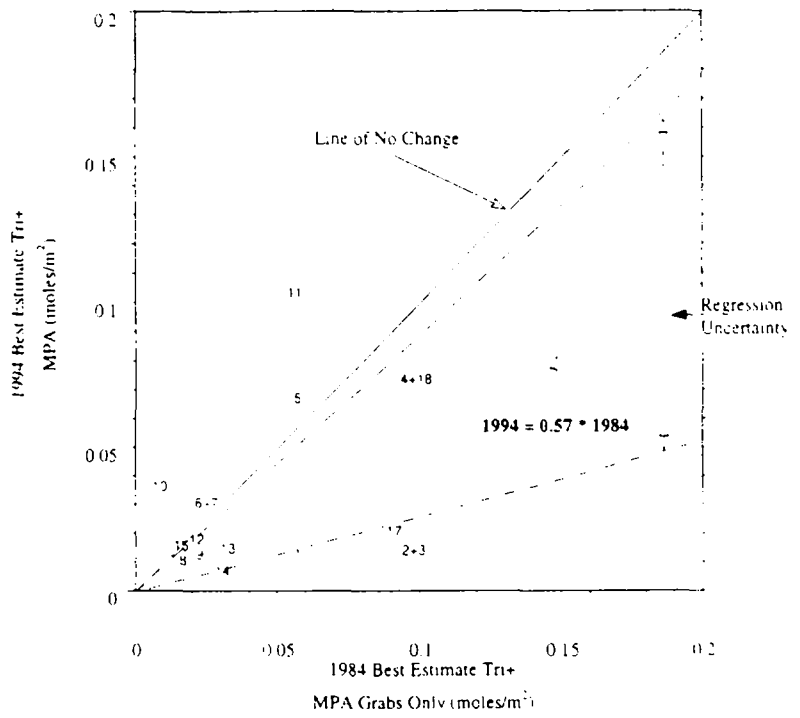
Notes.

Numbers on diagram represent cluster numbers.

Dashed lines represents regression through 0 and its uncertainty

Regression has a slope statistically different from unity (1).

Figure A-6
Best Estimate of Tri+ MPA for Cluster Areas:
1984 Cores Only vs. 1994 Cores



Summary of Fit

RSquare	?
RSquare Adj	?
Root Mean Square Error	0.029225
Mean of Response	0.03129
Observations (or Sum Wgts)	14

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|	Lower 95%	Upper 95%
Intercept	Zeroed	0	0	?	?	0	0
1984 Grabs only		0.5747982	0.143759	4.00	0.0015	0.2642253	0.885371

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
1984 Grabs only	1	1	0.01365464	15.9867	0.0015

Notes:

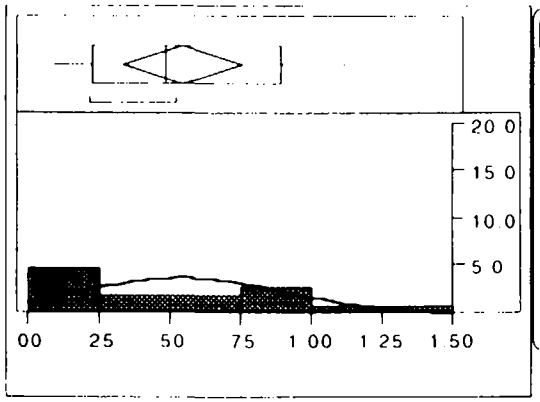
Numbers on diagram represent cluster numbers

Dashed lines represents regression through 0 and its uncertainty.

Regression has a slope statistically different from unity (1)

Figure A-7
Best Estimate of Tri+ MPA for Cluster Areas:
1984 Grabs Only vs. 1994 Cores

1994 Best Estimate Mean/1984 Best Estimate Mean in Cluster Areas



Quantiles

maximum	100 0%	1 2675
	99 5%	1 2675
	97 5%	1 2675
	90 0%	1 1394
quartile	75 0%	0 8983
median	50 0%	0 4857
quartile	25 0%	0 2306
	10 0%	0 1586
	2 5%	0 0910
	0 5%	0 0910
minimum	0 0%	0 0910

Moments

Mean	0 54653
Std Dev	0 36685
Std Error Mean	0 09804
Upper 95% Mean	0 75834
Lower 95% Mean	0 33472
N	14 00000
Sum Weights	14 00000

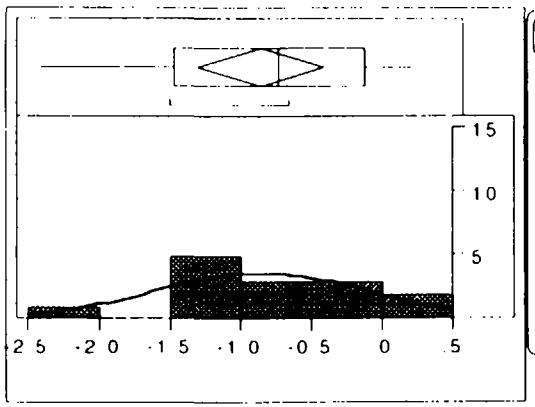
Test for Normality

Shapiro-Wilk W Test

W	Prob<W
0 906724	0 1400

Units: 1994 moles/m^2
1984 moles/m^2

Natural Log of 1994 Best Estimate Mean/1984 Best Estimate Mean in Cluster Areas



Quantiles

maximum	100.0%	0 2370
	99.5%	0 2370
	97.5%	0.2370
	90 0%	0 1241
quartile	75 0%	-0 1079
median	50 0%	-0 7249
quartile	25.0%	-1 4673
	10 0%	-1.9415
	2 5%	-2.3972
	0.5%	-2 3972
minimum	0 0%	-2 3972

Moments

Mean	-0 84742
Std Dev	0 76525
Std Error Mean	0.20452
Upper 95% Mean	-0 40557
Lower 95% Mean	-1 28926
N	14 00000
Sum Weights	14 00000

Test for Normality

Shapiro-Wilk W Test

W	Prob<W
0.935325	0.3486

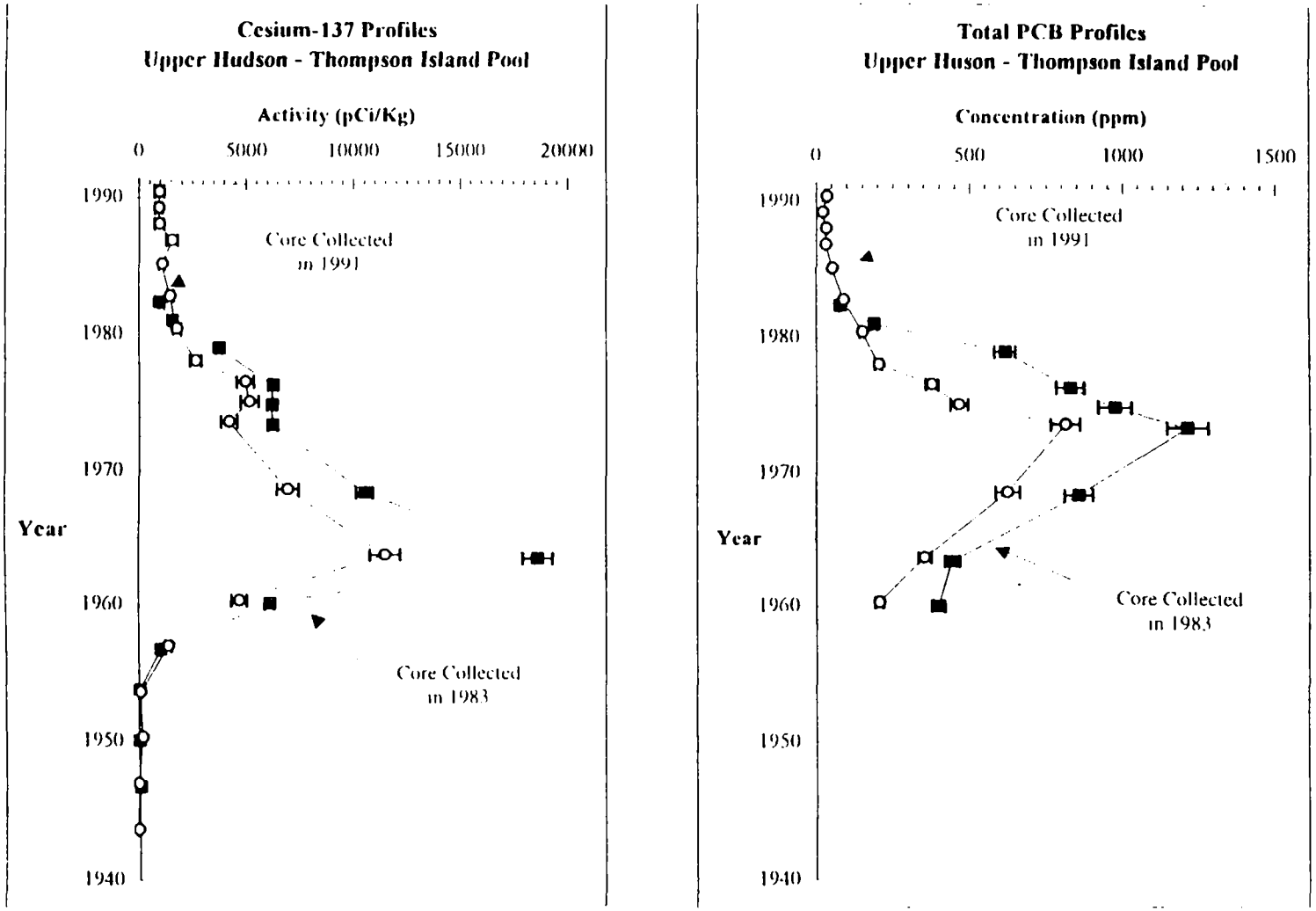
Delta$_M$	
Best Estimate of Mean	-45%
Upper Confidence Limit[1]	-4%
Lower Confidence Limit[1]	-59%
Geometric Mean	-57%
Upper Confidence Limit[2]	-33%
Lower Confidence Limit[2]	-72%

Notes:

1. Confidence limit derived from best estimate of confidence limits given underlying log-normal nature of the data.
Note the higher probability of the W statistic for the log-transformed data, supporting this approach. See text for discussion.
2. Confidence limits based on log transformed data as given above under Natural Log statistics.

Figure A-8

Distribution of the Tri+ MPA Best-Estimate-of-Mean Ratios (1994/1984) for Cluster Areas



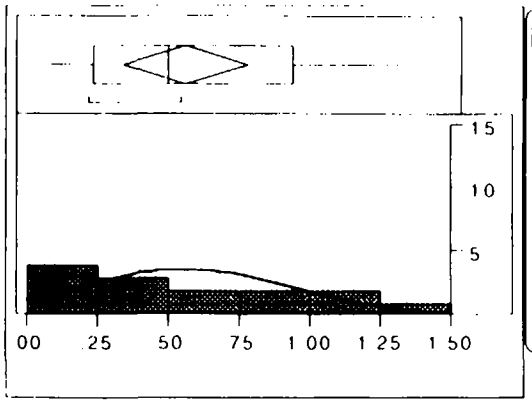
From McNulty, 1997 (Figure 2)

TAMS/TetraTech

Figure A-9

Cesium-137 and Total PCB Profiles for Cores Collected in 1983 and 1991 from the Thompson Island Pool

1994 Best Estimate Mean/1984 Best Estimate Mean in Cluster Areas



Quantiles

maximum	100 0%	1 3210
	99 5%	1 3210
	97 5%	1 3210
	90 0%	1 1855
quartile	75 0%	0 9413
median	50 0%	0 5060
quartile	25 0%	0 2370
	10 0%	0 1575
	2 5%	0 0900
	0 5%	0 0900
minimum	0 0%	0 0900

Moments

Mean	0 56643
Std Dev	0 38260
Std Error Mean	0 10225
Upper 95% Mean	0 78733
Lower 95% Mean	0 34552
N	14 00000
Sum Weights	14 00000

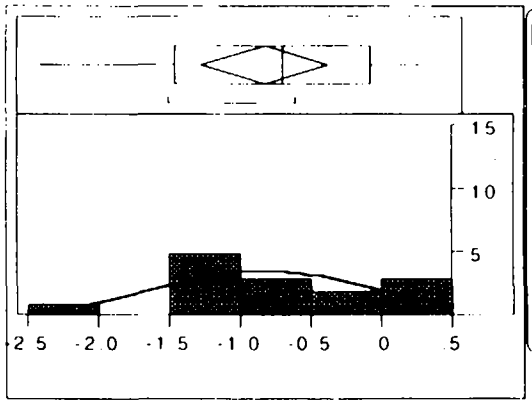
Test for Normality

Shapiro-Wilk W Test

W	Prob<W
0 910002	0 1559

Units: $\frac{1994\ moles/m^2}{1984\ moles/m^2}$

Natural Log of 1994 Best Estimate Mean/1984 Best Estimate Mean in Cluster Areas



Quantiles

maximum	100 0%	0.2784
	99.5%	0.2784
	97 5%	0.2784
	90 0%	0 1636
quartile	75 0%	-0 0612
median	50 0%	-0 6828
quartile	25 0%	-1 4397
	10 0%	-1 9498
	2.5%	-2.4079
	0.5%	-2 4079
minimum	0 0%	-2 4079

Moments

Mean	-0 81620
Std Dev	0.77513
Std Error Mean	0.20716
Upper 95% Mean	-0.36865
Lower 95% Mean	-1.26375
N	14.00000
Sum Weights	14.00000

Test for Normality

Shapiro-Wilk W Test

W	Prob<W
0.940250	0.4038

Delta$_M$	
Best Estimate of Mean[3]	-43%
Upper Confidence Limit[1]	1%
Lower Confidence Limit[1]	-58%
Geometric Mean	-56%
Upper Confidence Limit[2]	-31%
Lower Confidence Limit[2]	-72%

Notes:

1. Confidence limit derived from best estimate of confidence limits given underlying log-normal nature of the data.
Note the higher probability of the W statistic for the log-transformed data, supporting this approach. See text for discussion.
2. Confidence limits based on log-transformed data as given above under Natural Log statistics.
3. 1984 Best-Estimate-of-Mean represents the 1984 data corrected for dechlorination loss between 1984 and 1994 using the factor of 0.953 developed from the matched core data in McNulty, 1997.

Figure A-10

Distribution of the Tri+ MPA Best-Estimate-of-Mean Ratios (1994/1984) for Cluster Areas with 1984 MPA Corrected for Dechlorination Loss Between 1984 and 1994

Appendix B

APPENDIX B

Revised Estimate of the 1984 Thompson Island Pool Sediment PCB Inventory

Estimation of the 1984 Thompson Island Pool Sediment PCB Inventory Using Thiessen Polygons and the Side Scan Sonar Results

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APPENDIX B

REVISED ESTIMATE OF THE 1984 THOMPSON ISLAND POOL SEDIMENT PCB INVENTORY

ESTIMATION OF THE 1984 THOMPSON ISLAND POOL SEDIMENT PCB INVENTORY USING THIESSEN POLYGONS AND THE SIDE SCAN SONAR RESULTS

TABLE OF CONTENTS

List of Tables

List of Figures

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Appendix B

Revised Estimate of the 1984 Thompson Island Pool Sediment PCB Inventory

Estimation of the 1984 Thompson Island Pool Sediment PCB Inventory Using Thiessen Polygons and the Side Scan Sonar Results

An estimate of the 1984 sediment total PCB inventory in the Thompson Island Pool using geostatistical analysis is presented in Chapter 4 of the Data Evaluation and Interpretation Report (DEIR), USEPA, 1997. This estimate used data from the 1984 NYSDEC sediment samples but did not consider sediment texture. Sediment texture is relevant because PCB concentrations are strongly correlated with shallow sediment texture, in that higher concentrations of PCBs are found in areas of finer-grained, shallow sediments. A similar degree of correlation was noted between Total PCB concentration and the side-scan sonar signal itself. (As discussed below, the side-scan sonar results form the basis for the assignment of sediment texture.) LRC figures 3-19 and 3-30 demonstrate the strength of the relationships between Total PCBs, sediment texture and side-scan sonar signal. The mean PCB concentration varies nearly an order of magnitude in correlation with these properties.

A revised estimate of the Thompson Island Pool PCB inventory in 1984 is presented in this Appendix which takes into account the relationship between PCB mass and sediment texture. The purpose of this analysis is to provide an alternate estimate of the sediment PCB inventory while also providing separate estimates for areas of fine-grained and coarse-grained sediments. The latter estimates could not be obtained from the previous analysis and were needed for modeling purposes.

Sediment texture information is available in two forms: visual texture classification for the sample points collected in 1984 and side-scan sonar sediment classification for the entire river bottom of the TI Pool, obtained in 1992 (*see* Section 4.1.1 of the DEIR for a complete discussion of the side scan sonar analysis). In this revision, the NYSDEC core and grab samples are separated into cohesive and noncohesive groups based on the 1984 visual texture classification. Noncohesive sediments typically are coarse-grained, such as medium to coarse sand or gravel. Fine-grained sediments, such as fine sands, silts and clays, are generally considered cohesive sediments.

The primary distinction between cohesive and noncohesive sediments is that cohesive sediments exhibit interparticle attractions whereas noncohesive sediments do not. Cohesive sediments exhibit very different flow-driven resuspension behavior than noncohensive sediments as a result of the inter-particle bonds. The mechanistically different resuspension processes for these two sediment types will be accounted for with different mechanisms in the Hudson River PCB transport models. The models require determination of the cohesive and noncohesive sediment areas and associated PCB mass.

In general, samples classified as predominantly clay, silt or fine sand were classified as cohesive sediment. The remaining samples which are predominantly sand, coarse sand or gravel are assigned to the noncohesive group. One sample had an ambiguous classification (FC) and was grouped with the noncohesive sediments. There are 503 cohesive sample locations (221 grabs, 282 cores) and 591 noncohesive sample locations (470 grabs, 121 cores). A list of the visual texture

classes and the assigned sediment types is provided in Table B-1.

A brief description of the geospatial technique used in this analysis is transcribed from page 4-33 of the DEIR (USEPA, 1997):

> A simple method for addressing the problem of irregular sample spacing (or coverage) and clustering of data is a graphical technique known as polygonal declustering (Isaaks and Srivastava, 1989). As with other approaches to estimating total mass from spatial data, this relies on a weighted linear combination of the sample values. Weighting is formed graphically, however, without any assumptions regarding the statistical distribution of the data, and spatial correlation is not explicitly modeled. In this method, the total area of interest is simply tiled into polygons, one for each sample, with the area of the polygon representing the relative weighting of that sample. The polygons, called Thiessen polygons or *polygons of influence*, are drawn such that a polygon contains all the area that is closer to a given sample point than to any other sample point. Polygonal declustering often successfully corrects for irregular sample coverage. Because no complicated numerical methods need be applied, polygonal declustering provides a useful rough estimate of total mass to which the estimates obtained by other methods can be compared.

In the analysis presented here, Thiessen polygons are formed around all 1984 cohesive sample points. This procedure was repeated for the noncohesive sample points. Using the side scan sonar sediment classifications, the Thiessen polygons are clipped so that the mass per unit area for the cohesive sample points (based on visual texture classification) is applied only to cohesive areas of the river (defined by side-scan sonar) and, similarly, the mass per unit area for the noncohesive sample points is applied only to the noncohesive areas. For the side scan sonar sediment classification, cohesive areas are defined as fine- or finer-grained and noncohesive areas are coarse- or coarser-grained based on the original interpretation of the side-scan sonar images (Flood, 1993). The means of calculating the mass per unit area is the same as described in the DEIR (USEPA, 1997).

Figure B-1 shows cohesive sediment sample points and the associated Thiessen polygons. The areas which are cohesive by the side scan sonar analysis are shaded to indicate the PCB mass per unit area derived from the corresponding cohesive sediment samples. The noncohesive data are shown in Figure B-2. This diagram is constructed in a fashion similar to Figure B-1, only based on non-cohesive sediment areas and noncohesive sediment samples.

The revised sediment Total PCB mass estimate for the entire Pool (14.9 metric tons) is in close agreement with the previous estimates presented in the DEIR (14.5 metric tons, *see* Table B-2). The estimated trichloro- and higher homologue inventory present in 1984 can be calculated by multiplying the mass of Total PCBs by 0.944, as discussed in Chapter 4 and Appendix E of the LRC. As discussed in the text, it is likely that the 1984 measurements most accurately represent the sum of the trichlorinated to decachlorinated homologues (Tri+). This correction yields the values given in the last column of Table B-2. The estimate for the Tri+ inventory of the entire Thompson Island Pool is 14.1 metric tons. Based on the discussion in Appendix E of the LRC, it is clear that while the inventory of trichlorinated and higher homologues is relatively well known for 1984, the total PCB inventory is less well known and, in fact, may be underestimated by a large percentage.

The issue of the estimation of sediment mass has been extensively addressed in Chapter 4 of the DEIR. As noted in this discussion, the spatial correlation of the individual sediment mass estimates obtained via sediment cores and grabs varies from subreach to subreach of the TI Pool. This is evident in the semivariogram analysis presented in the DEIR. Thus in subreaches 3, 4 and 5, where spatial correlation is high, the estimates for the sediment PCB inventory are relatively well known and local inventories can be considered well-described . In subreaches 1 and 2, where spatial correlation is poorer, the ability to infer local estimates for sediment inventory will be more limited and will have a greater dependence on the local sampling density rather than inference from other locations. As an overall estimate of the TI Pool, or as a basis for estimating the PCB inventories of large segments of the Pool such as the regions of fine-grained sediments, these uncertainties represent only minor concerns. While the analysis presented here does not permit the calculation of a statistically-based uncertainty, the fact that the Thiessen polygons, when corrected for sediment type, yield a sediment PCB mass estimate for the TI Pool (14.9 metric tons) which is within 3 percent of the mass estimate based on kriging (14.5 metric tons). This suggests that the uncertainty in these estimates is small and will have minimal impact on the Reassessment findings.

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APPENDIX B
TABLES

Table B-1
NYSDEC Sediment Survey Visual Texture Classifications and Assigned Sediment Type

Texture	Sediment Type	No. of Samples
Fine sand	Cohesive	342
Fine sand and wood chips	Cohesive	95
Clay	Cohesive	20
Muck	Cohesive	19
Fine sand and gravel	Cohesive	10
Silt	Cohesive	6
Clay and gravel	Cohesive	4
Gravel and clay	Cohesive	3
Fine sand and clay	Cohesive	2
Gravel and muck	Cohesive	1
Silt and wood chips	Cohesive	1
		503
Gravel	Noncohesive	461
Coarse sand	Noncohesive	65
Coarse sand and wood chips	Noncohesive	29
Gravel and wood chips	Noncohesive	29
Coarse sand and gravel	Noncohesive	3
FC and wood chips[1]	Noncohesive	1
Sand	Noncohesive	1
Sand	Noncohesive	1
Sand and wood chips	Noncohesive	1
		591

Note:

1. NYSDEC's sediment texture classification is FC for this sample, but the definition of FC is unknown.

Table B-2
Previous and Revised Thompson Island Pool Sediment Total PCB Inventory Estimates

Sediment Type	Previous Total PCB Mass Estimate (metric tons)[1]	Revised Total PCB Mass Estimate (metric tons)	Tri and Higher PCB Mass Estimate (metric tons)[2]
Cohesive		8.7	8.2
Noncohesive		6.2	5.9
Total	14.5	14.9	14.1

Notes:

1. From USEPA, 1997 - Based on the kriging analysis of the Thompson Island Pool.
2. Based on correction factor developed in Appendix E of the LRC (USEPA, 1998). These values are believed to represent the most accurate inventory of the Thompson Island Pool. This estimate represents the sum of trichloro to decachloro homologues only.

