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**REPORT ON THE PEER REVIEW OF THE DATA EVALUATION AND
INTERPRETATION REPORT AND LOW RESOLUTION SEDIMENT
CORING REPORT FOR THE HUDSON RIVER PCBs SUPERFUND SITE**

—Final Report—

Prepared for:

**U.S. Environmental Protection Agency, Region II
Emergency and Remedial Response Division
290 Broadway, 18th Floor
New York City, NY 10007-1866**

**EPA Contract No. 68-W6-0022
Work Assignment No. 3-12**

Prepared by:

**Eastern Research Group, Inc.
110 Hartwell Avenue
Lexington, MA 02421**

June 3, 1999

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NOTE

This report was prepared by Eastern Research Group, Inc. (ERG), an EPA contractor, as a general record of discussion for the peer review meeting. This report captures the main points of scheduled presentations and highlights discussions among the reviewers. This report does not contain a verbatim transcript of all issues discussed during the peer review. Additionally, the report does not embellish, interpret, or enlarge upon matters that were incomplete or unclear. EPA will evaluate the recommendations developed by the reviewers and determine what, if any, modifications are necessary to the current modeling approach. Except as specifically noted, no statements in this report represent analyses or positions of EPA or of ERG.

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LIST OF ABBREVIATIONS

| | |
|---------------|--|
| DEIR | Data Evaluation and Interpretation Report |
| DNAPL | dense, nonaqueous phase liquid |
| DOC | dissolved organic carbon |
| EPA | U.S. Environmental Protection Agency |
| ERG | Eastern Research Group, Inc. |
| GE | General Electric Company |
| HRC | high-resolution sediment coring |
| LRC | Low Resolution Sediment Coring Report or low-resolution sediment coring |
| MDPR | molar dechlorination product ratio |
| MW | molecular weight |
| NYSDEC | New York State Department of Environmental Conservation |
| PCA | principal component analysis |
| PCB | polychlorinated biphenyl |
| ppm | parts per million |
| RPD | relative percent difference |
| TID | Thompson Island Dam |
| TIP | Thompson Island Pool |

EXECUTIVE SUMMARY

Six independent peer reviewers critiqued the following reports prepared as part of the U.S. Environmental Protection Agency's (EPA's) reassessment of the Hudson River PCBs Superfund site: the "Data Evaluation and Interpretation Report," the "Low Resolution Sediment Coring Report," and Responsiveness Summaries for both documents. After thoroughly discussing and debating the scientific rigor of the main conclusions of these reports, the reviewers unanimously agreed that the reports were acceptable. Four of the six reviewers found the reports "acceptable with minor revisions;" the other two reviewers found the reports acceptable, but they were unsure if their recommended revisions were "minor" or "major."

When answering the questions in the charge, the reviewers generally agreed with the major conclusions of the DEIR and LRC (e.g., the sediments in the Thompson Island Pool act as a source of PCBs to the water, the data suggest that most hot spots have lost PCBs, widespread burial of PCBs is not occurring, and so on), but they suggested that some conclusions should be modified to more accurately reflect the supporting data. At the close of the peer review meeting, every reviewer listed his major findings and recommendations. Following is a list of specific recommendations that at least two reviewers made during their closing statements. Specific examples of other suggested revisions and recommendations made by the reviewers can be found throughout this report.

- The reviewers unanimously agreed that the reports should have included multivariate statistical analyses to identify and quantify trends and patterns among the data, but especially for evaluating the large volume of congener-specific data.
- Every reviewer thought the reports should have more prominently acknowledged the uncertainty associated with some major findings. The reviewers were particularly concerned with reporting estimated PCB mass losses from hot spots as firm numbers. The reviewers suggested that reporting a range of estimated mass losses might have been more appropriate.
- The reviewers agreed that the DEIR's original finding on anaerobic dechlorination of PCBs was not supported by the data. The reviewers thought a more accurate conclusion would

indicate that dechlorination is predictable at higher PCB concentrations, but this should not be taken as evidence of lack of dechlorination at lower concentrations.

- Several reviewers recommended that EPA publish a concise summary of the main findings of the DEIR, the LRC, and the Responsiveness Summaries.
- Several reviewers recommended that EPA validate selected conclusions in the DEIR with the results from more recent water column sampling data.
- Several reviewers agreed that the DEIR and LRC did not fully characterize the fate of PCBs in the Hudson River. Two reviewers indicated that EPA should have considered evaporative losses, photochemical degradation, and aerobic degradation in the reports.

1.0 INTRODUCTION

This report summarizes an independent peer review by six experts of the following documents the U.S. Environmental Protection Agency (EPA) released as part of its reassessment of the Hudson River PCBs Superfund site:

- The February 1997 "Data Evaluation and Interpretation Report" (DEIR) (TAMS et al., 1997)
- The December 1998 "Responsiveness Summary" for the DEIR (TAMS et al., 1998a)
- The July 1998 "Low Resolution Sediment Coring Report" (LRC) (TAMS et al., 1998b)
- The February 1999 "Responsiveness Summary" for the LRC (TAMS et al., 1999)

To facilitate their evaluations of these reports, the reviewers also were given copies of the "Hudson River Reassessment Database," which contains all of the sampling data used to prepare the above reports.

The six reviewers attended two meetings, which were both open to the public. The first meeting, which took place in Albany, New York, on January 11–12, 1999, included several presentations and a tour of the Upper Hudson River to familiarize the reviewers with the site and its environmental history. The second meeting, which took place in Albany on March 16–18, 1999, was the forum in which the reviewers critiqued the above documents. Eastern Research Group, Inc. (ERG), a contractor to EPA, organized the expert peer review and prepared this summary report.

This introductory section provides background information on the Hudson River PCBs Superfund site, the scope of the peer review of the DEIR and LRC, and the organization of the report.

1.1 Background

In 1983, EPA classified approximately 200 miles of the Hudson River in the state of New York as a Superfund site, due to elevated concentrations of polychlorinated biphenyls (PCBs) in sediments. The sediments are believed to have been contaminated by discharges of PCBs over approximately 30 years from two General Electric (GE) capacitor manufacturing plants, one in Hudson Falls and the other in Fort Edward. The superfund site runs from Hudson Falls to New York City. After an initial site assessment, EPA issued an "interim No Action decision" in 1984 for the contaminated sediments of the Hudson River PCBs site.

Since 1990, EPA has been reassessing its earlier decision to determine whether a different course of action is needed for the contaminated sediments in the Hudson River. EPA is conducting this reassessment in three phases: compiling and analyzing existing data for the site ("Phase I"), collecting additional data and using models to evaluate human health and ecological risks ("Phase II"), and studying the feasibility of remedial alternatives ("Phase III"). As part of Phase II, EPA's contractors conducted field studies to characterize levels of PCBs in the water and sediments of the Hudson River to better understand the factors that affect the fate and transport of PCBs in this system. The original findings of these studies are documented in the DEIR and LRC. Since EPA released these reports, several parties submitted comments during the designated public comment periods, after which EPA's contractors prepared Responsiveness Summaries to address the comments.

To ensure that the assumptions, methods, and conclusions of the DEIR, the LRC, and their Responsiveness Summaries are based on sound scientific principles, EPA decided as per policy to obtain an expert peer review of the documents. The remainder of this report describes the scope and findings of this independent peer review.

1.2 Scope of the Peer Review

ERG managed every aspect of the peer review, including selecting reviewers, briefing the reviewers on the site, and organizing the peer review meeting. The following subsections describe what each of these tasks entailed.

1.2.1 Selecting the Reviewers

To organize a comprehensive peer review, ERG selected six independent peer reviewers who are engineers or senior scientists with demonstrated expertise in any combination of the following technical fields:

- River sedimentology
- Low and high resolution sediment coring
- Hydrology and water column fate and transport
- Geochemistry
- Analytical chemistry of PCBs
- Anaerobic dechlorination of PCBs

Appendix A lists the six reviewers ERG selected for the peer review meeting; brief bios that summarize each reviewer's areas of expertise can be found in Appendix C. Recognizing that few individuals specialize in every technical area listed above, ERG ensured that the collective expertise of the selected peer reviewers covers the six technical areas (i.e., at least one reviewer has expertise in analytical chemistry of PCBs, at least one reviewer has experience in river sedimentology, and so on).

To ensure the peer review's independence, ERG considered only individuals who could provide an objective and fair critique of EPA's work. As a result, ERG did not consider in the reviewer selection process individuals who were associated in any way with preparing the DEIR or the LRC or individuals associated with GE or any other specifically identified stakeholder.

1.2.2 Briefing the Reviewers

Given the large volume of site-specific information in the DEIR and LRC and the fact that none of the reviewers had extensive experience with the Hudson River PCBs site, ERG organized a 2-day meeting prior to the actual peer review to provide the reviewers with background information on the reports and to tour the Upper Hudson River. The purpose of the meeting was to familiarize the reviewers with the site; the reviewers did not provide technical comments on EPA's reports during this briefing. A copy of the minutes from this briefing can be found in Appendix G.

To focus the reviewers' evaluations of the documents, ERG worked with EPA to develop written guidelines for the technical review. These guidelines (commonly called a "charge") were presented during the briefing meeting and asked the reviewers to address at least the following topics: whether the main conclusions of the DEIR and LRC are well supported by the data; if the data presented in these reports is sufficient for understanding fate and transport mechanisms in the Upper Hudson River; and if additional analyses should be performed to verify certain findings of the reports. A copy of this charge, which includes many additional topics and questions, is included in this report as Appendix B.

In the weeks following the briefing meeting, ERG requested that the reviewers prepare their initial evaluations of the DEIR, the LRC, and the Responsiveness Summaries. ERG compiled these "premeeting comments," distributed them to the reviewers, and made copies available to observers during the peer review meeting. These initial comments are included in this report, without modification, as Appendix C. It should be noted that the premeeting comments are preliminary in nature and some reviewers' technical findings might have changed based on discussions during the meeting. As a result, the premeeting comments should not be considered the reviewers' final opinions.

The peer reviewers were asked to base their premeeting comments on the written materials distributed by ERG: the DEIR, the LRC, and the Responsiveness Summaries. Though not

required for this review, some reviewers might also have researched site-specific reports they obtained from other sources.

1.2.3 The Peer Review Meeting

The peer review meeting, which was held at the Albany Marriott Hotel in Albany, New York, on March 16–18, 1999, was attended by the six expert reviewers and at least 30 observers. Appendix D lists the observers who confirmed their attendance at the meeting registration desk. The schedule of the peer review meeting generally followed the agenda, presented here as Appendix E. As the agenda indicates, the meeting began with introductory comments both by the designated facilitator and by the designated chair of the peer review meeting. (These and other introductory comments are summarized below.) For the remainder of the meeting, the reviewers discussed and debated several technical issues when answering the questions in the charge. During the technical discussions, the reviewers provided many comments, observations, and recommendations. The agenda included two time slots for observer comments, which are summarized in Appendix F of this report. An ERG writer attended the meeting and prepared this summary report.

On the first day of the meeting, Jan Connery of ERG—the designated facilitator of the peer review—welcomed the six reviewers and the observers to the 3-day meeting. In her opening remarks, Ms. Connery introduced Dr. Ken Reimer (a peer reviewer and the technical chair of the meeting), stated the purpose of the peer review meeting, and identified the documents under review. To ensure the peer review remained independent, Ms. Connery asked the reviewers to discuss technical issues among themselves during the meeting and to consult with EPA only for necessary clarifications. Ms. Connery explained the procedure observers should follow to make comments. Finally, she reviewed the meeting agenda.

Following Ms. Connery's opening remarks, the peer reviewers introduced themselves, noted their affiliations, identified their areas of expertise, and stated that they had no conflicts of interest in conducting the peer review. Selected representatives from EPA and from EPA's

contractors then introduced themselves and identified their roles in the site reassessment. To orient the peer reviewers and observers to EPA's ongoing site reassessment efforts, Mr. Doug Tomchuk (EPA) then gave a presentation describing the history, current status, and planned future activities for the Hudson River PCBs site. Mr. Tomchuk also discussed the importance of peer review in the ongoing site reassessment efforts. Mr. Tomchuk then reviewed the four major conclusions of the DEIR and the LRC, but he did not interpret, or expand on, the assumptions and findings documented in the reports.

As a transition into technical discussions, Dr. Ed Garvey of TAMS Consultants gave a presentation on the main findings of the Responsiveness Summary for the LRC—the only report that was not available prior to the January briefing meeting. Dr. Garvey clarified several findings documented in this Responsiveness Summary, but he focused on several topics: the precision of the data; the use of radioactive isotopes to “date” the sediments; approaches used to quantify the extent of anaerobic dechlorination; the significance of wood chips in the sediment cores; and the general findings of the appendices to the LRC.

Following Dr. Garvey's presentation, Dr. Reimer began to chair the technical discussions of the peer review meeting. Dr. Reimer first identified several common themes among the reviewers' premeeting comments, and then worked with the peer reviewers to answer the questions in the charge, following the agenda. The remainder of this report summarizes the peer reviewers' discussions and documents their major findings and recommendations.

1.3 Report Organization

The structure of this report reflects the order of questions in the charge to the reviewers: Section 2 of this report summarizes the reviewers' discussions on specific questions regarding the DEIR; Section 3 summarizes the discussions on specific questions regarding the LRC; Section 4 summarizes the discussions on general questions that apply to both documents; and Section 5 highlights the discussions that led to the reviewers' final recommendations. Section 6 of this

report lists all references cited in the text. In these sections, the initials of the reviewers are used to attribute technical comments and findings to the persons who made them.¹

As mentioned earlier, the appendices to this report include a list of the peer reviewers (Appendix A), the charge to the reviewers (Appendix B), the premeeting comments organized by author (Appendix C), a list of the observers who confirmed their attendance at the meeting registration desk (Appendix D), the meeting agenda (Appendix E), summaries of the observers' comments (Appendix F), and minutes from the January briefing meeting for the reviewers (Appendix G).

¹ The initials of the reviewers are: RB (Dr. Reinhard Bierl), PL (Dr. Per Larsson), KM (Dr. Keith Maruya), RM (Dr. Ron Mitchum), KR (Dr. Ken Reimer), and BR (Dr. J. Bruno Risatti).

2.0 RESPONSES TO SPECIFIC QUESTIONS REGARDING THE DEIR

The peer reviewers opened their discussions by addressing the seven questions in the charge that related to the DEIR. In answering these questions, each reviewer presented his initial thoughts and comments, which the reviewers as a group then further discussed. At the end of the discussion on a given question, the chair summarized the common themes expressed by the reviewers and indicated areas where reviewers had differing opinions. A general record of the peer reviewers' discussions on the DEIR, organized by question, follows. The reviewers' final conclusions and recommendations for the DEIR are presented in Section 5.0.

Note: Throughout this section, the initials of the reviewers are used to attribute comments to the individuals who made them: RB=Dr. Reinhard Bierl, PL=Dr. Per Larsson, KM=Dr. Keith Maruya, RM=Dr. Ron Mitchum, KR=Dr. Ken Reimer, and BR=Dr. J. Bruno Risatti.

2.1 Responses to Question 1

The first question in the charge relating to the DEIR asked the reviewers: "Is the documented PCB load, which originated from the TI Pool [the Thompson Island Pool], consistent with a source consisting of historically deposited PCB-contaminated sediments?" The reviewers made the following comments and observations when responding to this question:

- *The Thompson Island Pool (TIP) sediments act as a source of PCBs.* The six reviewers unanimously agreed the data reported in the DEIR indicate sediments in the TIP act as a source of PCBs to the water column in the Hudson River, but the reviewers made several caveats in reaching this conclusion. Two reviewers, for example, noted that some of the water column transect data presented in the DEIR provide evidence of other PCB sources, particularly upstream sources, in addition to sediments of the TIP (RM,KM). Two reviewers emphasized, however, that changes in PCB loads and congener profiles during the summer low-flow conditions quite clearly indicated that the TIP sediments act as a source of PCBs (KM,KR). To put this finding into perspective, one reviewer commented that sediments downstream of the Thompson Island Dam (TID) likely also act as a source of PCBs, though he still agreed that sediments in the TIP are a source as well (KM).
- *Questions regarding whether "historically deposited" sediments act as a source.* Though the reviewers agreed that the TIP sediments acted as a source of PCBs, several reviewers did not think the water column transect data were sufficient for determining the extent to which recently deposited sediments and sediments buried at depth contributed to the PCB

loading (KM,KR,PL). One reviewer noted that this distinction was particularly difficult to resolve because the terminology is vague (i.e., exactly what should be considered as "historically deposited" sediments?) and because he did not think the PCB congener profiles differed enough with depth to determine conclusively which sediment layers act as the predominant sources (KM). One reviewer modified his earlier findings by noting that the TIP sediments clearly act as a source of PCBs, despite the uncertainties as to when these PCBs were originally deposited (PL). In short, one reviewer thought, and others agreed, conclusions on exactly what layers of sediments contributed to the PCB loading were speculative (RM).

The reviewers revisited this finding towards the end of the meeting, but they did not modify their original finding: the TIP sediments act as a source of PCBs, but the relative contributions of recently deposited and historically deposited sediments is not known.

- *Questions regarding the mechanisms by which PCBs enter the water column.* Two reviewers indicated that many physical, chemical, and biological mechanisms (e.g., resuspension, partitioning, bioturbation) might contribute to the source of PCBs (RB,PL). One reviewer indicated that laboratory studies, rather than strict data collection and analysis, are ultimately needed to understand these mechanisms in the Hudson River; he also noted that the peer reviewers were not asked to determine the extent to which different mechanisms affect PCB transport in the Upper Hudson River (PL). After brief discussions, the reviewers agreed that the data collected for the DEIR did not determine exactly how PCBs move from the sediments to the water column, but this shortcoming did not modify their primary conclusion: regardless of what mechanisms are most important, the sediments in the TIP act as a source of PCBs to the water column.
- *Discussions of upstream sources of PCBs.* Two reviewers discussed at length the extent to which releases of PCBs as dense, nonaqueous phase liquids (DNAPL) from GE's upstream facilities might act as a source in the Upper Hudson River (RM,BR). These reviewers indicated that locating and quantifying releases from DNAPL upstream sources would be extremely difficult. All six reviewers considered whether partitioning of PCBs in the form of oil droplets might explain trends in the water column transect data, and one reviewer indicated that the congener profiles of the PCBs, particularly the presence of relatively large amounts of mono- and di- substituted PCBs, were inconsistent with an oil droplet source of PCBs in the TIP (KM). After a lengthy discussion on upstream sources, the reviewers agreed that DNAPL sources of PCBs at upstream locations, if any, do not change their general response to the original question (i.e., that the sediments in the TIP act as a source of PCBs to the water column).
- *Recommendations that this conclusion be verified by analyzing additional monitoring data.* Noting that the conclusions in the DEIR are based primarily on 1 year of water column transect data, one reviewer thought the role of TIP sediments should be further investigated by analyzing water column monitoring data from more recent years (KM).

The reviewer thought this verification was particularly important for evaluating river conditions during the winter months, because the DEIR data that was collected during the winter was confounded by an upstream release (the Allan Mill event) (KM). Two reviewers thought GE might have more recent water column data available for verifying this conclusion (KM,KR).

- *An improved statistical approach would have strengthened this conclusion.* Several reviewers found the statistical analyses in the DEIR difficult to follow and overly simplistic. One reviewer felt strongly that the DEIR should have included a clear framework that outlined the statistical analyses in the report (PL). This reviewer clarified that he thought the statistical tests used in the report were properly applied, but he found the analyses difficult to follow since a clear framework was not presented.

Commenting further on the statistical approach, several reviewers thought the DEIR relied too heavily on qualitative comparisons (e.g., similarity between diagrams of congener profiles) in reaching its conclusions. These reviewers thought conclusions would have been more convincing had they been better supported with quantitative, multivariate statistical tests (RB,RM,KR). One reviewer was largely unconvinced by simple plots showing that certain parameters might have "increased" or "decreased," without any comments on whether changes were statistically significant (KR). Another reviewer thought EPA's contractors should have adopted statistical approaches to identify outliers among the sampling data (RM).

- *Other comments regarding the treatment of analytical data.* When commenting on the role of TIP sediments, several reviewers offered general comments on the presentation of data in the DEIR. One reviewer noted that the DEIR included very little information, quantitative or qualitative, on analytical variability of the PCB measurements (KR). This reviewer indicated that EPA should have more prominently acknowledged in the DEIR the analytical variability of the water column transect data and sediment coring data. Noting that the analytical laboratory had quality assurance criteria that automatically excluded from consideration any samples that did not meet certain precision criteria, one reviewer thought the report should have clearly stated these criteria and the number of samples that were excluded as a result (RM).
- *Comments on data quality.* Since the quality of the water column transect and sediment coring data were relevant to every question in the charge, the reviewers decided to state their general findings on data quality when responding to Question 1. Two reviewers commented that the quality of the monitoring data, as a whole, appeared to be acceptable (KM,RM). Another reviewer agreed with this general statement, but he again suggested that the DEIR should have clearly documented measurement precision for each PCB congener (KR).

2.2 Responses to Question 2

The second question asked the reviewers: "Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g., temperature)?" The reviewers made the following comments and observations in response:

- *Comments on the two-phase partition coefficients.* The reviewers unanimously agreed that the derivation and calculation of two-phase partition coefficients, including their corrections for temperature, were scientifically sound. As a qualitative check on the calculated values, one reviewer noted that the calculated two-phase partition coefficients generally increased with reported values of octanol-water partition coefficients, as is to be expected (KM). Another reviewer indicated that estimated partition coefficients for many congeners had widely variable values (RB), but a reviewer indicated that such variability is typical for deriving PCB partition coefficients from field measurements (KM).
- *Comments on the three-phase partition coefficients.* Several reviewers thought the water column transect data were insufficient for calculating reliable three-phase partition coefficients (RB,KM,RM). As evidence of this finding, one reviewer mentioned that three-phase partition coefficients for some congeners appeared to have unrealistic values, when compared to the coefficients for other congeners (KM). This reviewer thought the three-phase partition coefficients might include errors of an order of magnitude or greater and should not have been reported to two decimal places, as was done in the DEIR. The reviewers did not take exception with how mathematical expressions for the three-phase partition coefficients were derived (RM), but they thought additional data that characterize concentrations of dissolved organic carbon (DOC), including colloids, in the water column are needed for more accurate estimates of the three-phase partition coefficients (RB).
- *Use of partition coefficients in future modeling studies.* Two reviewers thought the partition coefficients should be used to develop empirical models of PCB transport mechanisms (RB,PL). These reviewers indicated that such modeling could quantify how temperature and other relevant parameters affect partitioning of PCBs in the Hudson River, which, in turn, would be useful for understanding underlying mechanisms of PCB transport (RB,PL).
- *Consideration of nonequilibrium partitioning and other "compartments" for equilibrium.* Noting that sorption and desorption kinetics affect partitioning of PCBs in the water column, one reviewer suggested that nonequilibrium effects might need to be considered in future modeling exercises (RB); other reviewers did not comment further on this topic.

Regarding other "compartments" to consider for partitioning, one reviewer noted several times that volatilization and photolysis of PCBs should have been addressed in the reports (RM). Other reviewers, however, were not convinced of the need to address these compartments in the analysis of equilibrium partitioning: one reviewer explained that photolysis is a nonequilibrium process (KR) and another reviewer acknowledged that EPA should eventually address volatilization in its reassessment, but not necessarily in these partitioning models (PL).

2.3 Responses to Question 3

The reviewers discussed at length the third question on the DEIR: "Are the conceptual models based on the transect sampling consistent with the data?" A summary of these discussions follows:

- *General agreement that the conceptual models were supported by the data and illustrated important aspects of PCB transport in the Hudson River.* Though the reviewers expressed several concerns about the conceptual models used to interpret the water column transect sampling data (these concerns are summarized below), they agreed that the models were generally consistent with the data and provided useful insight into PCB transport in the Hudson River. One reviewer felt, and other reviewers agreed, that the conceptual models presented in the Responsiveness Summary offered a much more defensible account of the water column transect data than did the models presented in the DEIR (KR).

Some reviewers identified what they considered to be particularly useful findings of the conceptual models. Two reviewers, for example, indicated that the conceptual models helped depict seasonal changes in PCB levels in the water column (KM, BR). They noted that the models clearly illustrated how PCBs in the water column, particularly those bound to suspended solids, increased during high-flow events and how levels of lower molecular weight PCBs tended to decrease with downstream distance during the warmer summer months, whether by volatilization, photolysis, or degradation. Another reviewer indicated that the models were useful for illustrating congener-specific trends (BR).

- *Models should have been supported by more sophisticated statistical analyses.* Almost every reviewer indicated that a more rigorous statistical analysis would have provided more compelling evidence of the models' findings than did the simple visual comparisons of congener profiles in the DEIR. One reviewer noted that he had conducted a principal component analysis (PCA) on a subset of the water column transect data to verify the conclusions drawn in the conceptual models (KR). This reviewer thought PCA or similar multivariate statistical analyses should have been conducted to quantify notable, but possibly subtle, trends among the large volume of monitoring data. Several reviewers

agreed and indicated that multivariate statistics would have particular utility in interpreting the large volume of congener-specific data (RM,BR,KR).

- *Concern about corrections made to the river flow data.* Several reviewers thought the conceptual models were consistent with the data, but were concerned about corrections that were made to the river flow data originally presented in the DEIR (RB,RM,BR). More specifically, river flow data for some stations presented in the Responsiveness Summaries were roughly 40 percent higher than the corresponding data presented in the DEIR. One reviewer found it difficult to verify whether this correction was made correctly and noted that the magnitude of the flow correction has a notable impact on the calculated PCB loads to the water column (RB). Another reviewer, however, explained that the magnitude of the flow correction has no bearing on the relative changes in PCB concentrations from one sampling station to the next (KM). This reviewer thought the conceptual models of the water column transect data provided insight into PCB transport, regardless of whether the flow corrections were correctly or incorrectly applied.
- *Consideration of parameters other than PCB concentrations in the conceptual models.* Several reviewers thought applying the conceptual models to pollutants other than PCBs might lead to a greater understanding of fate and transport of chemicals in the Upper Hudson River. For instance, one reviewer thought the models should be applied to measured levels of metals and chlorophyll, if such data are available (RB). In support of this recommendation, another reviewer noted that the U.S. Geological Survey has used metals and other contaminants to gain greater insight into physical processes in other rivers (BR). Another reviewer indicated that examining levels of chlorophyll might be worthwhile because in-situ production might be an important factor to consider in the relatively quiescent TIP (KM). Though these three reviewers recommended evaluating data trends and patterns for other parameters as part of the ongoing reassessment efforts on the Hudson River, none of these reviewers listed this recommendation among their major findings for the peer review meeting.
- *Miscellaneous comments.* When discussing the conceptual models, the reviewers made several comments that do not fall under the categories listed above. One reviewer, for example, noted that the database of sampling results was extremely difficult, and almost impossible, to use (KR). Further, some reviewers thought the conceptual models should have more prominently acknowledged the analytical variability of the laboratory measurements (KR) and the difficulties associated with quantifying congeners of lower PCB homologues in environmental samples (BR). Another reviewer thought the term "model" applies more to a mathematical construct that has predictive capabilities, and that the "conceptual models" in the DEIR were more simply "conceptual reasoning" (PL).