APPENDIX B
FIGURES

Figure B-1
Cohesive Sediment Mass per Unit Area

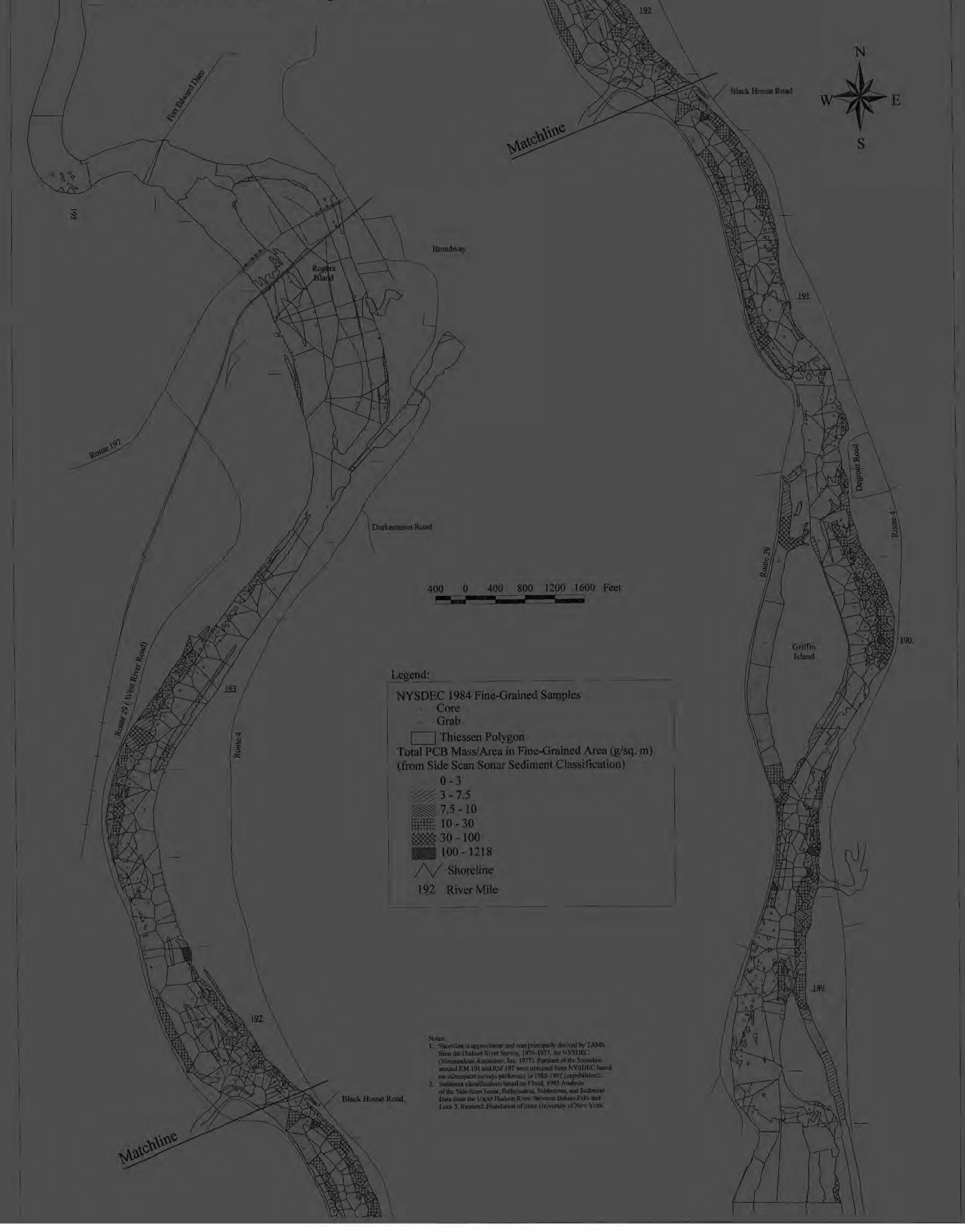

Figure B-1
Cohesive Sediment Mass per Unit Area

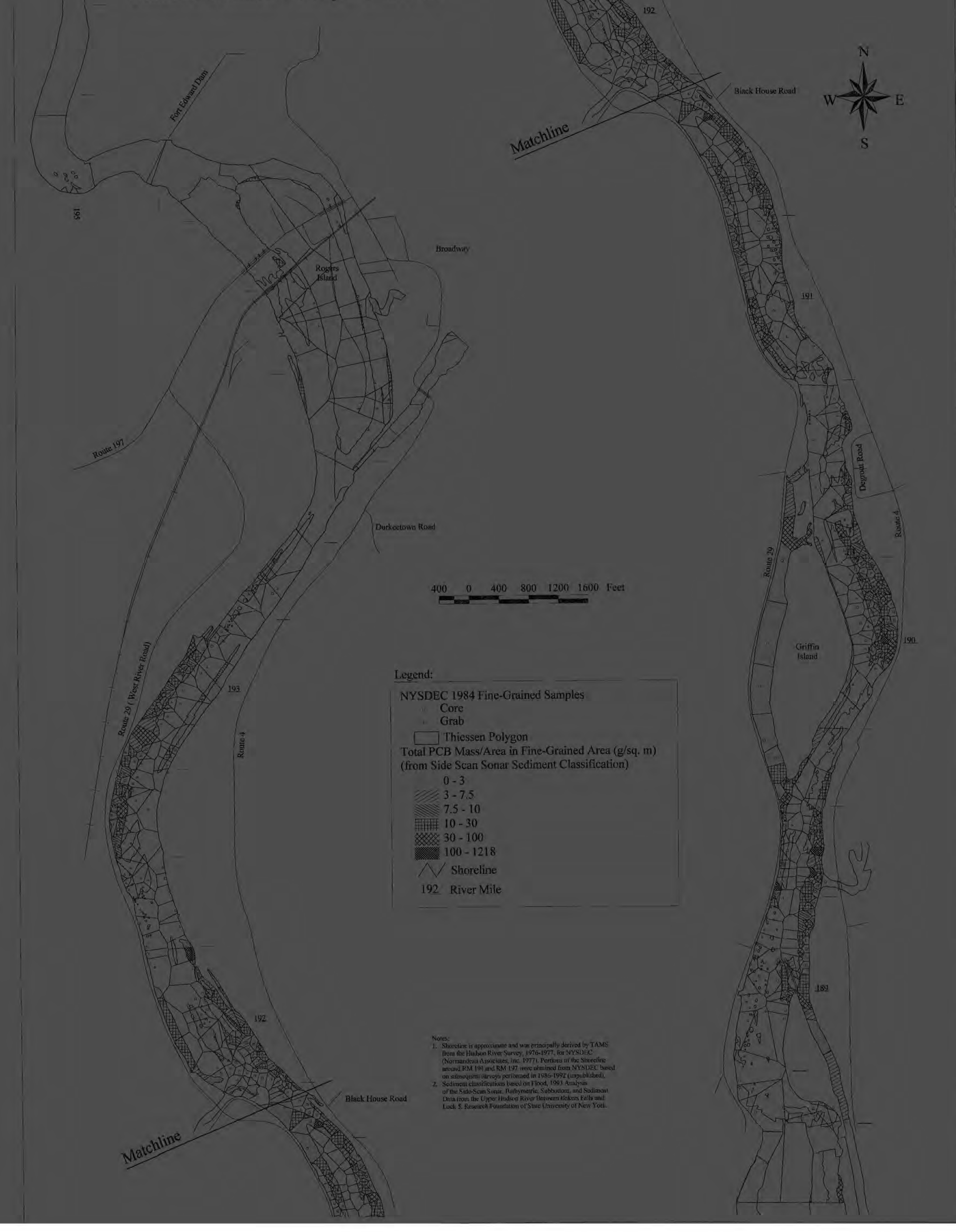

Figure B-1
Cohesive Sediment Mass per Unit Area

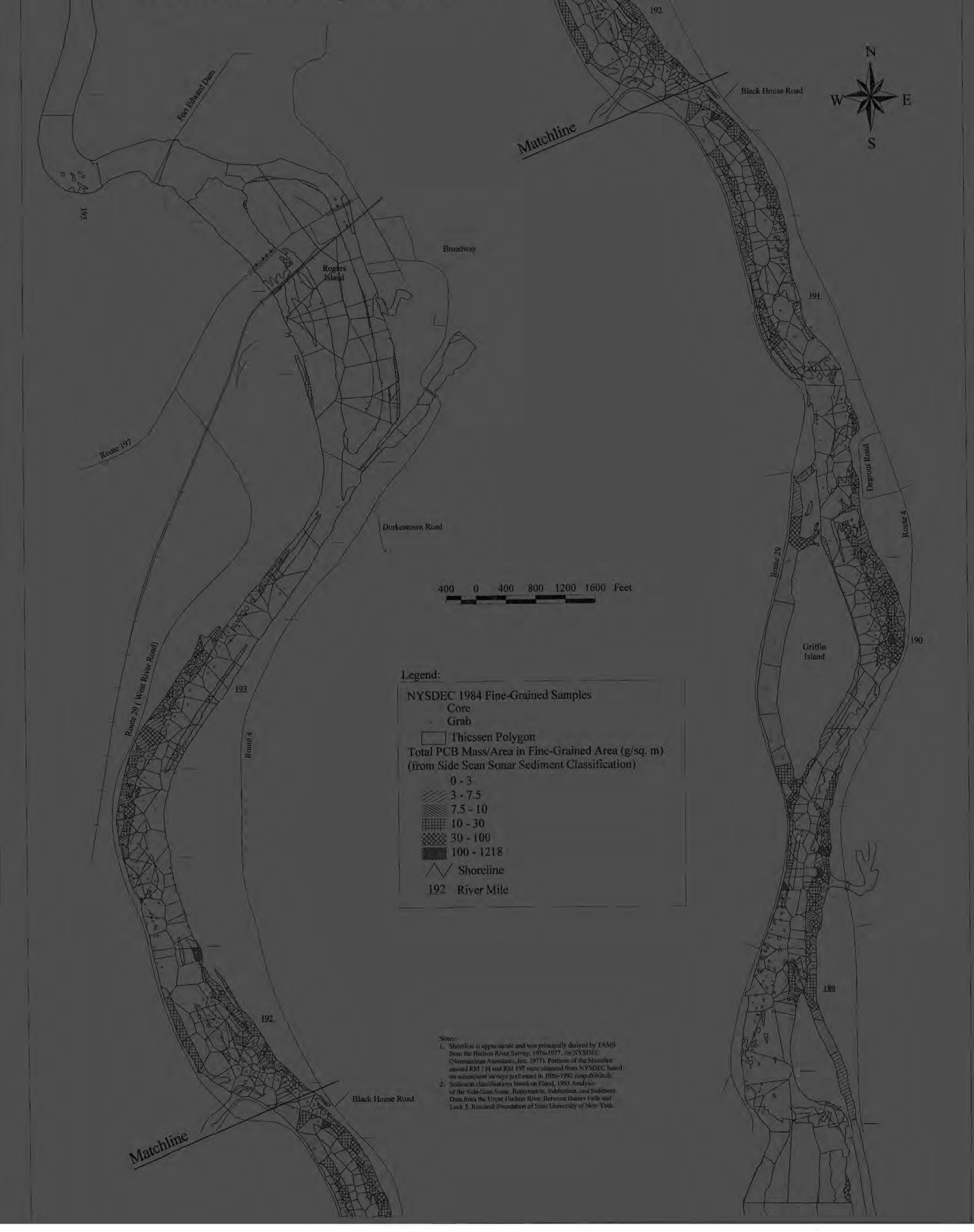

Figure B-2
Noncohesive Sediment Mass per Unit Area

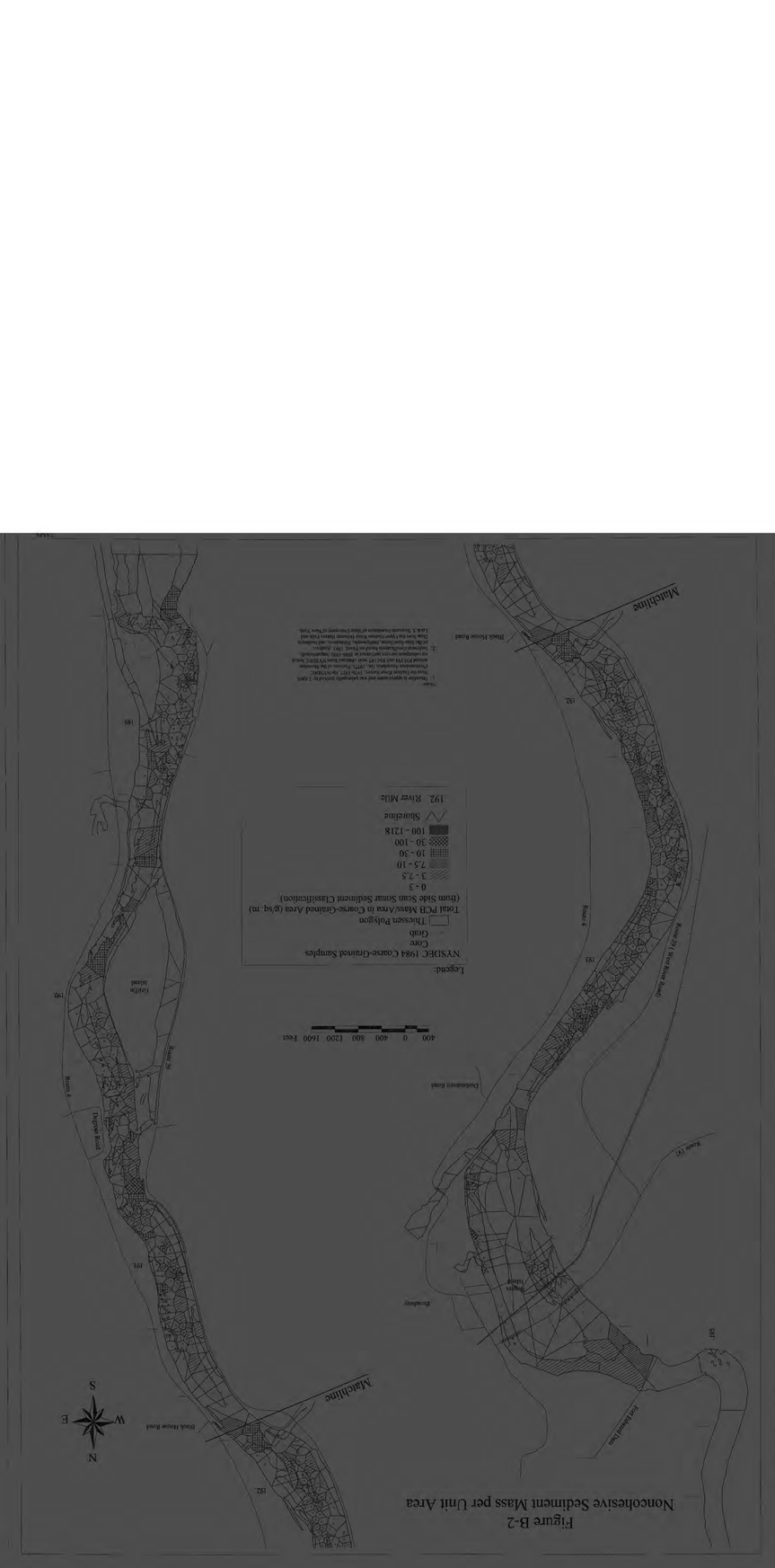

Figure B-2
Noncohesive Sediment Mass per Unit Area

Figure B-2
Noncohesive Sediment Mass per Unit Area

Appendix C

APPENDIX C

Revised Estimates of PCB and Suspended Solids Loads in the Upper Hudson River

Estimation of 1993 Upper Hudson PCB and Suspended Solids Loads During the Transect and Flow-Averaged Sampling Events

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APPENDIX C

REVISED ESTIMATES OF PCB AND SUSPENDED SOLIDS LOADS IN THE UPPER HUDSON RIVER

ESTIMATION OF 1993 UPPER HUDSON PCB AND SUSPENDED SOLIDS LOADS DURING THE TRANSECT AND FLOW-AVERAGED SAMPLING EVENTS

TABLE OF CONTENTS

List of Tables

List of Figures

APPENDIX C

REVISED ESTIMATES OF PCB AND SUSPENDED SOLIDS LOADS IN THE UPPER HUDSON RIVER

ESTIMATION OF 1993 UPPER HUDSON PCB AND SUSPENDED SOLIDS LOADS DURING THE TRANSECT AND FLOW-AVERAGED SAMPLING EVENTS

TABLE OF CONTENTS

List of Corrected Figures for the DEIR

APPENDIX C

REVISED ESTIMATES OF PCB AND SUSPENDED SOLIDS LOADS IN THE UPPER HUDSON RIVER

ESTIMATION OF 1993 UPPER HUDSON PCB AND SUSPENDED SOLIDS LOADS DURING THE TRANSECT AND FLOW-AVERAGED SAMPLING EVENTS

TABLE OF CONTENTS

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APPENDIX C

REVISED ESTIMATES OF PCB AND SUSPENDED SOLIDS LOADS IN THE UPPER HUDSON RIVER

Estimation of 1993 Upper Hudson PCB and Suspended Solids Loads During the Transect and Flow-Averaged Sampling Events

DISCUSSION

In this Appendix, corrections factors are discussed and applied to the Phase 2 transect and flow-averaged events to account for changes in the understanding of Upper Hudson River conditions which have come to light since the release of the Data Evaluation and Interpretation Report (DEIR). As discussed in the corrections to Section 3.2 of the DEIR (*see* the Responsiveness Summary for Volumes 2A, 2B and 2C), the transect and flow-averaged event calculations required revision due to new information pertaining to flow and loads in the Upper Hudson. As a result, two sets of correction factors were developed for the load estimates. The development of these factors is described below

Flow Corrections

The first corrections stemmed from a comparison of the USEPA, USGS and precipitation data as discussed in the correction to Section 3.2.2 of the DEIR (*see* the Responsiveness Summary for Volumes 2A, 2B and 2C). A short review of the flow data issue for 1993 is presented here as a service to the reader.

Because of dam construction activities which occurred in 1993, the regularly recorded USGS staff gauges at Stillwater and Waterford were effectively destroyed and the long-term USGS flow measurements at these stations were stopped. The loss of the two flow monitoring gauges occurred just prior to the inception of the USEPA water column measurement program. Notably, the staff gauge measurements at Ft. Edward were not affected by the construction activities.

To remedy the lack of direct flow measurements, both the USGS and the USEPA attempted to estimate river flow based on other available data. The USEPA used NYS barge canal staff gauges located throughout the Upper Hudson between Ft. Edward and Waterford in a correlation analysis to develop a river flow/barge canal staff gauge relationship which could be used to discern flow at various points in the Upper Hudson. This analysis is described in Section 3.2.2 of the DEIR. The USGS used the limited number of tributary staff gauges in the Upper Hudson valley to estimate the net yield of the watershed below Ft. Edward. This information was also translated into flow estimates. Both models utilized the Ft. Edward staff gauge measurements to represent total flow to that point. These efforts resulted in two partially independent flow estimates.

To discern the better estimate, a comparison was made of summer time precipitation with the average incremental increase in flow between Ft. Edward and Stillwater as calculated by the USEPA and the USGS relationships. This analysis showed that the USEPA estimates overestimated the average incremental flow between Ft. Edward and Stillwater relative to the historical USGS measurements. That is, the USEPA data indicated an relatively high runoff yield per unit of precipitation. Conversely, the USGS estimate fell within the range of prior historical measurements of flow and precipitation. On this basis, the USGS estimates were ultimately selected over those calculated by the USEPA.

This comparison was not available at the time of the preparation of the DEIR and the USEPA results were originally selected for the calculations presented in the DEIR. Since the comparison suggests that the USGS estimates are more in line with prior measurements, the original transect and flow-averaged load calculations were revised to reflect these flows. The USEPA database issued in July, 1998 (release 4.1) contains the USGS flow data reflected in the revisions presented here.

In general, the USGS and USEPA flow estimates agreed to within about 10 percent at higher flow conditions but the USGS flow estimates were 35 to 50 percent lower when total river flow was less than approximately 5,000 cfs at Ft. Edward. When these lower flows are applied to the USEPA PCB and suspended solids measurements, proportionately lower loads are estimated for Stillwater and Waterford. These results will be discussed later in this Appendix. Tables C-1 and C-2 represent the correction factors for the flow estimate revision. Note that in each instance the flow estimate correction factor (CF) is defined as follows:

$$CF = \frac{Flow_{USGS}}{Flow_{USEPA}}$$

It should be noted as well that the USEPA flows for the Schuylerville station are also affected by changes in flow data for Stillwater and Waterford. This is because the flow at this station was obtained by proportioning the flow increase between Ft. Edward and Stillwater on the basis of drainage basin area. Thus, the changes in Stillwater flow are partially reflected in the flow at Schuylerville. Typically, the flow correction at Schuylerville resulted in a decreased flow estimate of 25 percent or less relative to the original USEPA estimate (*i.e.*, the revised flow at Schuylerville was 75 percent or more of the original flow estimate).

In addition to the modifications to the mainstem station flow estimates, the flow estimates for the major tributaries between Ft. Edward and Waterford also required modification. Specifically, flow estimates for the Batten Kill and Hoosic River were revised in proportion to their drainage basin contributions and to the changes in flow at Stillwater and Waterford. Flow correction factors were always less than unity for the Batten Kill, reflecting the similar direction of change at Schuylerville. The corrections for the Hoosic River were both greater and less than unity, corresponding to the direction of change for the Waterford flow estimates. Note that although the

flow corrections for these tributaries can be fairly large (as much as a 78 percent decrease), the correction has little impact on the river's PCB load calculation since the tributaries contribute so little PCB mass.

Correction for Potential Bias in the TI Dam Monitoring Station

As noted in the corrections to section 3.2 of the DEIR (*see* the Responsiveness Summary for Volumes 2A, 2B and 2C), recent sampling collected by GE in the vicinity of the TI Dam indicates a consistent difference between the water column PCB concentration at the TI Dam monitoring station and that at a center channel monitoring station nearby. (Note that GE's TI Dam monitoring point is on the west wing wall of the TI Dam while the USEPA's monitoring station is located in about 3 to 4 feet of water about one-quarter mile upstream of the Dam. At present, interpretations of the GE and USEPA data suggest both locations capture the western-most portion of the flow at the Dam.) An analysis was completed for the available data pairs covering 1997 and 1998. The results of the analysis are presented in Section 1 of the USEPA review contained in Book 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C.

The analysis yields the correction factors shown in Table C-3 (reproduced from Table 1-3 of Volume 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C). These factors are dependent on both river flow and the PCB concentration at Rogers Island, at the upstream end of the TI Pool. The description of the model used to develop the correction factors is described in Section 1.1 of Volume 3 of the Responsiveness Summary for Volumes 2A, 2B and 2C. A portion of that text is reproduced here as an aid to the reader:

> To understand the relationship [between the TI Dam monitoring station and the actual load crossing the Dam], consider the extremely simplified conceptual mode shown in Figure [C-1], in which downstream flow through the TIP is indicated by arrows. Discrepancy between shore concentrations (C_1) and mixed concentrations at the dam (C_2) presumably arises because there is an additional load in the near-shore area (L), which is not immediately mixed laterally. Consider a case in which transport is laterally mixed at some point (say, the end of Griffin Island). At this point, there is a flow of magnitude Q_0 with a concentration of C_0. Downstream (i.e., in the areas of the TID-West sampling station) full lateral mixing does not occur, and an additional load, L, is introduced. For simplicity, assume that the flow is split into two portions, with a flow of Q_1 going through the near-shore portion, and a flow of Q_0-Q_1 going through the main channel. These flows then mix and recombine at the dam. It is important to realize that the concentration in the near-shore area is determined by both the upstream concentration and the local loading, L. Under these conditions, the concentration in the near-shore area (TID-West) would be given by
>
> $$C_1 = C_0 + L/Q_1$$

while the mixed center channel concentration at the dam would be given by

$$C_2 = C_0 + L/Q_0$$

The ratio would then be

$$\frac{C_2 \quad C_0 + L/Q_0}{C_1 \quad C_0 + L/Q_1}$$

This ratio depends on the relative magnitude of Q_1 to Q_0, indicating that lateral mixing intensity presumably increases with the magnitude of Q_0. As Q_1 increases toward Q_0 (implying instant lateral mixing of L), the ratio should approach 1. The ratio also depends on the relative magnitude of C_0 versus L. As the upstream concentration increases, the ratio should again increase toward 1 because the contributions from the near-shore area are swamped by upstream loads.

Thus, the high bias seen in initial GE sample comparisons is a joint result of low flows and low upstream concentrations. The bias results from incomplete lateral mixing of what is likely (to a first approximation) a fixed local load. If this load is small relative to the upstream load, or if mixing is high, the bias is reduced. Thus, it is entirely inappropriate to apply the apparent bias correction observed in 1996–1997 to the entire observed time series at TID-West. In particular, a much smaller bias correction should apply during conditions prior to 1995 in which much higher upstream loads were observed.

In the model described above, the GE main channel monitoring station would be represented by the concentration C_0, since this location would not "see" the additional loading introduced in the near-shore environment. Ultimately, the actual load crossing the TI Dam (C_2) lies between the near-shore value C_1 and the main channel value C_0. *See* the discussion in Section 1 of the USEPA commentary concerning this issue.

Essentially, the data show the greatest correction at low flow conditions (less than 4000 cfs) and when the upstream load at Rogers Island is at levels less than 17 ng/L. Higher flows and higher Rogers Island concentrations diminish the need for a correction.

Assuming that the center channel value is closer to the "correct" value for determining the total load at the Dam, these correction factors were applied to the 1993 TI Dam samples as shown in Tables C-1 and C-2. Corrections for the 1993 data set for the TI Dam station were only required in about two-thirds of the sampling events. Specifically, transects 1, 2, 4 and 8 and flow-averaged event 1 did not require corrections due to the combination of high flow and high concentrations at

the Rogers Island station. The correction factor for the remaining transects and flow-averaged events was 0.8 (*i.e.*, a 20 percent decrease in concentration and load) since all events had Rogers Island concentrations well above the threshold of 17 ng/L.

Application of the Corrections

The flow and concentration corrections described above were appropriately applied to the various transects and flow-averaged events. Note that the flow corrections affect both PCB and suspended solids loads. Using the revised flows, the suspended solids loads for transects 1, 3, 4 and 6 were revised and replotted. Figures 3-32 to 3-35, representing these sampling events in the DEIR, have been corrected and are included in this Appendix.

In a similar fashion, the figures in the DEIR representing the PCB loads for the transect and flow-averaged events were updated to reflect the revised flows as well as the TI Dam bias corrections described above. Corrected versions of Figures 3-38, 3-40, 3-43, and 3-44 to 3-49 are included in this Appendix. These figures represent transects 1, 3, 4, and 6 as well as flow-averaged events 1, 2, 3, 5, and 6. New plots, representing transects 2, 5 and 8 and flow averaged event 4, are presented here as well in Figures C-2 to C-5, respectively. These plots were developed using the revised flows and the TI Dam correction as appropriate. Lastly, a set of diagrams describing the Mohawk River's dissolved, suspended and total PCB loads has been added to all transect plots when available (specifically Figures 3-38, 3-40, 3-43, 3-47, C-2 and C-3), to permit the direct comparison of the Mohawk River loads with those of the Upper Hudson at Waterford. An additional revision to these figures is the reporting of the total PCB load at each station in both mg/s and kg/day as an aid to the reader.

Interpretation of the Revised Estimates in the Upper Hudson

As discussed in the USEPA corrections to Section 3.2 of the DEIR (found in the Responsiveness Summary for Volumes 2A, 2B and 2C), the revised flow estimates change the low flow conditions far more extensively than the high flow conditions due to the similarity of the USEPA and USGS high flow estimates and the larger disagreement between the low flow estimates. This is clearly in evidence in the correction factors shown in Tables C-1 and C-2.

For suspended solids, the flow revisions yield proportionately lower loads at Stillwater and Waterford for transects 1 and 6 while transects 3 and 4 have slightly higher loads at these stations. The revised estimates do not change the initial interpretations given in the DEIR with regard to suspended solids loads. The suspended solids loads are relatively constant throughout the Upper Hudson within any individual sampling event during the period of study with the exception of the resuspension event seen in transect 3, attributed to the spring flood event on the Hoosic River. (As noted in the Responsiveness Summary for Volumes 2A, 2B and 2C, the Hoosic River flood event represents a 1-in-3 year event and not a 1-in-100 year event as stated in the DEIR.)

The interpretation for the PCB loads of the Upper Hudson was more affected by the flow revisions. An additional set of figures was developed for this Appendix to aid in the examination of the data. Figures C-6 to C-17 represent the transect PCB loads plotted as a function of river mile. Each transect is represented in two plots, the first showing total PCB load as a function of river mile, the second showing homologue load as a function of river mile. Note that only monochloro- to tetrachlorohomologues are represented on the second plot since these homologues represent the majority of PCB mass in the water column. A similar set of plots was developed for the flow-averaged events (see Figures C-18 to C-29), exhibiting total PCB load and homologue loads for each sampling event. Lastly, two figures presenting transect 8 results are included as Figures C-30 and C-31. Transect 8 was a unique sampling event and is described later in the text.

In subsequent discussions, the transects and flow-averaged events are organized based on season and the notable features of the sampling event. In general, this organization follows the discussions presented in Section 3.2.6 of the DEIR and the reader is referred to this section for more detailed discussion. In the discussions to follow, differences between the original interpretation and that based on the revised results are noted. Based on the revised results, the transect and flow-averaged events were separated into 3 groups, specifically winter-early spring (low flow-cold water), spring flood (high flow) and late spring-summer (low flow-warm water). PCB transport during these three periods show different characteristics. Note that this is two less groups than discussed in the DEIR. This does not supersede the groups presented in the DEIR but is done to simplify the discussion of the impact of the revised flows. Specifically, transect 3 is now examined under both winter and spring flood conditions rather than by itself as a transitional event. Flow-averaged events 2 and 3 are examined in the context of the summer sampling events.

Winter - Early Spring

The first period, represented by transects 1, 2 and the upstream portion of transect 3 above Stillwater, is characterized by the typical TI Dam load consisting of a monochloro- and dichlorohomologue-dominated mixture. However, both transects 1 and 2 have some sampling or analytical problems associated with them. The issue with transect 1 affects only the Rogers Island sample and prevents the calculation of a net TI Pool contribution. As discussed in the DEIR, the Rogers Island sample in transect 1 is unlike any other sample collected during the Phase 2 investigation (See Figure 3-38). As such its concentration and congener pattern is suspect. Results for transect 1 are plotted in Figures 3-38, C-6 and C-7.

In transect 2, analytical problems relating to blank laboratory contamination affected many congeners, in particular, BZ#1 and #4. The measurement of BZ#4 was compromised for the TI Dam, Schuylerville and Stillwater samples. Since BZ#4 comprises the vast majority of the dichlorohomologue mass, the dichlorohomologue loads for these stations are suspect as well. The homologue plots for Schuylerville and Stillwater clearly show the impact of the BZ#4 issue, since there is essentially no dichlorohomologue mass without the congener (see Figure C-2). The quantitation of BZ#1 was also an issue in several of the transect 2 samples. BZ#1 constitutes the

vast majority of the monochlorohomologue mass, so the proportion of total mass represented by this homologue is also suspect. As a result of the high frequency of blank contamination issues, little can be inferred from this transect. Nevertheless, the results for this transect are presented in Figures C-2, C-8 and C-9.

Transect 3 had no important analytical problems and the portion of the transect upstream of Stillwater presents conditions similar to transect 1 (see Figures 3-40, C-10 and C-11). When these two transects are examined together, several basic observations can be made. Specifically, the homologue pattern of the TI Dam load is quite distinct from the Rogers Island load seen in transect 3 and later transects. Transect 3 yields a large gain in water-column load across the TI Pool as seen in later transects as well. Transect 2 also suggests such a gain across the Pool although its results are much more uncertain as described above. Downstream of the TI Dam under these conditions, the homologue pattern is well preserved (see Figures 3-38 and 3-40). In transect 1, all homologue loads appear to be translated relatively conservatively (to within 25 percent) all the way to Waterford (see Figure C-7). In transect 3, there appears to be some gain in load to Stillwater but note that the homologue patterns are largely unchanged (compare Figures 3-40 and C-10). Figures C-11A and C-11B show the similarities among the homologue loads *vs.* river mile. This suggests the load gain may be due to uncertainties in the flow estimates resulting from the flow transition which was occurring during transect 3 rather than a true addition to the water column inventory. Thus, clearly in transect 1 and most likely in transect 3, the water column load originating above the TI Dam is transported in a near-conservative manner, for all homologues. As will be shown, this was not the case in summer.

Spring Flood

The high flow events were largely unaffected by the flow and TI Dam revisions. As a result the conclusions drawn for these events remain the same. Transect 4, transect 8, flow-averaged event 1 and a portion of transect 3 all characterize this period in the river. During the earliest spring sampling event (*i.e.*, transect 3 between Stillwater and Waterford), the spring flood on the Hoosic River delivers a large suspended matter load (see Figure 3-33) but resuspension from the Hudson River bottom also adds significantly (note the difference between the Hoosic River suspended solids load and the suspended solids load at Waterford). The additional suspended solids load is attributed to scour of the Hudson River bottom which also serves to contribute a very large PCB load (ca. 19 kg/day). The net result of this addition is clearly expressed in the distinct change in the homologue pattern of the water column load (see Figure 3-40). This event clearly documents the occurrence of river bottom scour with accompanying PCB transport.

The major spring flood sampling event, transect 4, shows PCB loads in the Upper Hudson to be transported conservatively to Waterford. This is evident in all three figures for this transect (Figures 3-43, C-12 and C-13). Total PCBs as well as the individual homologues are transported to Waterford in an apparently conservative manner. Note that the TI Dam station is not represented on these plots due to the influence of the Moses Kill on this sampling station during this particular

event. *See* Section 3.2.6 of the DEIR text for further discussion of this issue. Evident in this event is the increase in the monochlorohomologue load as a result of passage through the TI Pool, despite the large overall loading from upstream. This homologue is then transported along with the others to Waterford. Additionally, as noted in the DEIR text, there is no evidence of a scour event in the Hudson River below Stillwater during this event despite the fact that the river flows are higher than those noted in transect 3. Based on this observation, it appears that the scour event in transect 3 is related to the way in which the high flow of the Hoosic River enters the Hudson, perhaps serving to scour river sediments in the vicinity of the Hoosic River confluence.

Flow-averaged event 1 is essentially unchanged as a result of the revisions and describes a condition similar to that seen in transect 4. Specifically, the principal load is derived above Rogers Island with an additional monochlorohomologue load obtained in the TI Pool (see Figures 3-44, C-18 and C-19). In this event, some tetrachlorohomologue load is lost and some dichlorohomologue load is gained across the TI Pool, making this portion of the transect similar to that seen in transect 1. These two events (flow-averaged event 1 and transect 1) both suggest a partial removal of the Rogers Island load and replacement with TI Pool-derived PCBs as a result of passage through the Pool. This is based on the extensive change in homologue pattern which occurs during these events coupled with the relatively minor change in total loading. Other Phase 2 sampling events generally have minor Rogers Island loads so that evidence for this hypothesis is less clear.

The last station in flow-averaged event 1 had some issues regarding the accuracy of the samples collected as measures of the true loading condition between the TI Dam and Waterford. Specifically, local dam construction was causing some obvious resuspension during the first week of sample collection. For this reason, the individual samples were composited into 2 one-week composites instead of a single two-week composite and analyzed. Both values are represented in Figures C-18 and C-19. The line connecting Waterford with TI Dam is based on the average of the pair of composites at Waterford. In this figure the one-week composites are multiplied by the average water flow for the corresponding week rather than the average flow for the two weeks. The resulting loads for the two composites are quite different (*see* Figure C-18), reflecting the impact of the dam construction on the first sampling week and yielding a substantially higher PCB load relative to the second week. The suspended solids results also demonstrate the impact of the dam construction, with a mean suspended solids concentration of 46 mg/L during the first week and 8.4 mg/L during the second week. The higher suspended solids concentration corresponds to the higher PCB load shown in Figure C-18. As a result of the dam construction it is unclear what the true PCB load at Waterford would have been during this period. Nonetheless, the homologue data can provide some insights here.

Specifically, as shown in Figure C-19, the average trichloro- and tetrachlorohomologue loads clearly increase downstream of the TI Dam as expected due to the resuspension of sediment caused by the dam construction. However, the monochloro- and dichlorohomologue loads do not increase relative to the TI Dam loads. This would be expected if the TI Dam loads were translated downstream in a near-conservative fashion with subsequent addition of a large quantity of low-level

PCB contaminated sediment. These sediments would have little monochloro- and dichloro-homologue content since the concentration would be too low to support extensive dechlorination. In fact the PCB concentration on the suspended matter during the first week of this sampling event contained only 2 mg/kg of Total PCBs, consistent with this scenario. (An extensive discussion of the relationship between PCB sediment concentration and the extent of dechlorination can be found in Chapter 4 of the DEIR.) Thus despite the impact of the dam construction, the underlying homologue distribution appears consistent with the results of transect 4 at least for the less-chlorinated homologues, *i.e.*, near-conservative transport of PCBs from TI Dam to Waterford during high flow conditions. Notably, it also clear that the dam construction had a major impact on PCB loads at Waterford, generating loads very comparable to the spring runoff event captured by transect 4.

One last sampling event, transect 8 is presented here which was not presented in the original Report. This sampling event is a unique event in that it is neither a timed transect nor a flow-averaged event. Instead, the samples were collected in a single day without regard to timing. This collection effort represented a simple sampling opportunity, since flow-averaged event 1 was commencing and the river flow was rapidly rising. The results of this transect are presented in Figures C-4, C-30 and C-31. Because the sampling event was neither sequenced nor averaged over time, the samples are not directly related to each other, unlike the other sampling events. For this reason, the changes in load among the stations, particularly between TI Dam and Waterford, may not reflect the true load changes. Nonetheless, the similarity of the homologue pattern between TI Dam and Waterford supports the condition seen in the other spring high flow events, that is, near-conservative transport through the Upper Hudson. Independent of the conservative transport issue, these samples do yield the instantaneous loads at the time of sampling. The most useful information to be drawn from this event is the individual scale of the loads, which are substantially lower than transect 4 (50 percent or more, see Figure C-12) despite the fact that this event represents a rising and higher water flow relative to transect 4. In fact, these loads are very similar to the average load for the subsequent two week period captured in flow-averaged event 1. As discussed in response DG-1.15B to the DEIR, these results indicate that transect 4 captured the major PCB transport event of the year since the sampling event represented the flow peak conditions of the first major flow event of the year.