2.4 Responses to Question 4

The fourth question in the charge asked the reviewers: "Does the sampling at the TI Dam-West location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?" The reviewers discussed these two questions at length and offered several general responses:

- *Cancellation of sampling and analytical biases.* The reviewers understood that corrections made for a sampling bias altered the quantitative findings of the DEIR, but they did not think these corrections affected the general conclusion that the TIP sediments are a primary source of PCBs to the Hudson River (RB,PL,RM,KR). More specifically, a reviewer noted that the corrections made for the sampling bias were almost entirely offset by other corrections made to laboratory analytical data (KM). Assuming both corrections were made correctly, this reviewer thought the sampling bias had little impact on the DEIR's findings. Two reviewers commented that the algorithm, or "box model," EPA used to derive the corrections appeared to be valid (PL,KM).
- *Comments on the clarity of the question.* Several reviewers thought the first part of Question 4 did not clearly indicate which water column sampling data was corrected and how this correction was made (KM,BR,KR). At the reviewers' request, EPA's contractors identified the three sampling locations in the vicinity of the TID—GE's "west wing wall" location, GE's "center channel" location, and EPA's location about ¼ mile upstream from the dam—and explained the sampling bias and the corresponding data corrections. An observer offered to present additional data to clarify this issue, but the meeting facilitator noted that presenting such information would be more appropriate during the observer comments.
- *Other comments regarding potential sampling biases.* One reviewer thought the use of a different sampling technology, such as one that pumps water from different depths of the river, might have provided a more accurate account of concentrations of PCBs in the water column (PL). Nonetheless, this reviewer believed EPA's corrections for the sampling bias were appropriate.
- *Implications of PCB concentrations in near-shore areas being higher than those in the center channel.* The reviewers raised and discussed several implications of the spatial variations of PCB concentrations: they agreed that the greatest implications pertain to calculating PCB load to the water column and estimating the inventory of PCBs in the sediments. Regarding PCB loads, one reviewer explained, and the others agreed, that load

estimates would be biased if water column samples were collected in a channel with artificially high or low PCB concentrations (KM). More specifically, they thought uncorrected sampling results from a near-shore "hot spot" location might lead to a different estimate of PCB loads than sampling results from the center channel. Regarding PCB inventories, two reviewers indicated that the inventory might be understated if relatively high concentrations of PCBs in near-shore sediments have not been adequately characterized (KM,RM). The reviewers agreed to revisit the issue of PCB inventories during their discussions on the LRC, summarized in Section 3 of this report.

The reviewers briefly discussed several other implications of the spatial variations in PCB concentrations. These implications include, but are not limited to, a hypothesis that PCB loads to the water column might actually be lower than expected if near-shore contaminated sediments are not submerged during seasonal low-flow conditions (KM) and an observation that local river flow patterns, which affect sediment deposition and resuspension, also change considerably from the center channel to the shoreline (BR).

After answering the specific questions in the charge, the reviewers revisited their response to this question later in the meeting. One reviewer expanded on his earlier discussions about the implication of higher PCB concentrations in near-shore sediments: he noted that an undersampling of near-shore sediments might have biased the geostatistical analysis of the 1994 PCB inventory to lower levels (KM). He explained that, in cases where near-shore cores were not collected, the kriging and polygonal declustering analyses would use PCB concentrations measured in deeper sections of the river to estimate PCB concentrations in near-shore sediments. Other reviewers did not comment on this observation and indicated that their earlier summary statements were sufficient.

2.5 Responses to Question 5

The reviewers answered the fifth question: "Are the geostatistical techniques (polygonal declustering and kriging) correctly applied?" as follows:

- *General agreement that the geostatistical techniques were correctly applied.* The reviewers agreed that the findings from the geostatistical analyses gave a reasonable approximation of the PCB inventory and that EPA's contractors appeared to have applied the techniques correctly. Since most of the reviewers did not have extensive experience using these geostatistical techniques, however, they did not comment in detail on this topic.
- *Concerns about the selected geostatistical techniques.* Though he agreed that EPA's contractors had applied kriging and polygonal declustering analyses correctly, one reviewer thought the spatial heterogeneity of PCBs in the sediments necessitated the use of more sophisticated analyses of the PCB inventory (RB). This reviewer recommended nonlinear statistical techniques for this purpose, but he did not specify a particular test or method that

would be best suited for such analyses.² He also recommended gathering more data to characterize the spatial variations in PCB concentrations more thoroughly, but another reviewer commented that the results of EPA's side-scan sonar study already offered insight into the spatial heterogeneity of the river sediments (PL).

- *Concerns about presenting inventory estimates without addressing uncertainty.* Though the reviewers thought the geostatistical analyses were valid, one reviewer noted, and several reviewers agreed, that EPA's reports did not acknowledge the uncertainty associated with estimating PCB inventories from a finite number of sediment cores (KR). Given the uncertainty in making this estimate, this reviewer recommended the reports acknowledge that the calculated PCB inventory is only an estimate of the actual inventory. He also suggested that EPA consider presenting a range of inventory estimates, rather than presenting a single value.

2.6 Responses to Question 6

The sixth question on the charge asked the reviewers: "Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR)) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?" The reviewers discussed these two questions at length and offered several general responses:

- *Agreement that the MDPR is an approximate measure of the extent of anaerobic dechlorination.* The reviewers agreed the MDPR provides a useful characterization of dechlorination, though they identified several potential shortcomings with the MDPR. These shortcomings relate to the fact that the MDPR is calculated from concentrations of several PCB congeners from the lower homologues. Noting that the lower homologues are the most difficult to measure, one reviewer thought the MDPR might be biased by the analytical method (BR). Furthermore, because lower homologue PCBs are more likely to be removed from sediments than higher homologue PCBs (whether by pore water diffusion, aerobic degradation, or some other mechanism), several reviewers indicated that the sediment coring data do not characterize the amounts of dechlorination products that have actually been formed (KM,BR,KR). The reviewers noted that the DEIR did acknowledge these potential shortcomings of the MDPR.

² When reviewing the draft peer review report, this reviewer indicated that EPA could have used "disjunctive kriging" or "kriging in terms of projections." The reviewer indicated that these more complex approaches may help gain accuracy in non-linear estimators. The reviewer recommended that EPA consult the following software library: "Glayton V. Deutsch and Andre G. Journel: GSLIB: Geostatistical Software Library and User's Guide. Oxford University Press, 1997.

The reviewers also discussed the implications of the MDPR being calculated from concentrations of both "near final" and "terminal" dechlorination products. The reviewers thought this calculation was defensible, provided that ortho dechlorination of PCBs in the Hudson River does not occur (as is stated in the DEIR). During this discussion, two reviewers indicated that their own research has observed ortho dechlorination in sediments (BR, KR); however, another reviewer noted that several research projects on Hudson River sediments have not provided much evidence of ortho dechlorination (KM). The reviewers did not comment further on this topic.

- *Alternative measures for quantifying the extent of dechlorination.* The reviewers identified alternative measures for characterizing dechlorination in the Hudson River sediments, but they were not certain whether these alternative measures would provide any greater insight into the issue. One reviewer suggested that EPA could have examined "parent-daughter" dechlorination pairs to characterize overall levels of dechlorination, but this reviewer noted that this approach would suffer from some of the same shortcomings as the MDPR (KM). Another reviewer suggested that EPA quantify dechlorination strictly from data trends for heavier PCB congeners, which are not as difficult to measure and are not as likely to partition to the water column (BR). When discussing these alternatives, a reviewer asked whether EPA's contractors had considered variations of the MDPR to estimate the extent of dechlorination. As a point of clarification, EPA's contractor indicated that the Responsiveness Summary for the LRC contains such an analysis.
- *Other comments on estimating the extent of dechlorination.* Two reviewers offered other insights when discussing the appropriateness of the MDPR. One reviewer did not think the DEIR acknowledged the uncertainty associated with estimating the extent of dechlorination: he thought presenting point estimates of dechlorination ratios without including error bounds or appropriate caveats did not reflect the associated uncertainties (KR). Another reviewer emphasized that dechlorination has no bearing on the total mass of PCBs in the river sediments, since dechlorination merely transforms PCBs and does not remove them entirely from the system (PL). This reviewer thought the transformation of PCBs was notable since dechlorination products are generally more mobile than the higher-chlorinated PCBs (PL).

2.7 Responses to Question 7

The reviewers discussed at length the final question in the charge related to the DEIR, which asked: "The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?" The reviewers addressed the following topics when answering this question:

- *Comments on the wording of the question.* Two reviewers commented that this question in the charge was open to several interpretations. One reviewer, for instance, explained that he addressed simply whether dechlorination could occur at PCB concentrations below 30 mg/kg (30 parts per million [ppm]) while other reviewers might have answered a different question: whether *predictable* dechlorination occurs at these levels (KM). Another reviewer noted that people might have differing opinions on what constitutes *significant* predictable dechlorination (KR). Despite the ambiguities in the question, the reviewers focused their discussions on whether thresholds for anaerobic dechlorination, in a general sense, are scientifically plausible and whether the 30 ppm threshold reported for the Hudson River is supported by the available data. The following bullets summarize these, and other, discussions relevant to Question 7.
- *Discussion on whether concentration thresholds for dechlorination are plausible.* The reviewers talked at length about whether concentration thresholds for dechlorination are consistent with fundamental physical and biological mechanisms. One reviewer noted that he has observed concentration thresholds for dechlorination and other biological phenomena in his own research (BR), but another reviewer indicated that other studies have observed dechlorination occurring at levels considerably lower than 30 ppm (KR). Two reviewers were not surprised by this discrepancy, noting that conditions that affect biological activity in river sediments are different from those in controlled laboratory conditions (BR) and real-life river conditions often vary notably from river to river (PL). Several reviewers confirmed these comments by identifying the many parameters affecting biological processes (e.g., temperature, nutrients, inhibitors, organic carbon) that might have unique levels in the Upper Hudson River.

The reviewers then identified fundamental biological and physical processes that might explain thresholds. One reviewer commented that, under certain conditions (e.g., severely limited diffusion or unavailable nutrients), dechlorination kinetics can conceivably become imperceptibly slow, so as to give the appearance of a concentration threshold for dechlorination (KM). Another reviewer agreed, but had difficulty believing the findings in the DEIR because the report failed to offer a mechanistic explanation for the apparent concentration threshold (PL). The remainder of the reviewers' discussion on thresholds focused specifically on the likelihood that they apply for dechlorination in the Upper Hudson River.

- *Discussion on whether the DEIR and LRC data support a concentration threshold for dechlorination.* The reviewers unanimously agreed that the sediment coring data from the DEIR and the LRC do not support the reported 30 ppm threshold for dechlorination, and one reviewer went further in stating that the data do not support a threshold occurring at *any* concentration (RM). The reviewers gave several reasons for rejecting this finding. Noting that a large subset of the sediment cores were not considered in the dechlorination calculations, for example, one reviewer wondered whether this selective use of data might have masked more general trends (KM). Another reviewer did not think enough samples

with PCB concentrations lower than 30 ppm were available to reach a firm conclusion that dechlorination does not occur below this threshold (KR).

Other reviewers offered different perspectives on this topic: one reviewer thought EPA's sediment coring data supported a predictive empirical relationship between the extent of dechlorination and PCB concentrations greater than 30 ppm; however, he did not think this data implied that dechlorination ceases at lower concentrations (PL). Agreeing with this sentiment, another reviewer emphasized that no conclusion should be drawn about dechlorination in sediments with PCB concentrations below 30 ppm (KR). Finally, one other reviewer highlighted some exceptions to the basic trend reported in the DEIR, for example, a small subset of sediment cores with relatively high PCB concentrations had very little evidence of dechlorination (BR). Later in the meeting, this same reviewer listed three sediment cores with PCB concentrations lower than 30 ppm that showed evidence of dechlorination. After thoroughly reviewing these arguments, the reviewers all agreed the data provided in the DEIR and LRC do not support the 30 ppm dechlorination threshold. Based on this finding, one reviewer thought a summary statement in the DEIR ("PCBs in sediments with less than 30 ppm are largely left unaffected by the dechlorination process") should be qualified (KR).

- *Agreement that dechlorination is predictable at "higher" PCB concentrations.* After answering the specific questions in the charge, the reviewers revisited Question 7 to further debate whether the extent of dechlorination is predictable. Several reviewers commented that the figures in the DEIR clearly demonstrate a relationship between the extent of dechlorination and PCB concentration, at least among the sediment cores with relatively high PCB levels (PL,BR,KR). The reviewers did not specify the lowest PCB concentration at which the extent of dechlorination appears to be predictable, but one reviewer did not think predictable dechlorination occurred at levels near 30 ppm (KR). Based on these discussions, the reviewers unanimously agreed with the summary statement: "There is predictability of dechlorination at higher PCB concentrations, but this should not be taken as evidence of lack of dechlorination at lower concentrations."
- *Comments on whether dechlorination might be a function of time (i.e., age of sediments).* The reviewers briefly discussed the possibility that the extent of PCB dechlorination varies as a function of time. They indicated that available data provide conflicting answers to this question: some studies by other researchers have reported considerable dechlorination in freshly deposited sediments (KM), yet many of the Hudson River cores showed little evidence of dechlorination in some of the older sediments (BR). Focusing on the Hudson River sediments, another reviewer commented that the coring data clearly show that the extent of dechlorination is more dependent on PCB concentration than it is on time (KR). This reviewer cautioned, however, that the greater dependence on PCB concentration does not imply that dechlorination is totally independent of time, as he documented in his premeeting comments. The reviewers did not discuss this topic further.

- *Comments on the presentation of data.* One reviewer thought presenting dechlorination data on a logarithmic scale, as was done in the DEIR, was inconsistent with the mathematical derivation of the MDPR (RM). This reviewer asked EPA's contractors to clarify several issues related to the presentation of the data, after which he still concluded there was no scientific basis for using logarithmic scales to depict the dechlorination results. He thought EPA's contractors chose to use logarithmic scales simply to fit the data to a trend.

3.0 RESPONSES TO SPECIFIC QUESTIONS REGARDING THE LRC

The peer reviewers continued their discussions by addressing the seven questions in the charge that related to the LRC. The scientific chair followed the same format as used in the previous discussion about the DEIR in facilitating these discussions: individual reviewers were asked to present initial thoughts on the questions; the reviewers as a group then further discussed and debated these initial comments; and finally the chair summarized the common themes expressed by the reviewers and indicated areas where reviewers had differing opinions. A general record of the peer reviewers' discussions on the LRC, organized by question, follows. The reviewers' final conclusions and recommendations for the LRC are presented in Section 5.0.

Note: Throughout this section, the initials of the reviewers are used to attribute comments to the individuals who made them: RB=Dr. Reinhard Bierl, PL=Dr. Per Larsson, KM=Dr. Keith Maruya, RM=Dr. Ron Mitchum, KR=Dr. Ken Reimer, and BR=Dr. J. Bruno Risatti.

3.1 Responses to Question 1

As the charge in Appendix B shows, the first question specific to the LRC asked: "In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?" The reviewers' comments and main findings on this topic follow:

- *Comments on comparing cores collected in 1984 to those collected in 1994.* The reviewers unanimously agreed that EPA's contractors used a reasonable method to compare sediment coring results between 1984 and 1994. Several reviewers thought no other defensible methods could have been used, given the difficulties laboratories had measuring levels of mono- and di-substituted PCBs (PL,KM,BR). Individual reviewers made several other observations regarding the data comparisons. For instance, one reviewer felt confident in the data comparison, partly because the majority of PCB releases to the Hudson River were reportedly Aroclor 1242, which likely produced consistent peaks among the chromatograms; he said he would have been less confident in comparisons involving complex mixtures of Aroclors (KM). Two reviewers thought the comparison between the 1984 and 1994 data had greater uncertainty than the LRC acknowledged. As a result, they thought the comparison should have been presented as an approximation of a trend, rather than as a concrete estimate (RM,KM). Finally, one reviewer added, and

several other reviewers agreed, that the data comparison would be better supported by a detailed review of the 1984 sampling effort (e.g., analyzing archived samples and extracts, inspecting chromatograms) (RB).

- *Comments on comparing cores collected in 1977 to those collected in 1994.* The reviewers had no confidence in quantitative comparisons between the 1977 and 1994 sediment coring data sets. Moreover, two reviewers thought the LRC did not describe the 1977 sampling effort in detail nor did it propose a method for comparing the 1977 and 1994 data (KM,KR). Based on the lack of confidence in the quality of the 1977 data, one reviewer concluded that any comparison between the 1977 and 1994 data sets would be speculative (KM). Two reviewers indicated they would be more confident in the 1977 data set if samples could be reanalyzed and chromatograms examined (RB,KM).
- *Discussion on the quality of the 1977 and 1984 data.* While reviewing the methods used to compare the data sets, the reviewers expressed several concerns about data quality for the previous coring studies. The main concern was that very little information was provided on the extraction procedures, precision estimates, use of internal standards, and other quality assurance measures that were used in the 1977 and 1984 sampling and analytical programs (RB,PL,RM). On the other hand, some reviewers offered reasons to believe the data quality from the past sampling efforts, particularly from 1984, was acceptable. Based on his experience with EPA's oversight of laboratory quality assurance in the 1980s, for example, one reviewer was satisfied that the 1984 data were likely of a reasonable quality, though he was less confident in the quality of the 1977 data (RM). Agreeing with this sentiment, another reviewer noted that he did not think analytical variability for PCB measurements had changed dramatically between 1984 and 1994 (PL). As noted above, several reviewers suggested that the best way to gain greater confidence in the past data is by carefully reviewing chromatograms and reanalyzing archived samples or extracts, if such information is available.

3.2 Responses to Question 2

The reviewers discussed at length the second question in the charge on the LRC, which asked: "In the Upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?" The reviewers addressed the following topics when answering this question:

- *Evaluation of the techniques used to compare sediment concentrations from two different years.* The reviewers agreed the combined “point-to-point” and “area-to-area” comparison was a reasonable approach for examining changes in PCB mass loading between two different years, but they had several comments on how these approaches were applied. First, given the heterogeneity of the sediments, several reviewers indicated that the “area-to-area” comparisons presented in the Responsiveness Summary are much more defensible than the “point-to-point” comparisons originally reported in the LRC (KM,BR). Second, several reviewers emphasized that statistical techniques alone cannot compensate for heterogeneous sediments, as implied by the question in the charge; these reviewers explained that only larger sample sizes can effectively reduce uncertainty in the sediment core comparisons (PL,KM,BR). Third, two reviewers noted that EPA used acoustical techniques to characterize sediment properties and heterogeneity in areas where cores had not been collected—an issue that was discussed in greater detail later in the meeting (see Section 3.7 of this report) (PL,KM). Finally, one reviewer thought the LRC should have included more information on the factors that contribute to the spatial heterogeneity of PCB concentrations (e.g., is the heterogeneity caused by historical deposition areas, differing sediment characteristics, or other factors?) (RB).
- *Comments on the reported loss of PCBs from sediments in most sampling locations.* The reviewers agreed the sediment coring data indicate a general trend of PCB loss from sediments in most locations. Several reviewers added, however, that estimated amounts of PCB loss should be interpreted with caution due to the uncertainty inherent in comparing sediment cores collected in different years (RB,PL,KM). Another reviewer noted that the analytical variability in the measurements alone complicates efforts to quantify PCB losses (RM). The reviewers discussed the implication of uncertainty further when answering Question 3, as summarized in the next section.

3.3 Responses to Question 3

The reviewers continued their discussion on the estimates of PCB loss from river sediments when answering the third question in the charge: “What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?” The reviewers’ responses to this question focused on the following issues:

- *Recommendations for acknowledging the uncertainty in the reported PCB loss.* The reviewers unanimously recommended that EPA’s reports not present discrete estimates of the PCB inventory loss without caveats about the uncertainty associated with the calculation. More specifically, one reviewer suggested that point estimates of PCB loss

could be bracketed by estimates of uncertainty (KM), while other reviewers thought the loss estimate should simply be reported as a range of values without a point estimate (RB). The reviewers noted that the estimate of 40 percent loss of PCBs has considerable uncertainty, but they added that the sediment coring data do support a loss of PCBs from most areas of the TIP (see response to Question 3, above).

- *Comments on how the analytical variability affects the PCB loss estimates.* To focus their discussions on analytical variability, the reviewers asked EPA's contractors to clarify how they calculated relative percent difference (RPD) and whether the RPD accounts for sampling variability. The contractors responded that they calculated RPDs from "true splits," which, in theory, strictly characterize analytical variability. Some reviewers were surprised that the average analytical variability was as high as 36 percent (RM,BR,KR): one reviewer noted that his laboratory routinely generates data with better precision (KR). Other reviewers found it difficult to comment on analytical variability, because little information was provided on the RPDs for the 1984 data set (KM,RM).

Despite these concerns about data variability, the reviewers agreed that the sediment cores provide a basis for evaluating changes in PCB inventory from 1984 to 1994. As noted above, however, the reviewers emphasized that quantitative comparisons are highly uncertain. Citing a figure in the LRC that presented congener-specific RPDs, one reviewer noted that the analytical variability among the 1994 data seemed to be random and not systematic (KM). This reviewer felt more comfortable with the PCB inventory comparisons due to the apparent absence of a systematic bias in the analytical data, but he emphasized that the reports should more prominently acknowledge the uncertainty associated with the estimated inventory loss.

3.4 Responses to Question 4

The reviewers then discussed the fourth question in the charge: "In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this 'gain' is primarily due to incomplete characterization in 1977 valid?" A summary of their responses follows:

- *Agreement that the apparent gain in PCB mass for Hot Spot 28 was not a valid finding.* The reviewers unanimously agreed that the apparent increase in PCB mass for Hot Spot 28 did not represent a true gain in mass, but merely resulted from the 1977 coring study failing to characterize Hot Spot 28 completely. One reviewer offered two reasons for questioning the validity of the 1977 mass loading estimates (KM). First, noting that the 1977 study did not sample an area of Hot Spot 28 that the 1994 study found to have relatively high PCB concentrations, this reviewer indicated that the 1977 study might have underestimated the spatial extent, and hence the mass loading, of the hot spot. Second, the reviewer explained

that the cores used in the 1977 study were not long enough to characterize the depth of the hot spot—a shortcoming that also caused an underestimation of the mass loading. For these and other reasons, the reviewers concluded that the quality of the 1977 data was unknown, but they thought the 1994 characterization of Hot Spot 28 seemed adequate.

- *Lack of other logical explanations for the apparent gain in PCBs.* Several reviewers could not envision any other logical reason (except for the incomplete characterization during the 1977 study) that could adequately explain the considerable increase in PCB mass in just one hot spot, while the PCB mass in other hot spots apparently decreased (RB,KM,RM).

3.5 Responses to Question 5

Continuing their discussion on losses in PCB inventory, the reviewers answered the fifth question in the charge, which asked: “Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below TI Dam?” The reviewers addressed the following issues in their response:

- *Comments on the wording of the question.* Two reviewers thought this question was open to several interpretations, due to ambiguity in the term, “significant losses” (PL,KR). For instance, one reviewer indicated that he could answer whether a loss of PCBs is *significant* from the perspective of downstream ecosystems, from the perspective of total inventory, or from the perspective of statistics (PL). This reviewer explained further that a 1 percent loss of PCBs from the sediments might be *significant* in terms of the implication on downstream ecosystems, but such a loss might not be *significant* when compared to the total PCB inventory in the sediments. Given these concerns, the reviewers decided to answer a more direct question: “Does the data set support the conclusion that losses have occurred from hot spots below the TID?” Responses to this question, which omits the word *significant*, are summarized below.
- *Agreement that PCB losses seem reasonable, but the amounts are difficult to quantify.* The reviewers unanimously agreed that the data presented in the LRC support the conclusion that sediments downstream from the TID have lost PCBs, but they thought estimates of the actual mass loss would be difficult, if not impossible, to quantify. The reviewers thought PCB losses seemed reasonable based on data reported in the LRC: noting that approximately 50 percent of the PCB inventory in the downstream hot spots appeared to lie within the top 9 inches of sediments, one reviewer thought it was conceivable that losses could have occurred (KM). Another reviewer agreed, stating that PCBs in the top 9 inches of sediment are probably available for transport to the water column in some manner, though the exact mechanism might not be known (KR). Yet

another reviewer argued against this reasoning, because he thought sediment cores collected by GE provided evidence that maximum PCB levels typically occurred at depths between 5 and 9 inches (BR). Nonetheless, this reviewer agreed with the basic summary finding: PCB losses have likely occurred from sediments downstream from the TID. (The reviewers decided to address the issue of how PCB concentrations vary with sediment depth when responding to the sixth question in the charge [see Section 3.6].)

The reviewers were concerned about attempts to quantify PCB losses from this stretch of the river since many of the hot spots were characterized only by the 1977 and 1994 sampling efforts. As summarized in Section 3.4, the reviewers questioned the quality of the data from the 1977 sampling.

- *Comments on the mechanisms contributing to PCB losses.* Two reviewers indicated mechanistic explanations for the loss of PCBs from sediments downstream of the TID (RB,PL). They agreed that particle transport (sediment resuspension) could have accounted for the PCB losses in this stretch of the Hudson River, but they were skeptical that either pore water diffusion or bioturbation were the primary mechanism of PCB transport to the water column (RB,PL). One of these reviewers recommended that future work on the site focus more on mechanistic explanations for observed data trends (RB).