Overall, these events describe in detail the PCB loads associated with the spring floods. The revisions of flow do not affect these events particularly and there is no TI Dam correction required. In transects 4, 8 and flow-averaged event 1, a large load is generated upstream of the TI Pool, in the range of 8 to 18 kg/day. Despite this large load, evidence of the TI Pool input can be seen in the addition of monochloro- and dichlorohomologue loads across the Pool. Below this point the homologue pattern is preserved to Waterford. In the detailed examination of transect 4 (and to some degree, flow-averaged event 1), total loads as well as the homologue pattern are preserved to Waterford, suggesting conservative transport during high flow conditions. Transect 3 between Stillwater and Waterford documents a significant local load produced by scour of the river bottom. This event documents the instability of sediment deposits below TI Dam, as suggested by the results

of the Low Resolution Sediment Coring Report, which documents large PCB losses from several previously-defined NYSDEC *hot spot* areas. Finally, dam construction in the vicinity of Waterford served to create a very significant PCB load, suggesting that such activities may need further control to prevent large PCB release events.

Late Spring - Summer

The period of May to September was characterized by two transects and five flow-averaged events. During this period, efforts by GE served to greatly diminish the scale of the loads released upstream of Rogers Island, beginning in June. Sampling events collected by both USEPA and GE prior to June, 1993 frequently show large loads entering the TI Pool at Rogers Island while sampling events collected after June consistently show a greatly diminished load at this station. This period (May to September) is also characterized by warmer water column temperatures and lower flows relative to the earlier conditions. Thus these sampling events are the most affected by both the flow revisions and the TI Dam bias correction.

For the purposes of examining the effects of the corrections, these sampling events can be combined since the impacts are similar. When these events were first examined, total PCB loads delivered to Waterford appeared very similar in magnitude to those present at the TI Dam. Notably, the homologue patterns changed as the river moved downstream from TI Dam to Waterford despite the consistency of the magnitude of the total load. The change in pattern became more and more pronounced from spring to summer. The revisions did not affect these patterns since they were only applied to flow or the total PCB concentration. The difference in the TI Dam correction factor for Total PCBs *vs.* the Tri+ sum was not used here since the difference in the factors was not found to be statistically significant. This finding may change as more data are obtained since such a difference might be expected due to the nature of the TI Pool source (*i.e.*, predominantly lighter congeners).

Flow-averaged events 2 and 3 represent conditions in May and June, respectively. As a result of the revisions, the total PCB load estimates at the TI Dam have decreased by 20 percent. For flow-averaged event 2, this still represents a large load gain across the TI Pool (see Figure C-20). For flow-averaged event 3 (see Figure C-22), this correction results in a minor load decline across the TI Pool, since there was a large Rogers Island load associated with this event. Nonetheless the load crossing the TI Dam during flow-averaged event 3 is still quite different from that at Rogers Island, again suggesting substantial replacement or modification of the upstream load during its passage through the Pool. This is consistent with the results seen in transect 1 and flow-averaged event 1.

The absolute loading level at Waterford for flow-averaged event 2 is essentially unchanged but due to the modification of the TI Dam load estimate, it appears that a small additional load (less than 20 percent) occurs between TI Dam and Waterford (see Figure C-20). A similar scale loss is apparent in the revised flow-averaged event 3 plot (see Figure C-22). However, both of these events show a marked decline in the fraction of monochloro-homologue between the two stations, representing about a 50 percent loss (see Figures C-21 and C-23). This change is beyond the

analytical uncertainty and suggests some other process may be involved beyond simple translation of the TI Dam load. Flow-averaged event 3 also shows a decline in the dichloro-homologue load, at roughly 15 percent. Again, the change in the proportion of the dichlorohomologue mass relative to the trichloro- and tetrachlorohomologues is more substantial and suggests an additional process affecting the PCB load.

Transect 5, flow-averaged event 4, flow-averaged event 5, transect 6 and flow-averaged event 6 sequentially span the entire summer of 1993. In each of these events, the load at Waterford is consistently lower than that at the TI Dam (see Figures C-14, C-24, C-26, C-16 and C-28, respectively). For transect 5 and flow-averaged event 4 which represent late June and early July, the load decrease is about 40 percent. Subsequent sampling events exhibit smaller total PCB losses, in the range of 12 to 16 percent. Notably the sampling event prior to transect 5 (flow-averaged event 3) exhibited a 20 percent loss. As seen in late spring sampling events, these losses do not occur consistently across all homologues. Specifically, these losses are almost exclusively related to parallel losses of the monochloro and dichlorohomologue loads (see Figures C-15, C-25, C-27, C-17 and C-29, respectively). These changes are quite substantial in terms of the proportion of these homologues at Waterford relative to the TI Dam and are well beyond any analytical uncertainty. Absolute declines in load are typically 30 to 50 percent for the dichlorohomologues and 80 to 100 percent for monochlorohomologues.

The trichloro- and tetrachlorohomologue groups typically show much smaller absolute changes in load, both positive and negative and on the scale of 20 percent. However, these groups clearly increase their importance relative to the total PCB load. In most instances as well, the proportion of tetrachlorohomologue increases relative to the trichlorohomologue. This suggests the addition of PCBs, perhaps from the sediments, with a higher fraction of tetrachlorohomologue relative to the water column load. Alternatively, this may represent a minor loss of the lighter trichlorohomologues during transit to Waterford. However, this loss would be far smaller than that seen for the monochloro- and dichlorohomologues.

A second observation concerning the loss of the lighter homologues can be made concerning the scale of the total transport. Over the period May to September, both the highest total loads at the TI Dam and the greatest mass loss of monochloro- and dichlorohomologues are associated with the sampling events occurring at the end of June and early July. This period is quite close in time to the mid to late June peak in PCB transport seen in the subsequent monitoring conducted by GE over the period 1994 to 1998 and suggests that this phenomenon was occurring in 1993 but was partially obscured by the release events occurring upstream.

Lastly, but perhaps most importantly, the results show that the trichloro- and tetrachlorohomologues are largely transported from the TI Dam to Waterford regardless of the time of year or rate of transport. These results suggest that transport of these homologues is largely conservative, since the loading rate set at the TI Dam is very close to that at Waterford, regardless of the absolute rate of loading. The relationship among the major homologue groups further supports

this with the ratio of trichloro- to tetrachlorohomologue mass staying fairly constant while moving downstream while monochloro- and dichlorohomologues tend to track each other, with large apparent mass losses occurring during warmer weather.

All of the discussions above are predicated on the validity of the TI Dam station as an accurate measure of the total PCB load as well as the homologue pattern of this load. The fact that there is apparent translation of the TI Dam loads during winter and spring conditions lends some credence to this assumption. However, the conclusions concerning the low flow conditions and the loss of the less chlorinated homologues may appear more tenuous since the interpretation of the data is less straightforward. In this instance the measurements at Schuylerville for transects 5 and 6 provide additional information to further support and confirm the interpretations given above. Specifically, transects 5 and 6 can both be examined in terms of the load changes between TI Dam, Schuylerville and Waterford. In both transects, the monochloro- and dichlorohomologue loads both peak at the TI Dam and then decline at a similar rate per river mile from the TI Dam to Schuylerville and then from Schuylerville to Waterford. This suggests that the loss process begins soon after the TI Dam under warm conditions but more importantly, that clear evidence for loss of these homologues exists independent of the TI Dam station. The flow-averaged events do not have data for Schuylerville but are clearly consistent with this loss phenomenon, confirming that the conditions seen in these transects apply throughout the summer. The internal consistency among all these sampling events also serves to support the TI Dam station as a useful measure of the Upper Hudson load.

A second observation can be made from the late spring and summer sampling events regarding the trichloro- and tetrachlorohomlogue loads. Evidence for a total PCB load gain downstream of the TI Dam station is only present in transect 6, based on the revised results. Specifically, this transect shows a small gain in total PCB between TI Dam and Schuylerville. All late spring-summer events show a net mass loss to Waterford. However, beginning with transect 5 in late June, these events show a consistent but relatively small increase in the tetrachloro- to trichlorohomolgue ratio (see Figures C-15, C-25, C-27, C-17 and C-29). In the two detailed sampling events, transects 5 and 6, this increase in the tetrachloro- to trichlorohomologue ratio occurs between TI Dam and Schuylerville, accompanied by net gains in their total loads. Below Schuylerville, these loads appear to be translated in a near-conservative fashion. Evidence for the increases in these loads below TI Dam is also apparent in the three summer flow-averaged events. Taken together, these events suggest a small additional PCB load is generated by the sediments between TI Dam and Schuylerville. Based on transect 6, the data suggest a slower rate of load production per mile across this river section relative to the TI Pool. (Note the change in slope in the load plots for the two homologues in transect 6 as seen in Figure C-17. Transect 5 could not be used in this comparison since no data are available for Rogers Island) Nonetheless, these results suggest this region to be a net source of the tetrachloro- and trichlorohomologues to the water column, with the region downstream simply transporting these homologues to the Lower Hudson.

The homologue signal indicated by the water column load gains from TI Dam to Schuylerville during summer conditions suggest a less dechlorinated source than that of the TI Pool. The results

also suggest a lower flux rate per mile, suggesting a lower PCB concentration or inventory available to drive the additional load. These observations are consistent with the historical measurements of PCBs which show the highest concentrations and inventories in the TI Pool and lower concentrations and inventories downstream. The higher concentrations of the TI Pool would tend to be more extensively dechlorinated, thus yielding a more dechlorinated PCB load.

Lastly, the late spring-summer events also demonstrate the importance of the TI Pool load to the entire suite of homologues and not just the less chlorinated ones. This is evident in all of the summer events in the majority of the monochloro-, dichloro- and trichlorohomologue loads for the entire Upper Hudson are clearly produced within the TI Pool. The tetrachlorohomologue load appears is principally generated from the Upper Hudson sediments, but the reach from TI Dam to Schuylerville yields a nontrivial portion of this load but still less than the TI Pool. With the anticipated, continued control of the PCB releases from the GE Hudson Falls facility to levels similar to those seen in 1997 and 1998, the Pool is expected to continue to represent the major source of all PCBs to the water column of the Upper Hudson.

Summary

The revisions of the conditions at the TI Dam, Stillwater and Waterford changed the relationships among the PCB loads observed at these stations to a limited degree. However, the most important conclusion regarding PCB loads remains intact and solidly-based. Specifically, the sediments of the TI Pool are the major source of PCBs to the water column during low flow conditions. Based on the level of source control at the GE Hudson Falls facility demonstrated in the GE/QEA Modeling Report (GE/QEA, March 1998) the sediments of the TI Pool sediments have clearly become the year-round dominant PCB source. Evidence for a sediment-based PCB source between TI Dam and Schuylerville is suggested by the internal consistency of the late spring-summer sampling events which is brought out more clearly by the revisions due the reduction in the TI Dam load estimates.

The near-conservative behavior of the total PCB load from TI Dam to Waterford discussed in the DEIR is apparently only characteristic of winter and spring conditions and does not apply to Total PCBs during late spring and summer. Low flow/low temperature or high flow conditions yield near conservative transport. During late spring and summer conditions, the total PCB load is not conservative and declines downstream of the TI Dam. However, the decline is largely confined to the less-chlorinated homologues, suggesting the occurrence of another process which selectively affects these homologues. Gas exchange or aerobic degradation are likely candidates for this loss. Sediment exchange is not a viable basis for removal of these homologues due to their low partition coefficients which largely prevent their preferential absorption relative to the higher chlorinated homologues.

Other Observations

It should be noted that transect 5 had an apparent sampling issue with the Rogers Island station. Specifically, the congener and homologue pattern associated with this particular sampling event was quite different from any other sample collected at this station. The pattern, as shown in Figure C-3, was a monochloro-, dichlorohomologue-dominated mixture, quite similar to that of the sediments. This sample also exhibited notably higher suspended solids concentrations relative to the upstream and downstream stations. Lastly, the sample seemed quite high in concentration given the prior remedial work completed earlier in the month by GE. On this basis it was concluded that the Rogers Island sample for this transect had incorporated a portion of local sediment during the sampling process, presumably due to a disturbance of the river bottom while the sample collector waded into the river to fill the sample bottles. Thus this station could not be used to estimate the load across the TI Pool. As a surrogate, the load at the remnant deposits station was substituted in the preparation of Figures C-14 and C-15, but the true load gain across the Pool can not be obtained for this transect. Notably, this transect was handled differently than transect 1 which had a similar sampling issue at Rogers Island. However, in the case of transect 5, the source of the problem with the Rogers Island samples was fairly well defined whereas in transect 1, the source of the Rogers Island sampling issue is unknown.

Although stated in the DEIR, the issue of the Mohawk River contribution is worth reviewing here. The presentation of the entire set of Mohawk loads in the revised and new plots shows that this source area, *i.e.,* the PCB load produced by the entire Mohawk water shed, is dwarfed by Upper Hudson load. The load from the Mohawk is typically less than 5 percent of the Upper Hudson load at Waterford under low flow conditions and less than 20 percent under high flow conditions. These results clearly show Upper Hudson as the source of PCBs to the Lower Hudson.

A last observation concerns the Troy sampling location, near the Green Island Bridge. Specifically, the load estimated at this location is inconsistent as an estimate of the load to the Lower Hudson relative to the sum of the Waterford and Mohawk loads. Most likely, the location, a shoreline sampling point, is too close to the confluence of the two tributaries and thus the samples obtained from this point do not always represent a well mixed sample. This is most evident in transect 4 (Figure 3-43) for PCBs and Figures 3-34 and 3-35 for suspended solids. As a result, loads calculated for this location should not be used as they are too unreliable.

Conclusions

From the discussions above the following conclusions can be made:

- Transport of trichloro- and tetrachlorohomologues appears to be nearly conservative throughout the year from the TI Dam to Waterford.

- Conservative transport of monochloro-, dichloro-, trichloro- and tetra-chlorohomologues downstream of TI Dam to Waterford occurs during high flow spring conditions based on total load and homologue pattern of downstream stations.

- Late spring-summer conditions suggest additional sediment-derived loading of a relatively small amount of trichloro- and tetrachlorohomologues (less than 20 percent of the TI Dam load) from the region between TI Dam and Schuylerville. No evidence exists for additional net loads downstream of Schuylerville.

- A late-spring-1993, TI-Pool-load maximum, similar to that seen by GE in later years, is suggested by the Phase 2 data as well.

- The anticipated decline in Waterford and Stillwater loads was partially offset by the revisions resulting from TI Dam bias correction such that the relationship among station load estimates did not change as much as expected. The net result of the revisions is lower overall loads (approximately 20% lower) in the Upper Hudson under low flow conditions, with high flow conditions largely unmodified from those estimated in the DEIR. The revisions did yield a more distinct and consistent decline in less chlorinated homologues at low flow + warm water conditions, suggesting loss of these homologues via a process such as gas exchange or aerobic degradation.

- The total proportion of the TI Pool contribution to the 1993 annual PCB budget for the Upper Hudson declines as a result of these revisions. However, its importance over the post-June 1993 does not decline appreciably, since its load appears undiminished over time while the Hudson Falls source has been substantially reduced.

- The TI Pool remains the major source of trichloro- and tetrachlorohomologue mass to water column during low flow in 1993 and year-round post-June 1993.

Overall, the corrections do not require a major revision to the main conclusions of the DEIR, with the exception of the concept of year-round conservative PCB transport. The TI Pool remains the dominant source under low flow conditions although there is evidence to suggest some release from sediments between TI Dam and Schuylerville. Year-round conservative transport is limited to the higher chlorinated homologues while the less chlorinated homologues are subject to substantial mass loss while enroute from the TI Dam to Waterford. Nonetheless, the Upper Hudson PCB loads remain the dominant source of PCB contamination to the Lower Hudson, with post-June 1993 contamination arising principally from the sediments of the TI Pool.

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APPENDIX C
TABLES

Table C-1
Correction to Original Transect PCB Load Calculations [1]

Transect No.	Mean Flow at Fort Edward (cfs)	Flow Adjustment[2]					TI Dam Load (concentration) Adjustment[3]
		Batten Kill	Schuylerville	Stillwater	Hoosic River	Waterford	
1	4924	0.67	0.93	NA[6]	0.31	0.67	None
2	4545	0.63	0.89	0.9	0.22	0.79	None
3	5103	0.29	0.79	0.75	5.92[4], 0.98[5]	1.05	0.8
4	17300	0.36	0.91	1	1.17	1.04	None
5	2400	0.44	0.85	NA[6]	0.23	0.6	0.8
6	2461	0.25	0.75	NA[6]	0.45	0.67	0.8

Notes:

1. Correction represents the ratio of the new flow or concentration over the original flow or concentration as reported in the DEIR. For example:
Transect 6 at Waterford

Original flow = 5,100 cfs
Revised flow = 3,400 cfs
Correction Factor (CF) = 3,400 / 5,100 = 0.67

2. Flow adjustments are based on a comparision of the USGS flows and those developed in the DEIR. See the corrections to Section 3.2 of the DEIR in the Reponsiveness Summary for the Phase 2 Reports: Volumes 2A, 2B and 2C.
3. TI Dam correction factor derivation is described in the USEPA's discussion in Book 3 of the Responsiveness Summary for the Phase 2 Reports: Volumes 2A, 2B and 2C.
4. This factor applies to the low flow condition sampled on 3/26/93.
5. This factor applies to the high flow condition sampled on 3/30/93 and note that no PCB sample was obtained on this date.
6. Not applicable since no sample was obtained at this station for this transect.

Table C-2
Correction to Original Flow-Averaged Event PCB Load Calculations[1,4]

Flow-Averaged Event No.	Mean Flow at Fort Edward (cfs)	Flow Correction at Waterford[2]	TI Dam Load (concentration) Adjustment[3]
1	18852	NA[5]	None
2	3385	1.05	0.8
3	2988	0.66	0.8
4	2484	0.56	0.8
5	2513	0.58	0.8
6	2515	0.5	0.8

Notes:

1. Correction represents the ratio of the new flow or concentration over the original flow or concentration as reported in the DEIR.

For example:

Flow-Averaged Event 6

Original Waterford flow = 7,080 cfs

Revised Waterford flow = 3,540 cfs

Correction Factor (CF) = 3,540 / 7,080 = 0.5

2. Flow adjustments are based on a comparision of the USGS flows and those developed in the DEIR. See the corrections to Section 3.2 of the DEIR in the Reponsiveness Summary for the Phase 2 Reports:Volumes 2A, 2B and 2C.

3. TI Dam correction factor derivation is described in the USEPA's discussion in Book 3 of the Responsiveness Summary for the Phase 2 Reports: Volumes 2A, 2B and 2C.

4. Flow corrections are only presented for Waterford since this is the only station downstream of TI Dam in the flow-averaged events.

5. Samples collected at Waterford were not applicable in this event due to local canal construction which is believed to have influenced the samples.

Table C-3
Correction Factors for the TI Dam PCB Loads

Empirical Bias Correction Factors		Total PCBs	ΣTri+
Low Flow, Low Upstream Concentration	Fort Edward Flow < 4000 cfs Fort Edward Concentration < 17 ng/l total PCBs *or* < 15 ng/l ΣTri+	0.64	0.69
Low Flow, High Upstream Concentration	Fort Edward Flow < 4000 cfs Fort Edward Concentration ≥ 17 ng/l total PCBs *or* ≥ 15 ng/l ΣTri+	0.80	0.88
High Flow, Low Upstream Concentration	Fort Edward Flow ≥ 4000 cfs Fort Edward Concentration < 17 ng/l total PCBs *or* < 15 ng/l ΣTri+	0.78	1.0
High Flow, High Upstream Concentration	Fort Edward Flow ≥ 4000 cfs Fort Edward Concentration ≥ 17 ng/l total PCBs *or* ≥ 15 ng/l ΣTri+	1.0	1.0

APPENDIX C
FIGURES

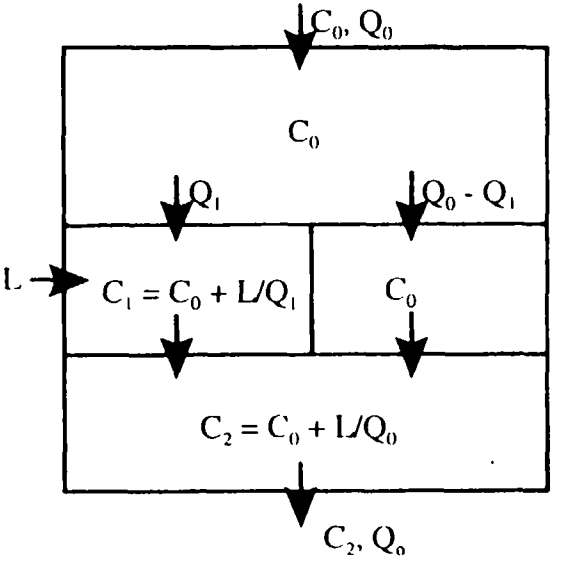
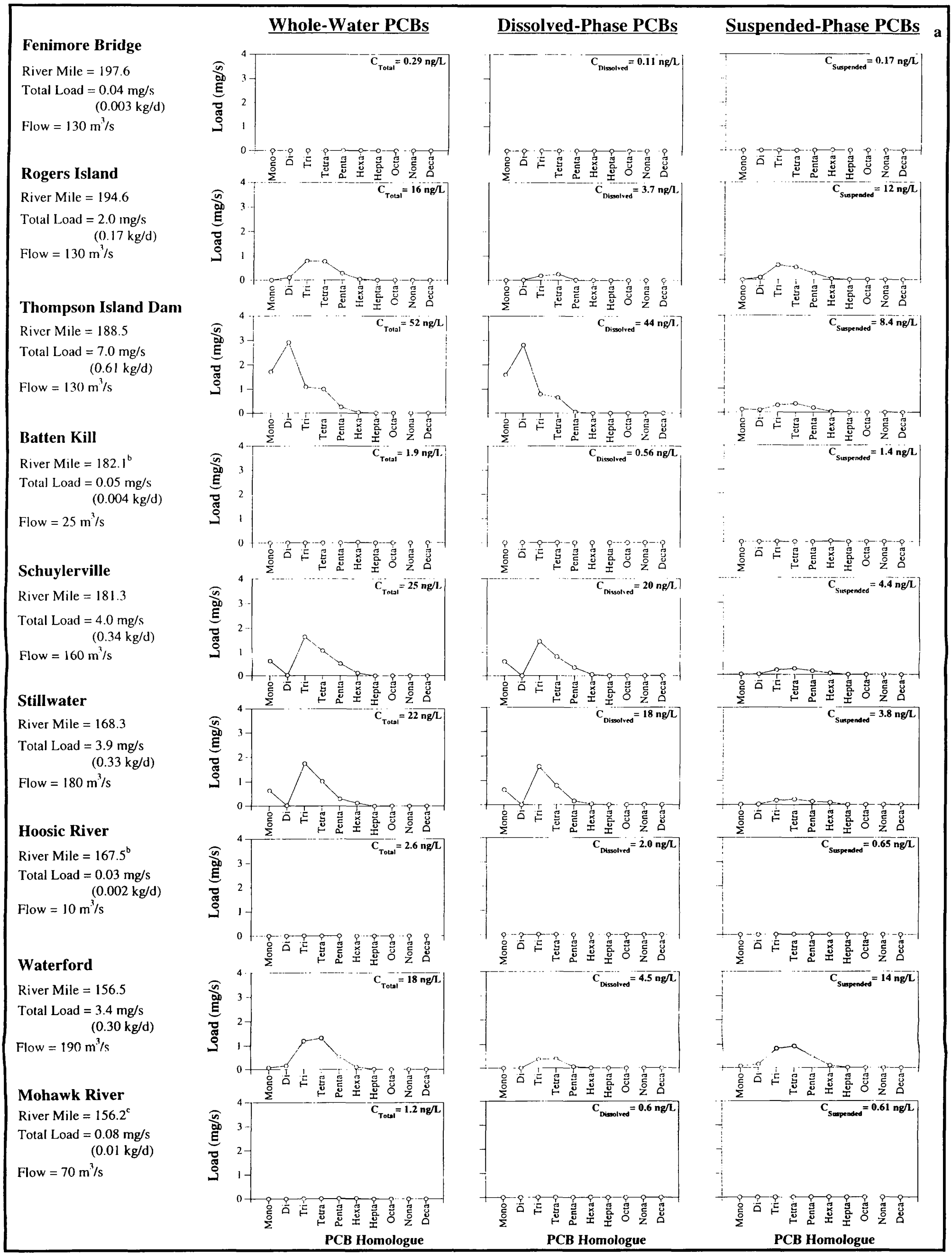


Figure C-1
Conceptual Model Of PCB Loads Near the TI Dam



Hudson River Database Release 4.1

TAMS/Tetra Tech

Notes:

a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).

b. Tributary river mile designations correspond to point of confluence with the Hudson River.

c. Transect 2 samples were collected during the period of February 19 to February 23, 1993.

Figure C-2
Upper River Water-Column Instantaneous PCB Loading for Transect 2 Low-Flow Conditions

Fenimore Bridge
River Mile = 197.6
Total Load = 0.04 mg/s (0.003 kg/d)
Flow = 80 m^3/s

Rogers Island[b]
River Mile = 194.6
Total Load = 25.6 mg/s (2.2 kg/d)
Flow = 80 m^3/s

Thompson Island Dam
River Mile = 188.5
Total Load = 14.6 mg/s (1.3 kg/d)
Flow = 76 m^3/s

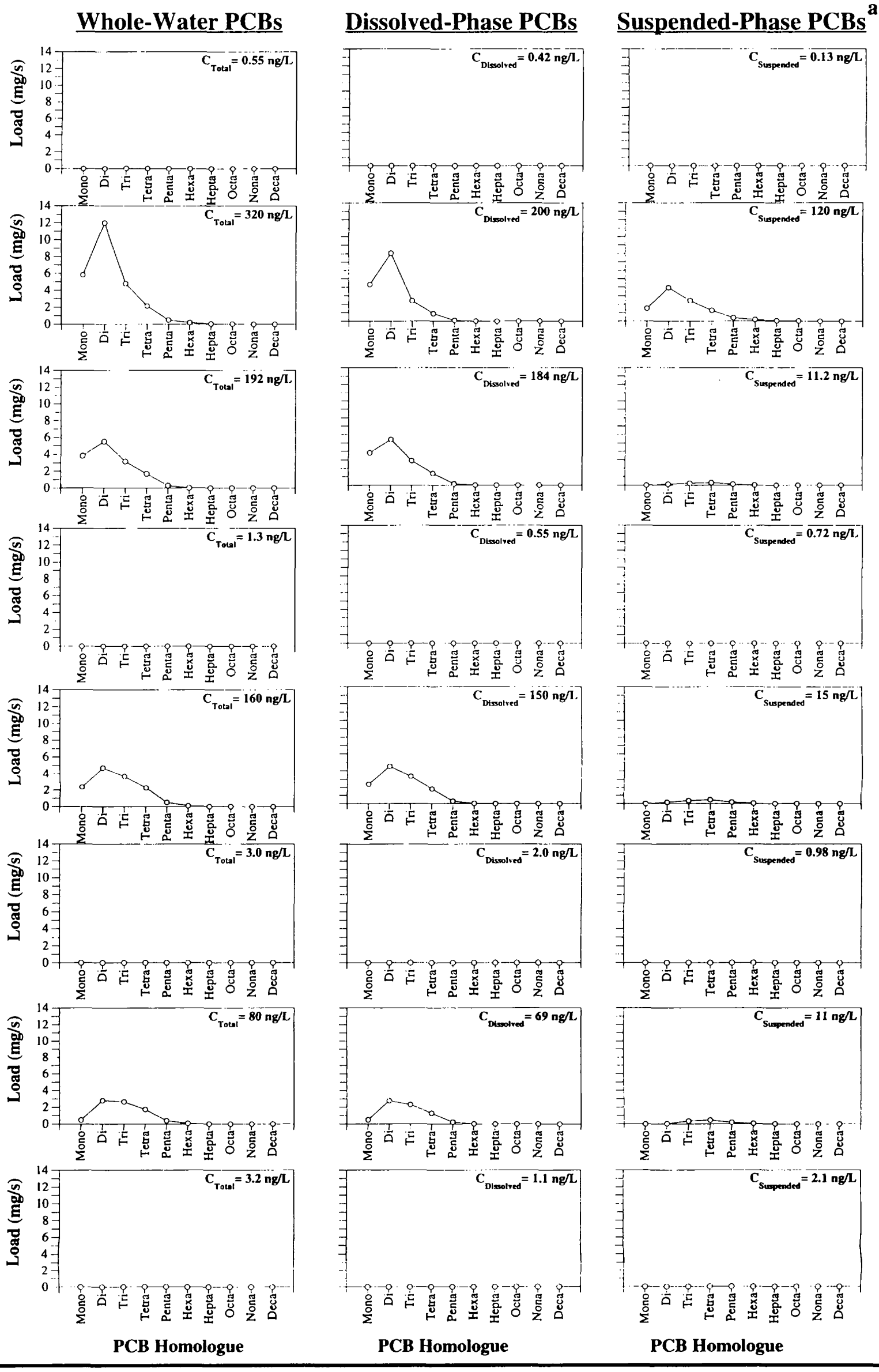
Batten Kill
River Mile = 182.1[c]
Total Load = 0.02 mg/s (0.002 kg/d)
Flow = 15 m^3/s

Schuylerville
River Mile = 181.3
Total Load = 13.7mg/s (1.2 kg/d)
Flow = 85 m^3/s

Hoosic River
River Mile = 167.5[c]
Total Load = 0.03 mg/s (0.002 kg/d)
Flow = 10 m^3/s

Waterford
River Mile = 156.5
Total Load = 8.2 mg/s (0.7 kg/d)
Flow = 102 m^3/s

Mohawk River
River Mile = 156.2[c]
Total Load = 0.13 mg/s (0.01 kg/d)
Flow = 41.1 m^3/s



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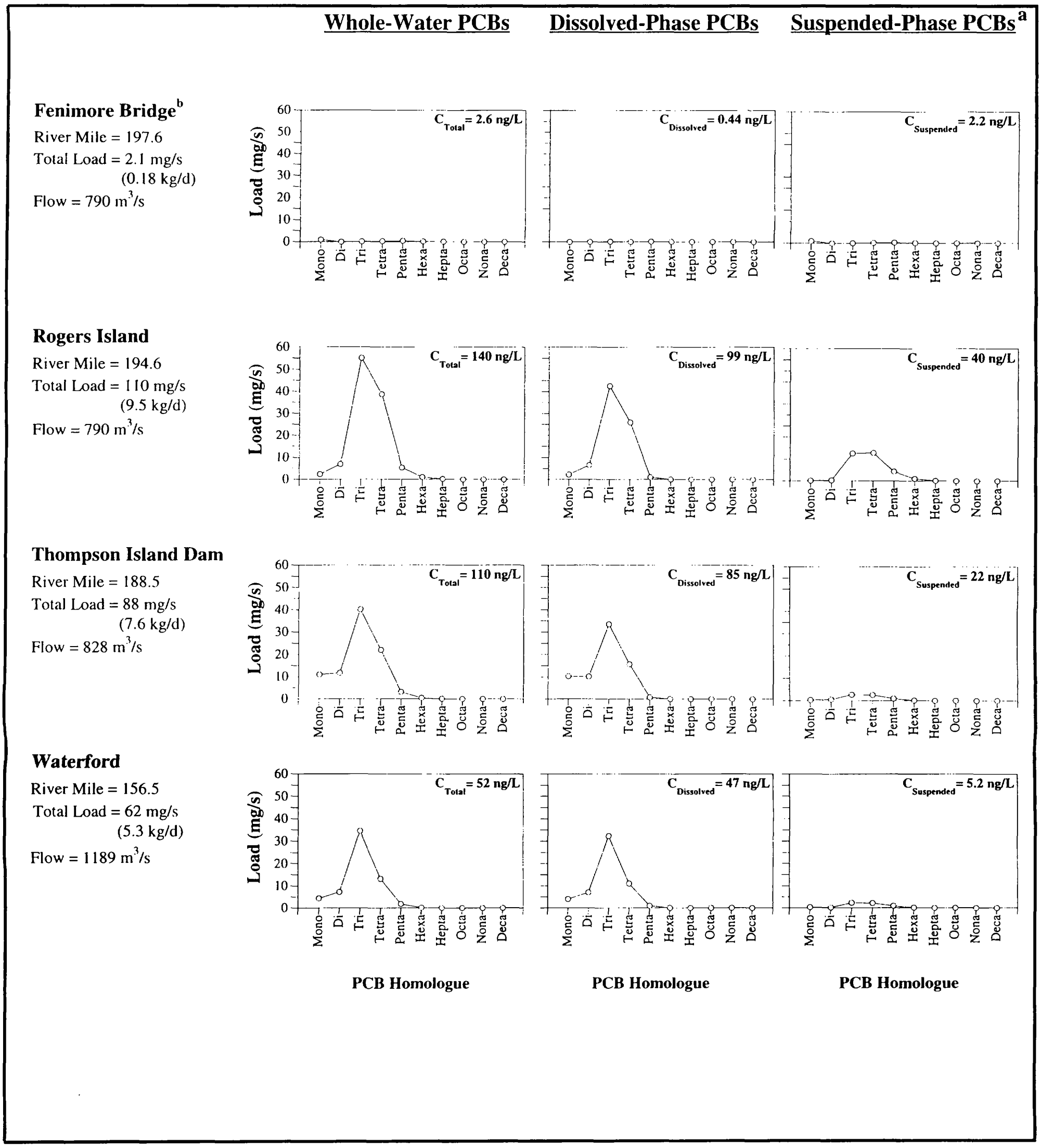
TAMS/Tetra Tech