3.6 Responses to Question 6

The reviewers debated several issues pertaining to the sixth question in the charge: “The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?” A summary of their discussion follows:

- *Comments on the wording of the question.* Several reviewers thought Question 6 was open to several interpretations, largely due to the terms “widespread” and “burial.” More specifically, one reviewer noted that different people might have different conceptions of what “widespread” actually means (KM). On a similar note, another reviewer indicated that he had difficulty answering this question because he was not sure how to interpret “burial” (i.e., exactly how many inches of sediment must deposit for “burial” to occur?) (RB). Due to these concerns, the reviewers carefully worded their responses to the question, which are summarized below.
- *Agreement that widespread burial of PCBs is not occurring.* The reviewers offered many different opinions on whether PCBs are being buried in the TIP, after which they agreed that the data in the LRC suggest that widespread burial does not appear to occur. One reviewer based this finding on how PCB concentrations varied with depth in the low

resolution sediment cores: for the hot spots in the TIP, he calculated that approximately 60 percent of the PCB inventory lies within the upper 9 inches of sediments (KM). This reviewer used this evidence to argue against burial of PCBs to depths of 9 inches or deeper. Another reviewer added that the water column transect data are inconsistent with widespread burial (RB). He explained that the water column data from the DEIR, which indicated that PCBs enter the water column from the TIP sediments (see Section 2.1), suggest that PCBs likely remain in the upper layers of the sediments and that widespread burial probably does not occur. Yet another reviewer agreed with both of these arguments and concluded that the weight of the evidence from EPA's reports is against deep burial of PCBs (KR).

During these discussions, one reviewer stressed that PCBs are likely being buried in certain parts of the Upper Hudson River (BR). Other reviewers agreed with this statement, but noted that "deep" burial does not appear to be widespread (PL,KM). All six reviewers eventually agreed that burial might occur in some places, but it does not appear to be widespread.

After answering the specific questions in the charge, the reviewers revisited Question 6, focusing primarily on whether "deep" burial of PCBs occurs. One reviewer explained that the depth of burial can have significant implications on the bioavailability of PCBs (KM). Another reviewer agreed, but noted that future modeling exercises will have to determine whether or not the PCBs are, in fact, bioavailable (KR). The reviewers then discussed basic data trends of the LRC, as summarized in one reviewer's premeeting comments (KM), and eventually agreed with their original summary statement: "There does not appear to be widespread burial."

- *Caveats on drawing conclusions from data collected over a 10-year period.* Though he agreed that widespread burial of PCBs does not appear to occur, one reviewer thought debating the evidence of burial from 1984 to 1994 might be a moot point, particularly because sediment deposition trends might easily be reversed during flood events (PL). Another reviewer agreed, citing his personal experience working with other rivers where flood events considerably alter the river sediments (BR). These reviewers asked EPA to clarify how flood events have historically affected the Hudson River. Representatives from EPA explained that the Hudson River has a relatively controlled flow, due in part to upstream reservoirs, and 100-year floods might not have as great an impact on sediment transport as one might expect. The reviewers did not discuss issues pertaining to flood events further.

On a related topic, however, another reviewer suggested that the conclusion of no widespread burial should be revisited in later years (KM). Noting that much of EPA's sampling data was collected during a release of PCBs from an upstream source, which might not be characteristic of PCB sources over the long term, this reviewer recommended

that EPA verify the finding of "no widespread PCB burial" during times when upstream sources of PCBs have been considerably reduced.

- *Comments on the importance of future modeling efforts.* One reviewer commented several times that modeling sediment deposition and resuspension might be the best approach for determining whether widespread burial of PCBs likely occurs (RB). Another reviewer agreed, but explained that such modeling was not included in the scope of the DEIR or the LRC (KM).

3.7 Responses to Question 7

The reviewers answered the seventh question, "Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?", as follows:

- *Agreement that interpretations of the sidescan sonar data seem appropriate.* The reviewers unanimously agreed that the interpretation of the sidescan sonar data seemed reasonable. One reviewer based this finding on his personal experiences with this acoustical technique (KR), and others based the finding on consultations with colleagues who have used the technique (KM, BR). Two reviewers commented that the sidescan sonar data seemed to complement many other findings presented in EPA's reports (KM, RM).
- *Miscellaneous comments.* The reviewers made several miscellaneous comments when discussing this topic. For instance, one reviewer indicated that sidescan sonar studies were particularly useful for differentiating fine-grained and coarse-grained sediments (BR). This reviewer thought the sidescan sonar data might help researchers identify sediments that likely contain PCBs, but he cautioned that the data cannot be used as an absolute indicator of where PCB-contaminated sediments occur. Another reviewer suggested "ground penetrating radar" data, which might be available from the U.S. Geological Survey, also could be useful for understanding the properties of the bedrock that underlies the river bed (RM). Finally, yet another reviewer thought the reports should have documented the operative details of the sidescan sonar study more extensively (e.g., describing how the geometry of the river bed might have affected the sonar reflectivity) (KR).

4.0 RESPONSES TO GENERAL QUESTIONS REGARDING THE DEIR AND LRC

After answering the 14 questions in the charge that were specific to the DEIR and LRC, the reviewers then discussed two general questions that addressed issues documented in both documents and their Responsiveness Summaries. When answering these questions, the reviewers reiterated many of the findings they had presented earlier in the meeting and offered additional comments for debate and discussion. A general record of the peer reviewers' discussions on the two general questions follows. The reviewers' final conclusions and recommendations for the meeting are listed in Section 5.0.

Note: As was done in previous sections, the initials of the reviewers are used to attribute comments to the individuals who made them: RB=Dr. Reinhard Bierl, PL=Dr. Per Larsson, KM=Dr. Keith Maruya, RM=Dr. Ron Mitchum, KR=Dr. Ken Reimer, and BR=Dr. J. Bruno Risatti.

4.1 The Usefulness of the Data Set for Understanding Fate and Transport of PCBs in the Upper Hudson River

The first general question asked the reviewers: "Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?" A summary of their responses, and the discussion that led to these responses, follows:

- *Agreement that the general conclusions of the reports are supported by the data.* After lengthy discussions on the question, and different interpretations of the question, the reviewers eventually agreed that the conclusions in the DEIR and LRC are generally supported by the data. In reaching this summary statement, one reviewer emphasized that the collective weight of evidence in the EPA reports supported the main conclusions and illustrated where PCBs generally originate and transport along the Hudson River, though this reviewer thought a lesser emphasis should have been placed on selected quantitative findings (KR). Most of the reviewers agreed, and indicated that the data collected by EPA's contractors were extremely thorough (RB,PL,RM,BR). One reviewer added that the compilation of data collected by EPA, GE, and USGS generated a very comprehensive database (RB). Despite these areas of agreement, the reviewers had differing opinions on certain aspects of this question, as summarized below.

- *Comments on transport mechanisms.* Though the reviewers generally agreed that the DEIR and LRC provided a basic understanding of PCB transport in the Hudson River, two reviewers suggested additional analyses of transport mechanisms. (Note, the reviewers identified other recommended analyses when responding to General Question 2.) First, noting that EPA collected only 1 year of water column transect data, one reviewer recommended validating the results of the transect study with data collected in more recent years (KM); this reviewer also noted that EPA's transect study did not fully characterize PCB transport between sampling locations (e.g., did PCBs transport conservatively between two locations? or was there trapping and resuspension?). Another reviewer thought EPA could have provided greater insight into PCB transport by conducting studies on sediment dynamics, even if only in the TIP, by more thoroughly characterizing the dissolved phase, and by analyzing data trends for other pollutants in the system (BR).
- *Comments on fate mechanisms.* The reviewers generally agreed that the DEIR and LRC did not provide sufficient data for understanding the fate of PCBs in the Hudson River, but several reviewers did not necessarily view this as a shortcoming of the reports. More specifically, several reviewers noted that EPA's study did not characterize the extent to which certain mechanisms remove PCBs from the Hudson River, such as evaporative losses, aerobic degradation, uptake by biota, and photolysis (PL,KM,RM). Nonetheless, other reviewers commented that losses by some of these mechanisms are not only very difficult to measure (RB) but also might not have been included in the scope of EPA's study (PL). Moreover, a reviewer suspected that EPA's future modeling efforts will address bioavailability and other phenomena related to the fate of PCBs (KR).
- *Discussion on the objectives of the study.* Two reviewers focused their responses on whether the reports, particularly the DEIR, met their stated objectives (RM,BR). Both reviewers were concerned that EPA's reports might not have identified "the major factors affecting the long term recovery of the Hudson"—an issue specified on page 1-3 of the DEIR. The reviewers did not discuss the study objectives further, but rather agreed to determine whether the general conclusions stated in the reports (and as modified in the Responsiveness Summaries) were supported by the data. That discussion is summarized in the previous bullet items.
- *Other comments on the data collected for the DEIR and LRC.* The reviewers raised, but did not discuss in detail, several general issues while responding to this question. For instance, one reviewer noted that a complete congener-specific mass balance could not be performed on the historical data, since the sampling effort in 1984 did not characterize the lower homologue PCBs (KM). Another reviewer recommended that EPA perform a more complete mass balance to characterize fate and transport of PCBs more completely (BR). This reviewer also thought the reports should have included representative chromatograms from sediment samples collected in different stretches of the river, such that readers can better understand the composition of PCBs in the sediments. Finally, one reviewer

suggested that future work should focus specifically on understanding the fate of coplanar PCBs, since these congeners might be important to distinguish due to their toxicity (RB).

4.2 Recommended Additional Data Analyses

The second general question asked the reviewers: "Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?" Since reviewers had identified additional analyses throughout the peer review meeting, they did not discuss and debate this question in detail. Rather, they compiled a list of recommended data analyses from their responses to earlier questions. The following bullet items present the recommendations and identify the reviewers who made them:

- All of the reviewers thought use of multivariate statistical analyses to quantify trends and patterns among the data would have strengthened the documents' conclusions.
- Two reviewers thought studies of sediment dynamics, at least for the TIP, concurrent with water column sampling might better illustrate PCB transport (BR,PL). One reviewer suggested that EPA should perform these studies during different seasons to characterize high-flow and low-flow conditions (BR).
- Noting that the "air compartment" for a PCB mass balance has not been quantified, one reviewer recommended further analysis of evaporative losses and photochemical degradation of PCBs (RM). This reviewer indicated that these issues could be addressed in many ways, such as by reviewing the scientific literature, modeling the processes, or actually measuring them. Other reviewers agreed that evaporative losses should be considered in EPA's future work on the site (PL,BR).
- Two reviewers recommended that the findings of the conceptual models presented in the DEIR should be validated against more recent water column sampling data (KM,KR).
- Several reviewers offered recommendations pertaining to interpretation and presentation of PCB analytical data in the reports. One reviewer suggested that EPA exhaust all possible methods for relating the 1977 sediment coring data to the 1994 data, such as analyzing archived samples and reviewing chromatograms, if any of this information is available (KM). Another reviewer agreed and added that the DEIR should clearly state the analytical variability of the water column and high resolution sediment coring measurements (KR).

- One reviewer suggested that EPA use more sophisticated statistical analyses, including nonlinear analyses, when calculating certain data trends (RB).

The reviewers reiterated some of these recommended data analyses, and added others, when presenting their final thoughts on the DEIR, the LRC, and the Responsiveness Summaries (see Section 5.0).

5.0 REVIEWERS' OVERALL RECOMMENDATIONS

After answering the specific and general questions in the charge, and after listening to the second set of observer comments, the reviewers reconvened to provide their final findings on EPA's reports.³ The reviewers decided to offer these findings as individual statements, during which other reviewers did not discuss or debate each reviewer's final recommendations. Section 5.1 summarizes each peer reviewer's final statements, and Table 5-1 in Section 5.2 identifies common themes among these final recommendations.

5.1 Peer Reviewers' Final Statements

The peer review meeting concluded with each peer reviewer providing closing statements on the reports, including an "overall recommendation" in response to the final question in the charge: "Based on your review of the information provided, please identify and submit an explanation of your overall recommendation for both the DEIR and LRC.

1. Acceptable as is
2. Acceptable with minor revision (as indicated)
3. Acceptable with major revision (as outlined)
4. Not acceptable (under any circumstance)"

A detailed summary of the peer reviewers' final statements, in the order they were given, follows:

- *Dr. Keith Maruya.* Dr. Maruya indicated that he accepted the main conclusions of the reports, though he did have suggestions and recommendations for improving them. First, he suggested that EPA publish a concise summary of the information provided in the DEIR, LRC, and the Responsiveness Summaries. He recommended the use of multivariate statistical analyses to make certain conclusions in these reports more convincing. Dr. Maruya also recommended the reports more prominently acknowledge the uncertainty in some key findings, like the estimated mass loss of PCBs.

³ Due to unforeseen circumstances, one reviewer (Keith Maruya) had to leave the peer review meeting at the end of the second day. He gave his final recommendations before the second set of observer comments.

Focusing specifically on the DEIR, Dr. Maruya first reiterated a recommendation he had mentioned earlier in the meeting: EPA should validate the findings of the conceptual models with more recent water column sampling data. He thought such validation would better quantify PCB sources between Roger's Island and Waterford during times when upstream sources of PCBs are negligible. Dr. Maruya then suggested that EPA consider the limnology of the TIP and other pools in the Hudson River for a better understanding of PCB transport (e.g., how primary production affects partitioning, fate, and transport of PCBs). On the topic of partition coefficients, Dr. Maruya recommended that EPA only use the two-phase coefficients derived in the DEIR until sufficient data are available to estimate the three-phase coefficients. Dr. Maruya did not think the data in the DEIR supported a 30 ppm threshold below which PCB dechlorination reportedly does not occur.

Commenting on the LRC, Dr. Maruya first concluded that the comparisons between the PCB inventories in 1984 and 1994 were reasonable and the data from 1977 were not sufficient for inventory estimates. He thought the analytical variability contributed to considerable uncertainty in the inventory estimates, which the LRC did not acknowledge. Dr. Maruya thought EPA should further consider how elevated PCB concentrations in near-shore sediments might have affected the inventory estimates. Finally, Dr. Maruya maintained that the sampling data suggest that widespread burial of PCBs does not occur.

Overall, Dr. Maruya thought the DEIR and LRC were both "acceptable with minor revisions."

- *Dr. Ken Reimer.* Dr. Reimer concluded that the weight of evidence of the data presented in the DEIR and LRC generally support the reports' main conclusions, especially as they were modified in the Responsiveness Summaries. He thought the data collected for the reports provided an adequate basis for EPA to proceed with its reassessment.

Dr. Reimer then listed several suggestions and recommendations. First, noting that the public might have difficulty identifying the basic messages of the DEIR and LRC, Dr. Reimer recommended that EPA prepare a succinct summary of the major findings of these reports. Second, he strongly recommended that EPA's reports present quantitative findings in appropriate context, particularly with respect to uncertainty. Dr. Reimer suggested that EPA consider presenting ranges of data when the actual values are not known. He cautioned EPA about "over interpreting" data.

Focusing on the main conclusions of the reports, Dr. Reimer indicated that they were generally supported by the data, but with a few caveats. He thought the conceptual models used to interpret the water column transect studies could be improved, for example, with the use of multivariate analyses to "fingerprint" sources of PCBs. Further, Dr. Reimer suggested that the reports not infer that anaerobic dechlorination of PCBs does not occur at PCB concentrations less than 30 ppm. He added, however, that dechlorination is "a

very minor issue" in terms of the overall problem of contaminated sediments. Dr. Reimer then discussed the issue of estimating PCB mass loss in the sediments: he thought the 1984 and 1994 were sufficient for making these estimates; he cautioned against presenting firm estimates of the mass loss; and he also cautioned against using the 1977 sediment coring data for this purpose. Finally, Dr. Reimer concluded that the data suggest that widespread burial of PCBs does not occur in the TIP and that the TIP sediments act as a source of PCBs to the water column.

Overall, Dr. Reimer found the DEIR and LRC to be "acceptable with minor revisions."

- *Dr. Reinhard Bierl.* Dr. Bierl opened his final statements by indicating that the data reported in the DEIR and LRC are sufficient for EPA to proceed with its reassessment, but he identified several aspects of the reports that should be improved to make them more convincing. Regarding the statistical methods used in the reports, Dr. Bierl recommended the use of multivariate analyses to quantify certain trends and additional statistical analyses to calculate changes in PCB inventories. Dr. Bierl then suggested that EPA qualify its quantitative estimates of PCB mass loss to put these figures into perspective. Dr. Bierl added that he wanted to see more information in the reports on the PCB analytical methods (e.g., quality assurance plans and standard operating procedures). He thought this information was particularly lacking for the previous sediment coring studies.

Noting the time gaps between the various sediment coring studies, Dr. Bierl recommended that EPA consider reviewing more recent sampling data and possibly even consider implementing ongoing monitoring studies. He thought future studies should focus on characterizing how PCBs partition between the suspended and dissolved phases, among other research topics.

Overall, Dr. Bierl found the DEIR and LRC to be acceptable with revisions, but he was not sure whether his recommended revisions should be considered "minor" or "major."

- *Dr. Per Larsson.* Dr. Larsson concluded that the data summarized in the DEIR and LRC identified major source areas of PCBs in the Hudson River and characterized the extent of contamination in these areas. Dr. Larsson found that the data indicate a loss of PCBs from the river sediments, but he thought the exact amount of losses are difficult to quantify. He reminded the reviewers, however, that even "a very small percentage" loss of PCBs might have very serious consequences on downstream ecosystems.

Dr. Larsson then reviewed his responses to selected questions in the charge. First, he found that the river sediments in the TIP undoubtedly act as a source of PCBs to the water column; he recommended that EPA include a basic model in the final report to estimate the source loading of the sediments. Second, Dr. Larsson commended EPA's work on differentiating dissolved phase PCBs from suspended phase PCBs—a distinction he thought would be important for future analyses of bioavailability. Third, Dr. Larsson noted

that he and other reviewers had questions about the mechanisms that cause PCBs to enter the water column; he suspected that particle transport (rather than bioturbation or pore water diffusion) is probably the primary mechanism affecting PCB transport. Finally, Dr. Larsson addressed the findings of PCB mass loss and sediment burial. He was convinced that PCBs are gradually transporting with the sediments, and he speculated that the river sediments will continue to redistribute in the future. Noting that the Hudson River is a dynamic system, Dr. Larsson cautioned against assuming data trends from a 10-year time frame are representative of river conditions over the longer term.

Based on his review of the documents, Dr. Larsson thought two specific revisions were necessary. He recommended the use of multivariate statistics for identifying and quantifying trends and patterns among the large volume of congener-specific data. He also recommended the reports thoroughly describe the data analysis methodology, such that the statistical analyses are transparent and easier to follow.

Overall, Dr. Larsson thought the DEIR and LRC were "acceptable with minor revisions."

- *Dr. Ron Mitchum.* Dr. Mitchum split his comments into those specific to the DEIR and those specific to the LRC. Beginning with the DEIR, Dr. Mitchum noted that many of the report's original conclusions had been "softened" in the Responsiveness Summary. He then offered several suggestions for future work on the site and improving the DEIR. He first recommended that EPA include in its ongoing analysis some assessment of evaporative losses and photochemical degradation of PCBs. Dr. Mitchum then suggested that EPA use multivariate statistical analyses to verify many of the findings in the report. He also suggested that the report's conclusions include discussions about uncertainty, particularly in regard to sampling and analytical variability. Dr. Mitchum thought the DEIR's original conclusion of a concentration threshold for anaerobic dechlorination was not well founded.

Dr. Mitchum then summarized his major findings pertaining to the LRC. First, he concluded that EPA did "the best job possible" in comparing the 1984 and 1994 sediment coring data. Dr. Mitchum added, however, that sampling and analytical variability limited the confidence he had in the estimated PCB inventories. Regardless of the uncertainty, Dr. Mitchum believed the 1984 and 1994 data sets support EPA's conclusion that the hot spots in the river have lost PCBs. He cautioned EPA against using the 1977 sediment coring data in the ongoing reassessment. Finally, Dr. Mitchum suggested that use of multivariate statistical analyses was needed to verify conclusions in the LRC.

Overall, Dr. Mitchum thought the DEIR and LRC were both "acceptable with minor revisions."

- *Dr. J. Bruno Risatti.* During his final statements, Dr. Risatti provided general comments about both reports, followed by comments specific to the individual reports. Dr. Risatti

thought the data collected for the reports provide a background for a better understanding of PCB transport in the Hudson River, but he did not think the reports should be considered as an "all encompassing" study. In general, Dr. Risatti was uncertain about some findings in the reports, due largely to the analytical variability in the data. He thought the PCB transport processes could be further characterized by conducting sedimentological studies concurrent with water column sampling. Though he found the reports extensive, Dr. Risatti thought they should have more thoroughly addressed the fate of PCBs by considering aerobic degradation and evaporative losses.

Focusing specifically on the DEIR, Dr. Risatti's primary finding was that EPA should reconsider its conclusions regarding anaerobic dechlorination, particularly the finding of a 30 ppm threshold below which dechlorination does not occur. He then reiterated that the MDPR might underestimate actual dechlorination, since the MDPR is calculated from concentrations of lower homologue PCBs that are more likely to transport from the sediments.

When presenting his comments on the LRC, Dr. Risatti suggested that the study had some evidence of cross contamination of the "vibracore" samples, and he recommended that EPA conduct a basic study to quantify the potential extent of this cross contamination. Noting that he had difficulties reading the LRC (and the DEIR), Dr. Risatti also recommended that EPA develop guidelines for writing technical reports in a format similar to articles in scientific journals.

Overall, Dr. Risatti found the DEIR and LRC to be acceptable with revisions, but he was not sure whether his recommended revisions should be considered "minor" or "major."

5.2 Summary of Peer Reviewers' Final Recommendations

The reviewers' final recommendations, which are detailed in Section 5.1, are summarized by peer reviewer in Table 5-1. (Note that this table does not incorporate any additional recommendations the reviewers made during earlier portions of the meeting.)

Table 5-1
Peer Reviewers' Final Recommendations

| Recommendation | Reinhard Bierl | Per Larsson | Keith Maruya | Ron Mitchum | Ken Reimer | J. Bruno Risatti |
|---|--|---------------------------------|---------------------------------|---------------------------------|---------------------------------|--|
| Overall DEIR recommendation | Acceptable, with revisions that fall between "minor" and "major" | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable, with revisions that fall between "minor" and "major" |
| Overall LRC recommendation | Acceptable, with revisions that fall between "minor" and "major" | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable with minor revisions | Acceptable, with revisions that fall between "minor" and "major" |
| Use multivariate statistical analyses of data | ✓ | ✓ | ✓ | ✓ | ✓ | |
| More prominently acknowledge uncertainty in conclusions; use data ranges to present findings that might be highly uncertain | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Publish a concise summary of the information in the DEIR, LRC, and Responsiveness Summaries | | | ✓ | | ✓ | |
| Consider the limnology of the TIP and other pools in the Hudson River (e.g., how primary production affects PCB fate and transport) | | | ✓ | | | |
| Validate the conceptual models and other findings with more recent water column sampling data | ✓ | | ✓ | | | |

Note: This table summarizes recommendations made during the peer reviewers' final statements; some reviewers might have made additional recommendations during their earlier discussions.

Table 5-1 (Continued)
Peer Reviewers' Final Recommendations

| Recommendation | Reinhard Bierl | Per Larsson | Keith Maruya | Ron Mitchum | Ken Reimer | J. Bruno Risatti |
|--|----------------|-------------|--------------|-------------|------------|------------------|
| Use two-phase partition coefficients until enough data are available to derive three-phase coefficients | | | ✓ | | | |
| Modify the conclusion regarding the 30 ppm threshold for anaerobic dechlorination | | | ✓ | ✓ | ✓ | ✓ |
| Further consider how elevated PCB concentrations in near-shore sediments might affect inventory estimates | | | ✓ | | | |
| Use more sophisticated statistical analyses to estimate PCB inventory | ✓ | | | | | |
| Provide additional details on the analytical methods used in the various sediment coring studies | ✓ | | | | | |
| Better characterize exchange of PCBs between the suspended and dissolved phase | ✓ | | | | | |
| Describe the data analysis methodology in the reports | | ✓ | | | | |
| Consider other compartments in the PCB mass balance (e.g., evaporative losses, photochemical degradation, aerobic degradation) | | | | ✓ | | ✓ |

Note: This table summarizes recommendations made during the peer reviewers' final statements; some reviewers might have made additional recommendations during their earlier discussions.

Table 5-1 (Continued)
Peer Reviewers' Final Recommendations

| Recommendation | Reinhard Bierl | Per Larsson | Keith Maruya | Ron Mitchum | Ken Reimer | J. Bruno Risatti |
|--|----------------|-------------|--------------|-------------|------------|------------------|
| Conduct sedimentological studies concurrent with water column sampling | | | | | | ✓ |
| Conduct an experiment to characterize the extent of cross contamination in "vibracoring" samples | | | | | | ✓ |
| Establish guidelines for writing future reports | | | | | | ✓ |

Note: This table summarizes recommendations made during the peer reviewers' final statements; some reviewers might have made additional recommendations during their earlier discussions.

6.0 REFERENCES

- TAMS et al., 1997. "Data Evaluation and Interpretation Report." Volume 2C of the Hudson River PCBs Reassessment RI/FS. Review copy. Prepared by TAMS Consultants, Inc., The CADMUS Group, Inc., and Gradient Corporation. February, 1997.
- TAMS et al., 1998a. "Responsiveness Summary for: Volume 2A: Database Report; Volume 2B: Preliminary Model Calibration Report; Volume 2C: Data Evaluation and Interpretation Report." Prepared by TAMS Consultants, Inc., The CADMUS Group, Inc., and Gradient Corporation. December, 1998.
- TAMS et al., 1998b. "Low Resolution Sediment Coring Report." Volume 2C-A of the Hudson River PCBs Reassessment RI/FS. Review copy. Prepared by TAMS Consultants, Inc., The CADMUS Group, Inc., and Gradient Corporation. July, 1998.
- TAMS et al., 1999. "Responsiveness Summary for: Volume 2C-A: Low Resolution Sediment Coring Report." Prepared by TAMS Consultants, Inc., and TetraTech, Inc. February, 1999.

APPENDIX A
LIST OF EXPERT PEER REVIEWERS



Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Data Evaluation and Interpretation Report Low Resolution Sediment Coring Report

Albany Marriott
Albany, New York
March 16 - 18, 1999

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APPENDIX B
CHARGE TO EXPERT PEER REVIEWERS



Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Data Evaluation and Interpretation Report Low Resolution Sediment Coring Report

**Albany Marriott
Albany, New York
March 16 - 18, 1999**

Charge

Members of this peer review will be tasked to determine whether the scientific analyses conducted for U.S. EPA's Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC) are credible, the conclusions valid, and whether the findings are appropriate to use to support the decision-making process for the Hudson River PCBs Site Reassessment study. The peer reviewers will base their assessment on the review of the DEIR and LRC, as well as additional information found in the Responsiveness Summary issued in December 1998 (responding to several documents including the DEIR) and the Responsiveness Summary for the LRC (which will be released in February 1999). The peer reviewers will also have available for their review the Hudson River Reassessment database, which contains all of the data used in the preparation of the above documents, along with other data.

The DEIR and LRC present the results of the geochemical analyses conducted on the water-column and sediment data collected for the Reassessment, as well as data collected by a number of other agencies and General Electric. It should be noted that there have been several changes in the available data since the time of the release of the DEIR in February 1997. These changes include a better estimate of flow for several reaches of the river, a recalculation of GE's PCB data due to an analytical bias, and the discovery of a sampling bias at the Thompson Island Dam monitoring station. These changes are discussed in the Responsiveness Summaries, and the analyses in the Responsiveness Summaries should supersede those conducted in the reports, as appropriate.

It is important to realize that the geochemical analysis conducted in the DEIR and LRC will be complemented by mass balance modeling and human health and ecological risk assessments to provide a thorough understanding of the fate and transport and impacts of PCBs in the Upper Hudson River. These other reports will address questions regarding the mechanisms that release PCBs from the sediment, toxicity, and bioavailability/biouptake. A peer review was previously conducted for the approach proposed to conduct the modeling for the Reassessment. After the modeling and the risk assessment reports are released, the Agency will also have those documents peer reviewed.

Specific Questions

Data Evaluation and Interpretation Report (DEIR)

1. Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?
2. Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g., temperature).
3. Are the conceptual models based on the transect sampling consistent with the data?
4. Does the sampling at the TI Dam-West location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?
5. Are the geostatistical techniques (polygonal declustering and kriging) correctly applied?
6. Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR)) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?
7. The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?

Low Resolution Sediment Coring Report (LRC)

1. In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?
2. In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?

3. What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?
4. In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this "gain" is primarily due to incomplete characterization in 1977 valid?
5. Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below TI Dam?
6. The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?
7. Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?

General Questions

1. Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?
2. Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?

Recommendations

Based on your review of the information provided, please identify and submit an explanation of your overall recommendation for both the DEIR and LRC.

1. Acceptable as is
2. Acceptable with minor revision (as indicated)
3. Acceptable with major revision (as outlined)
4. Not acceptable (under any circumstance)

APPENDIX C
PREMEETING COMMENTS, ALPHABETIZED BY AUTHOR

Note: Dr. Reinhard Bierl's premeeting comments were submitted on the first day of the peer review meeting. These comments are included at the end of this appendix.

Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

**Data Evaluation and Interpretation Report
Low Resolution Sediment Coring Report**

Premeeting Comments

Albany, New York
March 16-18, 1999

Notice

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Note: Premeeting comment materials have been reproduced as received.

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**Hudson River PCBs Site Reassessment RI/FS
Data Evaluation and Interpretation Report (DEIR) and
Low Resolution Sediment Coring Report (LRC)
Peer Review 2**

Charge for Peer Review 2

Members of this peer review will be tasked to determine whether the scientific analyses conducted for USEPA's Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC) are credible, the conclusions valid, and whether the findings are appropriate to use to support the decision-making process for the Hudson River PCBs Site Reassessment study. The peer reviewers will base their assessment on the review of the DEIR and LRC, as well as additional information found in the Responsiveness Summary issued in December 1998 (responding to several documents including the DEIR) and the Responsiveness Summary for the LRC (which will be released in February 1999). The peer reviewers will also have available for their review the Hudson River Reassessment database, which contains all of the data used in the preparation of the above documents, along with other data.

The DEIR and LRC present the results of the geochemical analyses conducted on the water-column and sediment data collected for the Reassessment, as well as data collected by a number of other agencies and General Electric. It should be noted that there have been several changes in the available data since the time of the release of the DEIR in February 1997. These changes include a better estimate of flow for several reaches of the river, a recalculation of GE's PCB data due to an analytical bias, and the discovery of a sampling bias at the Thompson Island Dam monitoring station. These changes are discussed in the Responsiveness Summaries, and the analyses in the Responsiveness Summaries should supercede those conducted in the reports, as appropriate.

It is important to realize that the geochemical analysis conducted in the DEIR and LRC will be complemented by mass balance modeling and human health and ecological risk assessments to provide a thorough understanding of the fate and transport and impacts of PCBs in the Upper Hudson River. These other reports will address questions regarding the mechanisms that release PCBs from the sediment, toxicity, and bioavailability/biouptake. A peer review was previously conducted for the approach proposed to conduct the modeling for the Reassessment. After the modeling and the risk assessment reports are released, the Agency will also have those documents peer reviewed.

Specific Questions

Data Evaluation and Interpretation Report (DEIR)

1. Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?
2. Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g., temperature).
3. Are the conceptual models based on the transect sampling consistent with the data?
4. Does the sampling at the TI Dam-West location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?
5. Are the geostatistical techniques (polygonal declustering and kriging) correctly applied?
6. Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR)) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?
7. The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?

Low Resolution Sediment Coring Report (LRC)

1. In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?
2. In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with

respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?

3. What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?
4. In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this "gain" is primarily due to incomplete characterization in 1977 valid?
5. Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below TI Dam?
6. The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?
7. Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?

General Questions

1. Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?
2. Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?

Recommendations

Based on your review of the information provided, please identify and submit an explanation of your overall recommendation for both the DEIR and LRC.

1. Acceptable as is
2. Acceptable with minor revision (as indicated)
3. Acceptable with major revision (as outlined)
4. Not acceptable (under any circumstance)

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Dr. Reinhard Bierl

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Comments not available at time of print

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Dr. Per Larsson

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Lund February 1999-02-23

Review of the "Data evaluation and interpretation report (DEIR) and low resolution sediment coring report (LRC).

Per Larsson
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University of Lund Sweden

1. Introduction and major conclusions

The PCB problem in the Hudson River system is in my view a serious one, and the extent of the problem has several aspects that cover such areas as exposure and effect of aquatic biota; transport of the compounds from the source areas to the lower Hudson river and ultimately to the sea; volatilization from river water to the atmosphere (with a consequent exposure to terrestrial environments or further atmospheric transport); contamination of groundwater and river bed soils. The risk for human exposure of PCB in the area from e.g. fish and by lower extent by (drinking) water is obvious. The list of problem areas can, furthermore, be expanded substantially.

As I see it, a few simple and straightforward questions or objectives can be drawn from the two reports cited above, and if these are answered or fulfilled, I find that the reports can be considered as acceptable. It is then obvious that the studies answering the questions need to be carried out in a scientifically acceptable way and that the conclusions drawn are appropriate. The questions or objectives are:

*The major source areas (sediment) for PCB contamination can be identified.

*What is the extent of the PCB contamination in the source areas?

*Has the extent of the PCB contamination in the sediment (concentration, mass) changed over time?

*PCB in the sediment of the source areas affects concentration in the water (i.e. there is a PCB transport over the sediment/water interface).

*What is the extent of the sediment to water transport of PCB?

*PCB from the source areas are transported downstream.

*How does PCB in the river water speciate between the dissolved and particulate phase? The answer to this question is interesting in two ways:

- i. the transport form of PCB in the river water (and possible resedimentation, readsorption, etc.)

- ii. for exposure to biota.

These are the major points that need to be evaluated, in order to establish a base for understanding of the fundamental behaviour of PCB in the upper Hudson River. Within the questions or objectives lie understanding of the potential variables of importance, like the effect of water discharge, water temperature, microbial activity etc. In addition to these points, other items of interest can be identified that cannot be considered to cover the main objectives, but may lead to understanding of the underlying mechanisms like:

*Is a potential change over time in PCB concentration in the sediment at one site due to transport to the water?

* Is a potential change over time in PCB concentration in the sediment at one site due to microbial, anaerobic dechlorination?

*Is a potential change over time in PCB concentration in the sediment at one site due to transport of contaminated sediment downstream?

* Is a potential change over time in PCB concentration in the surface sediment at one site due to burial by new, uncontaminated sediment?

The question of microbial, anaerobic dechlorination of PCB in the sediment is addressed thoroughly throughout the report, but for me this question has nothing to do with the main objectives of the studies. As anaerobic dechlorination as a process only dechlorinate congeners containing meta- and/or para positions and, consequently, reduce more chlorinated congeners to less chlorinated, it cannot be considered as a sink process for PCB. No ring cleavage or break-down of PCB occurs through this mechanism (e.g. Bedard et al. 1986). It will, however, have effects on the transport of PCB across the sediment/water interface (possibly increase the transport as low-chlorinated congeners have a higher transport-rate than high-chlorinated ones), and on toxicity and bioaccumulation.

In conclusion, I find that the important issues raised above have been addressed in the reports and in a majority of cases also have been satisfactory answered. I find that the two reports, DEIR and LRC, are acceptable. As no studies or reports are perfect, some minor revisions can be made as stated below, on parts of the material. My main negative comments are:

- a) Multivariate data are best treated by multivariate statistics, as by Principal Component Analysis (PCA), Cluster analysis or Regression Tree. PCA would have been suitable for the data sets, resulting in a more comprehensive and objective analysis of the data (Zitko 1989, Bremle and Larsson 1997). The results are now concluded from individual regression or correlation analysis, similarities of curves, tests

of individual data sets, congener pattern etc. I do not conclude that these analysis are carried out in a erroneous way, they would probably be good instruments to combine with e.g a PCA approach. They do not, however, give a good overview in analysis of the whole data set. The PCA could have been especially useful for the congener "fingerprinting" in source identification, comparisons between matrixes, and indications of processes as anaerobic dechlorination as well as for determining variable importance (like discharge, water chemistry, etc. (Zitko 1989, Bremle and Larsson 1997, Bremle and Larsson 1998).

- b) The sampling of river water for PCB is not as advanced as the sediment sampling program. It would have been better to have introduced more permanent sampling stations and pump up water from a defined water depth (10-20 cm below the surface in the centre of the river), and taken integrated, continuous water samples over time (Bremle and Larsson 1997). The water volumes taken in the sampling program, 17 L, is quite sufficient for PCB analysis, while 1 L is not (1 L sampling will lead to substantial errors in the quantification process). The separation in dissolved and particulate phase PCB by filtering is a good approach, that facilitate later transport and exposure estimates of PCB.
- c) Incomplete homogenisation of sediment samples, which could have been the case in the LRC program, may lead to errors in conclusions of PCB concentration and PCB mass in large sediment slices. It's tricky to homogenise a large amount of sediment containing low percentages of water. Note that I state may, it's hard to conclude from the reports that this was really the case.

2. Specific questions

2.1 DEIR

2.1.1. Historically deposited PCB contaminated sediment has been shown to contaminate the water of rivers (Brown et al 1985, Chevreuil and Granier 1991, Bremle and Larsson 1997). In principal, PCB transport from sediment to water of river systems is determined by i) water discharge, where high discharges (flooding) results in turbulence of the river sediment, and a consequent downstream transport of PCB contaminated particles (Chevreuil and Granier 1991). This transport does not change the PCB fingerprint in the water column (as stated in the report and Bremle and Larsson 1998) ii) temperature, where desorption (partitioning) from sediment is enhanced with increasing temperature and changing the PCB pattern to a low-chlorinated one (Larsson et al 1990). The process is enhanced by processes such as bioturbation by benthic invertebrates, and by microbial processes that mineralise organic matter in the sediment (Jeremiason et al. 1998, Larsson et al 1990). These processes are affected positively by concentration of PCB in the sediment (a higher sediment to water

transport) and the latter three negatively to the organic carbon content in the sediment (e.g. Steen et al 1978, Lara and Ernst 1990).

The present study shows that the PCB load into Thompson Island pool (TI) is less than the transport out of the pool, than revealing an addition of PCB from within the pool, a PCB transport from sediment to water. Further, water parcels is followed downstream by simultaneous sampling revealing some dilution of PCB by increasing water discharge and some smaller addition to the PCB load (or constant PCB mass transport depending on sampling station). Fingerprinting of PCB congeners within the TI pool water and downstream show that the PCB originated from the pool. The results are convincing, and very similar to results obtained for a PCB contaminated river system in Sweden (Larsson et al. 1990, Anon 1998), where one single source (a small lake with PCB contaminated sediments within the river system, water residence time about 4 h for the lake) affected the whole river system downstream.

2.1.2. The two-phase and three-phase models are appropriate to use for predicting PCB partitioning between the dissolved and particulate phase in the water, and the models can be scrutinised in detail by using the extensive international literature on this subject (e.g. Horzempa and DiToro 1983, Baker et al. 1986). I find the approaches a bit out of focus for the objectives of this study. Instead, it would have been useful to include an empirical modelling work on, for instance, TI pool using variables as sediment surface (as determined by coring and side scan-sonar) and sediment concentration of PCB, water discharge and temperature to predict transport and mass-balances over time (Larsson et al. 1990, Bremle and Larsson 1997). In this way an empirical model for PCB in the upper Hudson River can be constructed and applied for different situations. For prediction on bioavailability of PCB the proposed models seem to be appropriate (dissolved versus particulate PCB).

2.1.3. The conceptual reasoning of PCB fate in the upper Hudson River is convincing and show that the authors of the report know the literature. The discussion on how the sources (PCB containing sediment) affect PCB in the water column, how concentrations of PCB decrease downstream as a result of volatilisation, and adsorption/settling, dilution by increasing water discharge in the river as the catchment area increases, are logic and can be understood by the reader. The figures underlying the reasoning could have been simplified, given a logic system of location numbering etc., but this is just a technical matter.

2.1.4. I don't find that the sampling location would affect the conclusion that TI pool is the major source of PCB to the upper Hudson River system. As far as I understand, corrections have to be made only under low flow conditions. As the PCB load follow water discharge, the major PCB loads occur under higher flow situations. As stated in my introduction, however, water sampling near the riverbanks (sides) or just upstream of large objects should be avoided, as there is a risk of sampling turbated, nearshore sediment or upwelling sediment. The

possible erroneous sampling can be detected in the results by studying filtered particle amounts in the water (too high amounts of particle dry mass), as stated by the report authors.

2.1.5. The applied techniques for evaluating sediment-coring analysis, and to calculate PCB masses for larger sediment areas (i.e. hot spots) using polygonal clustering and kriging seem correct to me. A further development suggested by the report authors to use results from side scan-sonar to identify primary accumulation areas containing small particles high in PCB and organic content, and combine that with polygonal clustering (clustering coring points within an accumulation area), seems even better.

2.1.6. In order to evaluate if microbial, anaerobic dechlorination of PCB has occurred in the sediment, the authors use enrichment in congener 1, 4, 8, 10 and 19 versus the total sum of all congeners as an index. The index is quite appropriate, and will reveal if dechlorination has occurred for the sample. There are other ways of constructing similar indexes, the important factor to consider is that the proportion of the dechlorination products (congener 1, 4, 8, 10 and 19) can be compared with the same congeners in a sample not subjected to dechlorination (or a standard) and the difference revealed. This is simple to perform for a limited data set of congeners but when a larger data set is to be evaluated, indexes have limitations. It is then more appropriate to evaluate the whole PCB pattern by a multivariate method, like principal component analysis (PCB, Bremle and Larsson 1997). If significant dechlorination has occurred in samples, this will be revealed by clustering of these data in a PCA plot.

2.1.7. I fully agree that the degree of anaerobic dechlorination is a function of the original PCB concentration in the sediment. The predictive model (figure) showing that the extent of dechlorination start to be significant at ca 30 ppm PCB is elegant, and show scientific skill. As stated in the introduction, I don't find that the subject of anaerobic dechlorination of PCB is a central objective of the study. The study by Williams and May (1997) suggesting that low-temperature microbial degradation was significant for di- and trichlorobiphenyls in laboratory model systems, and possibly connected to the reduction/oxidation of the iron cycle in the sediment surface seems to have higher relevance (although I find objections to parts of this study).

2.2. LRC

2.2.1. It is obvious that comparisons between concentrations of PCB in sediment cores, taken in similar areas from 1977, 1984, and 1994, will show variations due to i) the sampling methods used ii) the improvement of the analytical methods used, like capillary columns iii) the use of surrogate and internal standards. I do not, however, consider this a serious problem since you have to expect variation due to the analytical methods used in a time period >15 years. I find the quality control of the present study satisfactory, as well as the use of dual GC-columns,

and use of surrogate standards,(it is a bit confusing though, that the use of octochloronaphtalene (OCN), did not work out. We have used it extensively when analysing sediment for PCB at the ecotoxicology laboratory at Lund University), and confirmation on GC/MS for some of the samples.

To my experience, there is a much greater variation in the field sampling strategies between different studies and years, that lead to variability in the data and make comparisons hard to do. This kind of problems are hard to overcome, due to lack of information.

2.2.2. It is indeed so that the spatial heterogeneity is large for sediment in rivers, and thus concentration of PCB (e.g. Bremle and Larsson 1998 and references herein) in a 10-15 year period, accumulation areas within a river may change due to flow events and man-made measures upstream. It is possible that the core sampling locations in 1984 or earlier are not the same (i.e. that they don't show identical conditions) as in 1994. There are no statistical techniques that help to compensate for this (as stated in peer review questions). The techniques (statistical analysis) used by the authors generally seem to be adequate. It is, however, impossible for me to follow the statistical template used. The approach should be very simple; data on PCB concentration in the sediment (e.g. $\mu\text{g/g}$ dry weight) or PCB mass per surface area of sediment ($\mu\text{g}/\text{dm}^2$) from the defined area are compared in two populations, one from 1984 and the other from 1994. The comparison is limited by the number of cores taken at each sampling occasion, and nothing else. As the populations are log/normally distributed, PCB concentration data are log-transformed. A simple comparison test will now reveal if the populations differ significantly or not, and the direction the difference (PCB concentration 1984 > PCB concentration 1994). If significant (and only then), the possible decrease between years can be calculated, as carried out in the present report. I cannot elucidate if this was the case, as the statistical approach/calculation pattern is not transparent (I cannot follow it from step to step). A flow scheme of the statistical tests used would have been a great help. Further, high spatial variability (or any other high variability) can only be described properly by using a larger number of samples, reflecting the variability.

3. 2.3. The results from the "replicate" samples in 1994 from TI pool show a 36% average variability. At the same time, conclusions are reached that a 40% loss of PCB has occurred from the TI pool sediment from 1984 to 1994. I did a very simple simulation, using the average 10 g PCB m^{-2} in sediment for TI pool in 1984, a 40% decrease to 1994 and simulated all other data, obtaining a standard deviation around 36% for the two data sets (the variation thus defined by the standard deviation and $n=19$ for each data set). Understanding that this is a major simplification, the results revealed that the decrease in PCB concentration was significant (Student's t , $p<0.001$). So I cannot see any problems with the conclusion, assuming that the number of samples underlying the analysis is large enough (again I cannot follow the statistical testing).

Table 1. A simulated data set for changes of PCB concentrations in TI pool from 1984 to 1994 (N=19 for each sampling occasion in time).

| Sample No | Sediment 1984 (g/m ²) | Sediment 1994 (g/m ²) |
|--------------------|--------------------------------------|--------------------------------------|
| 1 | 10 | 6 |
| 2 | 15 | 11 |
| 3 | 8 | 4 |
| 4 | 7 | 3 |
| 5 | 14 | 10 |
| 6 | 9 | 5 |
| 7 | 8 | 4 |
| 8 | 9 | 5 |
| 9 | 12 | 8 |
| 10 | 12 | 8 |
| 11 | 11 | 7 |
| 12 | 13 | 9 |
| 13 | 6 | 2 |
| 14 | 6 | 2 |
| 15 | 8 | 4 |
| 16 | 9 | 5 |
| 17 | 17 | 13 |
| 18 | 4 | 0 |
| 19 | 8 | 4 |
| Average | 9.8 | 5.8 |
| Standard deviation | 3.4 | 3.4* |

*= higher than the 36% variation mention earlier

2.2.4. In the study of 1994, the calculated mass of PCB in the sediment of Hot Spot 28 was 20 metric tons. Previous estimations resulted in a mass of 2 – 7 metric tons. In the present study there was no evidence of overall burial of "old" sediment, <50% of the sediment core profiles. The only possible transport that would result in a transfer of >10 metric tons of PCB in a sediment in a river is a very large resuspension event in the upstream river system, transferring contaminated sediment downstream from one hot spot and depositing the sediment in Hot Spot 28 (with no similar transport to other areas). This is highly unlikely. Another unlikely explanation is a direct PCB discharge to Hot Spot 28. Ruling out these explanations the proposed one seems likely; the previous calculations underestimated PCB mass.

2.2.5. I agree to the conclusion that losses of PCB have occurred from TI pool to the river system downstream. Highly PCB contaminated sediment in rivers will have a major impact on PCB concentration in water and aquatic biota within the area of deposition and downstream (Brown et al 1985, Larsson et al. 1990). This impact is caused by a transport of PCB over the sediment/water interface, i.e. a loss of PCB from the contaminated area. The PCB loss from sediment need not to cause any significant decrease of PCB in the sediment (decrease in concentration), to cause substantial increase of PCB in water and biota. I do agree that that losses have occurred from the TI pool and from hot spots downstream. If the magnitude of these losses over a 10 year-period exceed 10% or more, this is caused by particle transport. Contaminated sediment particles are resuspended and transferred downstream at high discharge events. These events are frequent in rivers. I do not conclude losses of this magnitude to be caused by desorption of PCB from sediment to water, bioturbation or anaerobic dechlorination.

2.2.6. Within a river, sediment is subjected to resuspension, transport and resedimentation. As pointed out earlier, the extent of these processes depends on the water discharge. As discharge follow a seasonal cycle, sediment transport events are likely to occur during spring flooding. As the magnitude of flooding may vary greatly in a decade and even more in a longer time span, the transport/resuspension events occur irregularly. Being a dynamic system, there are no true sediment accumulation areas in a river, all sediment may be transported downstream. Therefore, any burial of contaminated sediment is just temporary. This is also shown in the LRC study.

2.2.7. I find the results from the side-scan sonar and the connection to particle size distribution very convincing. It's a good approach for determining the extent of temporary accumulation areas of organic sediment and thus areas with high PCB concentration.

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Dr. Keith Maruya

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Specific Questions

Data Evaluation and Interpretation Report (DEIR)

- 1. Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?*

PCB contaminated sediments in the TI Pool were the most likely source of the water column loads described during summer low flow periods in the 1993 Phase 2 Transect study. A look at the corrected homolog distributions for the Transect study (Figs. 3-38, 3-40, 3-43 and 3-47 in Appendix C, LRC Responsiveness Summary) shows that for various flow conditions, total and dissolved PCBs greatly increase at the TI Dam relative to Rogers Island. In the absence of some undiscovered source, this sharp increase in dissolved PCBs strongly suggests a local source. Corrected estimates of PCB loading in the Upper Hudson are less consistent, with the bulk of the loading occurring above the TI Pool in the early transects of 1993 (Figs. C-6 and C-12 corresponding to Transects 1 and 4), switching clearly to the TI Pool during later, low flow transects (Figs. C-14 and C-16 corresponding to Transects 5 and 6). Both instantaneous ("transect") and 15d flow-averaged data reveal consistent patterns in loadings.

Load is the product of concentration and flow rate. Since it is assumed that flow rate increases with decreasing river mile (i.e. as one heads downstream), it follows that water column PCB concentrations in the river must decline after the TI Pool during summer low flow conditions. Conversely, PCB concentrations upstream of the TI Dam, and in particular in the TI Pool itself, must increase more rapidly than flow rate to sustain the consistent increase in loading observed. Plotting of total and dissolved PCB data for transect 6 illustrates this clearly (Fig. D1-1 below).

The origin of the PCBs within the TI Pool sediment inventory and what is meant by "historically-deposited" is less clear. From the LRC study, it is clear that "shallow" layers (<10 in depth) still contain a large PCB inventory at many TI Pool locations. Whether the water column PCBs originated from deeper, historically contaminated layers or recently deposited sediments cannot easily be determined. My own analysis of the LRC data indicates that sediment PCBs are split roughly 50:50 between shallow (0-8cm) and deep (>8 cm) layers (see also my comment on LRC Question 6). Each layer is dechlorinated, deeper layers probably being more so.

Another confounding factor that complicated interpretation of likely PCB sources, especially for the early 1993 transects (winter low flow and early spring high and transition flow), was the bulk release of Aroclor 1242-like PCBs from the Allen Mills source, reported to have ceased sometime during the middle of 1993. A major source of PCBs during this period was clearly the stretch above Rogers Island. Post 1993 water column data would have been extremely helpful, however, they were never put into a single, coherent presentation that this reviewer could comment on.

The only alternative explanation for these profiles is selective leaching of mono- and dichloro homologs from relatively immobile free product (oil droplets) upstream of the TI Pool. This would also require enhanced or accelerated "dispersion" of these homologs away from the source and a corresponding attenuation of trichloro- and higher homologs ("Tri+") in sediments upstream of the TI Pool. This scenario, however, would have been observed as a gradual shift in the homolog profile between the upstream Allen Mills source and the head of the TI Pool (Rogers Island). Since the sediments and water column samples collected at Rogers Island had a very different homolog pattern than that within the TI Pool (Figs. C-2 through C-4, and 3-38, 3-40, 3-43 and 3-47), this scenario is not a very likely one.