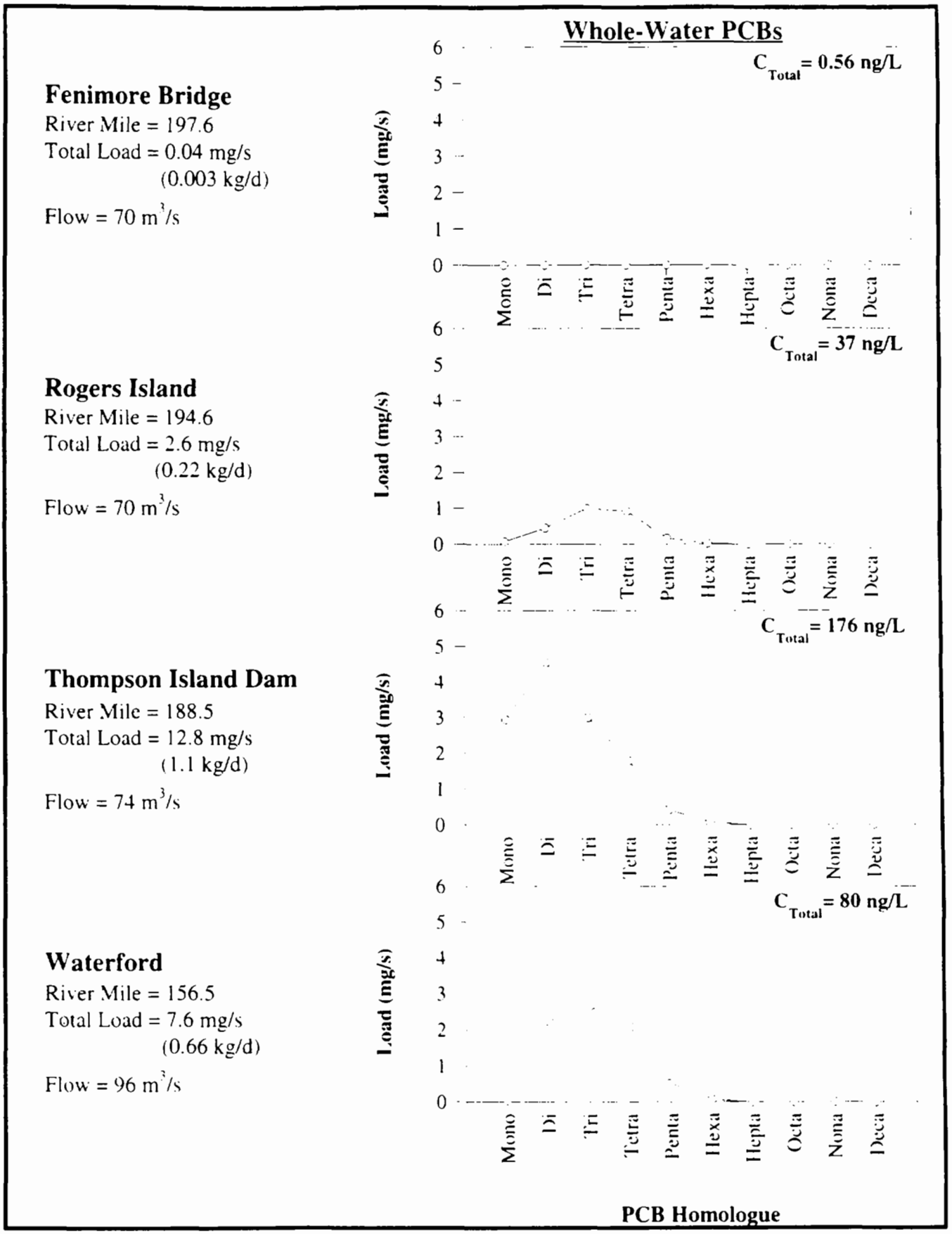
Notes:
a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).
b. Sediment is believed to have been disturbed during water-column sampling effort.
c. Tributary river mile designations correspond to point of confluence with the Hudson River.
d. Transect 5 samples were collected during the period of June 24 to June 30, 1993.

Figure C-3
Upper River Water-Column Instantaneous PCB Loading for Transect 5 Low-Flow Conditions



Notes:
a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).
b. No background sample was collected as part of Transect 8. The Fennimore Bridge sample shown here represents the two-week averaged background concentration for the period of April 23 to May 8, 1993 multiplied by the flow on April 23rd, 1993, the day of sample collection for Transect 8.

Figure C-4
Upper River Water-Column Instantaneous PCB Loading for Transect 8 High-Flow Conditions



Hudson River Database Release 4.1

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Note: Flow-Averaged 4 samples were collected during the period of July 6 to July 20, 1993.

Figure C-5
Upper River Water-Column PCB Loading for Flow-Averaged 4 Low-Flow Conditions

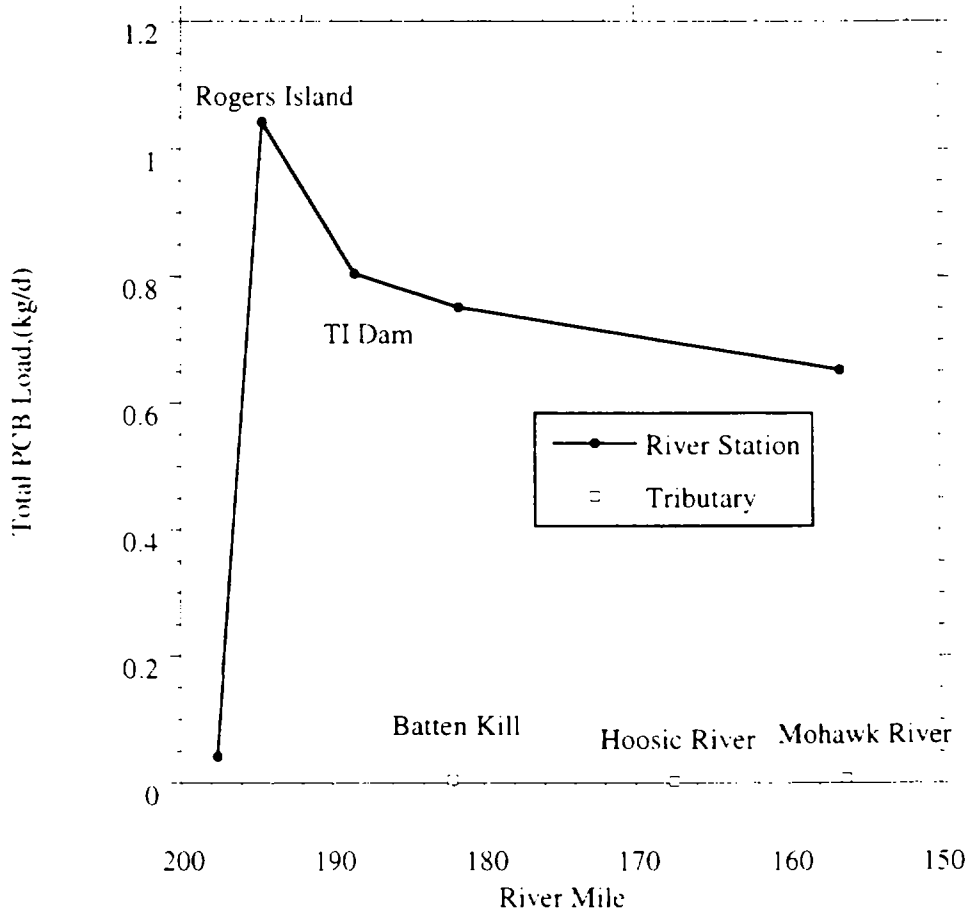


Figure C-6
Water-Column Instantaneous Total PCB Loads for Transect 1

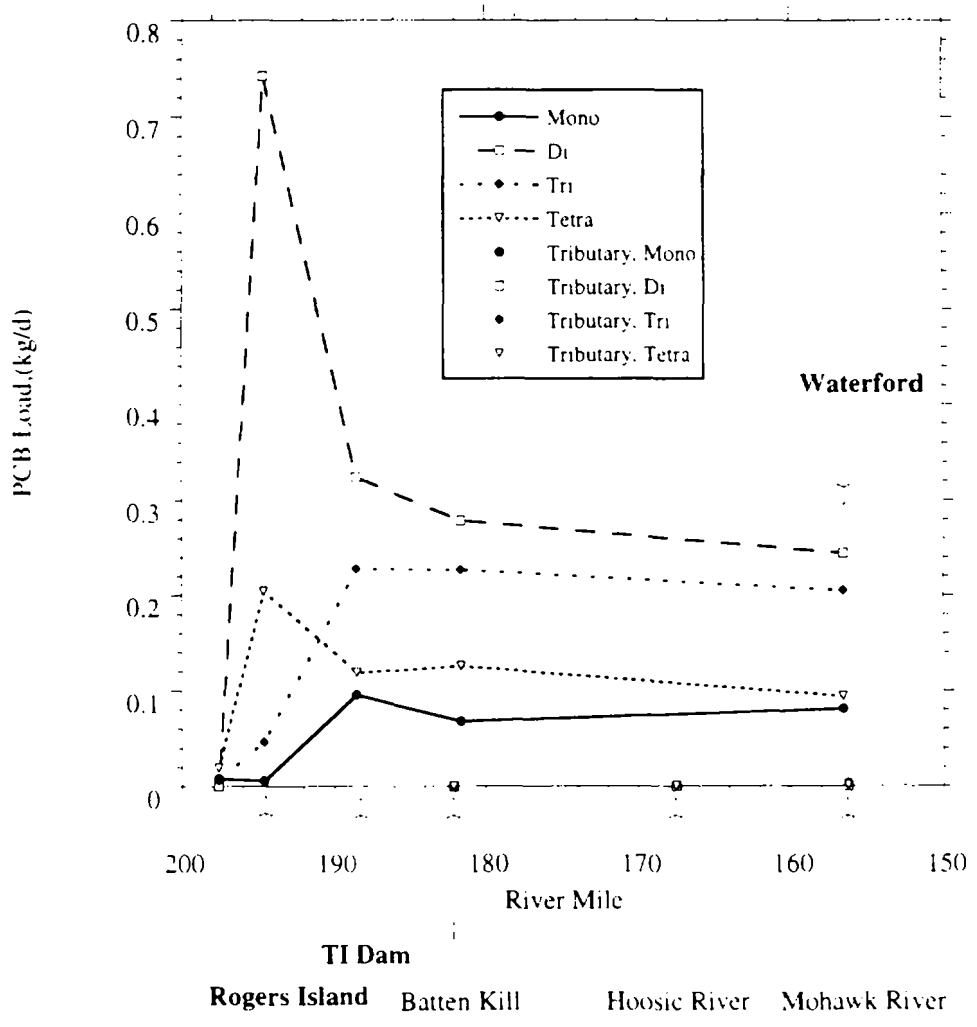


Figure C-7
Water-Column Instantaneous PCB Homologue Loads for Transect 1

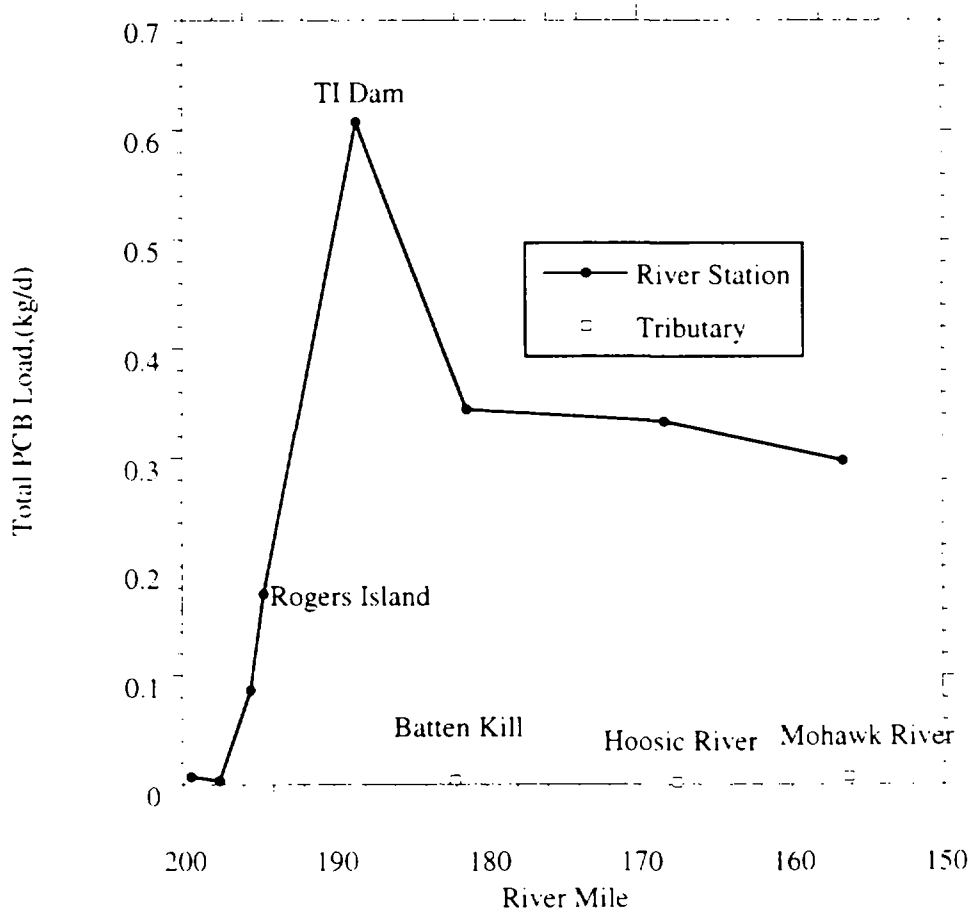


Figure C-8
Water-Column Instantaneous Total PCB Loads for Transect 2

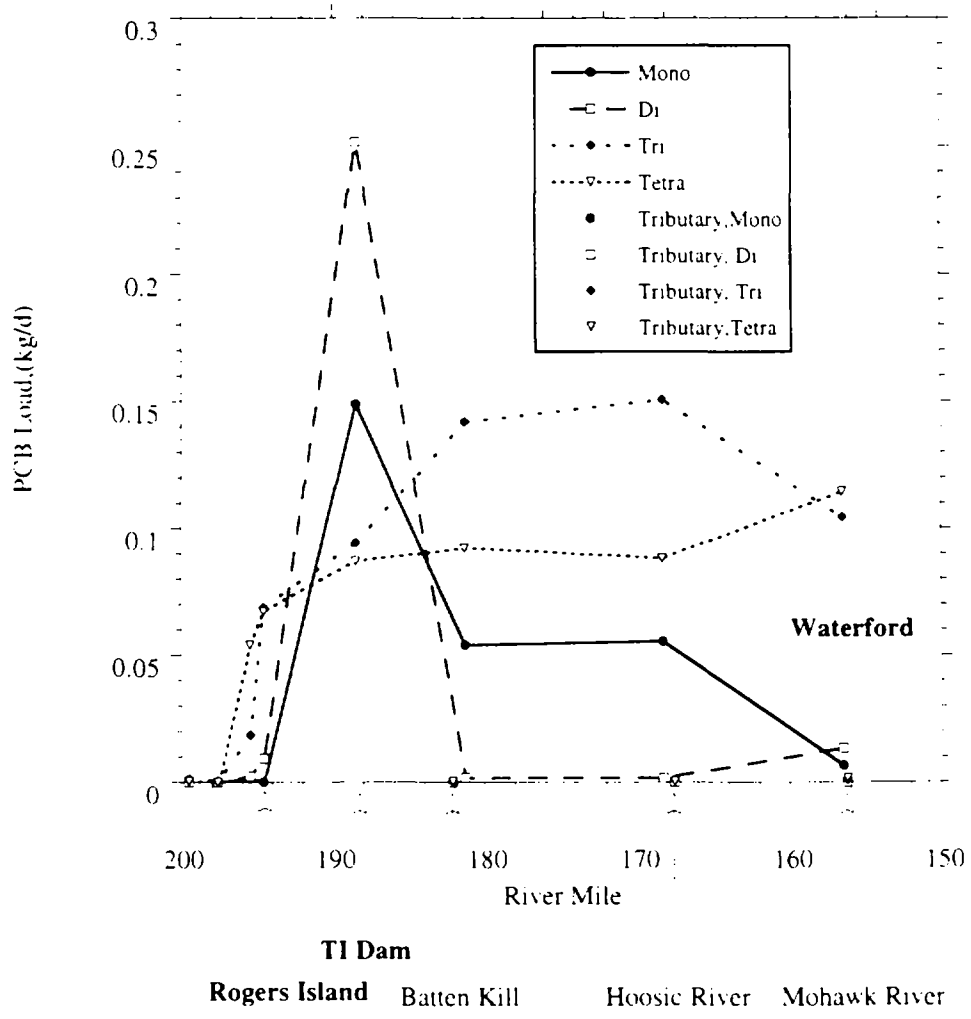
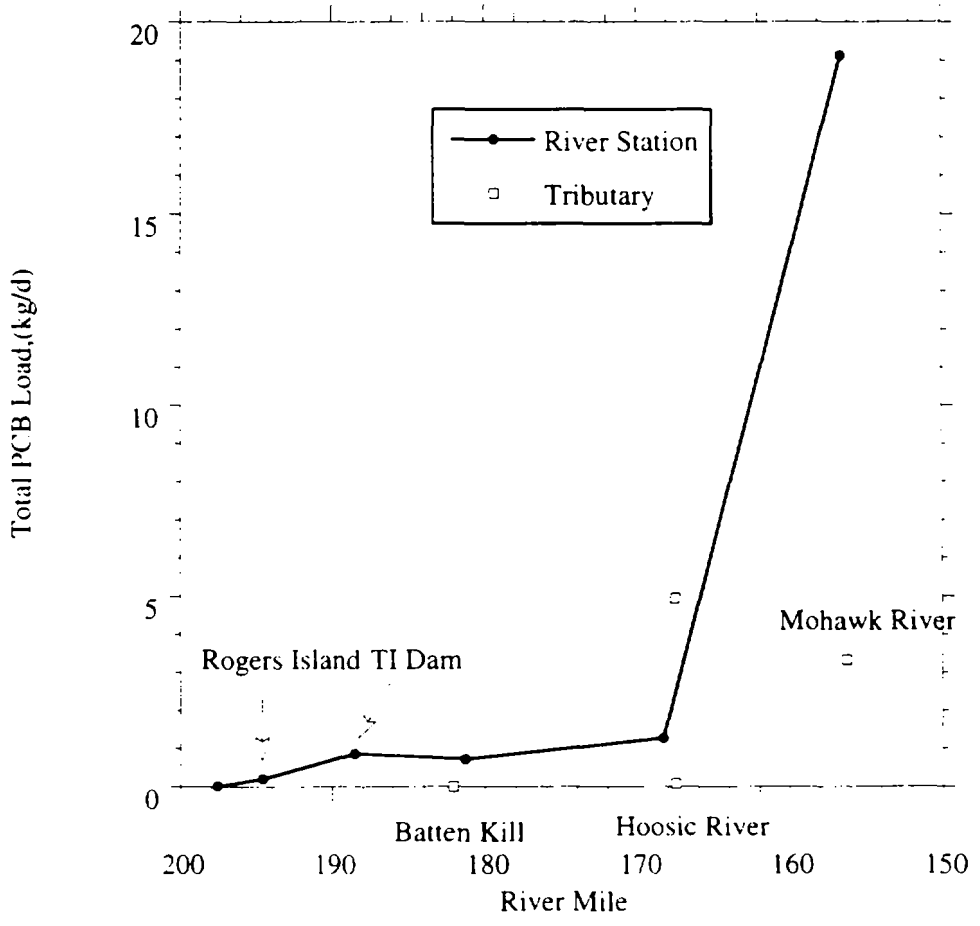
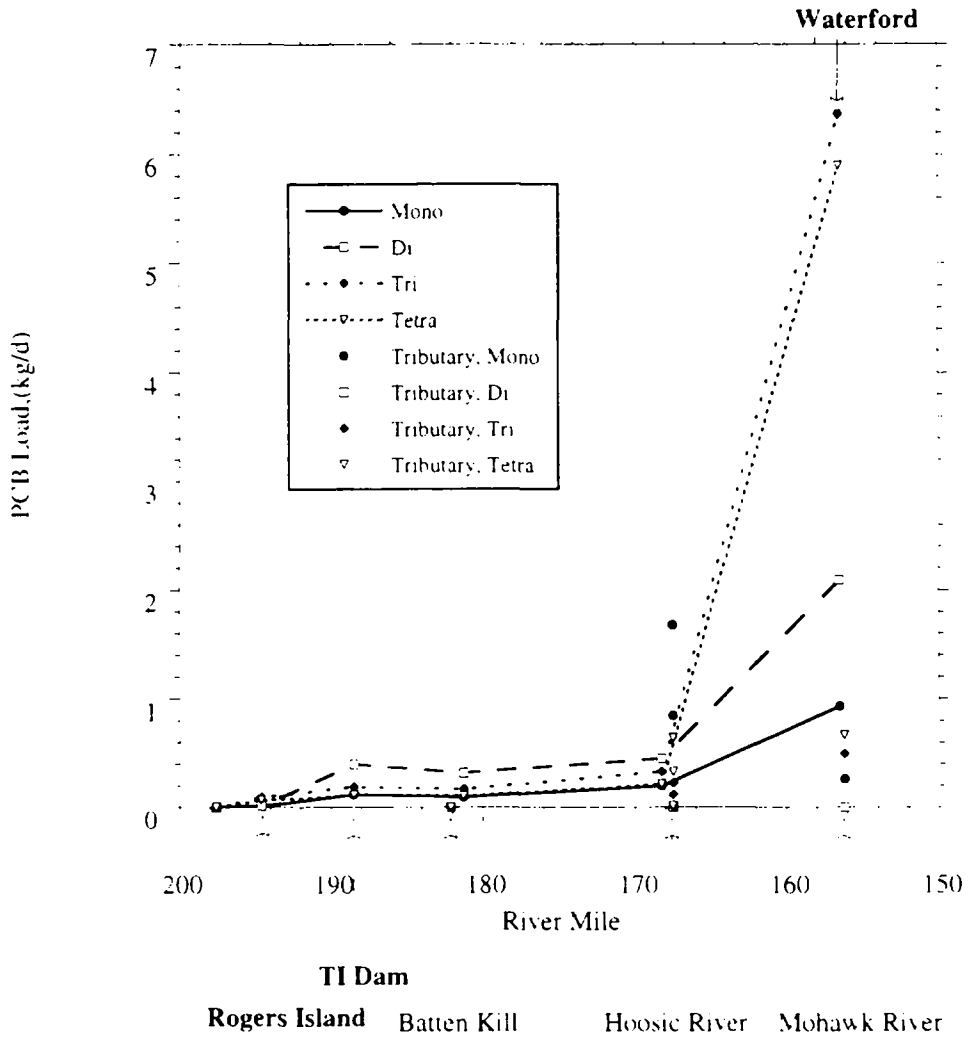


Figure C-9
Water-Column Instantaneous PCB Homologue Loads for Transect 2



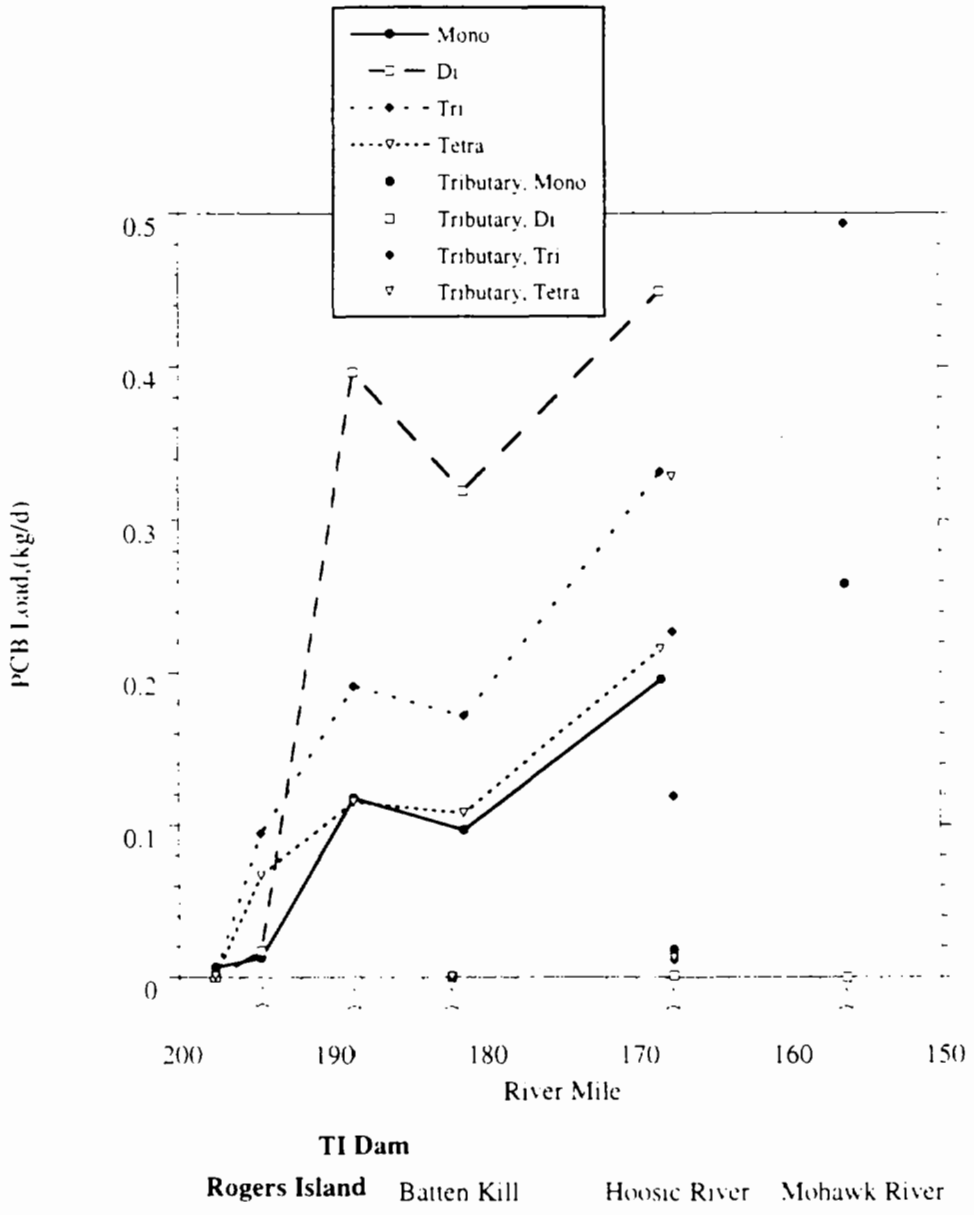
Notes:
Two sets of data were collected in Hoosic River

Figure C-10
Water-Column Instantaneous Total PCB Loads For Transect 3



Note:
Two sets of data were collected in Hoosic River

Figure C-11A
Water-Column Instantaneous PCB Homologue Loads for Transect 3



Note:
Two sets of data were collected in Hoosic River

Figure C-11B
Water-Column Instantaneous PCB Homologue Loads for Transect 3 Excluding Waterford

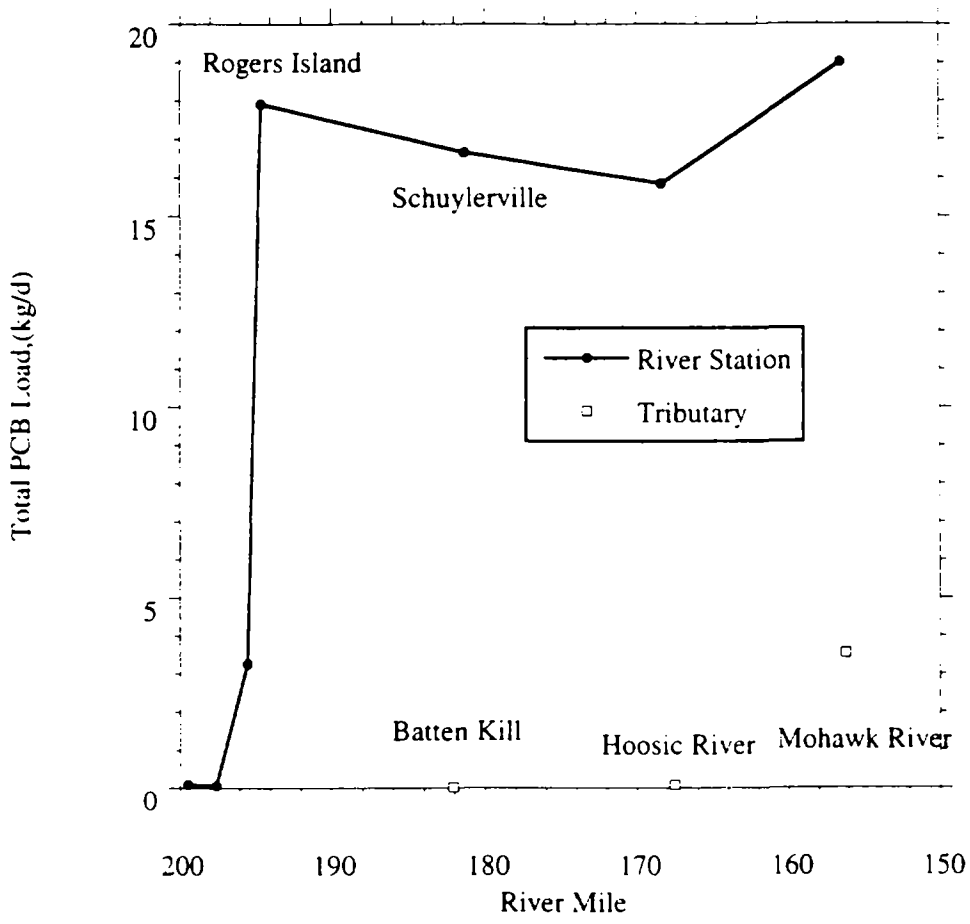


Figure C-12
Water-Column Instantaneous Total PCB Loads for Transect 4

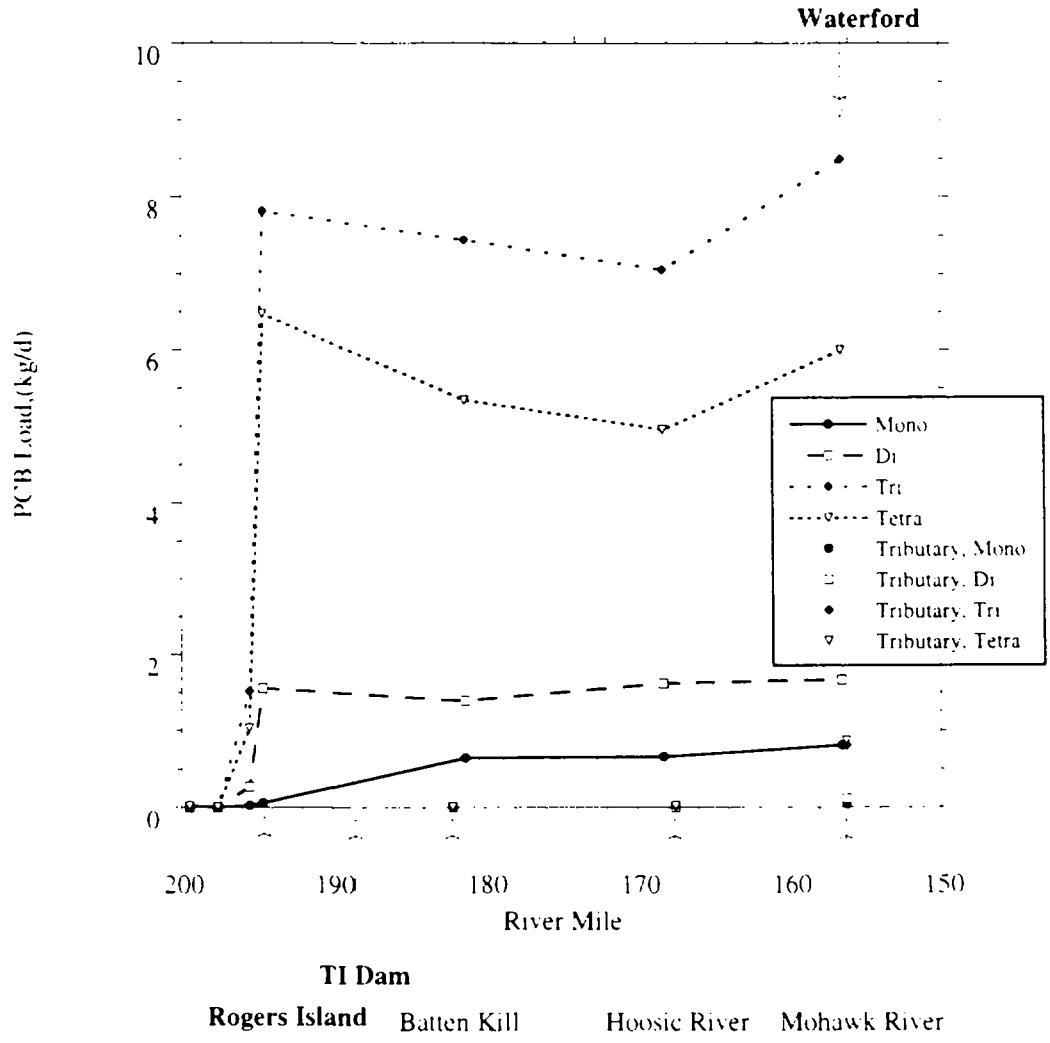


Figure C-13
Water-Column Instantaneous PCB Homologue Loads for Transect 4

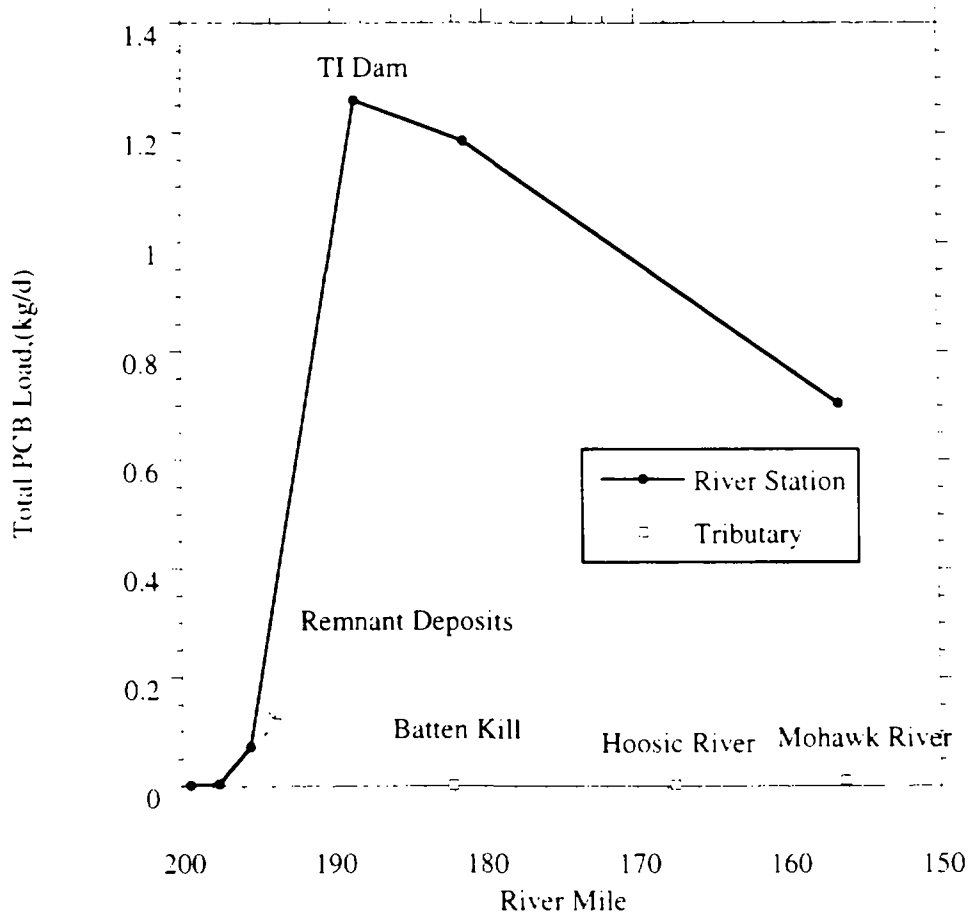


Figure C-14
Water-Column Instantaneous Total PCB Loads for Transect 5

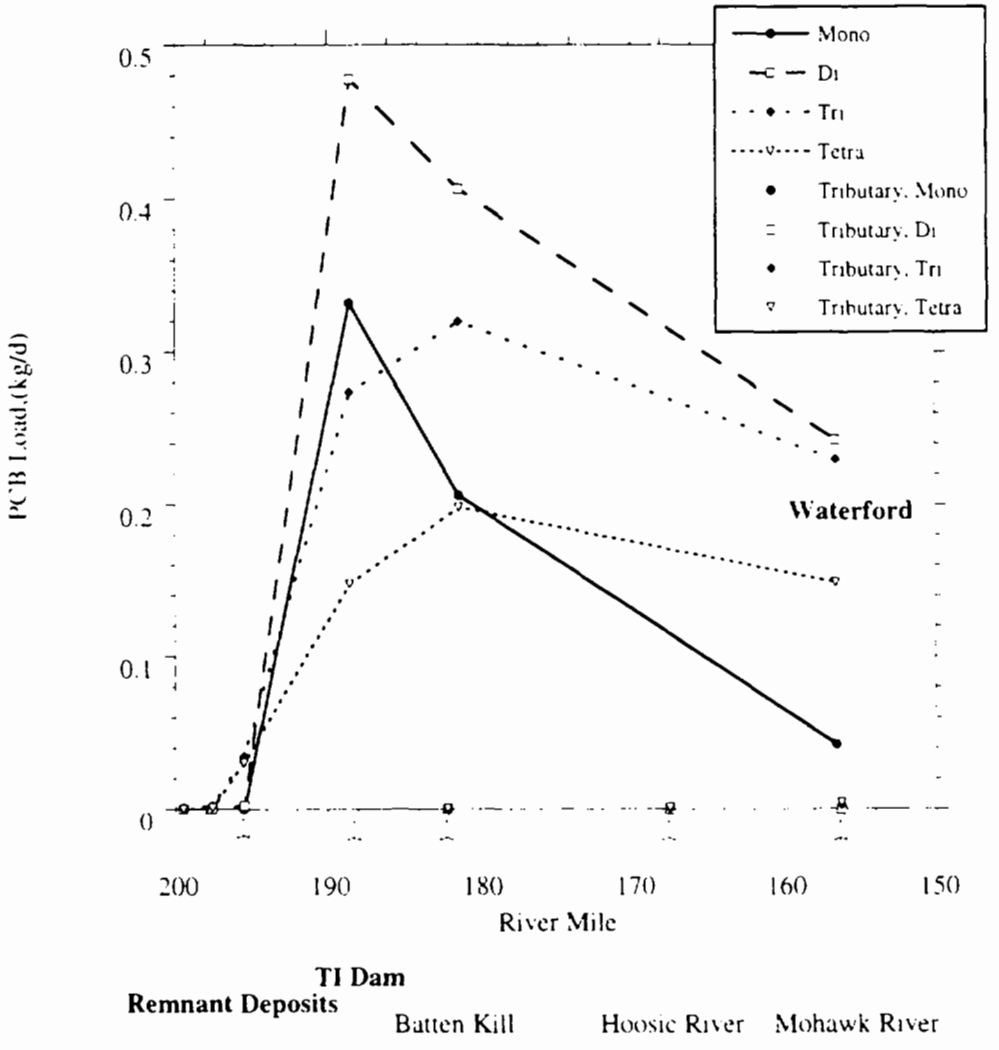


Figure C-15
Water-Column Instantaneous PCB Homologue Loads for Transect 5

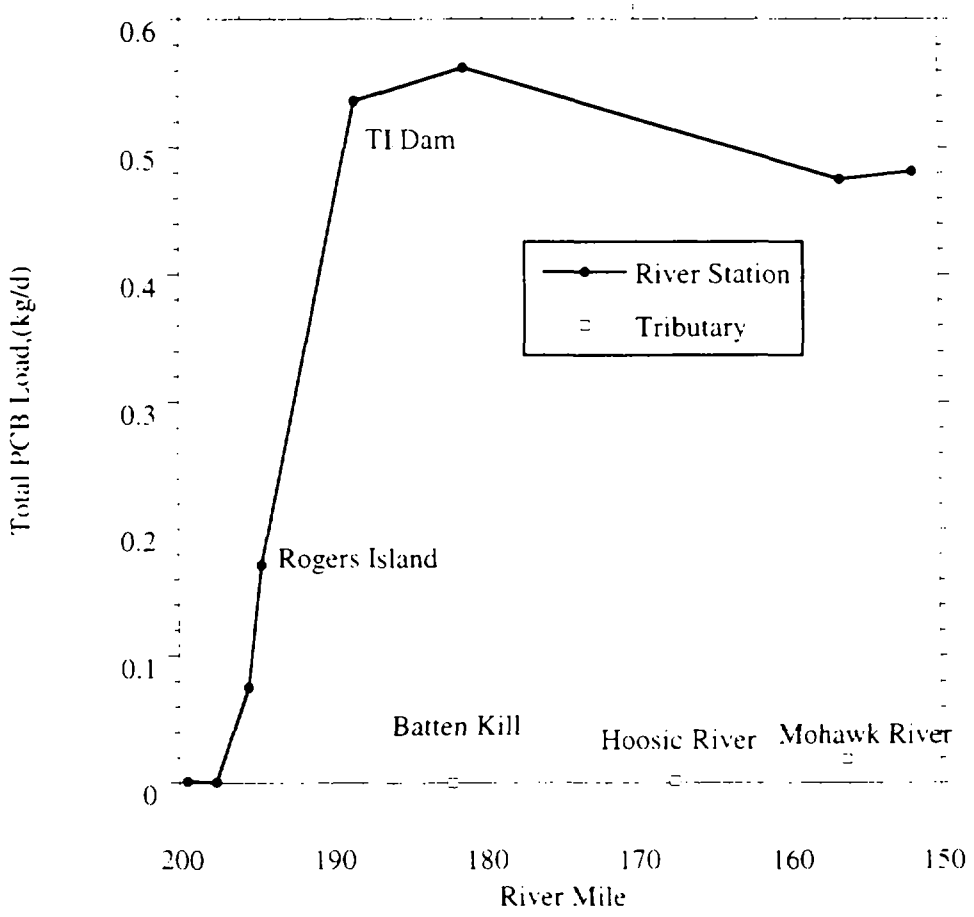


Figure C-16
Water-Column Instantaneous Total PCB Loads for Transect 6

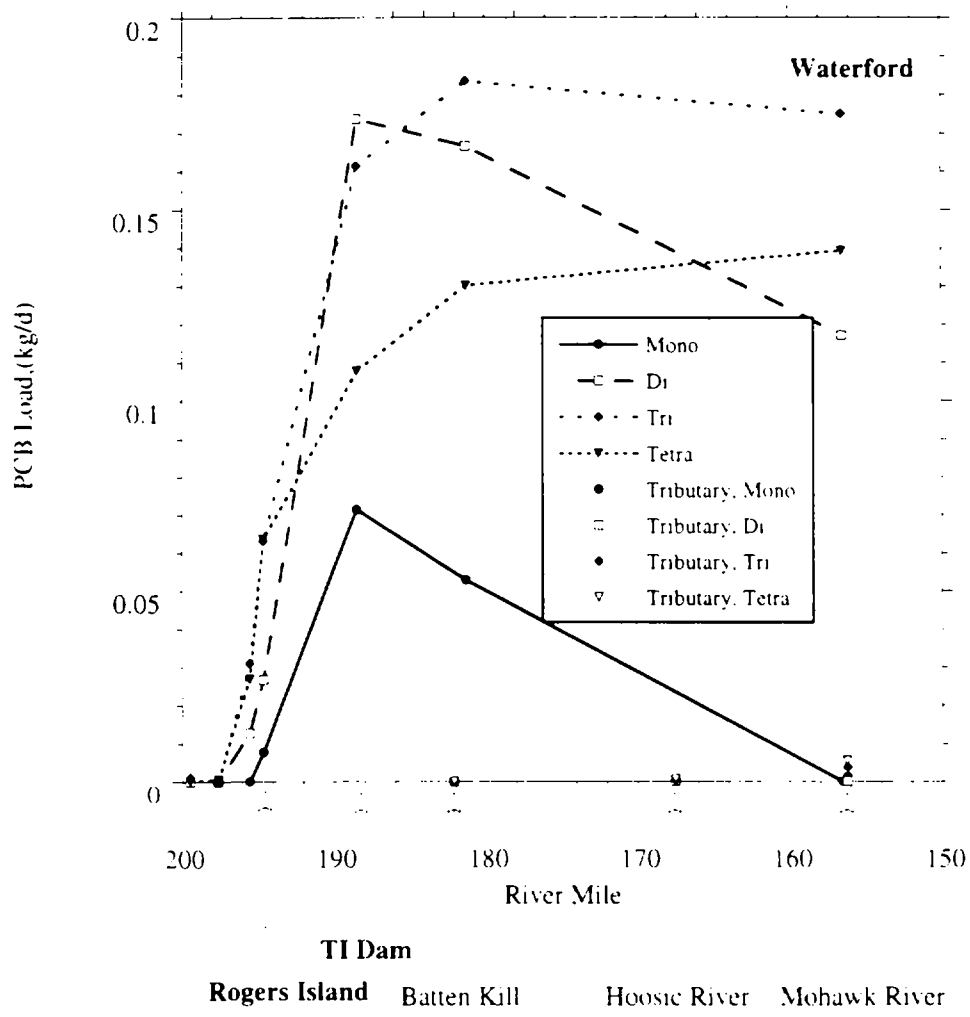
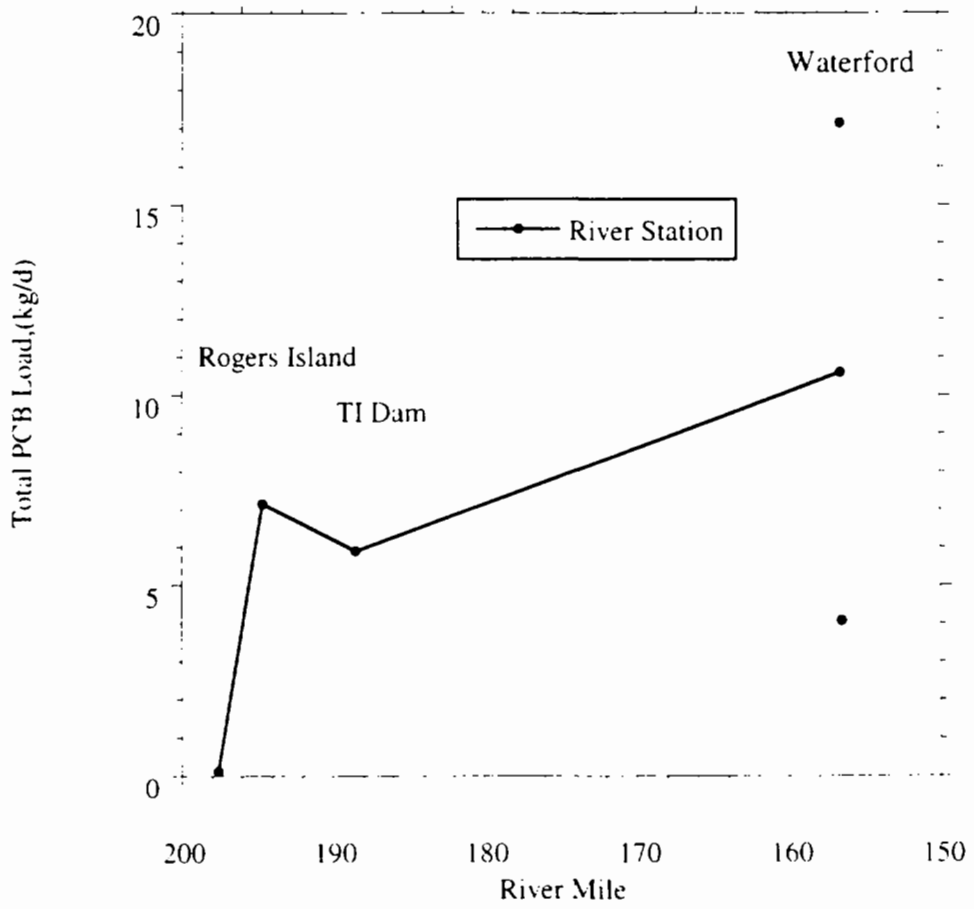
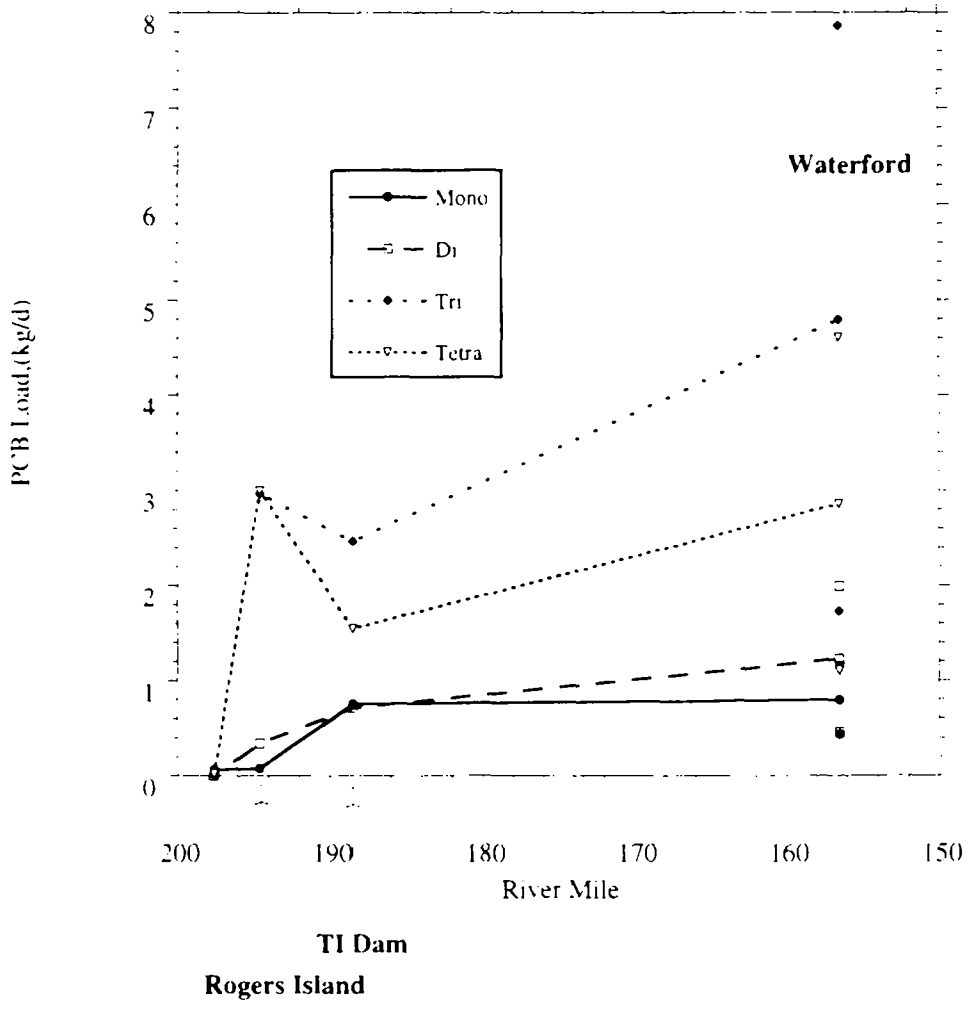


Figure C-17
Water-Column Instantaneous PCB Homologue Loads for Transect 6



Note:
Value represnting Waterford is the average of 2 one-week composites.

Figure C-18
Water-Column Total PCB Loads for Flow-Averaged Event 1



Note:
Values representing Waterford are the averages of 2 one-week composites.