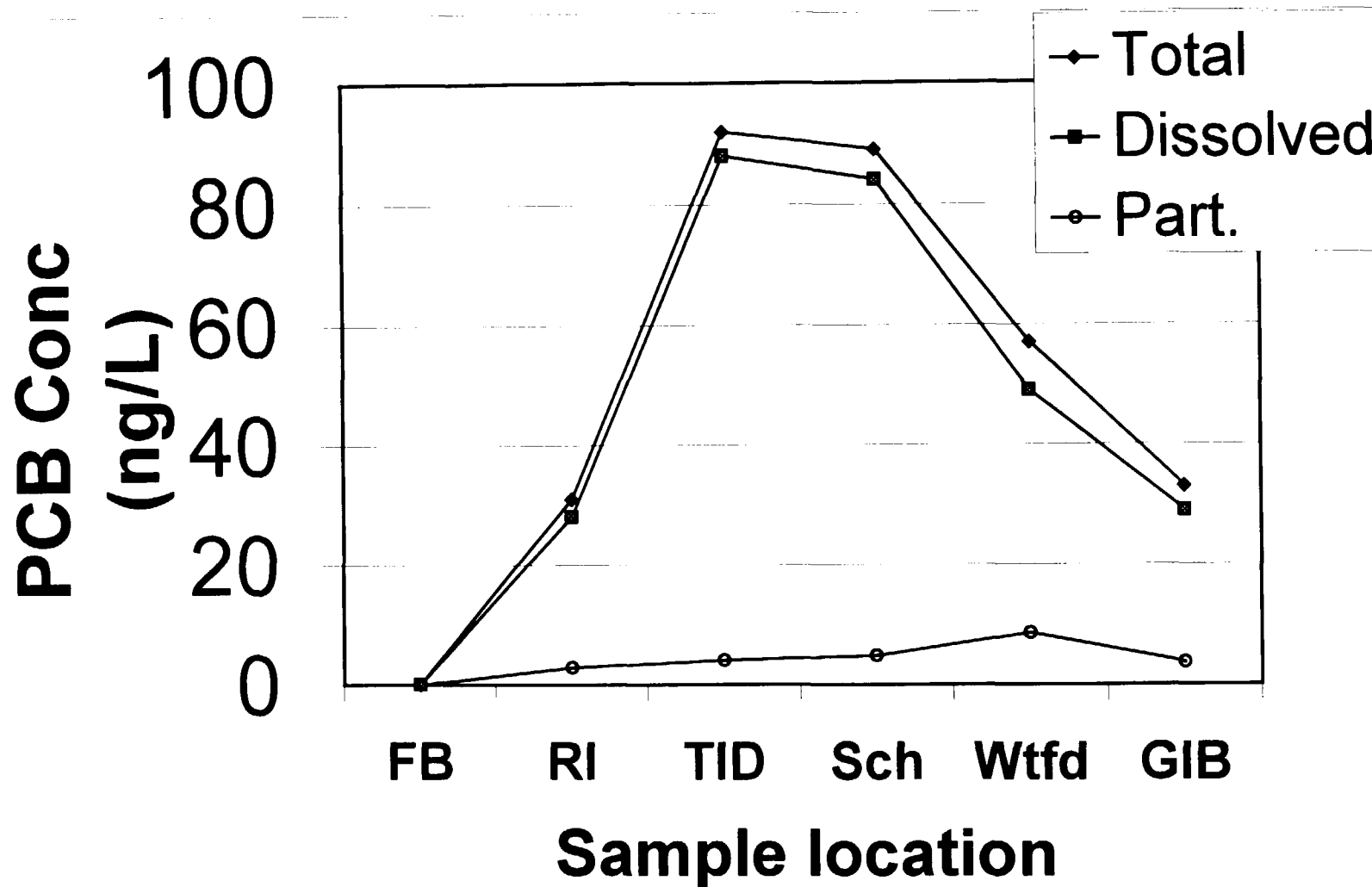


Fig. D1-1. Water Column PCB Concentrations for Summer-Low Flow Conditions (Transect 6)

2. Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (i.e. temperature)?

Based on its magnitude and trend relative to the octanol-water partition coefficient (K_{ow}), estimated values of the particulate organic carbon partition coefficient (K_{POC}) appear to be reasonable, but estimates of partitioning to dissolved organic carbon (K_{DOC}) should be viewed with skepticism and used with caution. The background discussion on two- and three-compartment partitioning theory and pertinent relationships/equations presented in section 3.1 of the DEIR are scientifically and mathematically sound. It is obvious, however, that *in situ* water column partitioning ratios reported in the Phase 2 study varied by orders of magnitude for the same congener, even when normalized to particulate organic carbon (POC) (see DEIR, Table 3-6a). A temperature correction was invoked to further help explain and account for this variability, the effect of which was consistent with experimental determinations (Warren et al. 1987). Estimates of K_{POC} and K_{DOC} were thus made based on attempts to fit available *in situ* data into equilibrium, mass balance and temperature correction relationships.

These estimates are presented for partitioning in the water column in Table 3-8 of the DEIR, and appear again as corrected values for bedded sediments (i.e. sediment and porewater distributions) in Table 2-2 of Book 3 of the DEIR Responsiveness Summary. In Table 2-2, K values are given for coeluting congener combinations with $K_{POC} > K_{DOC}$ without exception. My own analysis of the data show that log K's are positively correlated with log K_{ow} ($p < 0.01$; see Fig. D2-1 and Table D2-1 below). For New Bedford Harbor sediments, positive K_{POC} - K_{ow} associations were also noted by Burgess et al. (1996) and Brownawell and Farrington (1986). However, in Table 3-8, one curious exception is noted for BZ#8, where the estimated K_{POC} (5.19) is less than K_{DOC} (5.43). No explanation is given for this unique trend reversal, other than the fact that footnote "c" in Table 3-8 indicates some sort of blank problem. It is not clear if the congener specific results in Table 3-8 will be used in the future. If they are, I suggest that values for BZ#8 be revisited. If the data for BZ#8 turn out to be of questionable quality, interpolation or regressions based on aqueous solubility or K_{ow} , should be considered to estimate K values for this congener. For any future predictions of K, a quick check of the trend with increasing chlorines (or log K_{ow}) can be performed as a quick sanity check of the model.

On a more general note, it is not clear why all the effort was made to model the effects of DOC, especially since it was noted in the original version of the DEIR that DOC was fairly constant at ~5 mg/L in the water column. If these data were accurate, then one can conclude that DOC in the water column would exert a relatively constant and predictable influence in terms of partitioning. A case can be made that DOC in porewater of fine-grained sediment, although higher, would be relatively constant as well. In fact, in the example given in the DEIR Responsiveness Summary, Book 3, DOC was estimated @ 34 mg/L, ~10 times higher than that measured/assumed in the water column. The high degree of uncertainty in modeling the effects of DOC make it more of a mental exercise and less of a practical tool for modeling. The danger also exists that "over-manipulation" of model parameters such as partitioning constants can be abused to better fit *in situ* values.

I would thus recommend simplifying the partitioning model back to a 2-phase model instead of a 3-phase model. In the 2-phase model, DOC would be included as a more-or-less constant influence in the apparent or operationally defined dissolved phase.

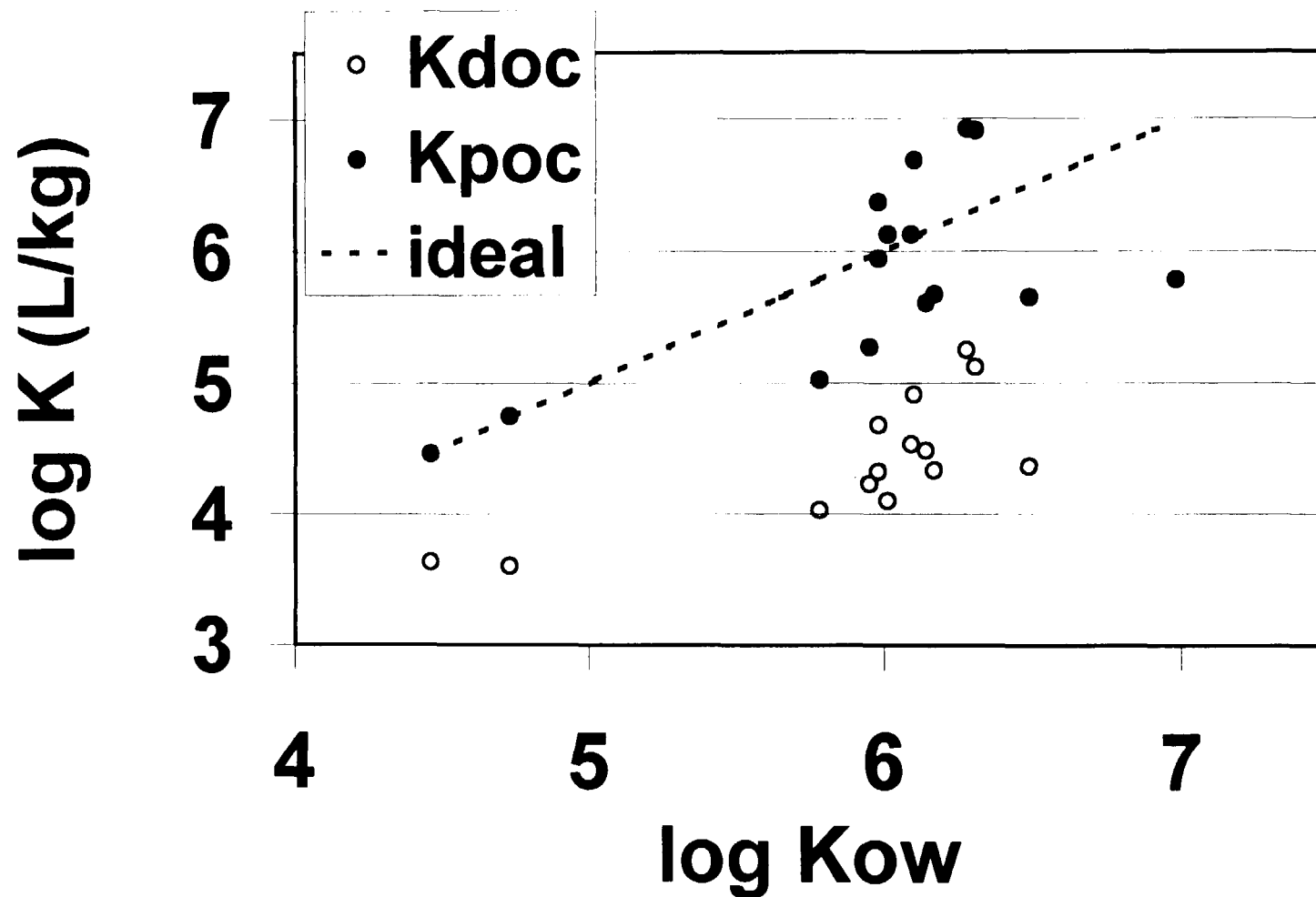


Fig. D2-1. Estimated Phase 2 log K's show increasing trend with $\log K_{ow}$ (Hawker and Connell 1988)

SUMMARY OUTPUT: log K_{oc} vs. log K_{ow} (H&C)

| <u>Regression Statistics</u> | |
|------------------------------|----------|
| Multiple R | 0.653364 |
| R Square | 0.426885 |
| Adjusted | 0.382799 |
| Standard | 0.490518 |
| Observatio | 15 |

ANOVA

| | df | SS | MS | F | gnificance F |
|-----------|----|----------|----------|----------|--------------|
| Regressio | 1 | 2.329824 | 2.329824 | 9.683055 | 0.008258 |
| Residual | 13 | 3.127909 | 0.240608 | | |
| Total | 14 | 5.457733 | | | |

| | Coefficient | andard Err | t Stat | P-value | ower 95% | pper 95% | ower 95.0 | pper 95.0 |
|------------|-------------|------------|----------|----------|----------|----------|-----------|-----------|
| Intercept | 2.76122 | 1.0368 | 2.663213 | 0.019515 | 0.52135 | 5.001091 | 0.52135 | 5.001091 |
| X Variable | 0.55038 | 0.176871 | 3.111761 | 0.008258 | 0.168274 | 0.932487 | 0.168274 | 0.932487 |

SUMMARY OUTPUT: log K_{doc} vs. log K_{ow} (H&C)

| <u>Regression Statistics</u> | |
|------------------------------|----------|
| Multiple R | 0.733528 |
| R Square | 0.538063 |
| Adjusted | 0.50253 |
| Standard | 0.416725 |
| Observatio | 15 |

ANOVA

| | df | SS | MS | F | gnificance F |
|-----------|----|----------|----------|----------|--------------|
| Regressio | 1 | 2.629623 | 2.629623 | 15.14239 | 0.001856 |
| Residual | 13 | 2.257577 | 0.17366 | | |
| Total | 14 | 4.8872 | | | |

| | Coefficient | andard Err | t Stat | P-value | ower 95% | pper 95% | ower 95.0 | pper 95.0 |
|------------|-------------|------------|----------|----------|----------|----------|-----------|-----------|
| Intercept | 1.088098 | 0.880824 | 1.235317 | 0.238572 | -0.81481 | 2.991003 | -0.81481 | 2.991003 |
| X Variable | 0.58472 | 0.150263 | 3.891322 | 0.001856 | 0.260098 | 0.909343 | 0.260098 | 0.909343 |

Table D2-1. Linear regression indicates statistically significant ($p < 0.01$) positive correlations between log K and log K_{ow}

3. *Are the conceptual models based on the transect sampling consistent with the data?*

The overall conceptual model invoked to explain the 1993 transect data is consistent with the corrected data/profiles contained in the LRC Responsiveness Summary, Book 1, Appendix C. This basic model, characterized by the reviewer in Fig. D3-1 below, translates the PCB load picked up in the upper reaches of the Upper Hudson via advection. Translation of PCBs into the water column of the TI Pool is expressed by a combination of sediment porewater exchange and advection/diffusion across the sediment-water interface, and exchange between resuspended sediment and the water column. This combination of processes is purported in the DEIR Responsiveness Summary, Book 3, to be consistent with the mono-, di- and trichloro homolog distribution observed for dissolved phase PCBs. Sediment porewater exchange was also found to be an important mechanism for PCB loading into the lower Hudson (Achman et al. 1996). Losses downstream of Rogers Island, and in particular downstream of the TI Dam, are suggested to be the result of gas exchange and/or aerobic degradation.

Because of their physicochemical properties including aqueous solubility and Henry's Law constants (see Fig. D3-2 below), mono- and diCBs will preferentially partition into the dissolved phase and into the atmosphere relative to heavier homologs. If air above the Hudson River is undersaturated, a constant flux of PCBs to the atmosphere can act to continually pull PCBs from the source (sediment) into the water column so that a concentration gradient is maintained.

More limnological data (e.g. residence times; chlorophyll *a*, temperature gradients/stratification during summer low flow conditions) would likely improve our understanding of the processes at work in the TI Pool. For example, this stretch would seemingly act much more like a lake than upstream and/or narrower stretches of the Upper Hudson. As such, the processes acting on PCBs that are enhanced under lake-like conditions will be most important. The larger surface area to volume, increased residence time and quiescent flow regimes would likely result not only in greater fluxes of PCBs out of sediments and into the water column, but also into the air! Mass transport between phases is dependent both on the magnitude of the concentration gradient and surface area. The increased dissolved phase PCBs thus provide a larger driving force for transport out of the water column into the air. This flux would increase under summer, low-flow conditions when both air and water temperatures are at their annual maximum.

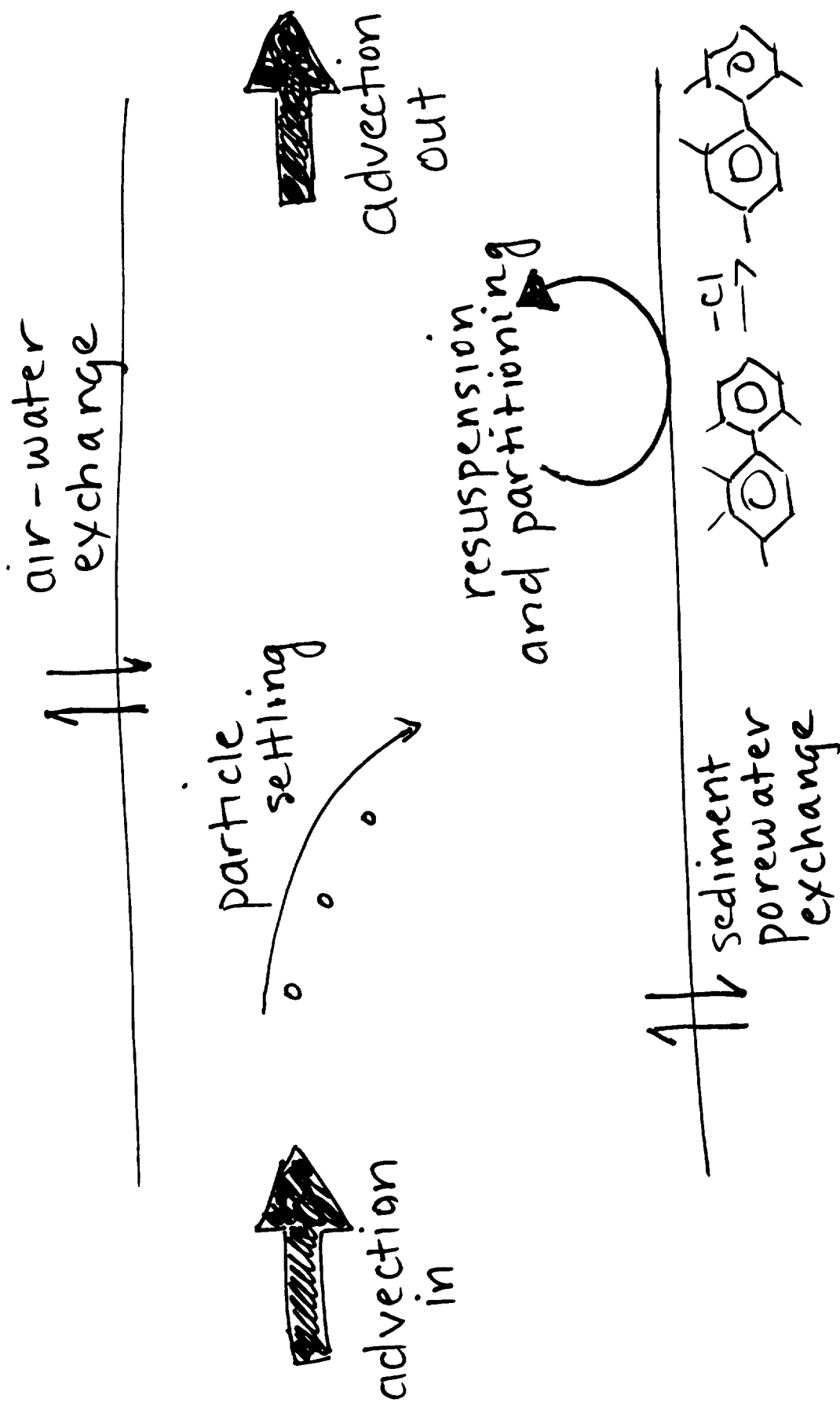


Fig. D3-1. Model of PCB loading and downstream transport.

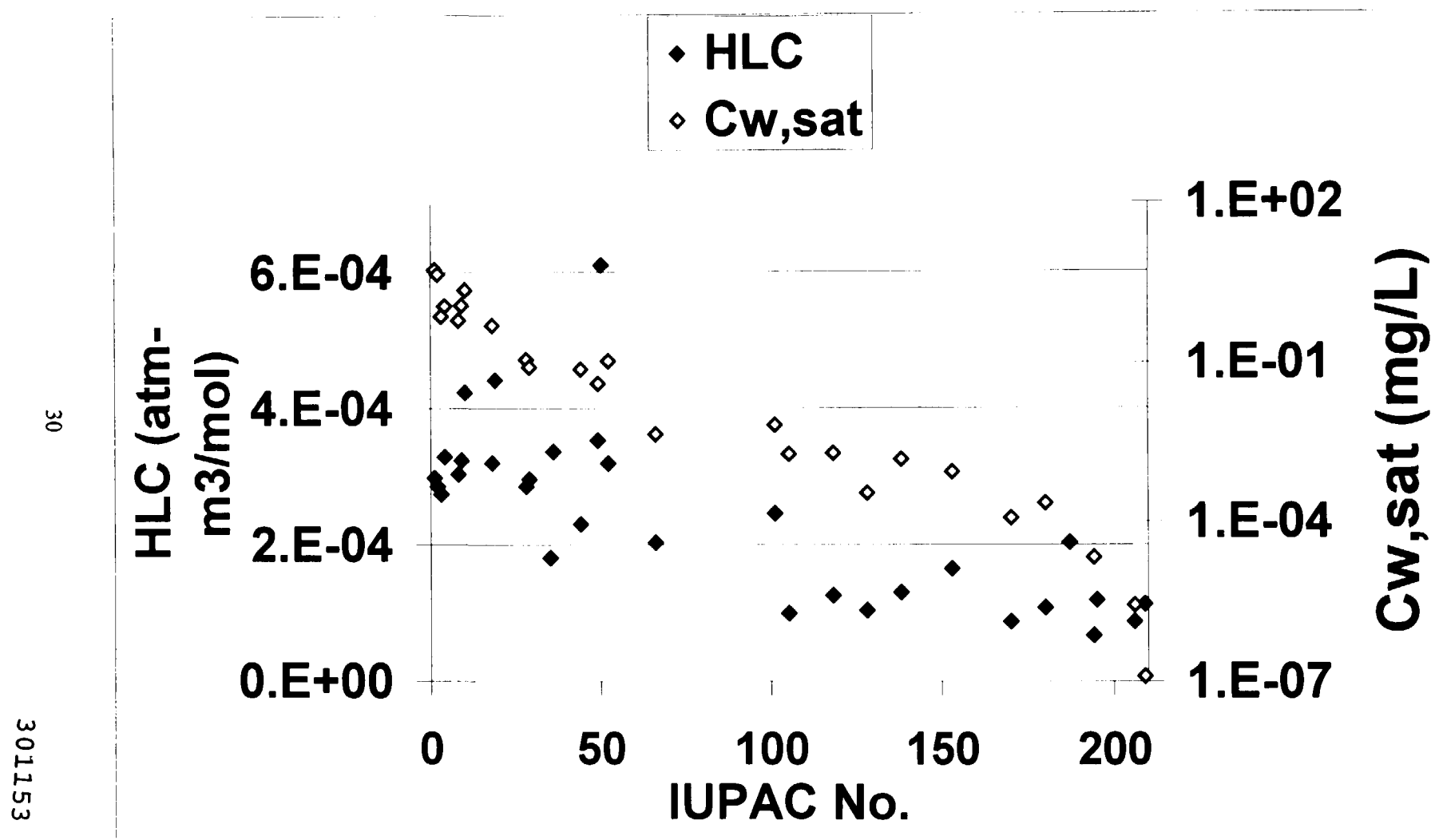


Fig. D3-2. Aqueous solubilities and Henry's Law constants (from Dunnivant et al. 1992)

4. *Does the sampling at the TI Dam-West location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?*

Clearly, accurate estimation of PCB loads, and changes thereof, in the fashion adopted by EPA, relies on representative sampling of River conditions. Lateral and vertical heterogeneity in water column PCB concentrations result in estimations with greater uncertainties. If the sampling station at the TI Dam renders artificially high concentrations, loading will be exaggerated; conversely, if the station is isolated in a mainstream channel or at a depth where concentrations are artificially low, loadings will be underestimated.

As thoroughly stated in Book 3 of the Responsiveness Summary for the DEIR, **any sampling bias imparted due to systematically high PCB concentrations measured at TI Dam West location were more than offset by the underestimation of water column PCB concentrations.** The analytical bias was deemed to be 40% on average whereas the sampling bias was 40% maximum (low-flow, low concentration @ Rogers Island), a condition that was deemed to exist in 2 of the 7 years that data was collected (1991-97). **These biases appear to be mostly a wash, and loadings stated in the original DEIR report appear to be correct in relative, if not absolute magnitude.**

If water column (and sediment) PCB concentrations are higher in nearshore areas, several implications to both modeling and monitoring efforts can be envisioned. First, spatial coverage and resolution criteria for estimating PCB mass inventory need to be revisited. Specifically, are "hot spot" near shore areas represented with sufficient spatial resolution? If the higher nearshore PCB concentrations were not accounted for in the Phase 2 kriging analysis, an underestimate of total PCB inventory may have resulted. Second, what is the degree of mixing between shallow and center-channel regimes of the TI Pool? Third, what are the airborne losses associated with shallow vs. deep portions of the Pool? Fourth, what is the net suspended sediment deposition rate in these areas? Are these fine grained near shore deposits/sediments subsequently scoured and/or resuspended during "first flush" Spring melt flow events?

5. *Are the geostatistical techniques (polygonal declustering and kriging) correctly applied?*

I am not qualified to give a detailed critique of these methods; however, I will offer the following general comments.

The polygonal declustering method described in section 4.2.3 of the DEIR resulted in the creation of Thiessen polygons of vastly unequal area (Plates 4-5 through 4-9 in the DEIR). Also, spatial correlation between adjacent sampling points is complicated by the high degree of heterogeneity in PCB levels, presumably also coupled to profound differences in sediment texture. Total mass inventory estimates from the LRC based on this first order method was 19.6 MT (DEIR, p.4-34), 16% less than the original 1984 assessment.

To better account for uncertainty associated with large unsampled areas, a geostatistical method known as kriging was applied. A semi-variogram function is used to represent the degree of "continuity" between PCB concentrations of adjacent sampling points. This approach was not successful for the full dataset but was deemed successful for various sub-reaches ("chopped up segments") of the TI Pool using a "block kriging" approach. An estimate of 14.5 MT resulted from this analysis, 38% less than the original 1984 estimate.

Clearly, estimates based on polygonal declustering are considered "conservative" (i.e. upper bound) whereas the lower estimates based on the kriging analysis are probably more accurate. However, the importance of nearshore areas with higher than expected PCB concentrations is unclear. Perhaps, a detailed assessment should be made on a short, spatial scale in two or three different reaches with (a) varying sediment texture and (b) significant nearshore PCB inventories, to "verify" the results of the kriging analysis (see also comments to DEIR Question 4 and General Question 2).

6. Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?

The change in MW (Δ MW) and molar dechlorination product ratio (MDPR) appear to be appropriate quantities for tracking the extent of dechlorination in Upper Hudson River sediment samples. The accumulation of *ortho*-substituted mono- and dichloro congeners (i.e. BZ#1, 4, 10, and 19) is consistent with the pattern of (reductive) dechlorination observed in this environment as reported in several papers (e.g. Bedard et al. 1996) and summarized in Bedard and Quensen III (1995). For example, it was noted that dechlorination patterns B, B' and C in Hudson River sediments were enriched in 2-chlorobiphenyl (BZ#1), 2,2'- and 2,6-dichlorobiphenyl (BZ#4 and #10), and 2,2',6- and 2,3',6-trichlorobiphenyl (BZ#19 and #27). BZ#8 is not a strictly *ortho* substituted congener so its inclusion in this ratio may be superfluous. That Δ MW and MDPR track well together is an additional indication that their representation of dechlorination is consistent.

There appear to be no significant problems associated with this approach for Upper Hudson River sediments. There are, however, alternate approaches as outlined in Quensen III & Tiedje (1997) that also give measures of the extent of *meta*- and *para* dechlorination. These methods require congener specific data which for the most part are available for the Phase 2 study. The first of these plots the average number of *meta* and *para* chlorines vs. *ortho* chlorines. This is compared to the unaltered source material (in this case e.g. 90-95% A1242; 5-10% A1254) and the vertical distance between the altered and unaltered source data point is a direct indication of the extent of dechlorination. The second method is the creation of "+/-" charts, subtracting mole fractions of individual congeners in a dechlorinated sample from the original or starting mixture. Individual molar increases and decreases should balance if dechlorination is the only transformation process involved.