Figure C-19
Water-Column PCB Homologue Loads for Flow-Averaged Event 1

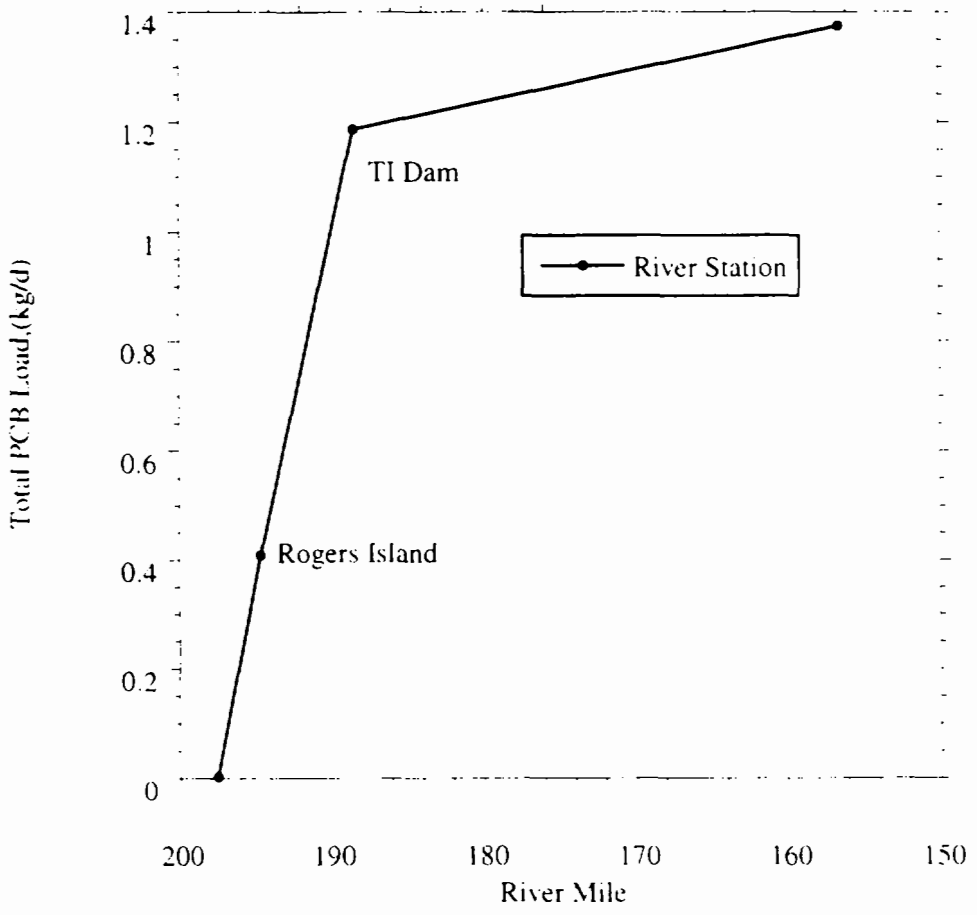


Figure C-20
Water-Column Total PCB Loads for Flow-Averaged Event 2

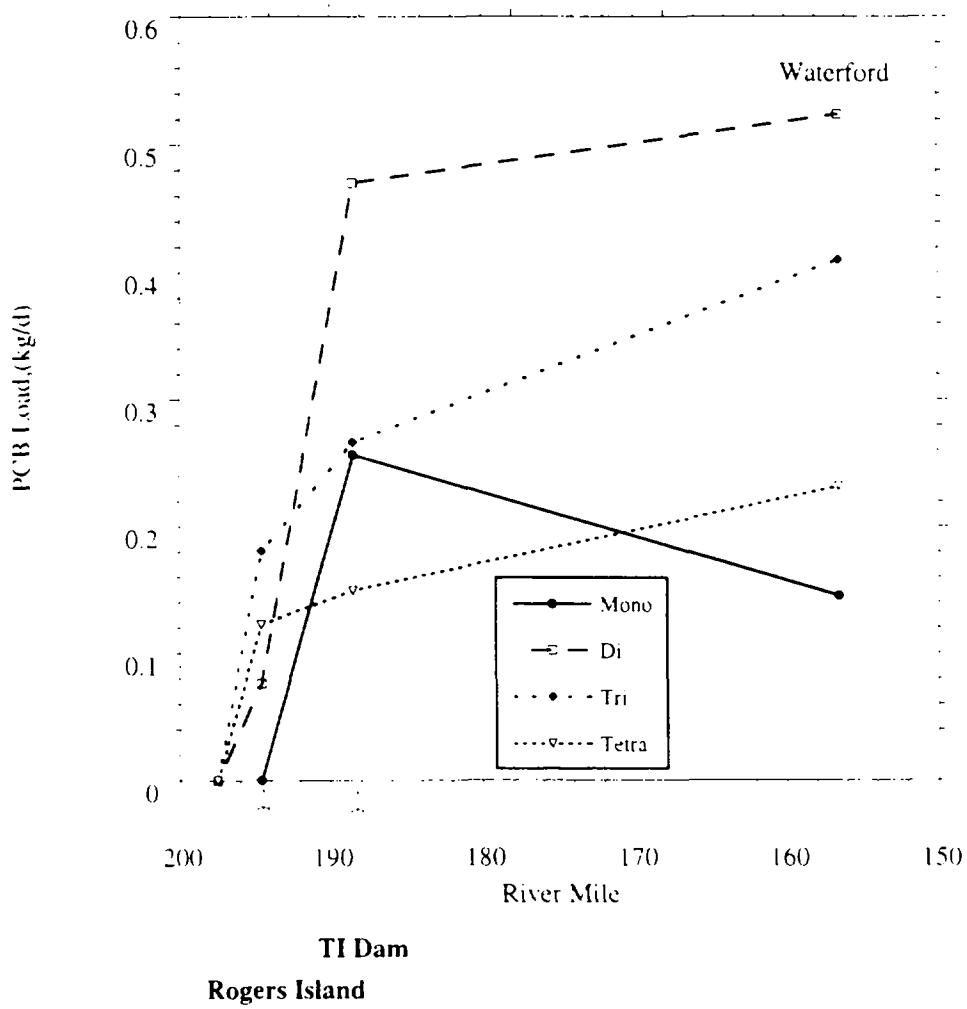


Figure C-21
Water-Column PCB Homologue Loads for Flow-Averaged Event 2

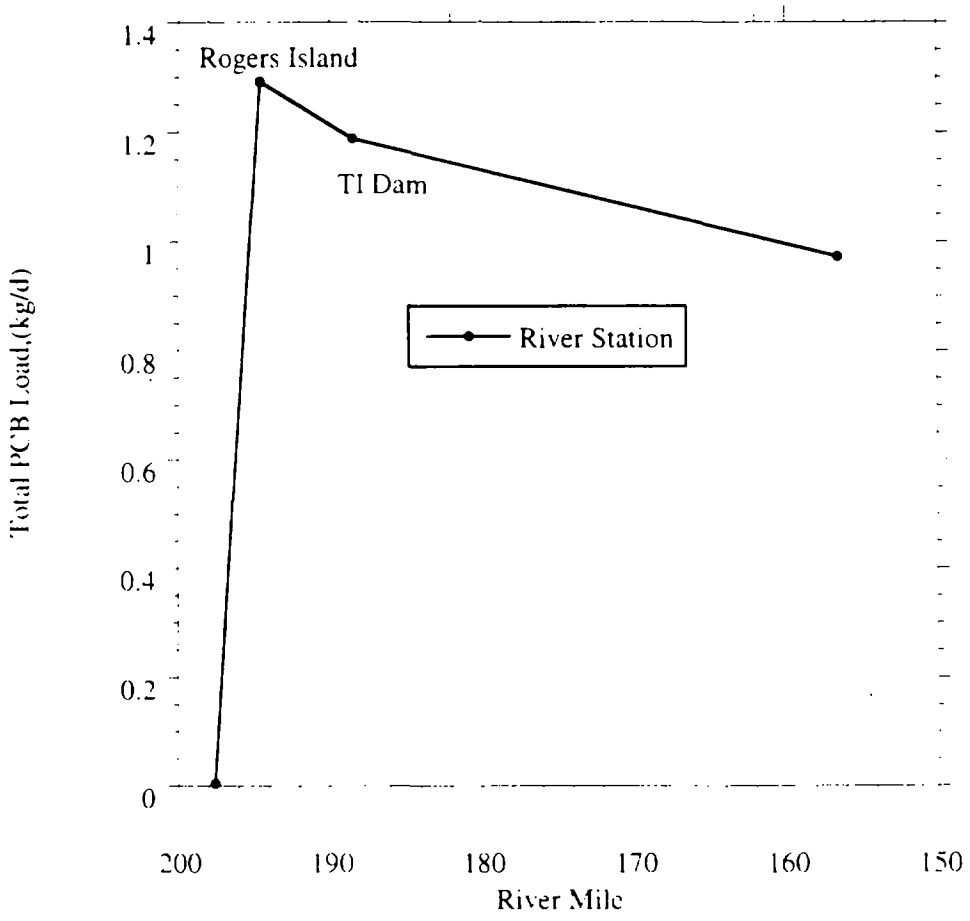


Figure C-22
Water-Column Total PCB Loads for Flow-Averaged Event 3

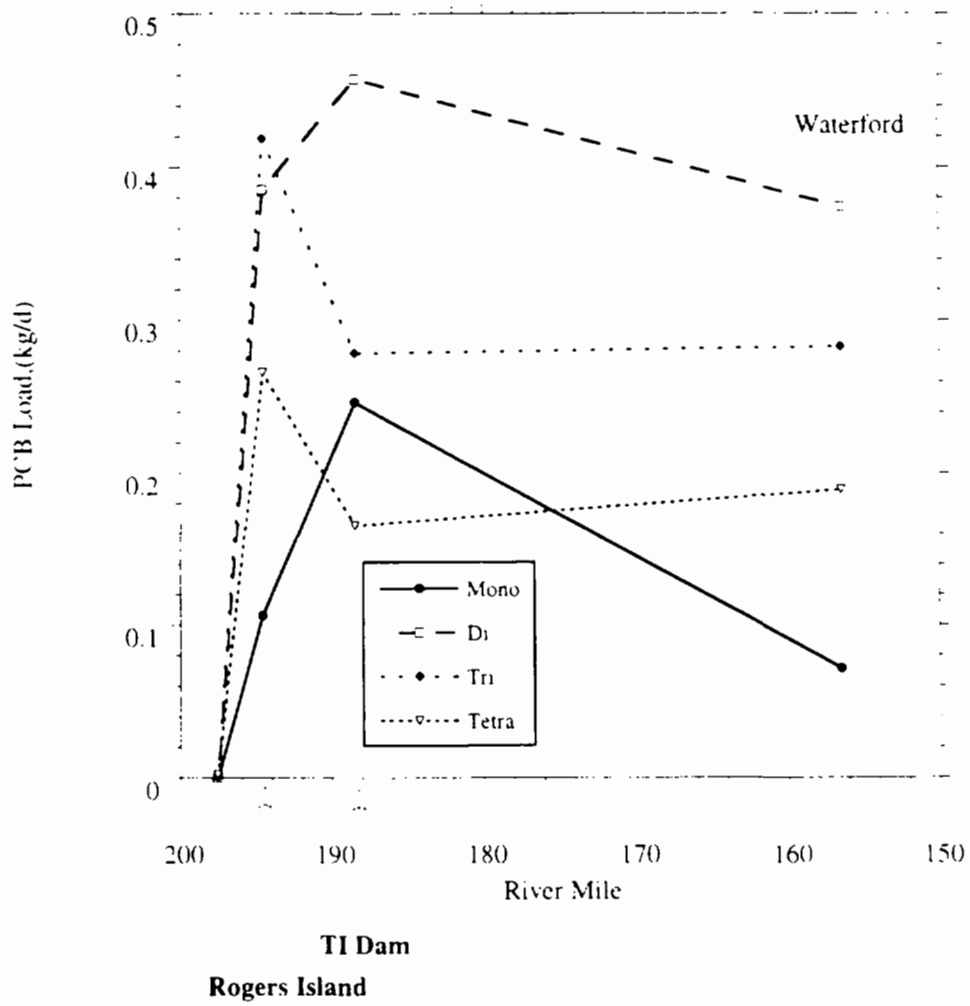


Figure C-23
Water-Column PCB Homologue Loads for Flow-Averaged Event 3

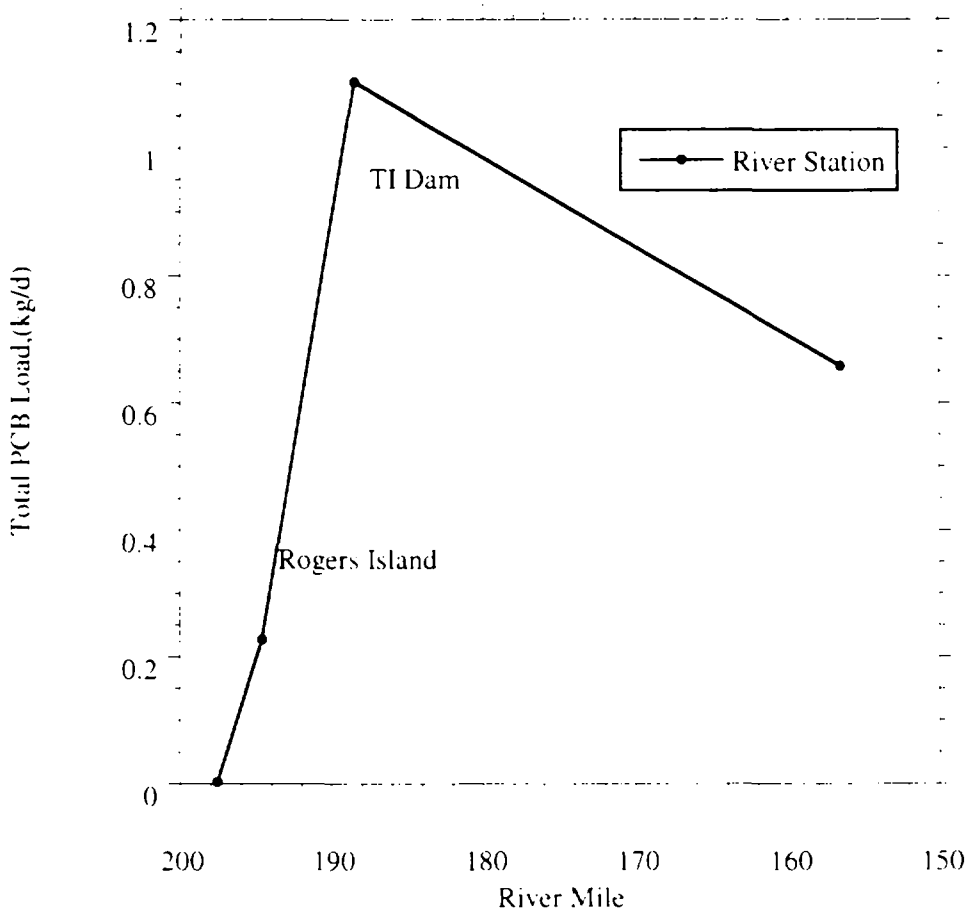


Figure C-24
Water-Column Total PCB Loads for Flow-Averaged Event 4

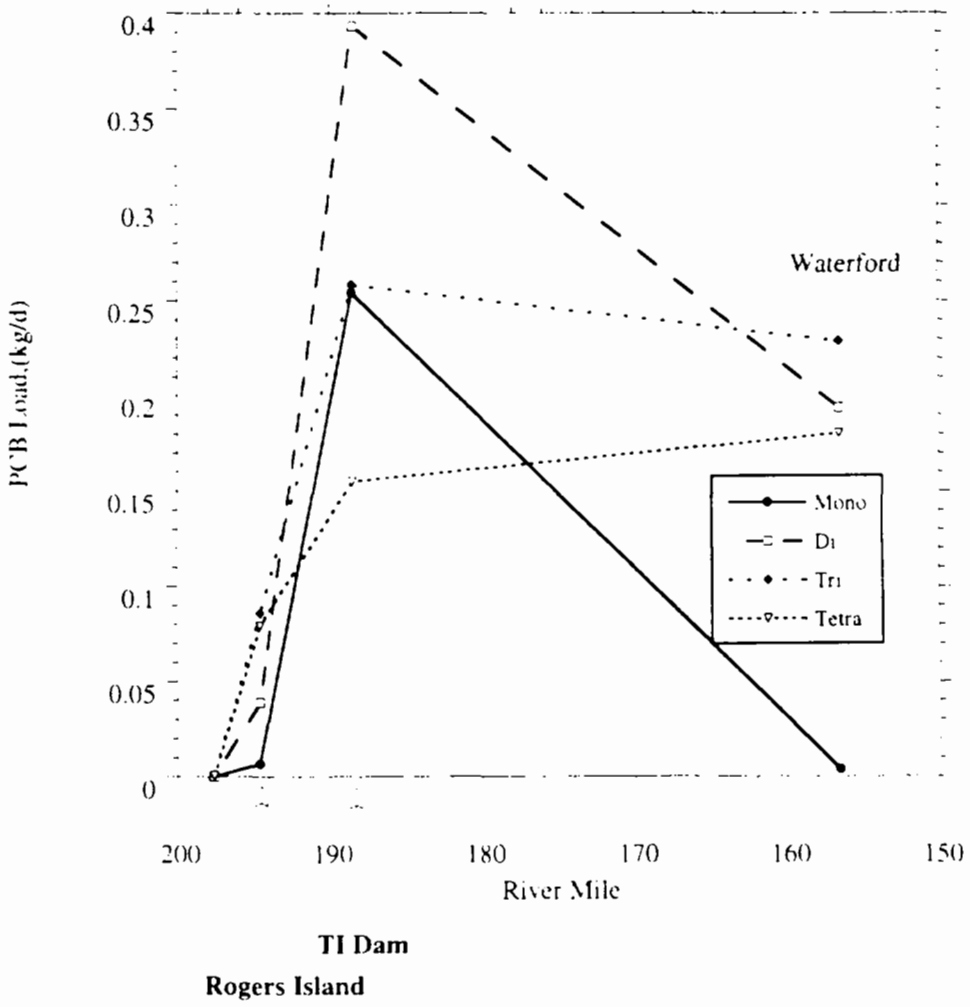


Figure C-25
Water-Column PCB Homologue Loads for Flow-Averaged Event 4

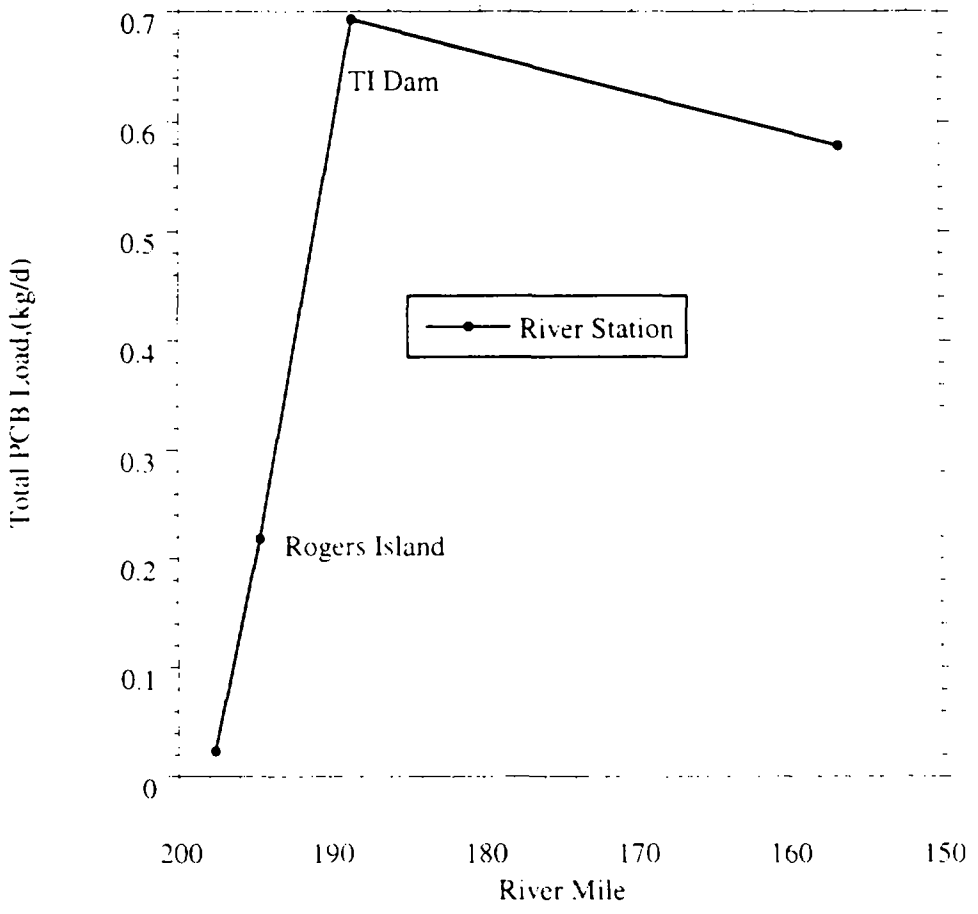


Figure C-26
Water-Column Total PCB Loads for Flow-Averaged Event 5

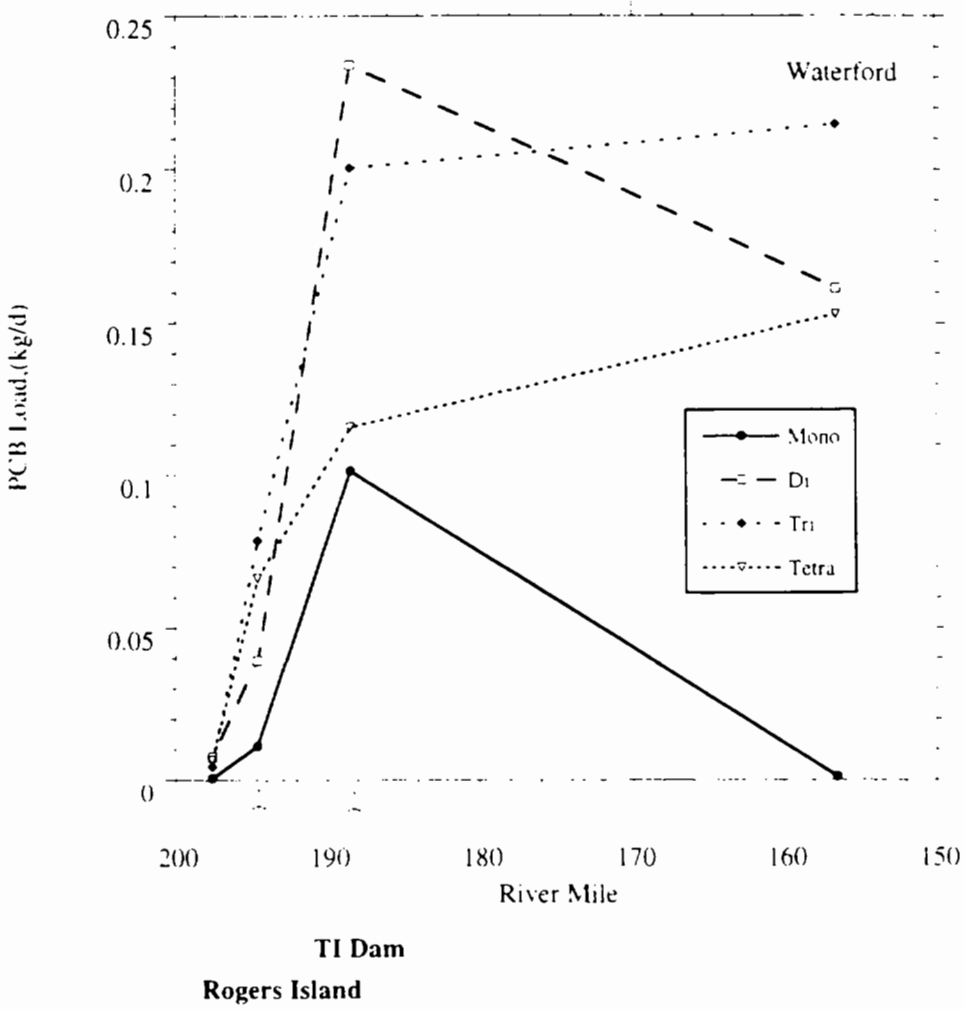


Figure C-27
Water-Column PCB Homologue Loads for Flow-Averaged Event 5

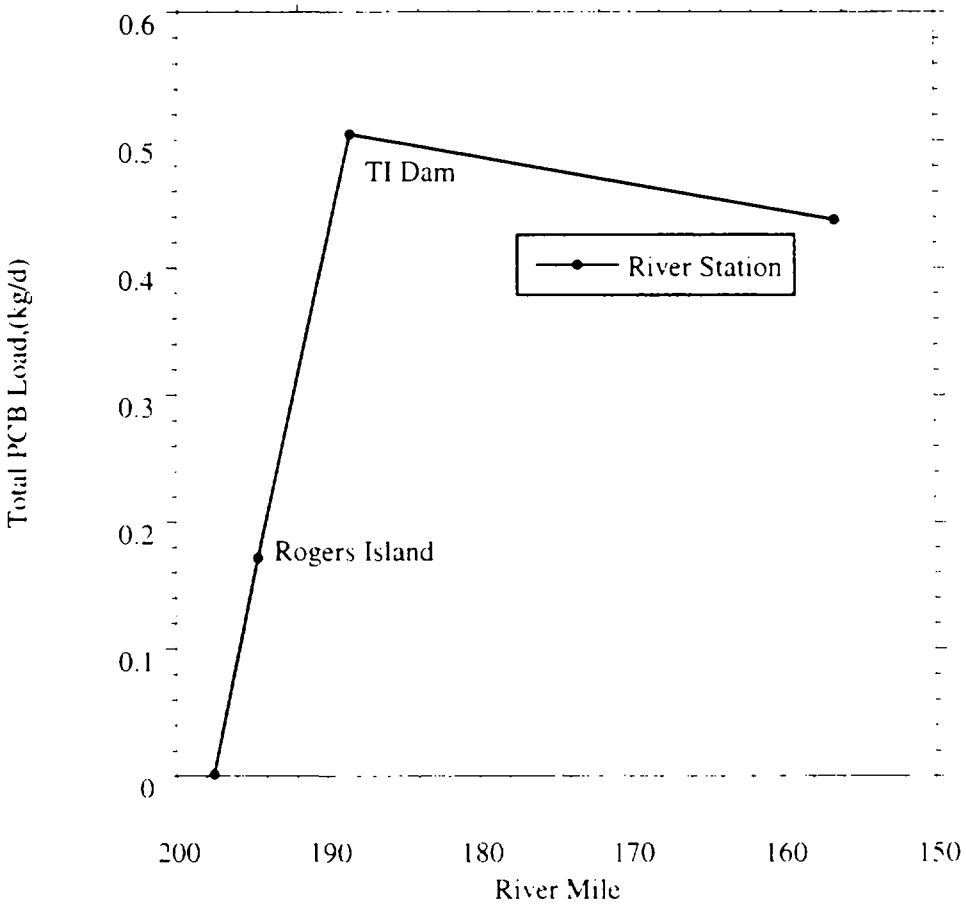


Figure C-28
Water-Column Total PCB Loads for Flow-Averaged Event 6

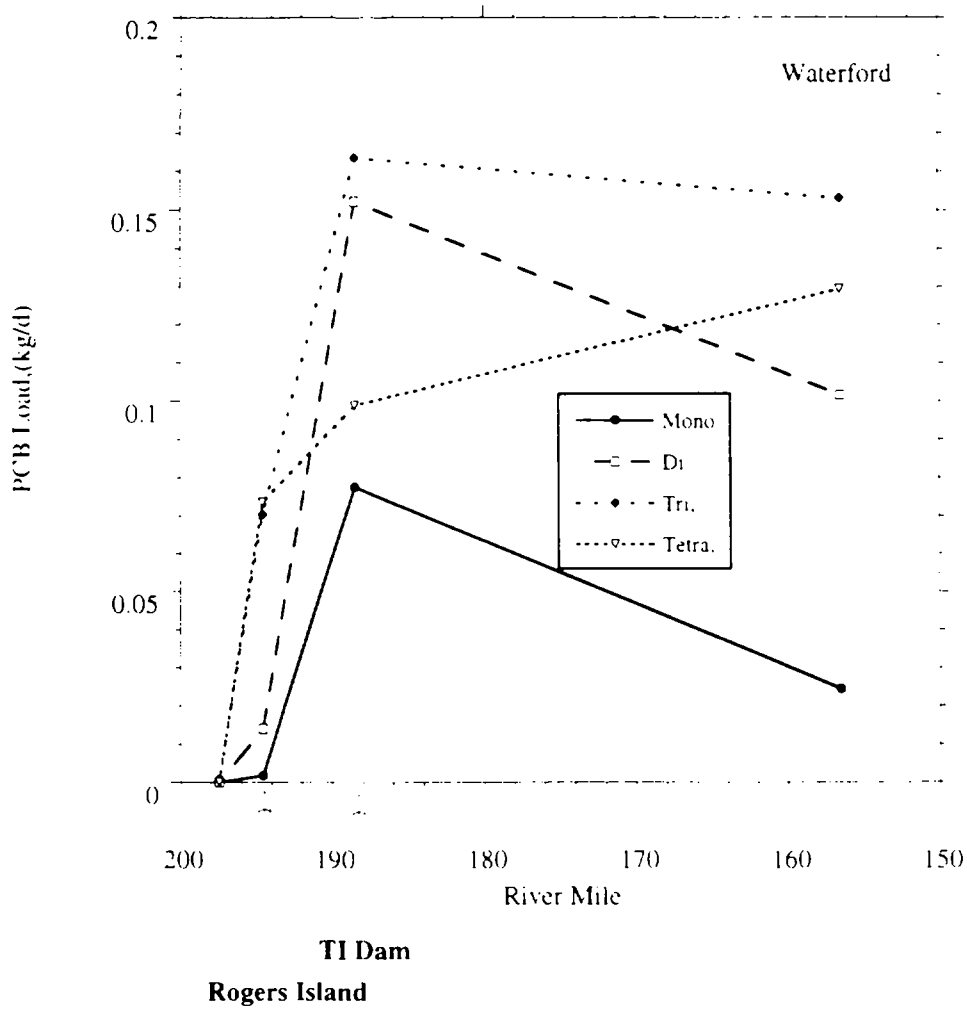


Figure C-29
Water-Column PCB Homologue Loads for Flow-Averaged Event 6

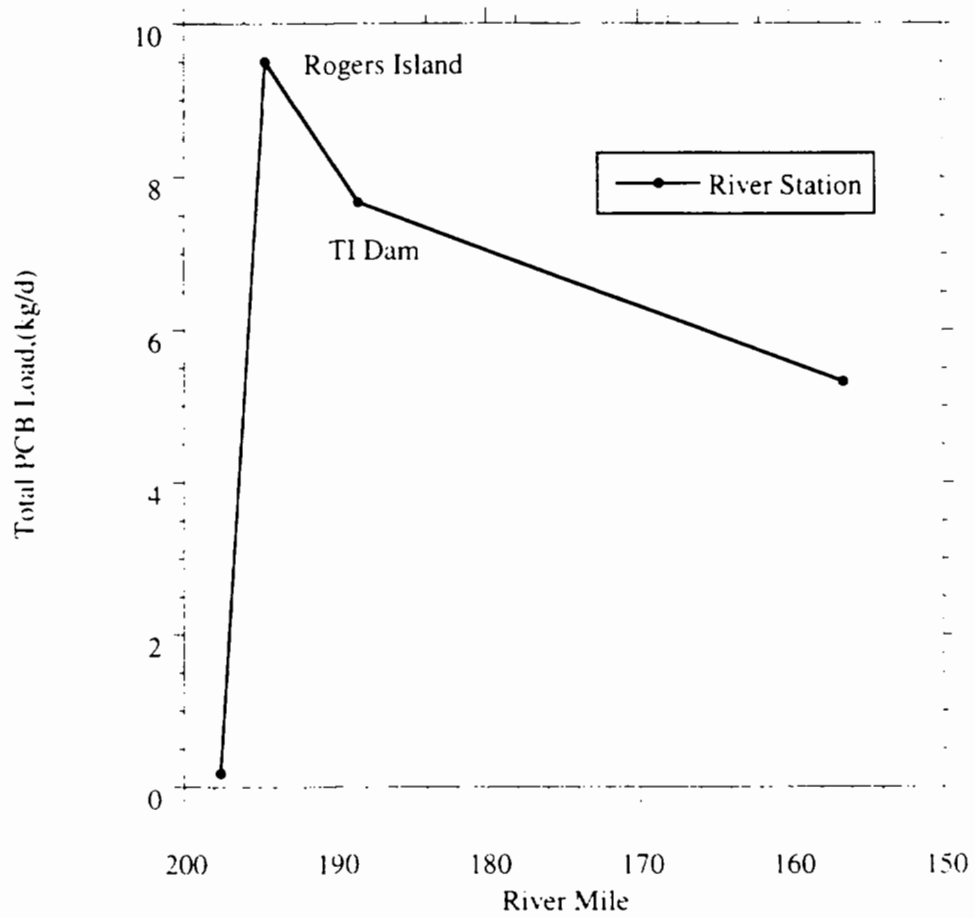


Figure C-30
Water-Column Instantaneous Total PCB Loads for Transect 8

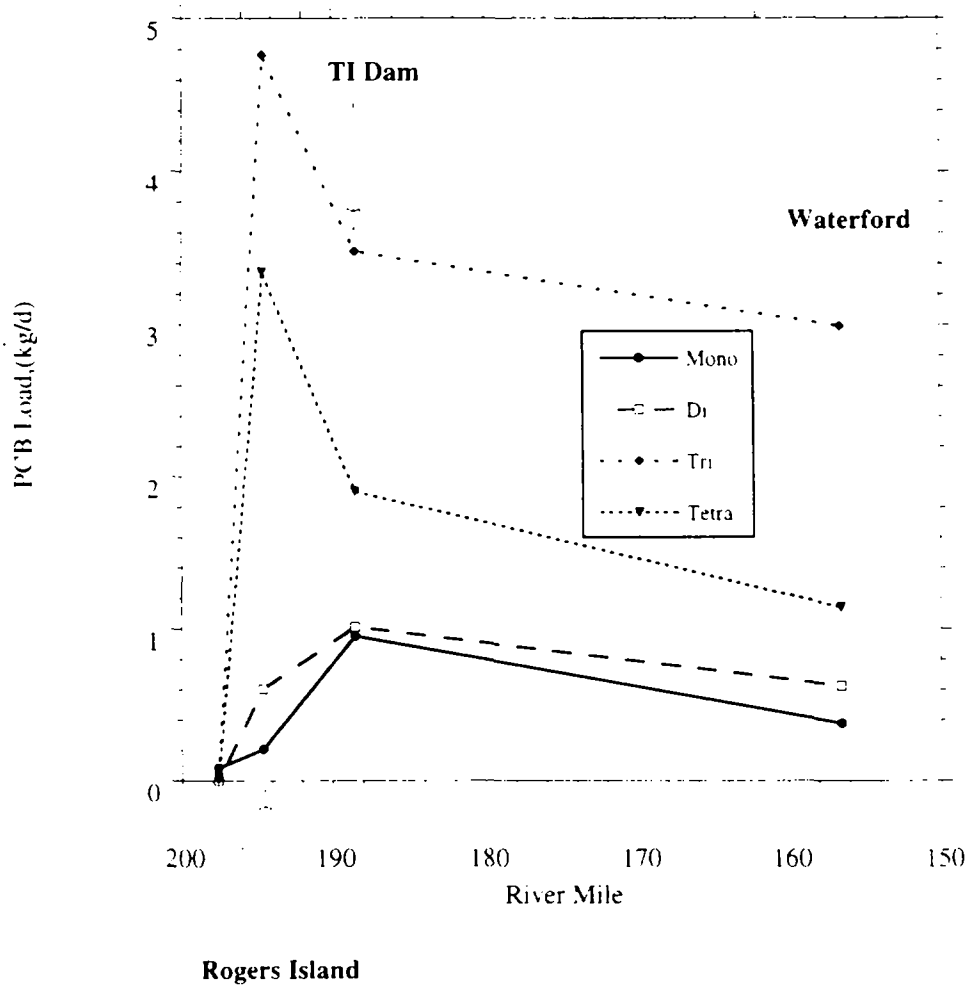
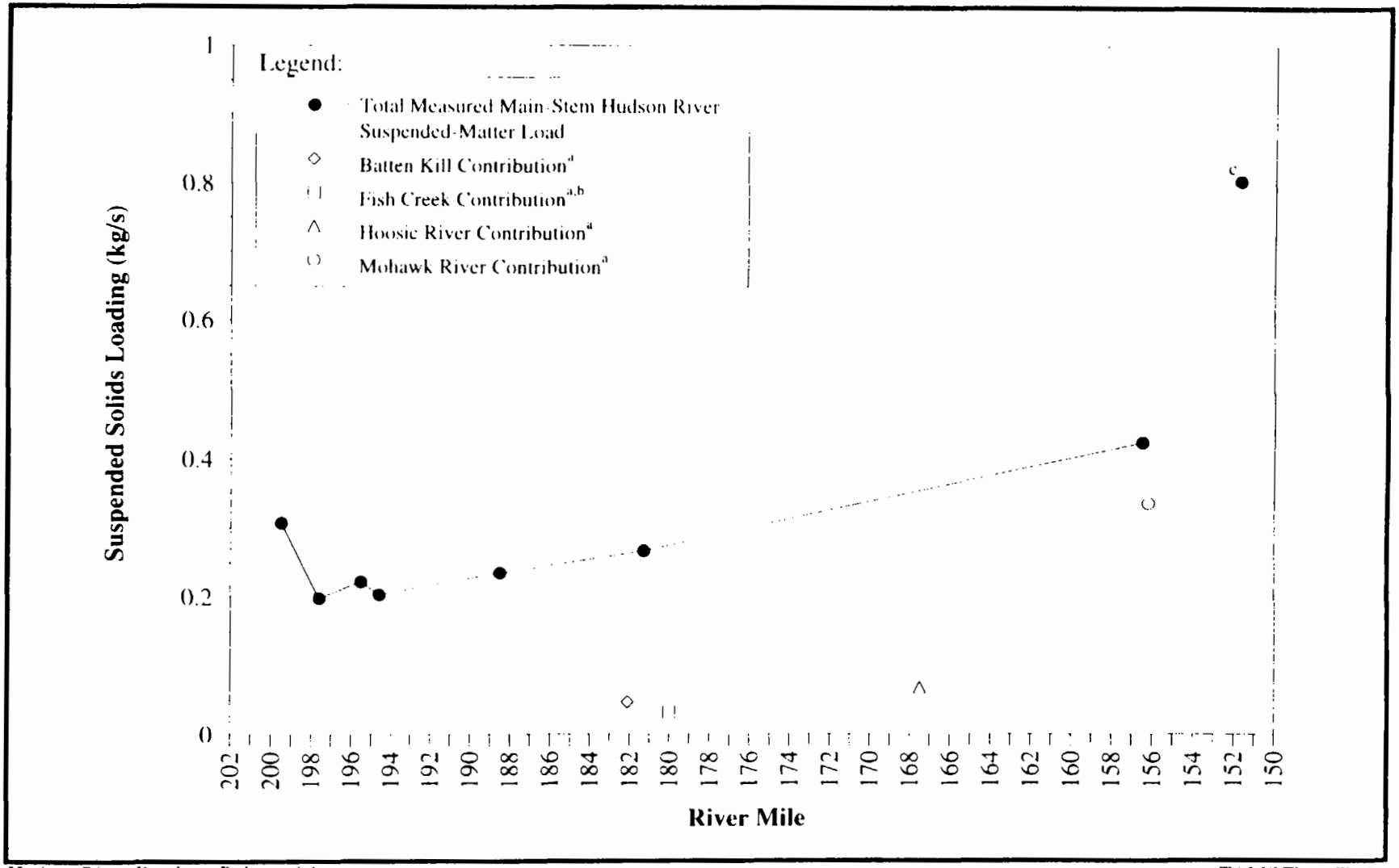


Figure C-31
Water-Column Instantaneous PCB Homologue Loads for Transect 8



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Notes:

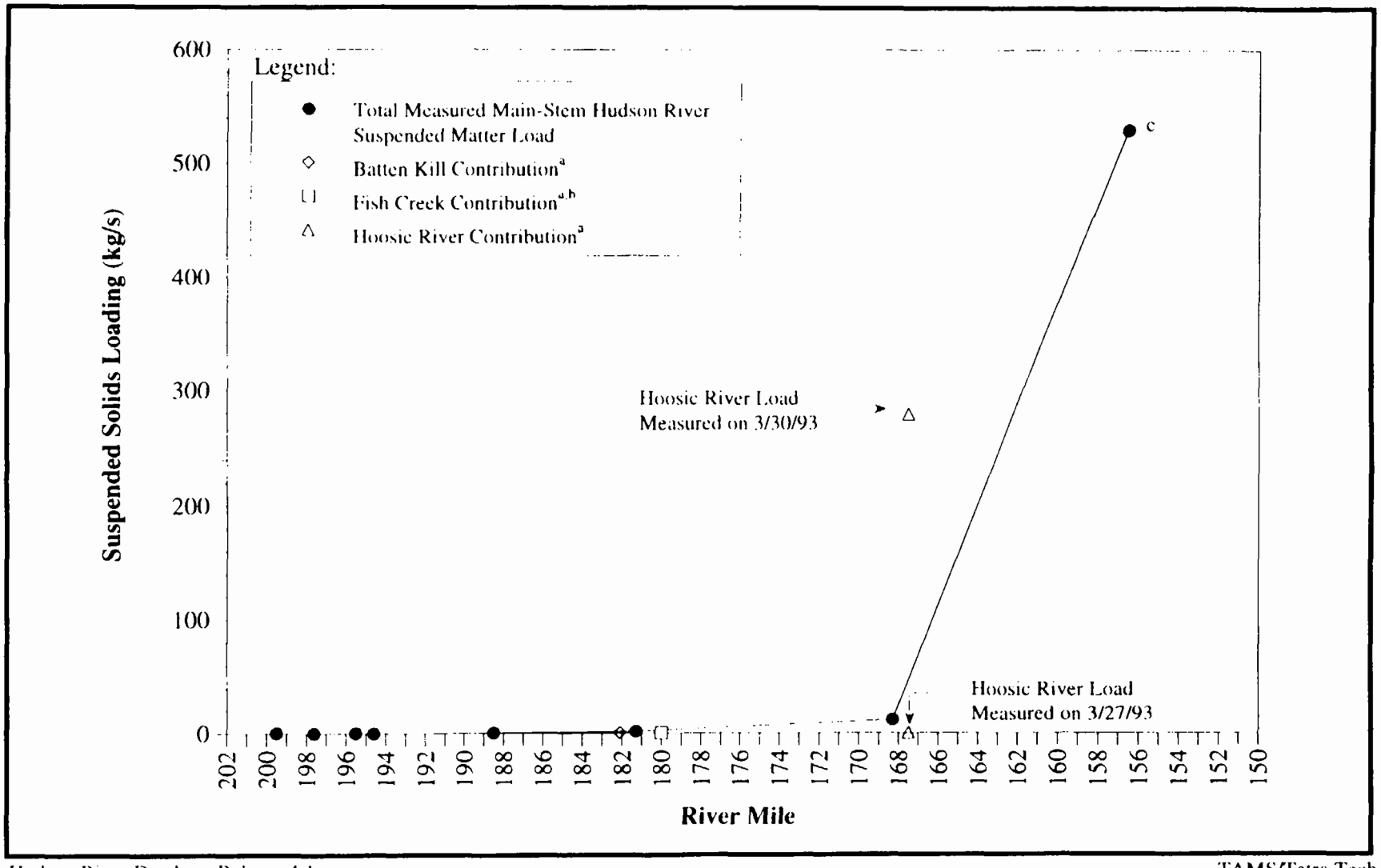
a) Tributary river mile designations correspond to point of confluence with the Hudson River.

b) Fish Creek suspended matter load is estimated using the suspended solids value for the Batten Kill and a flow estimate based on drainage basin area.

c) Sample is believed to over-represent upstream main Stem Hudson River loading due to incomplete mixing of the Mohawk River.

Figure 3-32 (corrected)

Suspended-Matter Loading in the Upper Hudson River - Transect 1 Low-Flow Conditions



Hudson River Database Release 4.1

TAMS/Tetra Tech

Notes:

a) Tributary river mile designations correspond to point of confluence with the Hudson River.

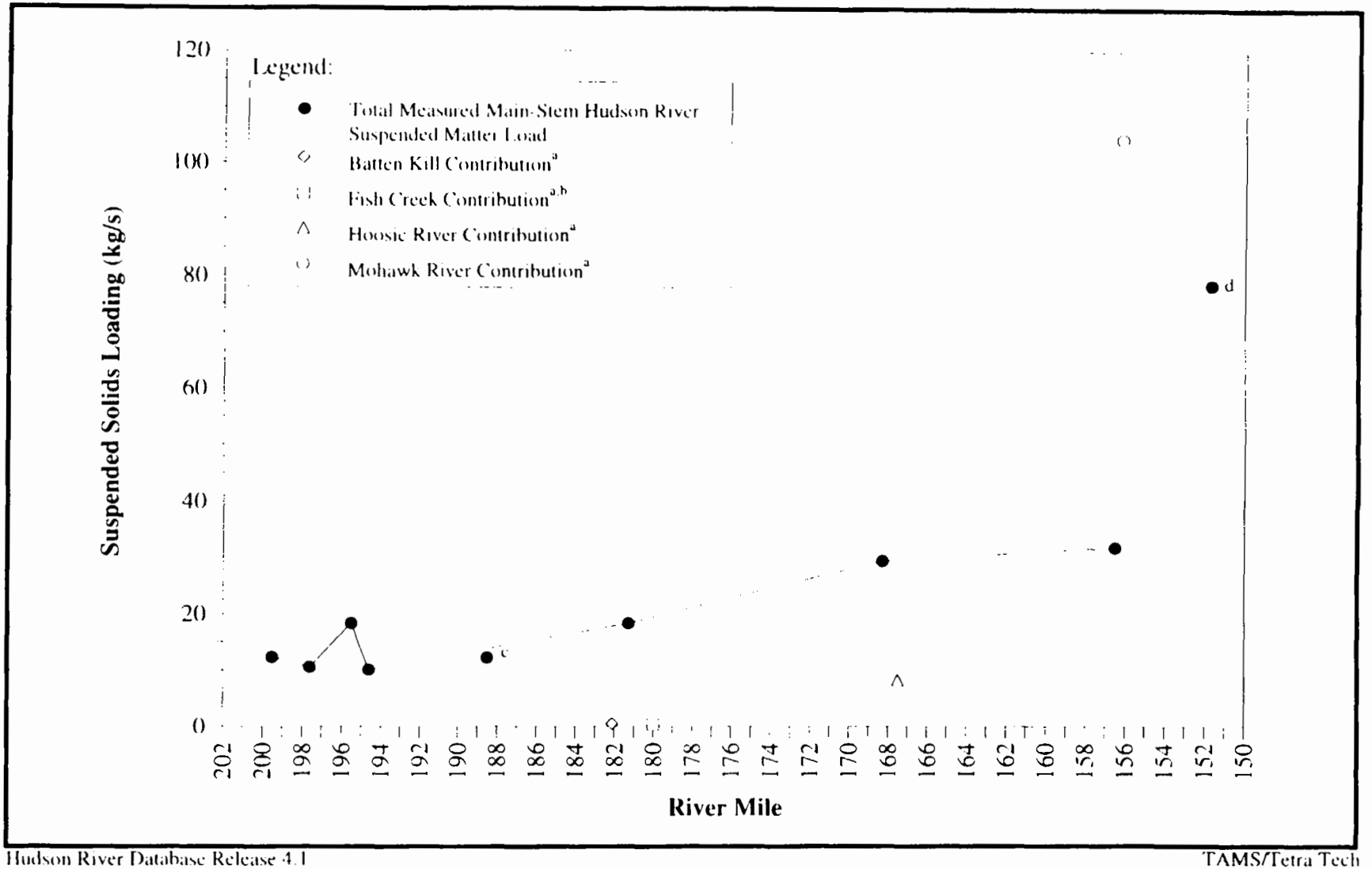
b) Fish Creek suspended matter load is estimated using the suspended solids value for the Batten Kill and a flow estimate based on drainage basin area.

c) Scour event due to onset of spring flood event in lower part of the Upper River.

Figure 3-33 (corrected)

Suspended-Matter Loading in the Upper Hudson River

Transect 3 - Transition between Low-Flow and High-Flow Conditions



Hudson River Database Release 4.1 TAMS/Tetra Tech

Notes:

a) Tributary river mile designations correspond to point of confluence with the Hudson River.

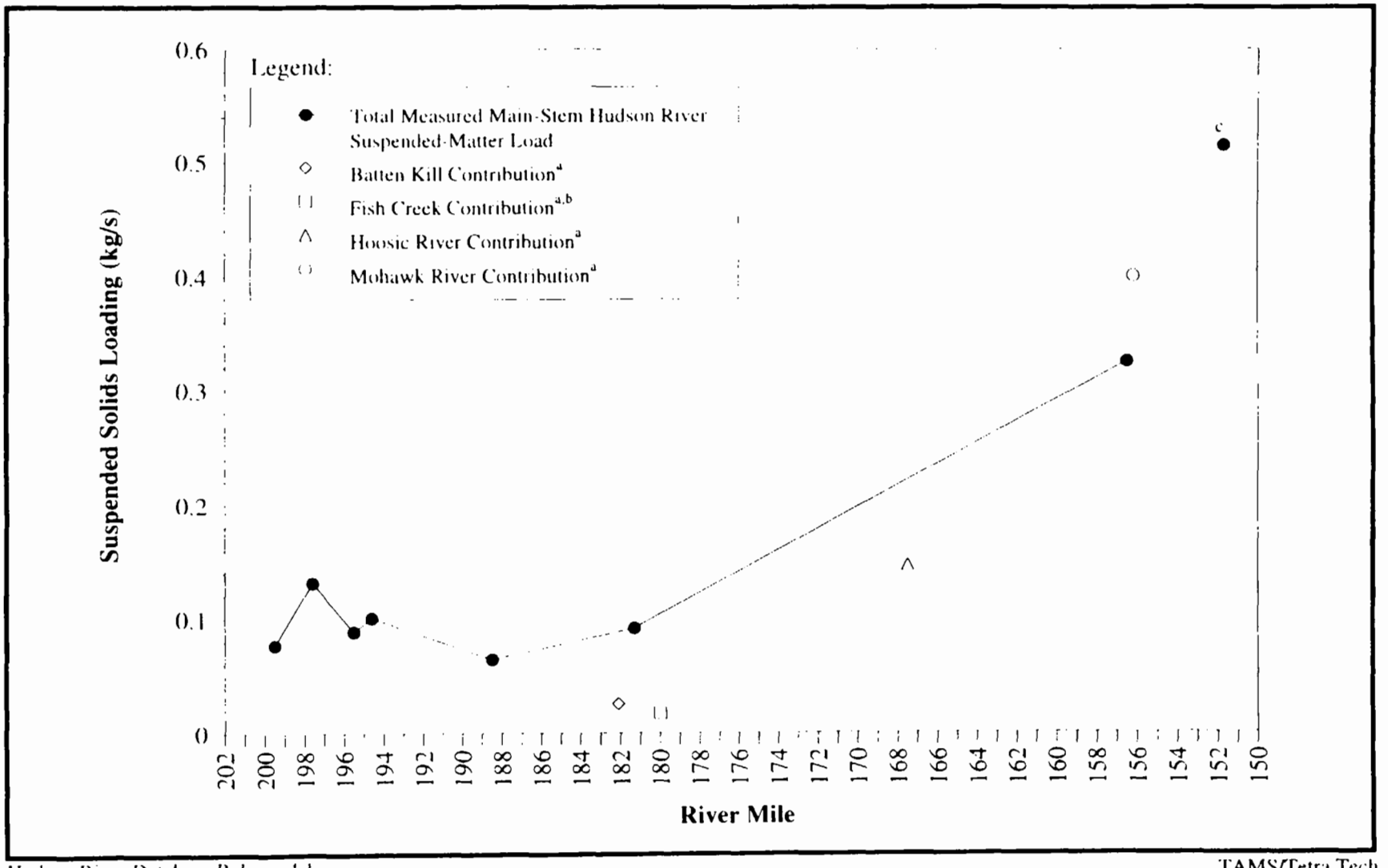
b) Fish Creek suspended matter load is estimated using the suspended solids value for the Batten Kill and a flow estimate based on drainage basin area.

c) Sample is believed to over-represent dilution by the Moses Kill due to proximity of sampling location to Moses Kill confluence.

d) Sample is believed to over represent upstream Main-Stem Hudson River loading due to incomplete mixing of the Mohawk River.

Figure 3-34 (corrected)

Suspended-Matter Loading in the Upper Hudson River - Transect 4 High-Flow Conditions



Hudson River Database Release 4.1

TAMS/Tetra Tech

Note:

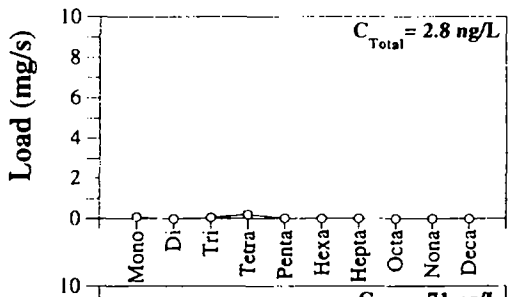
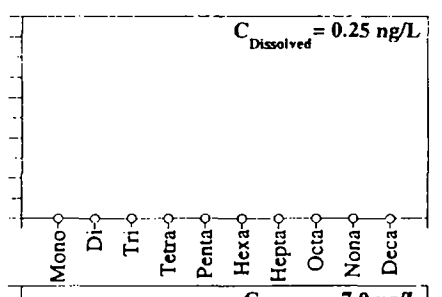
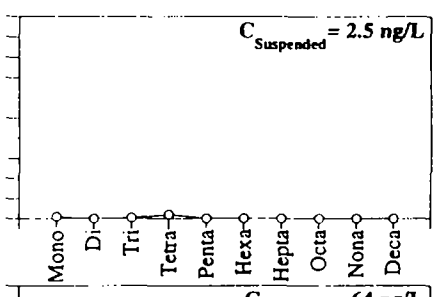
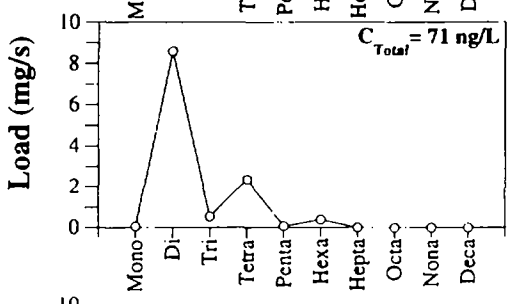
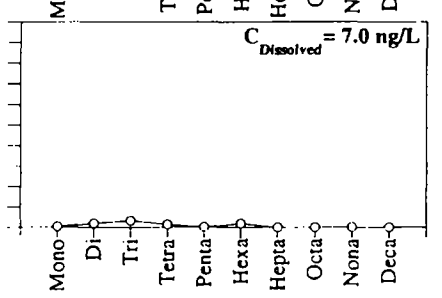
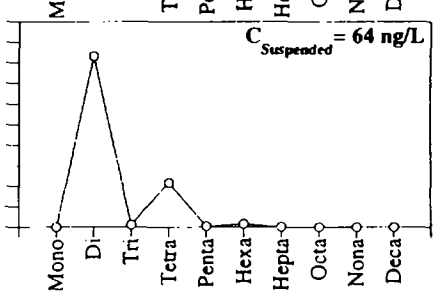
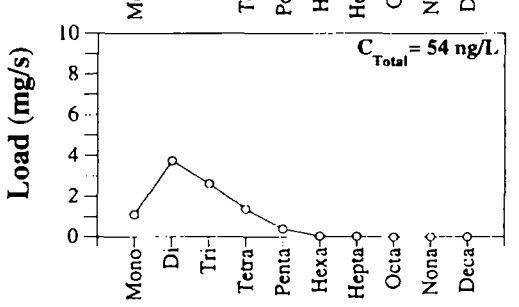
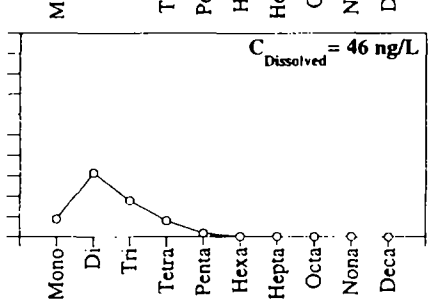
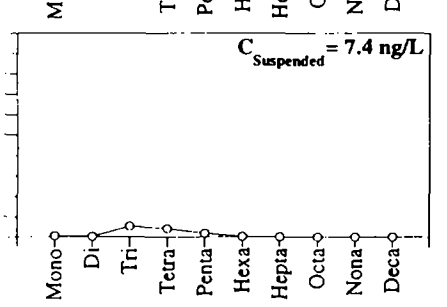
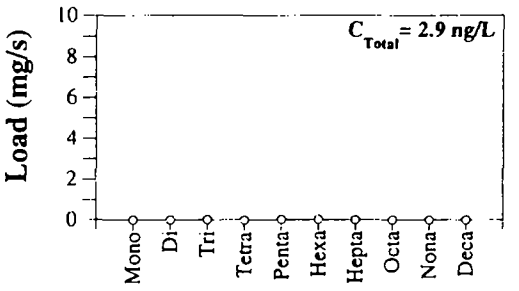
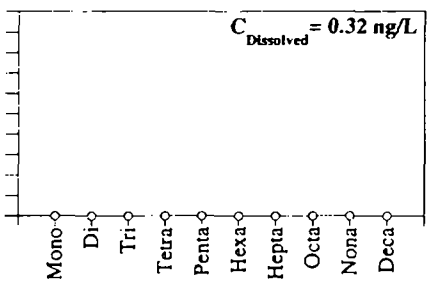
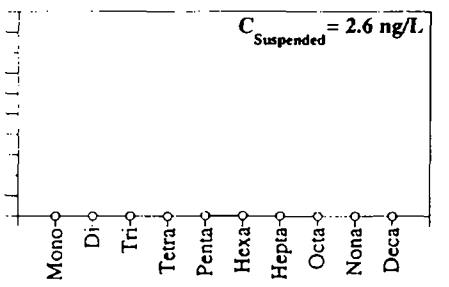
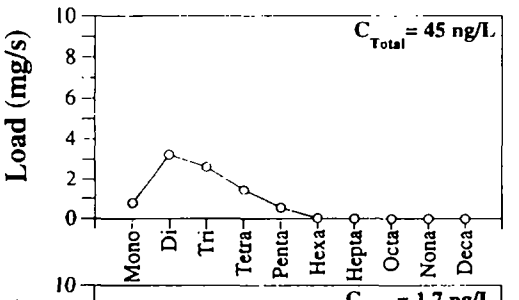
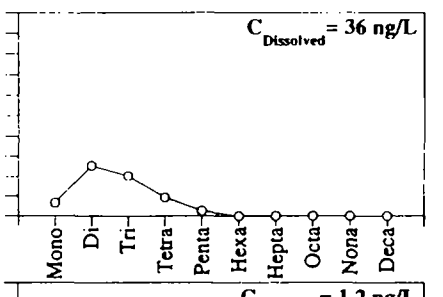
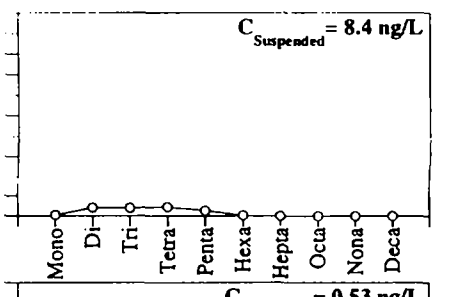
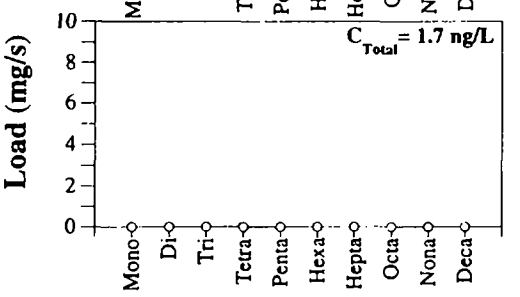
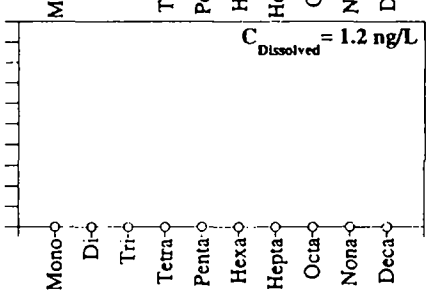
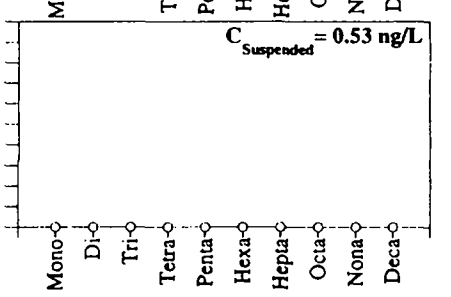
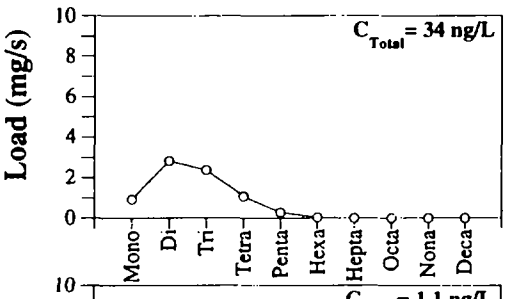
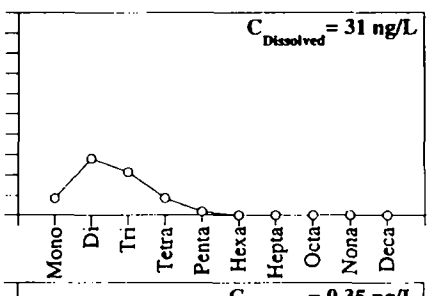
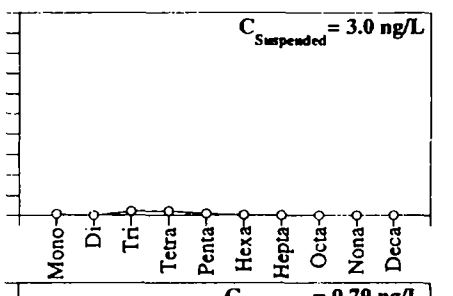
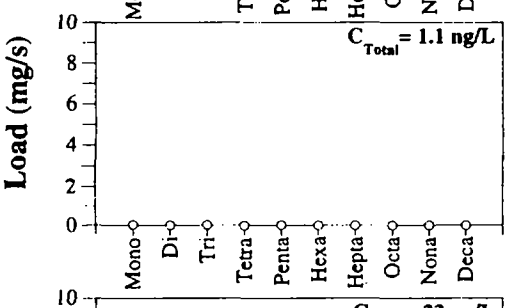
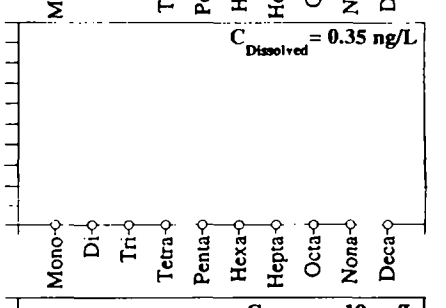
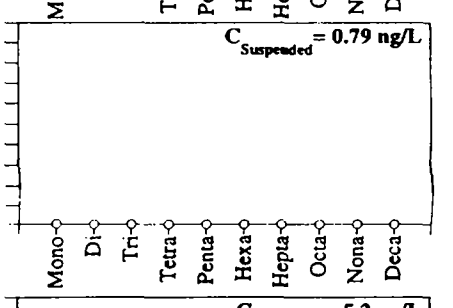
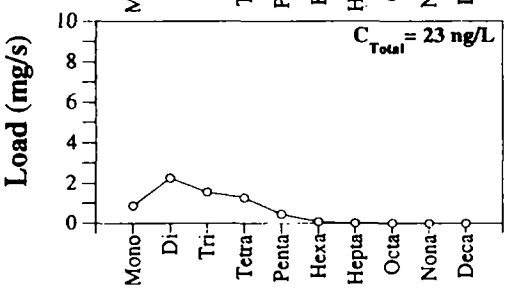
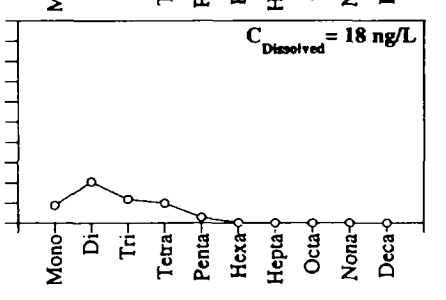
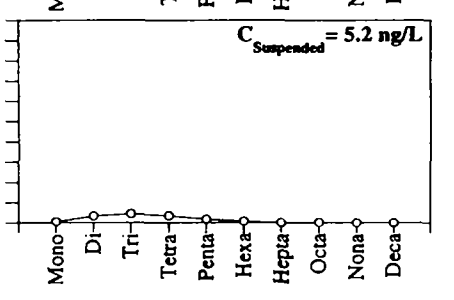
a) Tributary river mile designations correspond to point of confluence with the Hudson River.

b) Fish Creek suspended matter load is estimated using the suspended solids value for the Batten Kill and a flow estimate based on drainage basin area.

c) Sample is believed to over-represent upstream Main-Stem Hudson River loading due to incomplete mixing of the Mohawk River.

Figure 3-35 (corrected)

Suspended-Matter Loading in the Upper Hudson River - Transect 6 Low-Flow Conditions

	Whole-Water PCBs	Dissolved-Phase PCBs	Suspended-Phase PCBs[a]
Fenimore Bridge River Mile = 197.6 Total Load = 0.47 mg/s (0.04 kg/d) Flow = 170 m^3/s			
Rogers Island [b] River Mile = 194.6 Total Load = 12 mg/s (1.04 kg/d) Flow = 170m^3/s			
Thompson Island Dam River Mile = 188.5 Total Load = 9.3 mg/s (0.8 kg/d) Flow = 170 m^3/s			
Batten Kill River Mile = 182.1[c] Total Load = 0.06 mg/s (0.005 kg/d) Flow = 20 m^3/s			
Schuylerville River Mile = 181.3 Total Load = 8.7 mg/s (0.75 kg/d) Flow = 195 m^3/s			
Hoosic River River Mile = 167.5[c] Total Load = 0.03 mg/s (0.003 kg/d) Flow = 19 m^3/s			
Waterford River Mile = 156.5 Total Load = 7.6 mg/s (0.65 kg/d) Flow = 220 m^3/s			
Mohawk River River Mile = 156.2[c] Total Load = 0.09 mg/s (0.01 kg/d) Flow = 80 m^3/s			
Green Island Bridge River Mile = 151.7 Total Load = 6.6 mg/s (0.57 kg/d) Flow = 285 m^3/s			

Hudson River Database Release 4.1

TAMS/Tetra Tech

Notes:

a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).

b. The homologue pattern measured for this station was unlike any seen in other Phase 2 samples and is considered suspect.

c. Tributary river mile designations correspond to point of confluence with the Hudson River.

d. Transect 1 samples were collected during the period of January 29 to February 8, 1993.

Figure 3-38 (corrected)

Upper River Water-Column Instantaneous PCB Loading for Transect 1 Low-Flow Conditions

Fenimore Bridge
River Mile = 197.6
Total Load = 0.16 mg/s (0.01 kg/d)
Flow = 94 m^3/s

Rogers Island
River Mile = 194.6
Total Load = 2.4 mg/s (0.20 kg/d)
Flow = 94 m^3/s

Thompson Island Dam
River Mile = 188.5
Total Load = 9.9 mg/s (0.86 kg/d)
Flow = 98 m^3/s

Batten Kill
River Mile = 182.1[b]
Total Load = 0.02 mg/s (0.002 kg/d)
Flow = 11 m^3/s

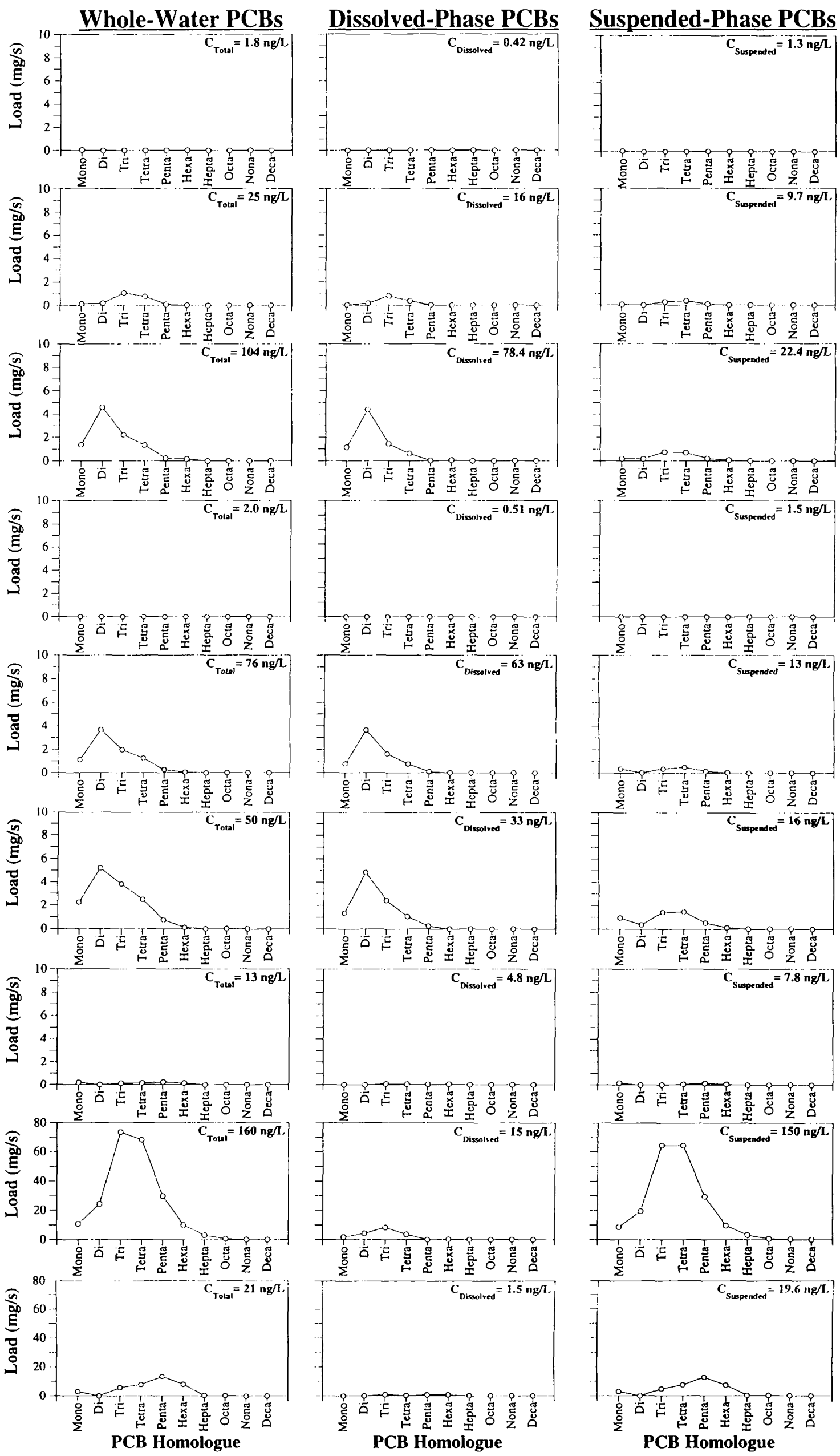
Schuylerville
River Mile = 181.3
Total Load = 8.4 mg/s (0.72 kg/d)
Flow = 110 m^3/s

Stillwater
River Mile = 168.3
Total Load = 15 mg/s (1.27 kg/d)
Flow = 300 m^3/s

Hoosic River
River Mile = 167.5[b]
Total Load = 0.9mg/s (0.08 kg/d)
Flow = 71 m^3/s

Waterford[c,d]
River Mile = 156.5
Total Load = 220 mg/s (19.1 kg/d)
Flow = 1360 m^3/s

Mohawk River
River Mile = 156.2[b]
Total Load = 38.4 mg/s (3.3 kg/d)
Flow = 1830 m^3/s



Hudson River Database Release 4.1

TAMS/Tetra Tech

Notes:

a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).
b. Tributary river mile designations correspond to point of confluence with the Hudson River.
c. Scour event due to onset of spring flood in lower part of the Upper River.
d. Vertical scale expanded to show full scour event loading.
e. Transect 3 samples were collected during the period of March 26 to March 31, 1993.