It is worth noting that although EPA/TAMS justified in detail the use of Δ MW and MDPR these parameters as overall good indicators of dechlorination, they chose to disregard a large portion of the LRC data where these parameters appeared to indicate "widespread" dechlorination in samples with lower total PCBs that were primarily from deeper core segments. (see also comments on DEIR Question 7).

7. *The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?*

Based on academic investigations into PCB dechlorination, and the selectivity with which a good deal of Phase 2 data was discarded from dechlorination analysis, I do not agree with this conclusion. The DEIR and LRC both show evidence that suggests that rates and extents of anaerobic reductive dechlorination in Upper Hudson River sediments are a function of PCB concentration. However, data from deeper sediments with lower concentrations that also appeared to show evidence of dechlorination were thrown out of the analysis. The reason given for excluding these data (constituting ~40% of all core data) was cross-contamination resulting from the core slicing procedure. **Inspection of the entire LRC core data (see Figs. 3-2 and 3-3 of the LRC), however, suggests that there is no relationship between MDPR or Δ MW and total PCBs.**

Abramowicz et al. (1993) showed that measurable dechlorination occurred in Upper Hudson River sediments collected near Ft. Edward (RM 194) that contained total PCB concentrations as low as 20 mg/kg. Although most laboratory investigations into PCB dechlorination utilize relatively high concentrations due to time constraints, there is no clear scientific basis for a single threshold.

In fact, there are many chemical and biological factors which are thought to impact rates and extents of in situ dechlorination. These include absence of oxygen, nutrient, carbon and electron donor availability and quality, PCB availability, organic carbon content and quality, and the presence of the appropriate microbes (Mohn & Tiedje 1992). Temperature has also been shown to affect not only rates and extents, but also patterns resulting from PCB transformation under anaerobic conditions (Wu et al. 1997). Whereas there is no doubt that higher PCB concentrations will increase the likelihood of PCB availability through porewater, given equal TOC, the order of magnitude heterogeneity observed for in situ partition coefficients reported in the DEIR (see also comments for DEIR Question 2) suggests that this generalization cannot be made with a high degree of confidence.

Low Resolution Sediment Coring Report (LRC)

1. *In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?*

The method described to correlate 1984 "total Aroclor" PCB concentrations with 1994 Phase 2 "congener specific" data appears to be valid. However, this is true only for Σ Tri+ homologs. No satisfactory method was given to correlate 1977 data with other years or to estimate mono- and dichlorohomologs for earlier periods. Clear biases exist among data sets arrived at using different PCB analytical methods. The 1976-78 and 1984 data sets tracked the response of a limited number (3) of packed column peaks in Aroclor standards, which ignored mono- and diCBs and thus underestimated their contribution. The 1994 LRC was based on congener specific analysis, the preferred and most accurate method to date. In Appendix E of the LRC, a linear correlation method was described to estimate "tri+" values from 1984 total Aroclor concentrations. For the "as if" analysis of 1994 Phase 2 high resolution core data using the Aroclor method, Fig. 2 of Appendix E shows that a strong correlation exists for Σ tri+ concentrations ($r^2 = 0.983$).

If PCB congener profiles had changed drastically between the 1984 and 1994 sampling, this correlational method would probably not yield adequate results. Since the composition of the major PCB contaminant, Aroclor 1242 in this case, is dominated by lower to mid-range congeners in term of chlorines per biphenyl molecule, the resultant degraded mixtures are potentially less complex and/or variable than would be for heavier Aroclor sources (e.g. 1254 and 1260). Another indication that this estimation scheme did not impart a significant bias is the fact that both PCB mass inventory losses and gains were determined.

Concerning 1976-78 data for hot spots below the TI Pool, it was stated on p.27 of Book 3 of the DEIR Responsiveness Summary that "The 1977 (USGS) sediment data are also suspected to approximate a sum of tri- and higher-chlorinated congeners, but may have a small upward bias relative to the 1984 results due to the use of Aroclor 1016 standard rather than an Aroclor 1242 standard. Unfortunately, surviving documentation of this analytical effort does not appear to be sufficient to definitively establish exactly what was measured in 1977." However, on p.4-27 of the DEIR, it was stated "The three peaks used were the same ones used by O'Brien and Gere for Aroclor 1016 in the 1978 analysis." **Based on this discrepancy and the general lack of information/analysis, I cannot comment on the comparability of 1977 data.**

Clearly, a major limitation of earlier PCB datasets is the absence of mono- and dichlorobiphenyl homolog data. Based on Table A-7 in the Responsiveness Summary for the LRC, these homologs account for ~ half of the entire inventory on a molar basis. In terms of assessing changes in PCB inventory, it is presumed that mono- and diCBs would be most mobile and losses to compartments not accounted for in Phase 2 DEIR measurements would be potentially the greatest. Then there is the impact of dechlorination which over a 16-18 year period might be expected to be significant. If a substantial fraction of the 1976-78 Σ Tri+ PCB mass was subsequently dechlorinated (and not desorbed), the "non-change" would be reflected only in the 1994 total PCB estimates, and not the Σ Tri+. This no-change in truth would be detected as a loss based on comparison of Σ Tri+. Losses between 1976-78 and 1994 were in fact reported in the LRC general conclusions. (see also comments to LRC Question 3). As repeatedly asserted throughout Phase 2 reports, this dechlorination change would be limited to 25% of the total PCB mass for Aroclor 1242; however this is still a significant fraction that could be unaccounted for.

2. *In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. How does sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?*

Based on the general agreement between the loss amounts stated in the original LRC analysis ("point-to-point comparison") and the Reassessment analysis ("cluster area"), the losses appear to be supported by the data. The original LRC point-to-point comparison resulted in a 39% mass loss for sediments with higher PCB inventories ($>10\text{g PCB/m}^2$). The Reassessment included regression and ratio-based analyses to estimate mass loss using the mass per area (MPA) parameter for PCB inventory. The regression analysis resulted in a mean mass loss of 59 ± 19 percent; the ratio-based analysis resulted in a mean mass loss of 45 percent (95% confidence range: -59 to -4 percent). A small correction (~5%) was also made for dechlorination.

Although spatial and temporal variability in sediment PCB concentrations are of concern, it is prudent to utilize as much of the collected data set as possible when making conclusions. Sediment texture (grain size) and total organic carbon (TOC) data are two classic examples of parameters that are typically correlated with the concentrations of particle reactive, hydrophobic contaminants like PCBs (LRC, Figs 3-20 and 3-21). The grouping of core data into 14 cluster areas served to eliminate sampling location bias caused by short scale spatial heterogeneity that could lead to very large errors when comparing data on a "point-to-point" basis, as was done in the original LRC analysis. In fact, 11 of the 14 cluster areas analyzed in the Reassessment were determined to be largely fine-grained sediments (LRC Reassessment, Book 1, Appendix A, p.A-5).

Thus, in all likelihood, the effect of spatial heterogeneity of PCBs is associated with differences in sediment types as measured by these parameters. In other words, as long as the basic sedimentological parameters were similar in cores collected from the same location, I would not expect sediment heterogeneity to impart significant comparative errors, as supported by the general agreement of mass change estimates from point-to-point and cluster area estimates.

3. *What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediment in the TI Pool?*

The LRC (p.2-18) reports an average relative percent difference (RPD) of 36 for total PCBs in core field splits. The formula for calculating RPD is also given on p.2-18. Total PCB concentrations in a given core segment are then used to calculate mass per unit area (MPA) estimates and length weighted averages (LWA) (LSR, eqs.4.1-1 and 4.1-2, p.4-3). Thus any error in the concentration term (C_i) are directly translated into these estimates. In fact, EPA/TAMS found that absolute changes could not be assessed because of this uncertainty. As a result, they switched to relative measures of mass change. The relative percent change in PCB inventory (Δ) is calculated according to Eq. 4.1-4 (p.4-6):

$$\Delta = [(MPA_{94} - MPA_{84})/MPA_{84}] * 100\%$$

In this representation, uncertainties in MPA estimates are now applied in both the numerator and denominator.

A problem with accepting a 40 percent decrease in sediment-associated PCB mass (actually 39%, p.4-17) would arise if one believed that the 36% uncertainty reported were primarily of a systematic nature. In other words, if the 36 percent uncertainty was consistently applied as an underestimation of 1994 data relative to the 1984 estimates, then little or no change in PCB inventory could be concluded. However, there appeared to be little/no evidence of extreme systematic bias in the 1994 data and so it can be assumed/concluded that these uncertainties would be expected to be somewhat random (i.e. an equal chance for underestimation and overestimation). This is supported in this case by inspecting the regression slopes for field split pairs for BZ#52 shown in Fig. 2-6 of the LRC where 11 slopes were less than unity and 10 were greater than unity. This suggests that on average field duplicates were biased high with the same frequency that they were biased low. As such, the tendency for mass losses to be real is not compromised.

I would like to point out that the confidence intervals around the reported 40-50 percent mass losses are substantial and reflect the uncertainty in the mean estimates. Reporting single values without mention of their rather large uncertainties in this case is misleading and should be avoided. **Thus, I do not feel that the 36 percent variability between replicates invalidates the conclusions of mass losses; however, the predictions of mass losses should be represented as ranges instead of single "mean" values to avoid misrepresentation/misinterpretation.**

4. *In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this gain is primarily due to incomplete characterization in 1977 valid?*

This conclusion appears to be the only plausible explanation for the substantial inventory increase and is supported by at least 2 pieces of evidence. First, there were widely divergent PCB concentrations for co-located cores (LRC, Plate 4-22). For example, the 1994 core exhibiting a length weighted average (LWA) PCB concentration of 1184 mg/kg was co-located next to the NYSDEC 1976-78 sediment grab sample whose reported mean PCB concentration was 176 mg/kg, almost one order of magnitude less. Second, several 1994 cores with significant PCB levels were collected in areas apparently not sampled in the 1976-78 survey. Two examples of this are the cores with LWA PCB concentrations of 680 and 267 mg/kg near the center of the large area of fine-grained sediments. It is also possible that accretion over the past 15 years has greatly increased the mass inventory at this location, or that inventories have shifted within the Hot Spot itself. These scenarios are not likely to have occurred based on the "stability" of location of most other major hot spots (see core profiles in the LRC, Appendix D).

5. *Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below TI Dam?*

Based on the significant inventories in shallow sediments and the potential difference/bias in PCB quantification, I am more inclined to believe the "losses" reported from these hot spots more than I would "gains". PCB inventory losses were reported for Hot Spots 31, 34 and 37; gains were reported for Hot Spots 28 and 39 (LRC, Table 4-10). Based on the PCB concentration profiles in Appendix D, I created a simple spreadsheet to estimate relative PCB inventories in up to 3 core horizons, i.e. the "shallow" (roughly 0-10in); "second" (8-20in) and "third" (>20in) core segments (see also LRC, Fig. 2-2). Based on my calculations, which simply sum the product of average core segment concentrations and the corresponding core length, 48% of the PCB inventory in sediments from these Hot Spots resides in the surface (0-10in) layer (Table L5-1). Thus it can be concluded that a large fraction of the PCB inventory associated with bedded sediment is not buried "deeply" and is available for resuspension and advection downstream, resulting in a net mass loss if replenishment from upstream sources did not keep up with losses to the water column (and beyond).

However, many of the cores collected were incomplete, particularly for Hot Spots 34, 37 and 39. In the LRC, it is acknowledged "PCB estimates derived from these incomplete cores probably underestimate the actual sediment inventory in the affected cores by less than 50 percent" (LRC, p.2-17). The other factor to consider for all PCB mass change estimates (between 1984 and 1994) is the presumed underestimation of PCB sediment inventory in the 1976-78 NYSDEC study. This underestimation is due to the use of packed column GC analysis and quantitation based on total Aroclors and would serve to increase confidence in mass loss estimates relative to those that concluded a mass increase.

Review of Phase 2 LRC

Maruya

| HS# | 25 | 28 | 31 | 34 | 35 | 37 | 39 | 41 | 42 | 43 | 44 | sum | % |
|-----------|-------|--------|------|------|------|-------|-------|-----|-------|-----|-----|--------|-----|
| a | 64 | | 108 | 179 | 4225 | 359 | 430 | 5 | 10430 | 194 | 198 | | |
| b | 186 | 270 | 3840 | 46 | 1100 | 120 | 8 | 919 | 4620 | 84 | 22 | | |
| c | 64 | 14050 | | 41 | 532 | 212 | 116 | 36 | 444 | 345 | 20 | | |
| d | 51 | 183 | 45 | 50 | 264 | 200 | 1000 | | 276 | | | | |
| e | 1500 | 17500 | 1430 | 392 | 4 | 150 | 1080 | | | | | | |
| f | 40 | 9500 | 44 | 7 | | 20 | 3905 | | | | | | |
| g | 950 | 1250 | 693 | 40 | | | 604 | | | | | | |
| h | 5900 | 15960 | 20 | 57 | | | 2665 | | | | | | |
| i | 860 | 12380 | 290 | 290 | | | 2355 | | | | | | |
| j | 2700 | 2655 | 130 | 3520 | | 1650 | 2396 | | | | | | |
| k | | 3890 | | 556 | | 168 | 1070 | | | | | | |
| l | | 1032 | | 672 | | 56 | 2160 | | | | | | |
| m | | 16660 | | 51 | | | 418 | | | | | | |
| n | | 9830 | | | | 63 | 251 | | | | | | |
| o | | | | | | 9770 | 16 | | | | | | |
| sum | 12315 | 105160 | 6600 | 5901 | 6125 | 12768 | 18474 | 960 | 15770 | 623 | 240 | 184936 | |
| mean | 1232 | 8089 | 733 | 454 | 1225 | 1161 | 1232 | 320 | 3943 | 208 | 80 | 1698 | |
| 0-10 | 9772 | 51656 | 3936 | 2134 | 5317 | 9831 | 3555 | 887 | 1472 | 377 | 82 | 89016 | 48 |
| 10-20 | 2503 | 42796 | 2324 | 3277 | 716 | 2582 | 9280 | 73 | 13014 | 218 | 84 | 76868 | 41 |
| >20 | 13 | 10683 | 1373 | 446 | 88 | 354 | 5639 | | 1285 | 28 | 72 | 19981 | 11 |
| check sum | 12288 | 105134 | 7633 | 5857 | 6121 | 12767 | 18474 | 960 | 15770 | 622 | 238 | 185865 | 100 |
| | | | | | | | | | | | | sum | % |
| %top | 80 | 49 | 52 | 36 | 87 | 77 | 19 | 92 | 9 | 61 | 34 | | |
| %interm | 20 | 41 | 30 | 56 | 12 | 20 | 50 | 8 | 83 | 35 | 35 | | |
| %bottom | 0 | 10 | 18 | 8 | 1 | 3 | 31 | 0 | 8 | 4 | 30 | | |

Table L5-1. Spreadsheet summary of PCB inventory in low resolution cores from downstream Hot Spots.

6. *The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would place in the LRC evidence against widespread burial?*

Since I don't know what is meant by "historically contaminated sediments", I chose to answer instead **"Are significant concentrations/inventories of PCBs available in the shallow layers of sediments in the TI Pool?"** And my answer to this question based on the data provided in the LRC is **yes**. Based on the PCB concentration profiles in Appendix C, I created a simple spreadsheet to estimate relative PCB inventories in up to 3 core horizons, i.e. the "shallow" (roughly 0-10in); "second" (8-20in) and "third" (>20in) core segments (see also LRC, Fig. 2-2). Based on my calculations, which simply sum the product of average core segment concentrations and the corresponding core length, 58% of the PCB inventory in TI Pool sediments resides in the surface (0-10in) layer (Table L6-1). Thus I conclude that a large fraction of the PCB inventory associated with bedded sediment is not buried "deeply".

Review of Phase 2 LRC

Maruya

| Core zon | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|----------|------|-------|------|-------|-------|------|------|------|-------|--------|-------|
| a | 400 | 320 | 0 | 800 | 2400 | 450 | 240 | 130 | 611 | 3400 | 6840 |
| b | 200 | 1040 | 1120 | 5500 | 1100 | 4000 | 324 | 264 | 0 | 2200 | 2160 |
| c | 1360 | | 0 | 8800 | 3860 | 0 | 1280 | 1050 | 1060 | 2430 | 1800 |
| d | 1120 | | | 3500 | 9200 | | 108 | 90 | 200 | 1530 | |
| e | | | | | 12500 | | | 252 | 450 | | |
| f | | | | | | | | | 290 | | |
| sum | 3080 | 1360 | 1120 | 18600 | 29060 | 4450 | 1952 | 1786 | 2611 | 9560 | 10800 |
| mean | 770 | 680 | 373 | 4650 | 5812 | 1483 | 488 | 357 | 435 | 2390 | 3600 |
| 0-10 | 1400 | 320 | 370 | 15200 | 9209 | 2450 | 672 | 45 | 740 | 6365 | 2750 |
| 10-20 | 1700 | 1040 | 370 | 3400 | 17892 | 2000 | 1280 | 1741 | 1871 | 3195 | 594 |
| >20 | 0 | 0 | 370 | 0 | 1959 | 0 | 0 | 0 | 0 | 0 | 7434 |
| check su | 3100 | 1360 | 1109 | 18600 | 29060 | 4450 | 1952 | 1786 | 2611 | 9560 | 10778 |
| Core zon | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | sum | % |
| a | 3400 | 6840 | 207 | 330 | 72 | 290 | 243 | 1400 | 960 | | |
| b | 2200 | 2160 | 138 | 80 | 60 | 25 | 490 | 360 | 6200 | | |
| c | 2430 | 1800 | 90 | 90 | 244 | 200 | 70 | 176 | 1125 | | |
| d | 1530 | | 660 | | 220 | 710 | 476 | 1360 | 7200 | | |
| e | | | 182 | | | | 259 | 0 | 2820 | | |
| f | | | | | | | | | | | |
| sum | 9560 | 10800 | 1277 | 500 | 596 | 1225 | 1538 | 3296 | 18305 | 111116 | |
| mean | 2390 | 3600 | 255 | 167 | 149 | 306 | 308 | 659 | 3661 | | |
| 0-10 | 6365 | 2750 | 538 | 386 | 474 | 1014 | 1538 | 2596 | 17743 | 63809 | 58 |
| 10-20 | 3195 | 594 | 668 | 56 | 122 | 104 | 0 | 700 | 563 | 37295 | 34 |
| >20 | 0 | 7434 | 68 | 56 | 0 | 104 | 0 | 0 | 0 | 9991 | 9 |
| check su | 9560 | 10778 | 1274 | 498 | 596 | 1222 | 1538 | 3296 | 18305 | 109873 | 101 |

Table L6-1. Spreadsheet summary of PCB inventory in low resolution cores from the TI Pool.

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General Questions

1. *Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?*

The simple answer to this ambitious question is no. Understanding the “fate and transport” of PCBs in the Upper Hudson requires an extensive multimedia investigation. An potentially important medium that has been ignored (i.e. no data collected or presented) is the gas phase. I would suspect airborne measurements of the lighter, more volatile PCBs might help with closure of the mass balance (see also comments to DEIR Question 3). Because these homologs are expected to be “more mobile” as the Phase 2 reports repeatedly point out, they are also more prone to partition into the gas phase, and leave the aquatic system entirely. This would be especially pertinent during warmer (low-flow) months, and possibly in slower-moving, larger surface area to volume quiescent pools such as the TI Pool. Evidence supporting the importance of this mechanism are the revised water column loads in Appendix C of the LRC Responsiveness Summary (“However, both of these events show a marked decline in the fraction of monochloro-homologue(s) between the two stations, representing about a 50 percent loss”, p. C-11). The 2 events referred to are transects 2 (May) and 3 (June) and the 2 stations are the TI Dam and Waterford. **Loss of PCBs to the air is never estimated or quantified.**

Another problem with Phase 2 comparisons of PCB mass inventory is the lack of mono- and dichloro homolog data for earlier years. According to McNulty (1997) as reported in the LRC Responsiveness Summary (Table A-7), roughly 40-50 percent (molar or mass basis) of PCBs in fine-grained TI Pool sediments are mono- and diCBs. However, for analytical reasons, comparisons could only be made for “Tri+” homologs. There are obviously competing processes that would determined the net shift, if any, in congener patterns over several years. Among these are dechlorination (shift toward lighter PCBs) and degradation (shift toward heavier PCBs), selective “weathering” (dissolution, diffusion/advection away from sediments; shift toward heavier PCBs), air-water partitioning (mentioned above; shift toward heavier PCBs?) and particulate-mediated transport (resuspension, scouring; no shift). These competing mechanisms are consistent with the advertised loss of PCBs from the sediment inventory, and also the maintenance of a relatively stable or declining water column load, if that is indeed what has happened since 1993.

Another limitation of this study was the collection and analysis of water column loading data for a single year (1993), a year that unfortunately was subject to transient upstream inputs. Clearly, loadings resulting from the Allen Mills source influenced PCB loading prior to June of 1993, and probably for at least several months thereafter assuming a stepwise transport downriver. Thus, it was difficult to assess the nature and degree of loading in the TI Pool, at least during the early months (winter low flow and spring flood conditions). Thus, water column monitoring data from post 1993 years would clearly be helpful (see also comments for General Question 2).

These limitations aside, I do believe that the data presented in the Phase 2 DEIR and LRC reports are adequate to (1) identify stretches of the Upper Hudson where major PCB loading to the water column occurred under summer low flow conditions, including as an example the TI Pool; and (2) suggest mass losses from many of the Upper Hudson hot spots, including the TI Pool. The major questions are thus shifted from “Where are water column PCBs coming from?” to “How long will these Hot Spots persist?” and “What is the ultimate fate of the PCBs introduced into the water column from these locations?”

2. *Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?*

Several additional analyses may help verify the general conclusions of the DEIR and LRC. The first has to do with "validating" the 1993 water column/PCB loading study. Reference was made throughout parts of the Phase 2 reports and the Reassessment Summaries concerning post 1993 water quality monitoring data, mostly compiled by GE. However, no coherent analysis and/or summary of this data was included. If enough data exist, it would be extremely useful to see if the same general water column PCB concentration and loading trends, particularly during winter low flow conditions, are observed for years where transient upstream inputs of PCBs (e.g. the Allen Mills source of the early 1990s) were absent/minimized.

The second analysis has to do with assessing the significance of elevated "nearshore" PCB contamination. It was not clear to me whether these areas were considered in the DEIR geostatistical analyses. They certainly were underrepresented in sheer numbers of coring locations (roughly 20 of 200 or $\leq 10\%$). The concern here would be whether PCB inventories were underestimated because these areas were "ignored" or incorrectly weighted in the analysis.

The third analysis would combine the major conclusions of the Phase 2 analysis to see if sediment PCB inventory losses are consistent with annual water column loadings and estimates of downstream transport. The difference between the two could then be investigated as losses via evaporation and/or in situ degradation in future monitoring and/or modeling exercises. This mass balance check was mentioned somewhere in the Reassessment Summary, but should be elevated into the summary of major Phase 2 conclusions.

A final analysis would reassess the compatibility of 1976-78 and Phase 2 PCB data. In my experience, total PCB estimates based on Aroclor or congener-specific data are generally strongly correlated, unless major congener/homolog shifts are present. This was done convincingly for the 1984 NYSDEC and Phase 2 data in Appendix E of the LRC. Statements made concerning Aroclor standards used for the 1976-78 data set were not consistent throughout the Phase 2 documentation, but if a consensus could be reached on what approach was used, a correlational analysis would help determine if these data were compatible.

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Dr. Ronald Mitchum

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February 26, 1999

This peer review is provided in response to the "Charge for Peer Review 2" given to the review panel on January 11 and 12, 1999. The following addresses the specific questions before the panel.

I. Data Evaluation and Interpretation Report (DEIR)

1. "Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?"

The TI sedimentary material was the result of several events, which deposited PCB. The first known event would have been associated with Federal Dam structure which was removed in 1973 and the sediment resulting from more recent and continuing releases associated with the GE Baker Falls Plant.

Response:

The determination of the source of PCB originating from the TI inlet pool can be formulated by comparing the congener distribution of the aroclor 1242 and that of biodegraded 1242 found in the sediment. The use of congener patterns will provide the most information where the use of homolog patterns will provide the least.

Figure 3-53 distinctly shows the redistribution of sediments caused by the destruction of the Federal Dam up river from the TI pool which occurred about 1973. This establishes that the sediment contained in the pool predominantly occurred via redistribution caused by that event.

The data has been treated using both congener and homolog patterns. The homolog data in figure 4-34 indicates that at normal to low flow conditions the load is consistent with the TI pool load. At high flow conditions where equilibrium was not established in the TI pool the down river load approximates the new material being released at Baker Falls.

A comparison of congener data in the same way the homolog data was compared in 4.34 can not be readily done. The use of multivariate statistical technique would have allowed a similar comparison.

In conclusion the data supports the thesis that the PCB load originates from the TI pool. Deviations from the model may occur during high flow upsets.

2. "Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g. temperature)?"

To define the porewater derived equilibrium concentration, the partitioning coefficients must contain the most important physical parameters. The equilibrium may be described as the ratio of the absorption and the desorption rate constants. The rate constants have a fundamental temperature term, which must be included. The discussion on page 3-15 and the derivation of the temperature term appears to be correct. The three-phase system would seem more appropriate, however, there was not enough data to apply the model consistently.

In addition to the three phases used in the model some PCB was lost to aerosol formation in the falls (dams), ripples, edge eddy currents and surface evaporation. This source may be minor, however, significant pesticide transport has been observed in fog water in the San Joaquin Valley located in California. The use of Henrys Law to explain away the importance of the process may not be warranted. PCB present at the surface may not behave as an ideal gas. If the mechanism is via aerosol formation, Henrys Law can not be invoked except to explain how PCB may be lost from the particle. Dechlorination by photolysis is a significant chemical degradation process (see Erickson pp. 37). This factor may be significant in the near surface water of a stagnate system, such as, the TI pool and the river flow.

The adequate representation by the two or three phase models is supported by the data. The comparison of the data with the model may suffer due to non-equilibrium events such as temperature currents, gradients and stratification within the system.

3. "Are the conceptual models based on the transect sampling consistent with the data?"

The conceptual models suggest that the TI pool is the source of the PCB down river either through resuspension of fine sediments or porewater equilibrium. The data is consistent with the above. The transect sampling events support the conceptual model.

4. "Does the sampling at the TI-West location impact EPA's conclusion that the sediments of the TI-Pool are the major source of PCBs to the

freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?"

The total net load resulting from the TI pool was calculated as the net increase observed from a sample point up river at mile 194.6 and at the dam at mile 188.5. The GE data as adjusted by EPA does show a gain across the pool, see figure 3-83. The EPA data set should be recalculated based upon the GE target sampling and the estimates revised. The GE data consisted of enough data points to fully characterize the gain due to the TI-Pool.