Figure 3-40 (corrected)
Upper River Water-Column Instantaneous PCB Loading for Transect 3
Transition from Low-Flow to High-Flow Conditions

Fenimore Bridge
River Mile = 197.6
Total Load = 0.68 mg/s (0.06 kg/d)
Flow = 580 m^3/s

Rogers Island
River Mile = 194.6
Total Load = 210 mg/s (17.9 kg/d)
Flow = 580 m^3/s

Thompson Island Dam[b]
River Mile = 188.5
Total Load = 120 mg/s (10 kg/d)
Flow = 600 m^3/s

Batten Kill
River Mile = 182.1[c]
Total Load = 0.28 mg/s (0.02 kg/d)
Flow = 27 m^3/s

Schuylerville
River Mile = 181.3
Total Load = 193 mg/s (16.7 kg/d)
Flow = 630 m^3/s

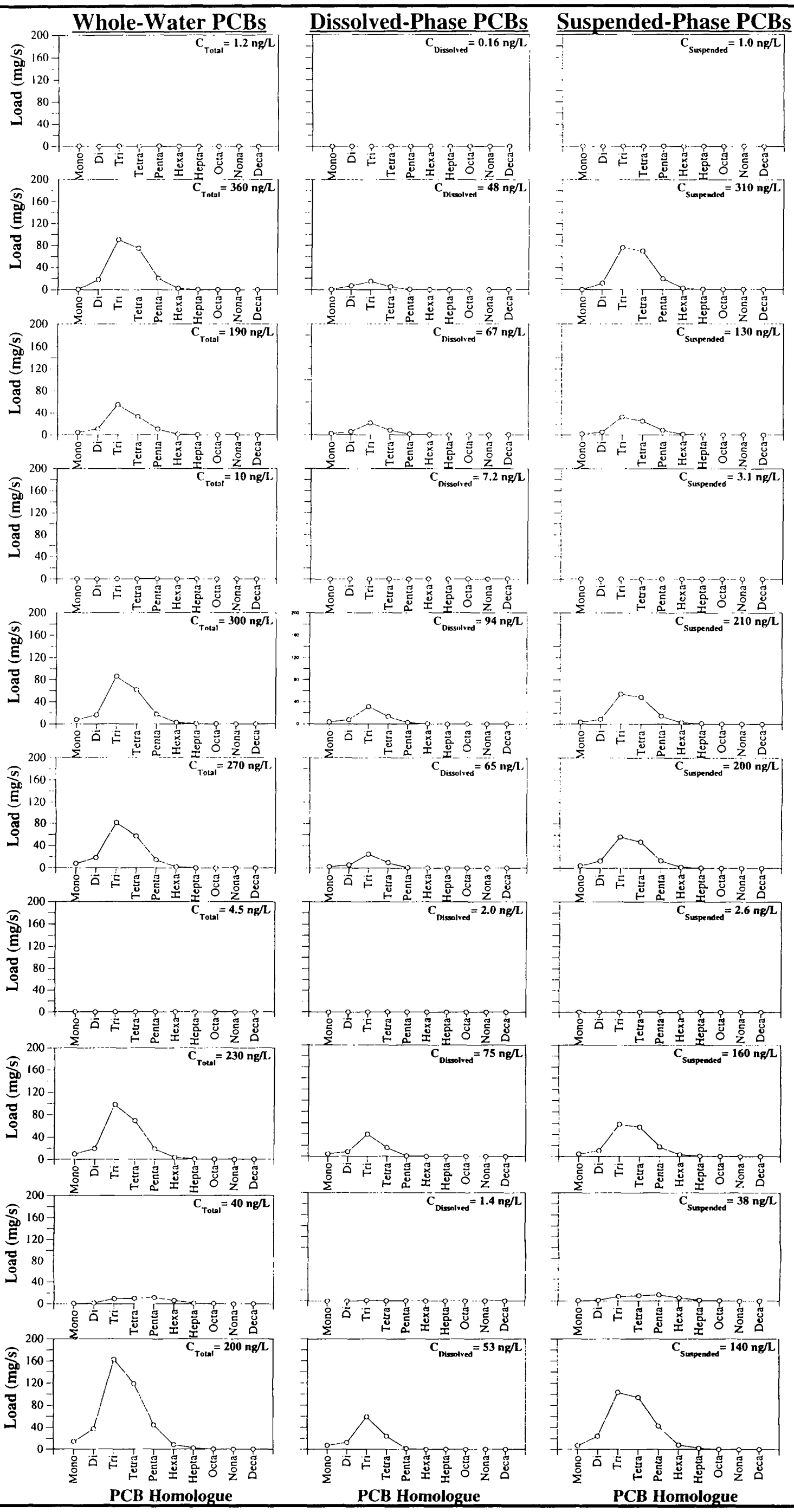
Stillwater
River Mile = 168.3
Total Load = 183 mg/s (15.8 kg/d)
Flow = 690 m^3/s

Hoosic River
River Mile = 167.5[c]
Total Load = 0.96 mg/s (0.08 kg/d)
Flow = 210 m^3/s

Waterford
River Mile = 156.5
Total Load = 220 mg/s (19 kg/d)
Flow = 940 m^3/s

Mohawk River
River Mile = 156.2[c]
Total Load = 41 mg/s (3.54 kg/d)
Flow = 1000 m^3/s

Green Island Bridge[d]
River Mile = 151.7
Total Load = 390 mg/s (33.7 kg/d)
Flow = 1970 m^3/s



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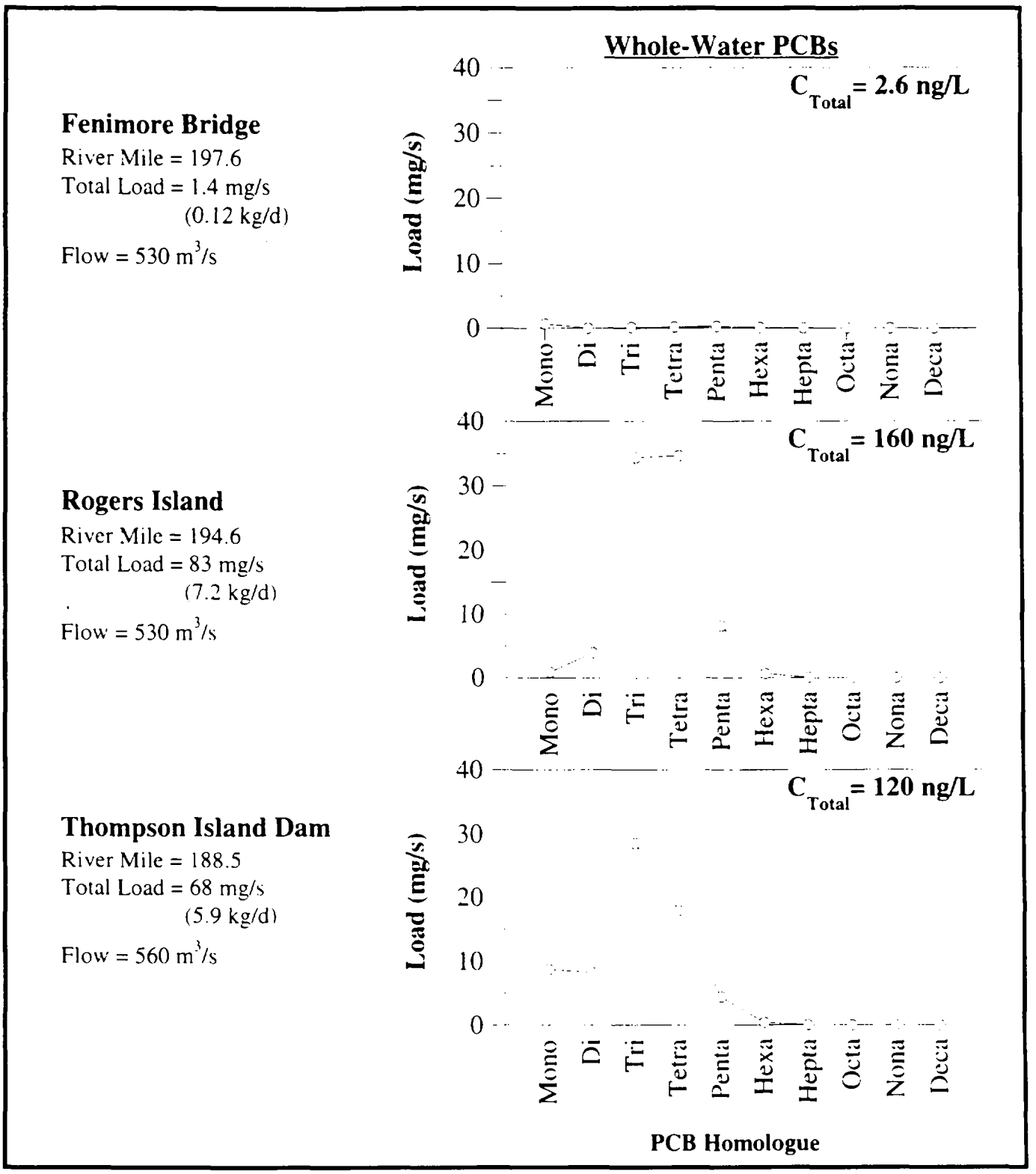
Notes:

a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).
b. Sample is believed to over-represent dilution by Moses Kill due to proximity of sampling location to Moses Kill confluence.
c. Tributary river mile designations correspond to point of confluence with the Hudson River.
d. Sample is believed to over-represent upstream load contribution due to incomplete mixing of the Mohawk River.
e. Transect 4 samples were collected during the period of April 12 to April 14, 1993.

Figure 3-43 (corrected)

Upper River Water-Column Instantaneous PCB Loading for Transect 4 High-Flow Conditions



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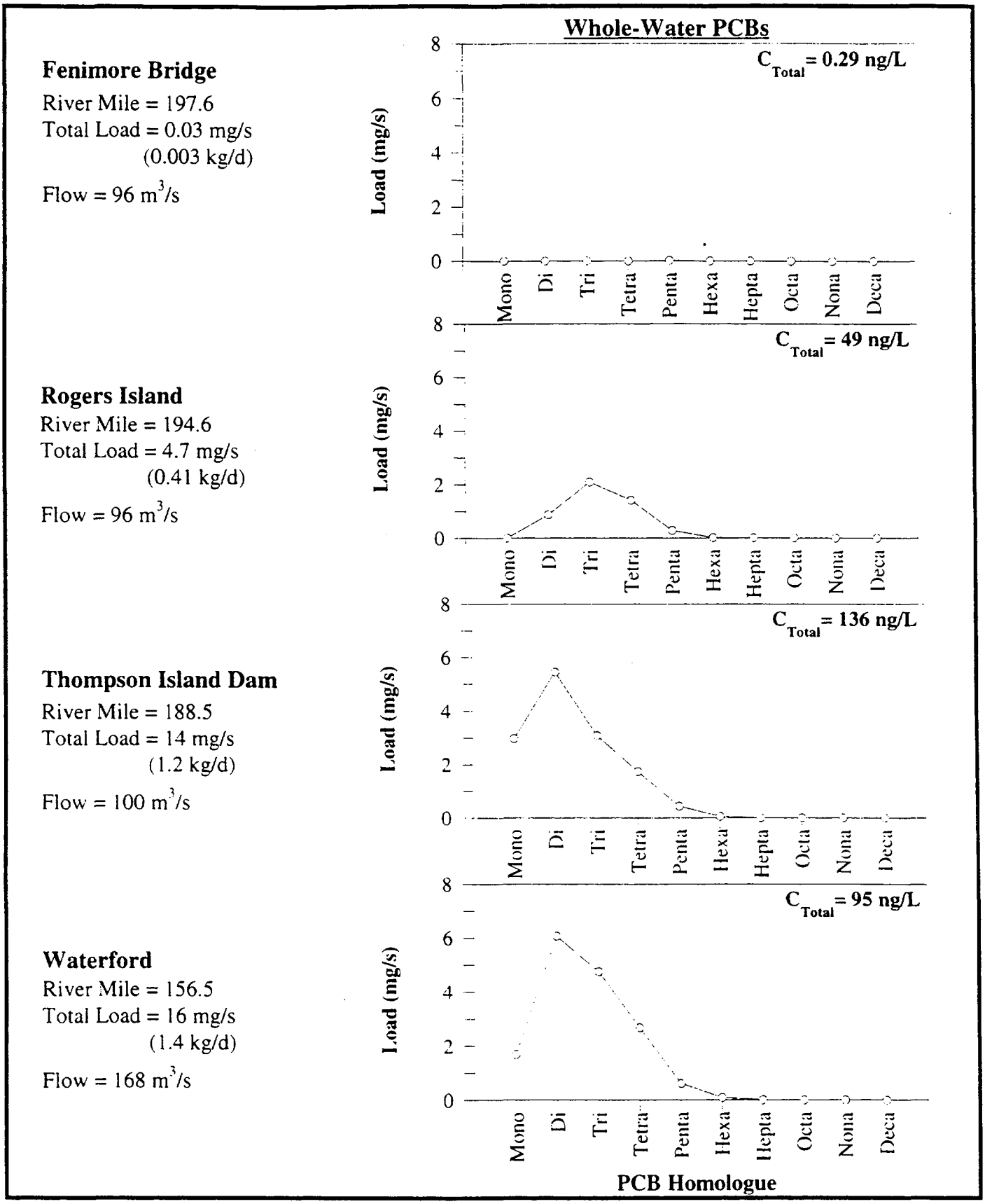
Notes:

a. Flow-Averaged Event 1 samples were collected during the period of April 23 to May 8, 1993.

b. Samples collected at Waterford are not represented here due to local canal construction which is believed to have influenced the samples.

Figure 3-44 (corrected)
Upper River Water-Column PCB Loading for
Flow-Averaged Event 1 High-Flow Conditions



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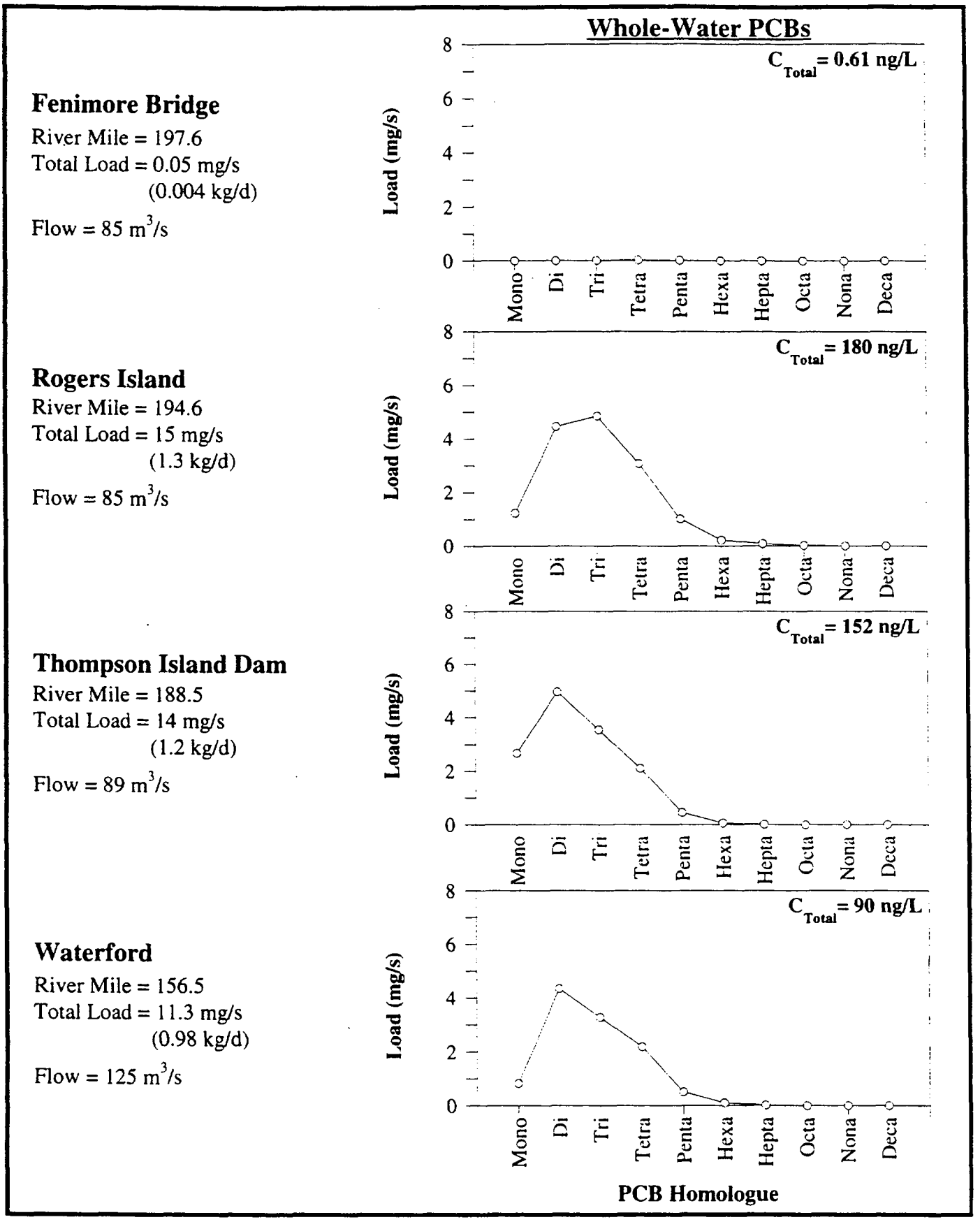
Note: Flow-Averaged 2 samples were collected during the period of May 12 to May 27, 1993.

Figure 3-45 (corrected)
Upper River Water-Column PCB Loading for
Flow-Averaged Event 2 Low-Flow Conditions



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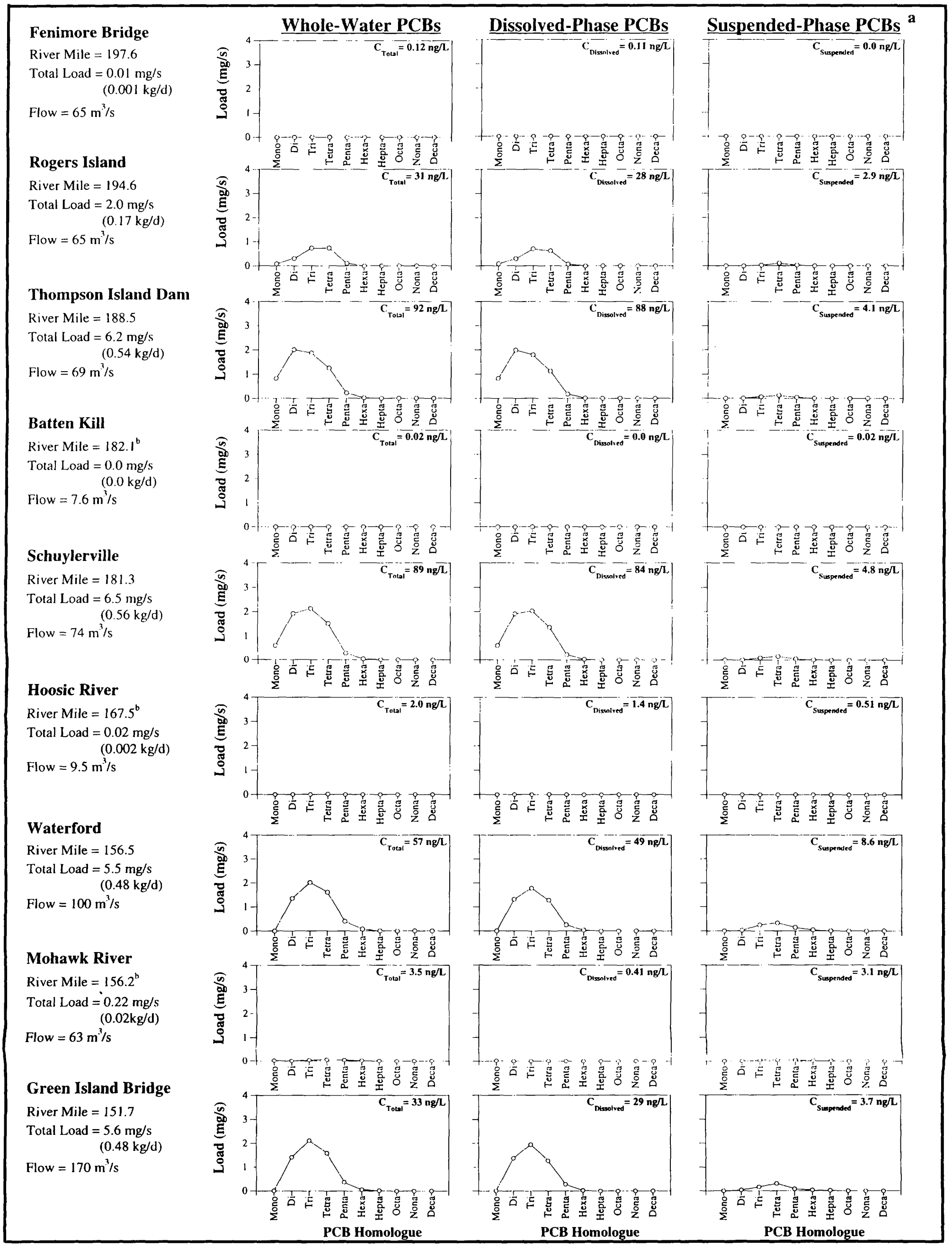
Note: Flow-Averaged 3 samples were collected during the period of June 6 to June 19, 1993.

Figure 3-46 (corrected)
Upper River Water-Column PCB Loading for
Flow-Averaged Event 3 Low-Flow Conditions



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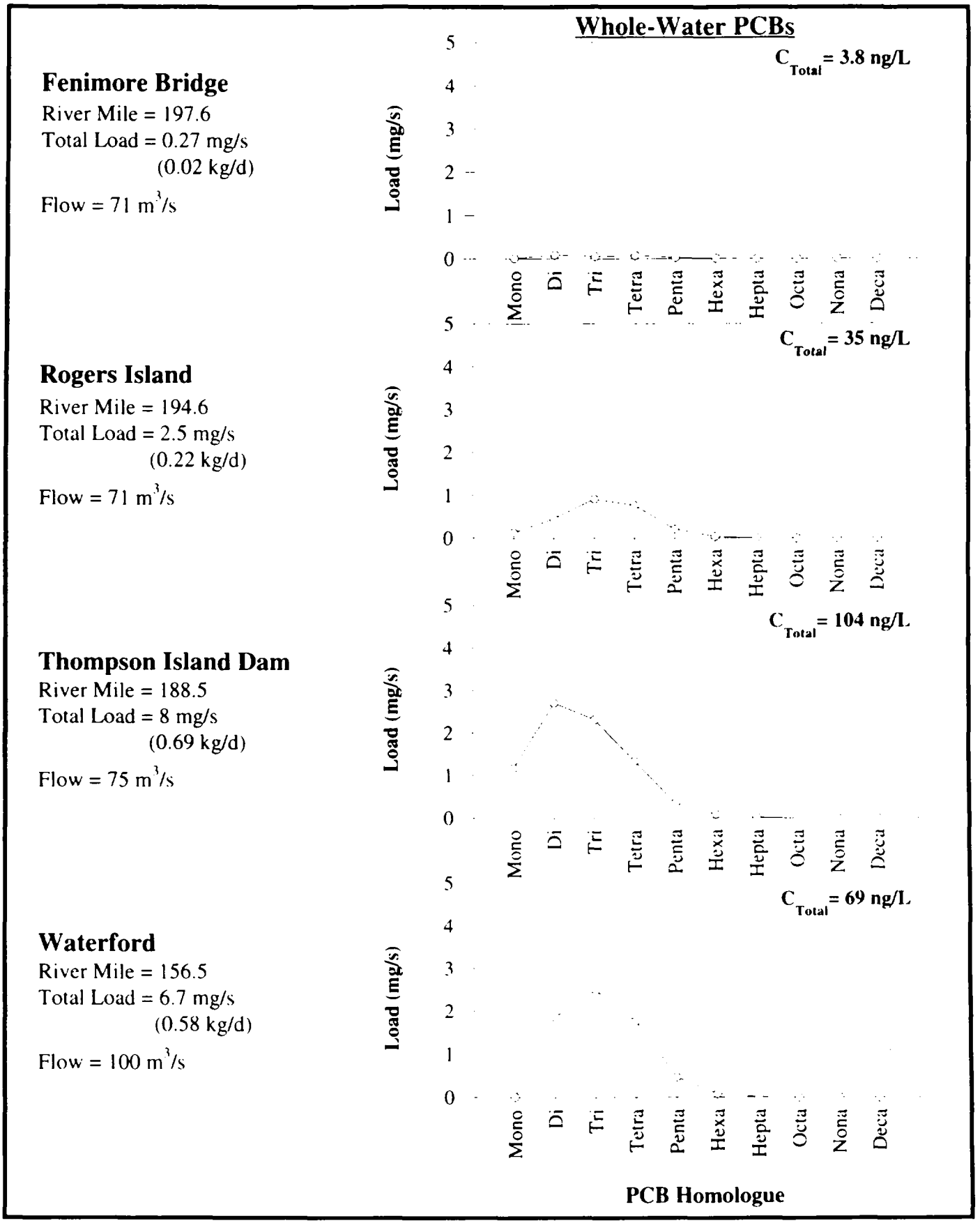
Notes:

a. Suspended-phase PCB concentration in ng/L calculated as function of dry weight concentration (ug/kg) and total suspended solids concentration (mg/L).

b. Tributary river mile designations correspond to point of confluence with the Hudson River.

c. Transect 6 samples were collected during the period of August 19 to September 1, 1993.

Figure 3-47 (corrected)
Upper River Water-Column Instantaneous PCB Loading for Transect 6 Low-Flow Conditions



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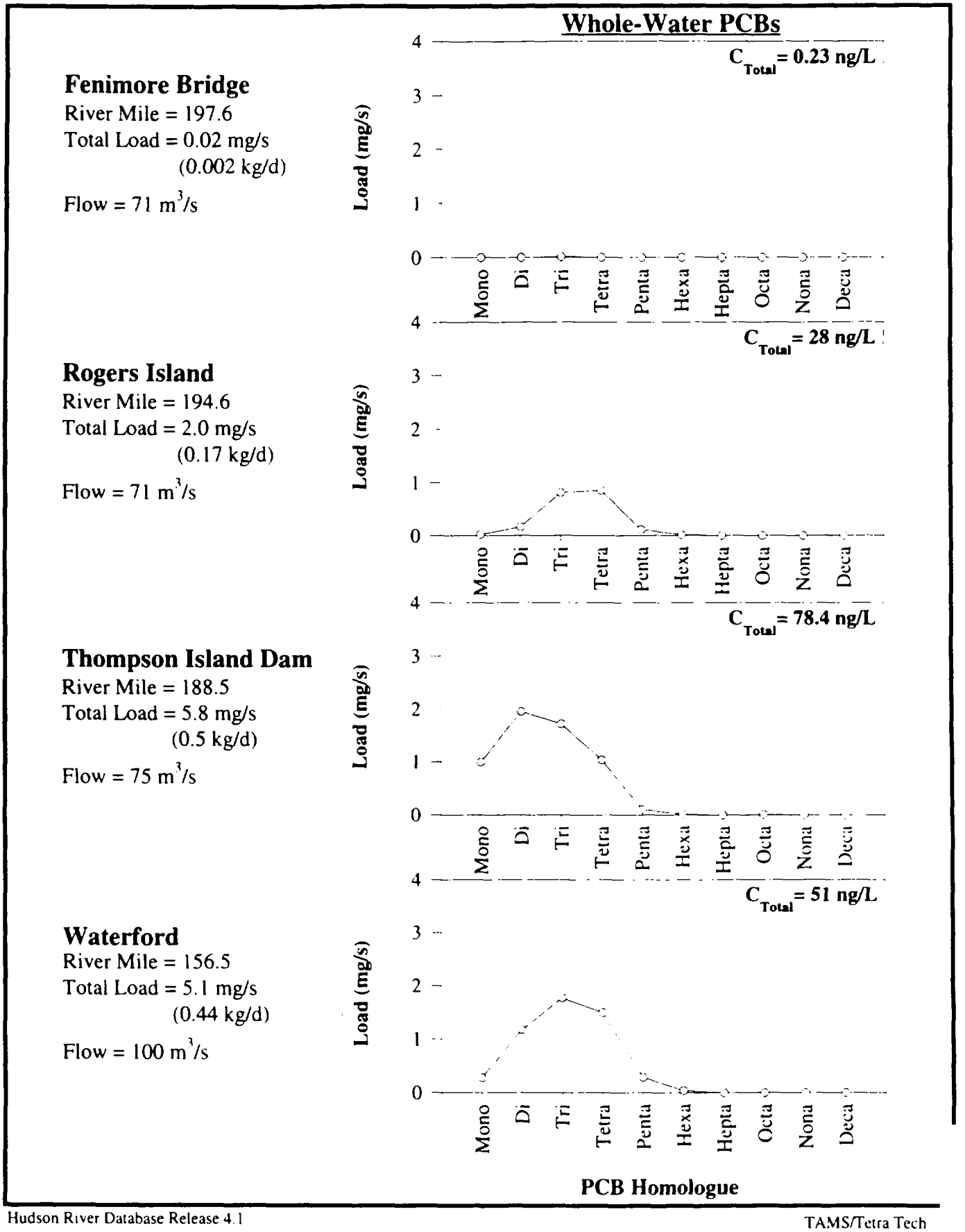
Note: Flow-Averaged 5 samples were collected during the period of August 2 to August 17, 1993.

Figure 3-48 (corrected)
Upper River Water-Column PCB Loading for
Flow-Averaged 5 Low-Flow Conditions



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Note: Flow-Averaged 6 water column samples were collected during the period of September 9 to September 23, 1993.

Figure 3-49 (corrected)
Upper River Water-Column PCB Loading for Flow-Averaged 6 Low-Flow Conditions