The flow through a system such as the TI pool is not uniform across the pool. The flow will be slower near the edge of the pool and faster near the center. A current will be established during high flow conditions, which will influence the concentration of PCBs in the water column. A concentration gradient across the dam should exist if equilibrium dynamics are used as the mechanism for developing the TI pool contribution to the down river PCB load. However, during low flow conditions the influence will be minimal and the over the dam concentration of PCB may reflect the equilibrium concentration in the pool.

5. No Comment – This is out of my area of expertise. The discussion presented a logical argument for the use of each.
6. "Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1,4,8,10 and 19 (MDPR)) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?"

The approach provides a quantifiable method to represent the dechlorination on a per sample basis and to compare it to other samples in the set. This appears to be a brut force method and the linearity of the plot in figure 4-21 simply represents the derivation of the equation 4-13, which is the equation for a straight line. The difference in the intercept between the regression line and the theoretical line may be due to the initial assumptions regarding the concentration of the total PCB rather than the PCB containing only ortho chlorines.

The MDPR approach loses the information, which may be present if each congener were treated. Use of a technique such as SIMCA or other

multivariate statistical packages may provide fine detail information regarding the dechlorination of the PCBs found in the Hudson River system. In addition information regarding possible changes to the dechlorination pattern due to further dechlorination or changes due to further sediment equilibration may be observed.

7. "The DEIR finds that the degree of anaerobic dechlorination is primarily a function of the original concentration rather than time, and accordingly that there is not significant predictable dechlorination in the sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?"

The rate of anaerobic dechlorination contains both a concentration term and a time term according to:

$$d[\text{dechlorination product concentration}]/dt = k [\text{original concentration}]$$

Therefore, the dependence upon the original concentration would be expected. No experiment was performed which would determine the time dependence. The time dependence may be on the order of days, weeks or months rather than years.

The 30 mg/kg was deduced from a plot of fractional dechlorination vs log total PCB. The basis for the plot comes from rearrangement of equation 4-13 to:

$$(.86/.14) \cdot \Delta M = \text{MDPR} \cdot 6.43 - .223$$

This equation predicts the intercept will be -.223 and if .86/.14 ΔM were plotted against MDPR the resultant slope of the line would be 6.43. There are no provisions for the log relationship. The use of a log relationship simply allows what would be a discontinuous relationship observed in figure 4-21 to now appear continuous.

The meaning of the data is as follows: The points which lie below the aroclor 1242 in 4-21 and those which are referred to as being below 30 ppm in figure 4-22 belong mostly to the class referred to as being derived from the fresh water lower Hudson River and a few representatives of the upper Hudson. This represents a change in congener pattern (ratio) in the lower Hudson. A multivariate analysis may have indicated that this group of samples belongs to a separate congener composition representing the lower fresh water Hudson.

II. Low Resolution Sediment Coring Report (LRC)

1. "In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?"

Some assumptions were made based upon the various methods used during these eras. In 1977 PCB analysis consisted mainly of packed column ECD analysis following drinking water methods developed by EPA or FDA. Only the significant homolog groups were separated. Typically the data was reported as the closest matching aroclor and reported as a total. Access to the data could not have resulted in the deciphering of homolog groups. The samples may or may not have been preserved and quality assurance programs were not in place to assure the integrity of the data.

In 1984 data were generated again using packed column technology and followed the NYSDEC program methodology. The data would have been reported as totals or homologs. The aroclor would have been identified. The data was most likely useable. There was no indication that the data had been validated. In 1994 the data collected consisted of congener specific data collected using capillary chromatography. The quality assurance protocols reflected a mature QA program. The data should be useable.

There are a couple of problems with the old data using packed column technology. First, one may want to interpret the groupings in packed column data as pure homolog groups, such as, Cl-3, Cl-4, Cl-5 etc. Although distinct peaks are seen in the chromatogram these are not pure homolog groups. Therefore, time travel of the data to 1994 was not possible. Using the data presented in the LRC, E-4, for the congener distribution within the individual quantification peaks for the various aroclors, reverse extrapolation to packed column data was made. The data is shown to be self-consistent when the tri + congeners are used in the extrapolation.

There are several assumptions, which have been made which detract from the use of the estimate. First, the data set has been corrected by NYSDEC to reflect an apparent oversight by Versar in the calculation of PCB concentration for aroclor 1242. Second, the work of Gauthier-TAMS may not have reproduced the column or conditions used for the NYSDEC study. Third, the data is not of known defensible quality. That is, the same quality standards were not in place in 1984 both in the laboratory or the field sampling.

The 1984 data at best should be used for estimation purposes only. In addition, since the old data does not reflect the lower homologues which play an important part in the assessment of the PCB containing sediments, its use may detract from conclusions regarding fate and transport.

2. "In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?"

Sampling errors associated with homogeneity, sample transects, and sample numbers and the statistical design associated with the sampling plan represent the single largest error associated with assessments of this nature. Comparison of sampling events provides the opportunity to propagate these errors. If the sampling plan covers an area with 300 ft transects, then the error associated with comparison of core samples 10 years apart may be large if the sediment has significant lateral heterogeneity. If the sampling plan included more samples with smaller transects than the error would be smaller.

The sampling used a grouping around the 1984 sample site. This will tend to average out sampling error associated with position.

Question 2.

Given that the data set for 1984 is internally consistent and that the data set for 1994 is internally consistent but that there is no common ground between the methods makes it likely that some bias may be introduced. Given the estimates of PCB concentration in the 1984 study and the error associated with sampling, an error estimate should be established which will define the likelihood of the data supporting loss of PCB from most locations.

3. "What is the impact of the difference between replicate samples in the 1994 sampling effort (36% average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?"

The variability of the 1994 and the 1984 data must be considered together. If the deviation, change from the mean is $\pm 18\%$, this is the only data available and the 1984 data is considered to have the same variability, then

an observed 40%, in 1994 may not be significantly different from the 1984 data.

4. "In the LRC, it was found that HOT Spot 28 contained much more mass than previous estimates. Is the conclusion that this "gain" is primarily due to incomplete characterization in 1977 valid?"

The insufficient characterization in 1977 could have resulted in the discrepancy observed. More likely the analytical and sampling methodology contributed to the apparent underestimate. Since the 1977 data is not of known quality.

5. "Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below the TI dam?"

The comparison of the 1984 and the 1994 data sets indicate that most of the hot spots lost mass during the 10 years. The sampling design is robust enough to have located the 1984 sediment sampling sites. The chemistry comparison may produce a bias due to uncertainties in the 1984 data set.

6. "The LRC found that the historically contaminated sediments in the TI pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?"

There is a preponderance of evidence in the DEIR and the LRC, which suggest the sediment borne PCB, are being redistributed to the water column. High-resolution cores supported the low-resolution core data. If the data under penning the conclusions are sound, widespread burial does not appear to be occurring.

7. "Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?"

I can not draw a conclusion due to my lack of knowledge of SSS.

General Questions

1. The data set has addressed many of the variables necessary to assess the fate and transport of PCB in the Upper Hudson.
2. New deposition from the GE Bakers Falls plant site appears to be occurring. Due to the high loading of PCB in the sediment, NAPL, may be of concern. Although none was reported in the LRC, sampling methods to determine NAPL were not used. The equilibration of the water column appears to be associated with the dissolution of NAPL from

the GE plant site. The loss of PCB either photochemically or by aerosol formation resulting from the stripping occurring below each dam on the Hudson may be factors, which influence the PCB load. Recalculation of the water column PCB load resulting from the apparent overestimate introduced due to sample inhomogeneity near the TID in the DEIR data needs to be performed.

Development of a multivariate statistical treatment of the data needs to be performed. Much of the information has been lost due to the data treatment using bivariate statistics.

Reviewer: Ronald K. Mitchum, Ph.D.
Review of the DEIR
March 4, 1999

Recommendation: Acceptable with minor revision

Review of the DEIR and associated Responsiveness reports indicate that the objective of the reassessment has been accomplished. Inclusion of the fate compartments consisting of air transport, resulting from the dams along the Upper Hudson, and photochemical degradation complete the overall conclusions. Perhaps of more concern is the bivariate statistical treatment of the data. It is understood that this may stem from a historical approach in which continuity of presentation was desired. The use of multivariate statistics will express obscured trends in the data. The congener specific analysis offers a rich data base from which to reassess and expand upon the conclusions drawn to date.

The plot representing the fractional dechlorination vs. the log of the dechlorination ratio appears to have no theoretical basis. The log transform removes the skewness in the data set and has led to an inadequate conclusion regarding the apparent 30 ppb dechlorination limit.

A recalculation of the PCB load leaving the TIP requires using the new GE data from the transect sampling across the dam. Inclusion of a model, which addresses the edge effects, may serve to explain the apparent sampling discrepancies observed.

Reviewer: Ronald K. Mitchum, Ph.D.
Review of the LRC
March 4, 1999

Recommendation: Acceptable with major revision

The LRC provides a current 5-year-old update to the 1984 sediment study performed by NYSDEC. The sampling design was adequate to assess the 1984 sampling points. The underlying data variability must be assessed to determine if the conclusions, which were drawn, are valid. The joint variability of the 1984 and the 1994 analysis events along with the sampling variability due to spatial variations need to be addressed. The conclusions then need to be reassessed. Although the data trend is present which suggests there has been a loss of hot spot PCB load below the TID are the measurements precise enough to define the loss.

The inclusion of data, which was derived from 1977, or earlier events has so much analytical uncertainty as to be unusable. Any conclusions drawn from these comparisons should be qualified or removed from the document.

The use of a bivariate data treatment rather than a multivariate statistical treatment may have obscured trends in the data. The congener specific analysis offers a rich data base from which to reassess and expand upon the conclusions drawn to date.

Dr. Ken Reimer

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Hudson River PCBs Site Reassessment (RI/FS)
Date Evaluation and Interpretation Report (DEIR) and
Low Resolution Sediment Coring Report (LRC)

Peer Review 2: Pre-meeting Comments

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March 1, 1999

Hudson River PCBs Site Reassessment (RI/FS)

Date Evaluation and Interpretation Report (DEIR) and

Low Resolution Sediment Coring Report (LRC)

Peer Review 2: Pre-meeting Comments

A. Introduction

The comments that follow are based on an evaluation of the DEIR and LRC reports as well as the corresponding Responsiveness Summaries. As noted in the charge for the peer review, the analyses in the responsiveness documents were considered to supersede those in the original reports. The Hudson River Reassessment Database (Release 4.1) was also used in preparing the following remarks. Reference was also made to the scientific literature as found in refereed reports, but not to other documents or reports dealing with this Hudson River issue.

Comments are divided into:

- Responses to the specific charge questions for the DEIR – Part B.
- Responses to the charge questions for the LRC – Part C.
- General question responses – Part D.
- Recommendations – Part E.

B. Response to DEIR Questions

- 1. Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB- contaminated sediments?***

There seems to be little disagreement that the combined TI Dam (TID) load – i.e. the PCB load originating above the TI Dam and including Hudson Falls, the Remnant Deposit area and the Thompson Island Pool (TIP) – is the major source of PCBs to the freshwater Hudson. It further

seems reasonable that the PCBs in the water column at the TID originate from the sediments of the TIP. The question remains – 'what portion of the sediments?'

In order to assess if it is historically contaminated sediments or some other source it is necessary to examine several lines of evidence – foremost among these is a change in homologue pattern across the TIP (DEIR, page 3-171).

Section 3.4.2 of the DEIR examines the nature of the PCB loading to the TIP. The results of the March 1993 Phase 2 and GE monitoring programs show similar homologue patterns at the Rogers Island station. Both analyses demonstrate (Figure 3-102) that the load largely consists of tri- and tetra-chlorinated congeners – suggestive of an Aroclor 1242-like source. It is suggested that this similarity, together with the highly variable loading, is due to the GE Hudson Falls releases. [It is interesting that the loading is higher at Rogers Island relative to the station at RM 195.5 near the Remnants Deposit although the congener patterns at the two stations are frequently the same. This raises the question of a PCB source from the Remnants Deposits, although GE has apparently concluded that they are only important as a source of secondary mobilization of PCBs from the Bakers Falls source (page 2-20).]

Section 3.4.3 indicates that the homologue patterns of the net TI Pool loading during two Transects (3 and 6) are characterized by a higher loading from the Pool with a homologue pattern dominated by dichlorobiphenyls. The data seems reasonable (compare Figures 3-102 with 3-103) but the case for temporal variations (Figure 3-103 March versus August) at the TI Dam is less persuasive as the reader has no knowledge of the analytical variability of the individual congeners. Indeed the lack of information regarding analytical precision is a major problem in reading the DEIR. Much is made about trends and visual comparisons but the reader cannot independently evaluate their significance.

Book 3 of the Responsiveness Summary provides additional evidence of a change in the homologue pattern. An argument is made (page 18) that, at a time of low load (summer 1997) and low flow, the data show "the usual strong shift to mono-, di- and tri-chlorobiphenyl dominated pattern" for the TID relative to Rogers Island. Unfortunately, this is difficult to see from the provided Figure (2-1). Figure 2-2 is more illustrative in that it shows, at a time of low upstream load (summer 1997), a shift to a pattern enriched in the mono- and di-chlorinated congeners relative to Aroclor 1242. It is noted that these data are similar regardless of whether the TID-West or center station data are used. This reviewer cannot, however, see that this plot makes the case for enrichment of the trichlorinated

congeners; the only apparently significant changes are in BZ#1 (mono) and BZ#4+10 (di). It is unfortunate that there is no comparison to the Rogers Island data in this instance as a direct comparison of the two patterns would have strengthened the argument. Nevertheless, as will be shown later in this document (Part B.3), an alternative analysis of the Transect 6 data by the reviewer confirms the difference in congener fingerprint between Rogers Island and the TI Dam.

Given that there is a distinctive change in the congener pattern, it remains to determine if this is derived from the sediments of the TIP. Section 3.2 of the DEIR makes the case that the “load at the TI Dam is derived almost entirely from the sediment given the consistency of the total TI Dam load and its homologue pattern.” The Responsiveness Summary provides the most direct evidence by making a comparison between Aroclor 1242 and the composition of the surface sediments from the TIP. The sediment patterns (Figure 2-3, page 22) appear to be significantly dechlorinated relative to unweathered Aroclor 1242 – less obvious are the suggested differences between the cores within a reasonable limit of analytical variability.

The enrichment in the lightly chlorinated PCBs in the water column could be a result of resuspension of dechlorinated sediment. An alternative mechanism is diffusion and pore water advection – which could move the more soluble congeners (dissolved and DOC-bound) into the surface sediments. The Responsiveness Summary makes the case (Sections 2.3.1 and 2.3.2) that the congener patterns can only result from a mix of pore water and direct exchange of sediment with the water column. It further argues (Section 2.3.3) that the less strongly sorbed lightest congeners will be more easily mobilized from depth relative to the more strongly sorbing congeners.

Section 5.4 of the Responsiveness Summary examines the potential effect of the Bakers Falls area releases on six sediment cores. Comparison of the Aroclor 1242 equivalent concentrations in the surface sections, 0-2 and 2-4 cm, suggests that surface layer PCB concentrations had been increased by recent upstream loadings. The evidence is not strong as many of the changes must be close to analytical variability (no comment is made as to what is significant or not). It is unfortunate that congener fingerprints were not used. In a reanalysis of some of the data by this reviewer (described later in this report), the Rogers Island East Core (core 26) appears to have a different composition than the other cores. It would be interesting to know if this is due to a greater proportion of recent input.

In conclusion, the PCB load can be reasonably associated with historically contaminated sediments but the contribution of recent inputs must also be considered. It would appear that USEPA has reached a similar conclusion, at least according to a statement in the DEIR Responsiveness Summary (Book 1, page DEIR-47) - "it is highly unlikely that either PCB type (i.e. old or recently-contaminated sediments) is solely responsible for the water column load generated by the sediments. Most likely, the PCB load is a combination of both recently deposited and older PCBs." I concur with this statement.

2. *Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g. temperature)?*

The calculation of the constants appears to have been conducted according to normal procedure but rigorous analysis is left to those more expert in this area. Comments are, therefore, restricted to concerns regarding the degree to which one can accept the conclusions drawn from these constants.

It is presumed that 126 vice 130 congeners were used in the analysis.

Figures 3-13, -14 and -15 plot $K_{p,a}$ for various congeners with River Mile for different Transects. Various conclusions are drawn - such as partitioning at Waterford (RM 156.6) is very similar to that in the freshwater portion of the lower Hudson (at least for Transects 1 and 6). Given at least the variability of the constants (not obvious and not shown on the plots), one must question the conclusions as well as the common sense in attempting an interpretation of any kind.

3. *Are the conceptual models based on the transect sampling consistent with the data?*

In general, the conceptual models are consistent with the data obtained from the transect sampling. The discussion put forth in Appendix C, Book 1 of the Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report is, for the most part, much more convincing than that in the DEIR itself.

Concurrence with several aspects of the general construct of the conceptual model for water column PCB transport (section 3.2.4, pages 3-59,60 of the DEIR) is straightforward and it is useful to briefly summarize these:

- It is clear from the data that there is no significant PCB load generated above Bakers Falls although it is optimistic to conclude that background = 0. It is unlikely that there is any region of the earth, including the poles, where there are zero PCBs.
- The principal source of PCBs to the freshwater Hudson is undoubtedly the GE facilities as there are no other apparent sources such as tributaries and atmospheric input is expected to be small. Direct input and re-release via sediment suspension and/or porewater exchange are the only remaining pathways.
- The congener patterns are consistent with a mixture of Aroclors with 1242 dominating.
- As noted in response to an earlier question, the TI Pool is a substantive source of PCBs, consistent with the framework for the conceptual model.

The conclusions of the “Revised Estimates of PCB and Suspended Solids Loads in the Upper Hudson River” (LRC Responsiveness Summary, Appendix C, Book 1, pages C-14, 15) indicate that the revisions do not require a major modification to the main conclusions of the DEIR. It is noted that concept of year-round conservative transport has been abandoned and that (page C-13) “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.” This seems reasonable in light of the revised load data.

I have less confidence in the congener specific arguments even though the presentation in the Low Resolution Coring Responsiveness Summary is much improved over that found in the DEIR. Visual comparison of homologue patterns (e.g. Figures 3-36 to 3-49, DEIR) is not very convincing – especially as it is not obvious as to how analytical variability would impact on the conclusions. Indeed, analytical variability is not mentioned –at least often – and the reader must ask whether it was forgotten. It is noted that several sections of the Responsiveness Summaries address this point and this is a distinct improvement. Nevertheless, it is very difficult *for the reader to determine* what is statistically significant or not.

Amongst Figures C-6 through C-31 (LRC Responsiveness Summary, Appendix C, Book 1) are plots showing the PCB load for mono-, di-, tri- and tetra-chlorinated congeners with River Mile. Considerable interpretation is made of the changes in these plots but it is not apparent what the

variation is about each point. In one instance (page C-11) a comment is made about a 50% loss in monochlorinated congeners and that this change is beyond the analytical uncertainty. This begs the question of what analytical uncertainty was considered when interpreting *any* of the plots. One can make some assumptions based on the comments regarding Figure C-31 (which shows a downward slope for all congeners from the TI Dam to Waterford) as it is stated (page C-9) that there is a "similarity of the homologue pattern between the TI Dam and Waterford" thereby suggesting that the slope is not significant. This raises questions about the interpretation of other plots, particularly those representing low PCB loads (lower concentrations near detection limit may be less reliable) from just the Figures. Statements (page C-11) such as "these changes are quite substantial...and are well beyond any analytical variability" are a distinct improvement over the DEIR but it should be stressed that there is no way that the reader can independently verify such conclusions with the information provided.

More worrisome is the use of homologue patterns in this section and throughout the report. In view of the rigor of the analytical program (i.e. 126 congeners in most cases) it is surprising that a more rigorous statistical approach was not used – such a principal components analysis (PCA) to interpret congener specific data.

In order to examine the conclusions made in the DEIR, three of the Transects (1, 4 and 6) were examined using PCA. Data were obtained from the Hudson River Reassessment Database (Release 4.1). Plots are appended as Annex A to this report. It should be stressed that this was a cursory attempt to see if the DEIR conclusions could be confirmed by another approach. Some interesting points can be noted and these are summarised for each of the Transects examined. Comparisons are made to the conclusions found in the DEIR and associated Responsiveness Summary.

Transect 4

Plot 1 presents the preliminary PCA for dissolved and particulate phases of the water column samples collected during this Transect (April; spring flood). Samples are labelled with d and p prefixes indicating dissolved and particulate phases. The first number denotes the sampling station number and the second the transect; e.g. the dissolved fraction collected at Rogers Island during Transect 1 is labelled d4-1. As time only permitted a cursory examination of the data, this discussion and those that follow will be similarly restricted. In simplest terms, samples that project in the same region of a PCA plot may be assumed to have similar compositions.

It can be noted that the dissolved and particulate samples generally project differently. The samples collected from Glens Falls and the Fenimore Bridge (stations 1 and 2 respectively) appear at the right side of the plot; tributaries are widely scattered throughout suggesting different and variable inputs of PCBs. These observations are consistent with the argument that the tributaries do not contribute to the congener composition of the Upper Hudson. Most pertinent is the behaviour of samples associated with stations at the Remnant Deposits (stn 3), Rogers Island (stn 4) and the series of samples from the Thompson Island Dam (stn 5), Schuylerville (stn 6), Stillwater (stn 7) and Waterford (stn 8). All samples from the Remnant Deposits to Waterford cluster tightly together. *This observation is consistent with the conclusion (page C-8, Book 1) that total PCBs are transported to Waterford in a conservative manner.*

Transect 1

Plot 2 displays the results of the sampling for this Transect (Jan/Feb). Fenimore Bridge and some tributaries project to the right side. The dissolved samples for the TI Dam, Schuylerville and Waterford cluster tightly – indicating similar composition – but are very different from the Remnant Deposits. The corresponding particulate samples are not as tightly grouped but appear to the left side of the plot. It was noted in the DEIR that the Rogers Island sample was suspect and this is confirmed by the PCA – both the dissolved and particulate samples project tightly and to the right side. *These observations are reasonably consistent with the conclusion that the water column load originating above the TI Dam is transported in a near-conservative manner, for all homologues.*

Transect 6

Plot 3 presents the results of the PCA for this transect (August). Once again, background samples (Glens Falls, Fenimore Bridge), both particulate and dissolved, project to the right side of the plot and the tributaries are widely scattered. The dissolved samples for the TI Dam, Schuylerville and Waterford are clustered as are the particulate samples (although these project to the left of the dissolved samples). The dissolved samples for the station at the Remnant Deposits and Rogers Island are tightly grouped but this is not the case for the particulates. This plot would suggest that the congener composition is maintained from the TI Dam to Waterford, not showing a loss in mono- and di-chlorinated congeners as discussed in the Responsiveness Summary. This difference may be due to the insensitivity of the PCA to the loss of the lightly chlorinated congeners (the PCA was run using all congeners) but it does raise questions.

The PCA plots do indicate that at low flow, sources above the Thompson Island Pool do not significantly influence the congener profile at the TI Dam through to Waterford. This provides additional verification of the importance of the TI Pool.

The surface sediments from the high resolution coring study were also examined by PCA (Plot 4). In general, background (s27 = core 27 at RM 202.9) projects to the right of the plot and tributaries and lower Hudson River samples are widely scattered. Most of the remaining samples project to the lower left with the exception of core 26 from Rogers Island East which is displayed to middle lower section of the plot.

It is recommended that the significance of the congener profile changes from the TI Dam to Waterford be discussed at the Peer Review.

4. *Does the sampling at bias of samples collected at the TI Dam-West sampling location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?*

The arguments put forward in Section 1.0, Book 3 of the DEIR Responsiveness Summary as well as Appendix C, Book 1 of the Responsiveness Summary for Volume 2C-A Low Resolution Sediment Coring Report appear reasonable. Evidence for the bias is persuasive but much of the effect appears to be mitigated by the analytical corrections.

The ratio between center channel and TID-West appears to approach unity as either flow or upstream concentration increases and this is consistent with the explanation provided – i.e. that increased flow creates greater lateral mixing and that as the upstream concentration increases it will overwhelm the effect from the nearshore areas. An intriguing argument is made (section 1.4, Book 3) that the actual daily load transported downstream may be an average of the TID-West and TIP-18C observations.

The correction factors and the revised load calculations are consistent with EPA's conclusion that the sediments of the TI Pool are the major source of PCB to the freshwater Hudson during low flow conditions. The conclusion (Appendix C, Book 1) that the net result of the revisions (including flow

corrections) is $\approx 20\%$ lower overall loads in the Upper Hudson under low flow conditions appears warranted.

Furthermore, the presence of a bias is consistent with the argument that hot spots within the TI Pool are a source of PCBs to the water column. The point made in the Responsiveness Summary (page 43) – “Elevated concentrations in near shore low velocity areas are consistent with a pore water flux loading mechanism, which would result in higher concentrations where dilution flow is lowest” – is quite reasonable.

5. *Are the geostatistical techniques (polygonal clustering and kriging) correctly applied/*

The techniques appear to have been correctly applied. I would prefer to see a range of estimates for the PCB inventory. Reporting the calculated inventory to a decimal place strikes me as overly optimistic and potentially misleading to the public – considering the variability in the results (not stated) and the two estimates – 19.6 and 14.5 - that have been determined.

6. *Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?*

The molar dechlorination product ratio (MDPR) relies on the measurement of five specific congeners in order to assess the degree of dechlorination in sediments. The congeners used (BZ# 1, 4, 8, 10 and 19) all possess chlorines in the ortho positions on the assumption that anaerobic dechlorination processes only remove meta and para chlorines.

The DEIR notes, correctly, that the less chlorinated congeners are more soluble and more susceptible to aerobic degradation processes and may be lost from the sediments more readily, in which case the MDPR will underestimate the actual degree of dechlorination. It might also be expected that the less chlorinated congeners could be lost, by similar mechanisms, from the sediments prior to the establishment of the anaerobic conditions that are essential to dechlorination – in such a case the MDPR would be reduced.

The MDPR will also underestimate the degree of dechlorination if ortho-substituted chlorines were removed. There is evidence in the literature of ortho-dechlorination [Van Dort and Bedard, Appl Environ Microbiol, May 1991, 1576-1578; Berkaw, Sowers and May, Appl Environ Microbiol, July 1996, 2534-2539 (marine sediments)]; if this is significant in the Hudson River sediments, the reliability of the MDPR will be compromised.

The change in mean molecular weight, ΔMW , is less susceptible to the points noted above. However, loss of the lighter congeners – a likely possibility – would increase the molecular weight of the mixture and reduce ΔMW .

Low values of MDPR and ΔMW found for the sediment samples from the Lower Hudson River are interpreted (DEIR, page 4-63; Figures 4-19,20) to be representative of lower levels of dechlorination with only some loss of lighter congeners. The linear relationship between MDPR and ΔMW (DEIR, Figure 4-21) is the most convincing evidence that contributions from the above-mentioned processes are minimal and that the approach is appropriate.

Both the DEIR and the LRC normalize data to BZ#52 (2,2'-5, 5'-tetrachlorobiphenyl). Considering the dechlorination argument, it is surprising that this congener does not undergo removal of the meta-chlorines.

7. *The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?*

No. I do not agree with the conclusion as originally suggested in the DEIR (page 4-68) in discussing Figure 4-22; namely, that "the distribution of the data strongly suggests that virtually all samples with PCB concentrations greater than 30ppm are measurably altered with respect to Aroclor 1242. More convincing are the conclusions stated in the Responsiveness Summary (Book 1, page DEIR-62 and elsewhere): "Below 30ppm, the occurrence of dechlorination is not predictable using ΔMW as a measure, because data fall above and below the initial ΔMW of Aroclor 1242. It is possible that samples with ΔMW values less than that of an Aroclor 1242 have undergone dechlorination and preferentially lost the mono- and di-chlorobiphenyls."

In our own work (unpublished) we have found no such threshold for dechlorination of even the more recalcitrant Aroclors (such as 1260). Experiments with concentration ranges from 5 to 500ppm gave essentially the same percent dechlorination (e.g. 80% removal of hexa-chlorinated biphenyls). Rates were low at low PCB concentrations but there was no threshold concentration in the range tested. Inhibition was noted above 500ppm for Aroclor 1260.

Although not part of this charge, the argument for lack of correlation of dechlorination with age is not totally convincing. Figure 4-23 in the DEIR appears to suggest this but the results could be overwhelmed by the relationship to total PCB concentration. Figure 4-24 could be interpreted as a correlation with age when analytical variability about each data point is included.

C. Response to LRC Questions

Note: The Responsiveness Summary for the LRC is quite extensive and includes numerous corrections as well as an alternative calculation for the comparison of sediment inventories in the Thompson Island Pool. The Summary was received later than expected and it was not possible to conduct a detailed review prior to the submission of pre-meeting comments. Accordingly, the following comments are intentionally brief. A more detailed examination will be completed prior to the peer review meeting.

1. ***In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?***

The correction factor developed in Appendix E of the LRC and the arguments supporting it seem quite reasonable. Using the Σ trichloro to decachloro homologues puts both sets of data on an equal footing. It is interesting to note (Responsiveness Summary, page LRC-41) that this approach is being reviewed – presumably this information will be made available before the LRC is considered complete.

Given the effort to make meaningful comparisons between the 1994 and 1984 data, it is surprising that there is little discussion of the potential problems associated with the 1977 information. It is noted (page 4-21, LRC) that “the simple sum of the reported Aroclor values yields an estimate for

total PCB concentration, which is probably the best that can be done to create a value for comparison to the low resolution coring results." It is agreed that this is probably the best that can be done but it does suggest that any trends derived from comparison of these data should be qualified.

2. *In the Upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sample heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is a loss from most locations supported by the data?*

Sample heterogeneity is always a concern in such an investigation. The Responsiveness Summary appears to provide a more convincing argument in favour of the validity of comparing the 1984 and 1994 data than does the LRC.

The sampling locations were reoccupied with quite good accuracy (Responsiveness Summary page LRC-5). Equally important is the fact that, within the clusters, the sampling density matched that of the NYSDEC study – thereby strengthening the ability to make comparisons. It is stressed that the intention of the study was to assess the direction and approximate magnitude of change of the PCB inventory over the intervening period. The reanalysis of the data – presented in Appendix A, does suggest that there has been a general loss; it further emphasizes the difficulty in assigning an absolute value to this loss. This seems more reasonable than the impression one might get from the LRC even though the word *approximately* is used in the discussion.

3. *What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?*

The point made in the preceding response is emphasized by this question. There is a tendency once a number – i.e. 40% - is cited to forget the 'approximately' qualifier.

A quick read of the Responsiveness Summary (Appendix A) suggests that the estimated loss has been revised but that the value is in agreement with that presented in the LRC. A case is also made (LRC-11 to 19) that the low-resolution cores have uncertainties closer to 20% vice the 37% originally

proposed. No mention is made in either report as to the uncertainty associated with the 1984 data, but one could assume that it is about the same – i.e. approximately 20-30%. The point (LRC-71) that dividing by the 1984 concentration has the effect of normalizing the 1994 and 1984 data to account for analytical uncertainty is a good one. Again, the data appear to be consistent with a loss of PCB inventory from the highly contaminated sediments of the TI Pool; a comment on the magnitude of this change is left to those who can more adequately review Appendix A.

4. *In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this “gain” is primarily due to incomplete characterization in 1977 valid?*

Yes. The argument that the 1977 samples underestimated the amount of PCBs whereas a more complete characterization was achieved in the recent program is reasonable. Several lines of evidence seem particularly persuasive. These include the ^{137}Cs data (Figure 4-25) which show that in 1994 the bottom of the core represented true background as well as the argument that there would be insufficient quantity of PCBs to so dramatically raise the sediment inventory between 1977 and 1994. The general statement that the earlier studies probably underestimated the PCB inventory provides additional support.

5. *Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below the TI Dam?*

The data set is consistent with a statistically significant loss of 50 to 80% for hot spots 31, 34 and 37 whereas hot spots 35 and probably 25 are unchanged. It is presumed that the term “significant” in this question relates to statistical significance. Caution should be used in calculating overall mass changes given the challenges in comparing the analytical data from the two eras.

6. *The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?*

The evidence provided in the LRC – in particular the loss of sediment inventory and that the depth of contamination has decreased or remained the same – is consistent with the water column information

described in the DEIR. Accordingly, the weight of evidence argues against widespread burial – at least deep burial.

7. *Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?*

The comparison of the sonar images with the 1976-1978 NYSDEC sediment survey seems reasonable.

D. **General Questions**

1. *Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?*

It would appear that the data set lays out the overall understanding of the fate of PCBs in the Upper Hudson. The debate that appears in the Responsiveness Summaries – namely the relative influence of the TIP and releases from the Hudson Falls facility – could, however, be dealt with by direct comparison of current data showing the relative loads at Rogers Island and the Thompson Island Dam. Several points allude to this comparison but I could find no direct evidence.

2. *Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?*

I would have liked to see more discussion of the effect of analytical variability in the DEIR documents and the application of techniques such as principal components analysis.

E. **Recommendations**

I will finalize my opinion at the Peer Review when I have heard the comments of the other reviewers but my preliminary opinion is that the DEIR and the LRC are acceptable.

The question of revisions hinges less on the need to make a more substantive argument than on what the reports will be used for next. If they are to be used as a basis for the next report and the new

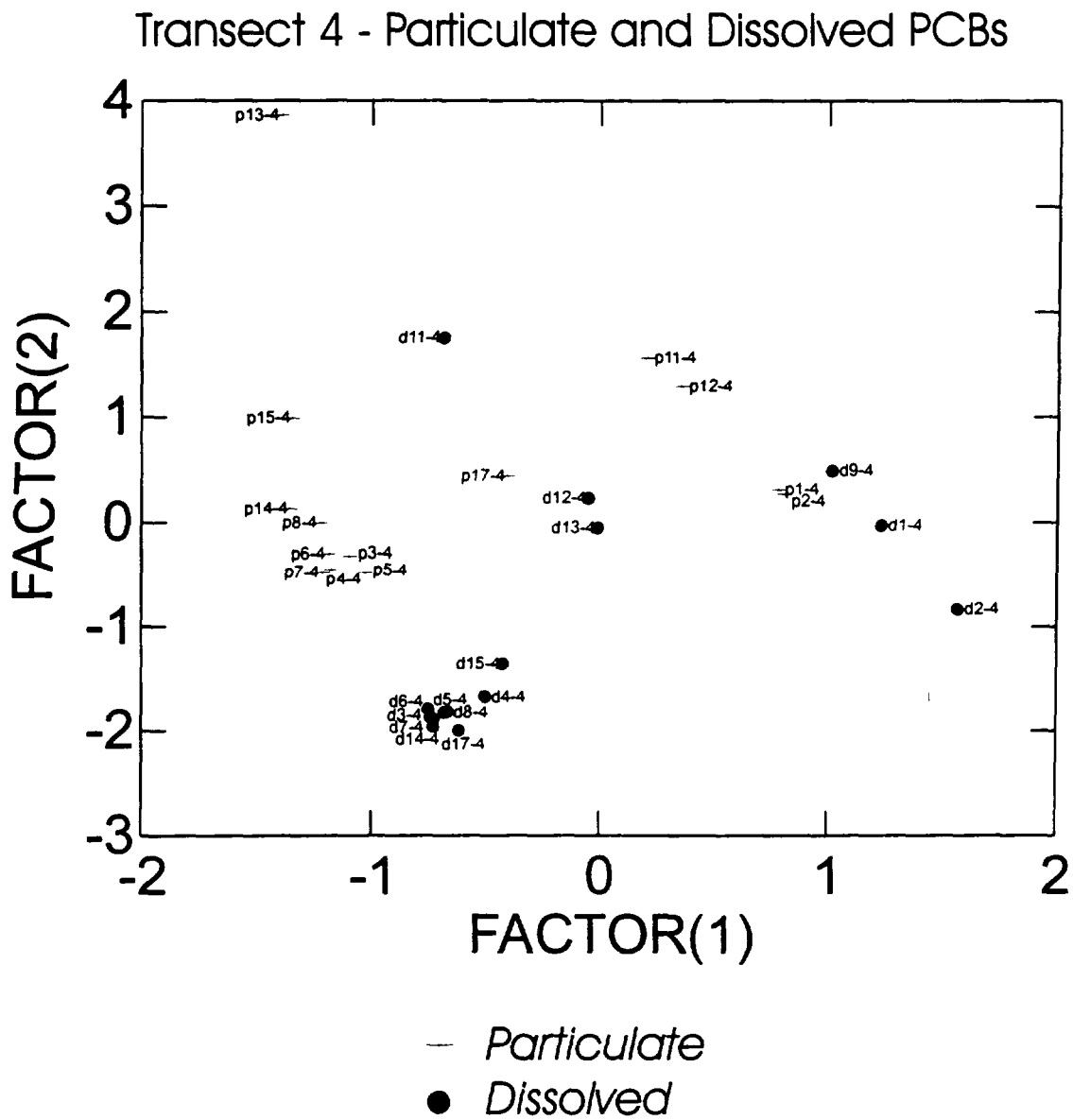
conclusions and statements that appear in the Responsiveness Summaries are to be incorporated at that point, there is little use in making revisions to the DEIR and LRC. If these conclusions are to be publicly accessible, however, a succinct summary document would be very useful.

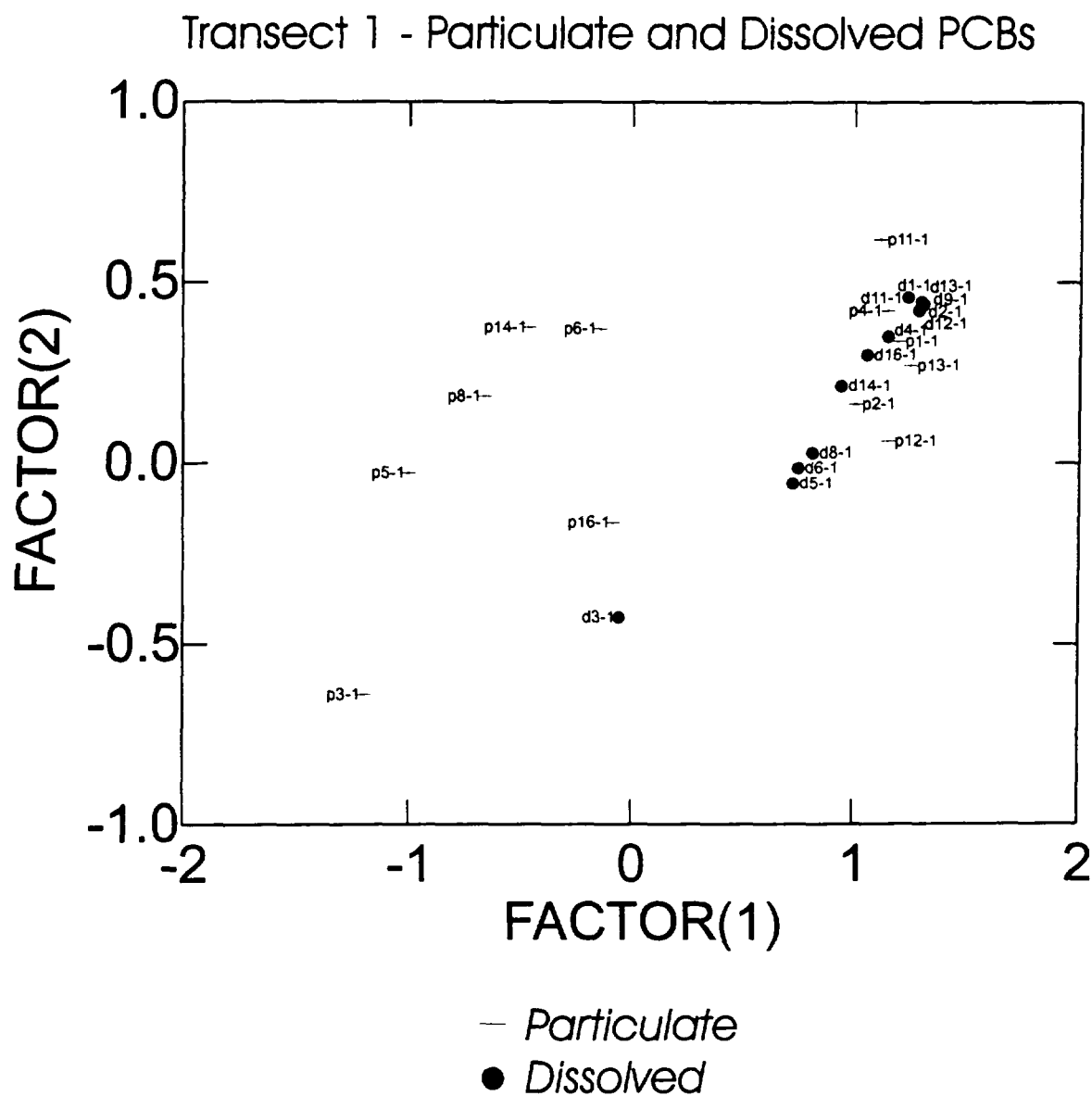
ANNEX A

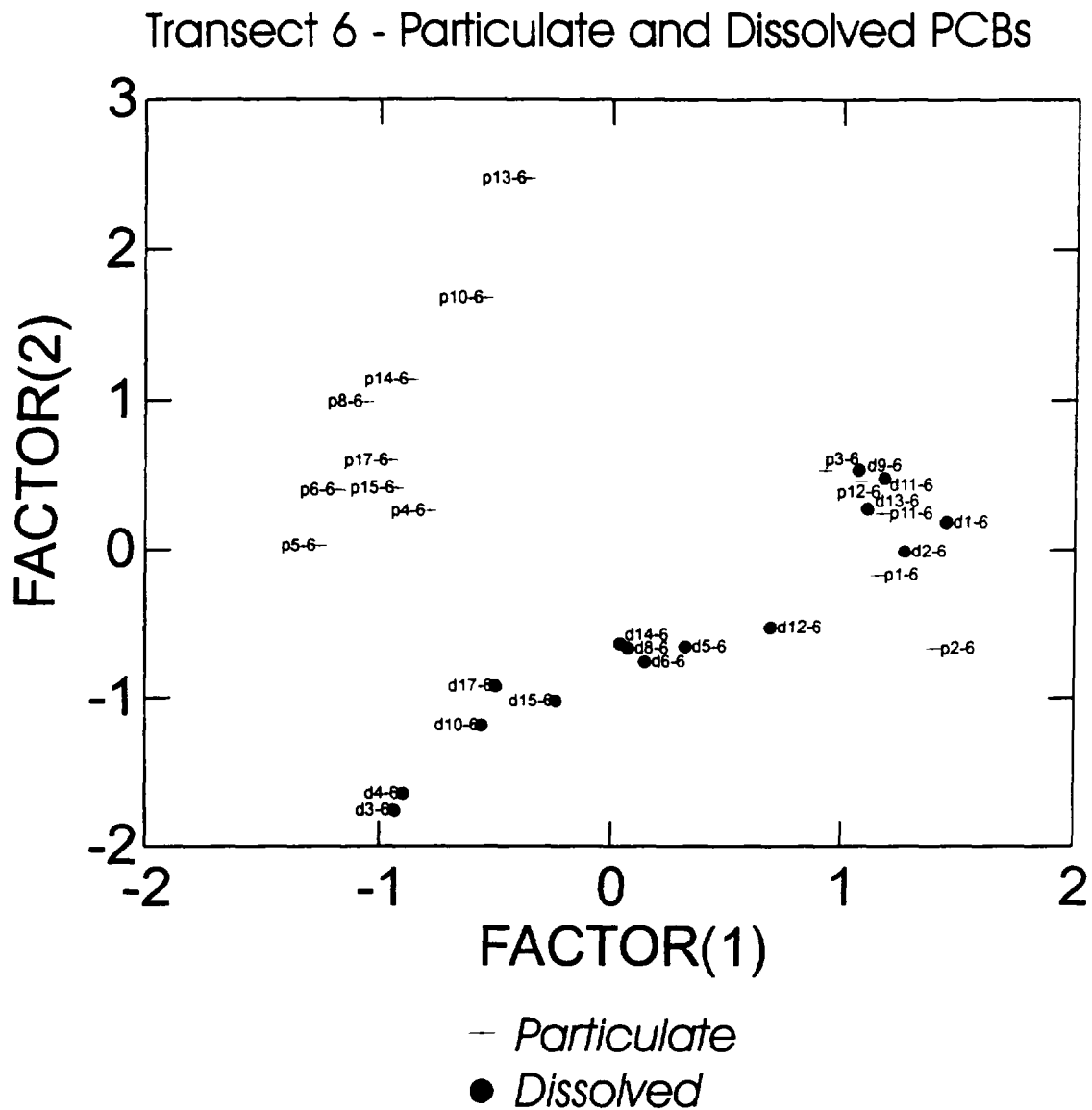
Principle component analysis (PCA) was carried out to explore patterns in the PCB congener data. In this indirect gradient analysis, all of the variables (in this case congeners) are considered simultaneously; variance in the congener data is explained by fitting a straight line through a multidimensional normal curve, using a converging iterative ordination algorithm, such that the residual sum of squares is minimized. This line is the first ordination axis, or first principal component. Further axes are constructed in the same way, with the constraint that they are uncorrelated. This technique is thus a convenient way to summarize multivariate data in two dimensional space.

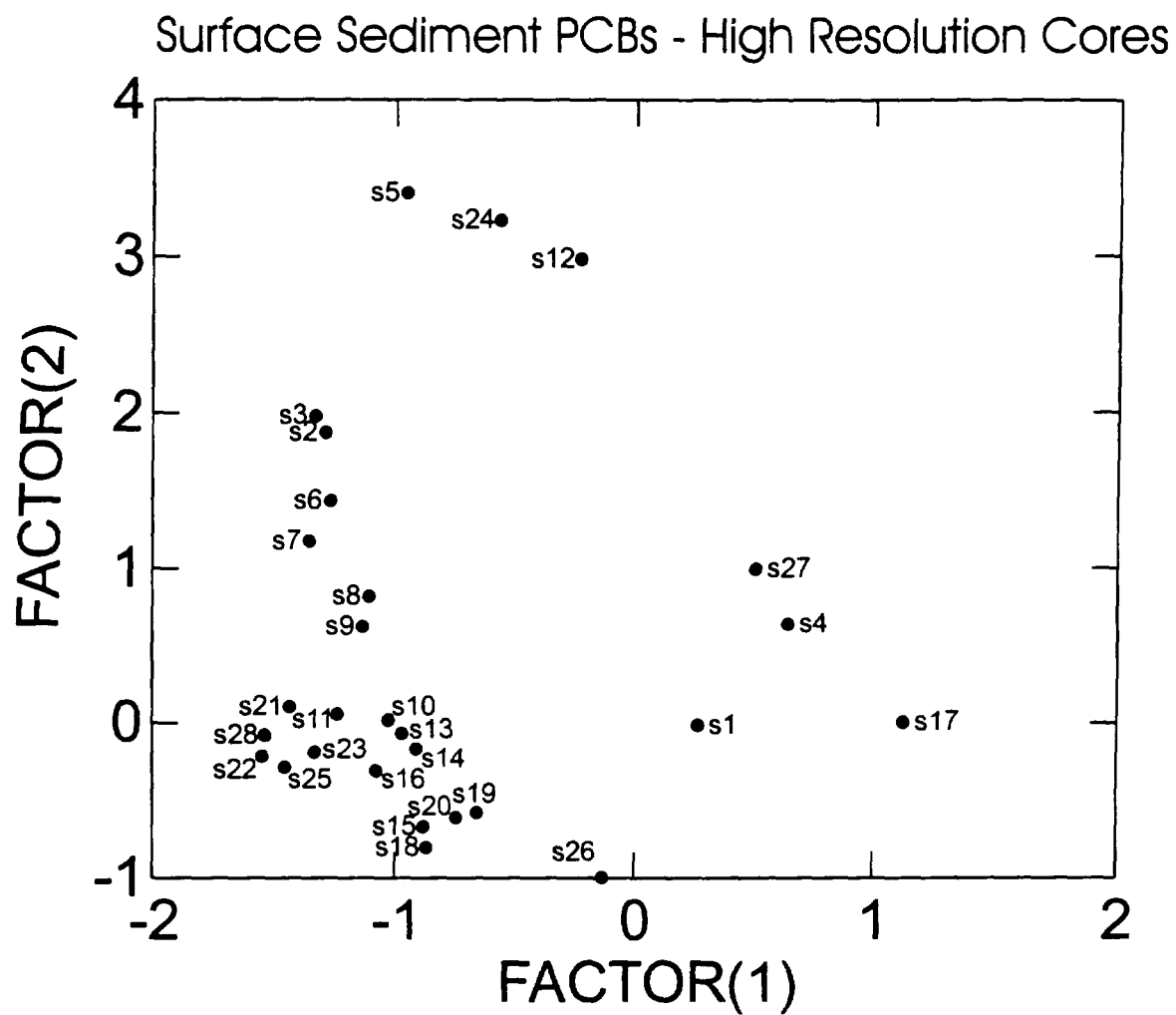
PCA was carried out using the statistical program SYSTAT (version 6.0.1). Twenty-eight surface sediments, and 83 water samples (separated into dissolved and particulate phases) were normalized using standard techniques and then ordinated according to their congener profiles (based on 126 congeners). PC axes 1 and 2 explained 44.3% and 7.0% of the total variance in the data indicating that PCB congeners explain the bulk of variation in the samples collected.

Plot 1









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Dr. James Risatti

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Dechlorination Index.

The dechlorination index, used in this report (MDPR), is based on a ratio derived from the sum of the molar concentrations of congeners BZ-1,4,8,10, and 19 found in the sample, divided by the sum of 126 congeners identified in the study (V:2C,bk1,pg 4-56). The degree of *in situ* dechlorination is determined relative to Aroclor 1242 by calculating a similar ratio from Aroclor 1242 and using the Aroclor 1242 index as a base value. This value (0.14) is subtracted from the sample ratio to give the degree of *in situ* dechlorination.

Harkness et al. (1993), characterized the extent of *in situ* dechlorination in a Hudson River sample by noting the amount of mono- and dichlorobiphenyls present relative to the predominant Aroclor originally released. The product of complete PCB dechlorination is an unchlorinated biphenyl molecule but in Hudson River sediments the dechlorination scheme favors removal of chlorines at the *meta* and *para* positions which leaves congeners containing *ortho* chlorines such as BZ 1,4, 8, 10, and 19 to accumulate as ultimate or penultimate products. For Hudson River samples the suite of congeners selected for the MDPR would appear to be reasonable but there are other issues inherent with the MDPR which reduce its effectiveness as an indicator of dechlorination.

The major problem associated with using a PCB dechlorination index based on final product accumulation is diminished confidence that the measured product is a true representation of the original compound mixture. In addition to lower ECD response (particularly BZ 1), the less chlorinated PCB congeners are subject to aerobic degradation and to physical-chemical movement out of the sample environment. Aerobic degradation has been recognized and has been well studied for some time (Ahmed and Focht, 1973, Furukawa, et al. 1978 and Beddard et al., 1986, among others); although some isolated cultures can degrade specific highly chlorinated biphenyls, most aerobic PCB degrading bacteria favor the less chlorinated mono-, di- and tri- chlorinated congeners as substrates. Furukawa, et al. (1978) also found that in addition to more rapid degradation of the lower chlorinated congeners, the non-chlorinated ring was preferentially degraded. A screening study by Beddard et al., (1986) indicated that BZ 4 and BZ 8, both of which are used for the MDPR, were rapidly degraded by the environmental isolates used in the study.

The mono-, di- and tri- chlorinated congeners are also more readily lost from the sample pool by sorption and partitioning into the sediment pore water and into the water column than are the more chlorinated congeners. In the report (pg 3-31), it has been recognized that the movement of BZ 1,4, and 8 out of the Thompson Island pool sediments "may be facilitated by binding to dissolved organic carbon" and that PCBs in general "may move from the porewater to the water column by diffusion and groundwater advection of dissolved and DOC-sorbed phases." (pg 3-31). Lastly, the report notes that because of their lower partitioning coefficients, the "concentration of mono- and dichlorobiphenyls is enhanced in porewater relative to more highly chlorinated congeners, which may facilitate loading of these congeners from the sediment to the water column" (pg 3-39) and that the sediments of the TI Pool

released less-chlorinated congeners typical of dechlorinated sediments found in the Pool (pg. 3-2). Under ideal conditions (temperature, pH, DOX), biological and partitioning processes may become strongly interactive as biodegradation of the less chlorinated congeners maintains a disequilibrium in the sediment porewater and near the sediment surface.

Loss of the lighter congeners (BZ 1,4, 8, 10, and 19) directly affects the sensitivity of the MDPR by underestimating the amount of dechlorination. The underestimated difference depends on the MDPR estimate and the amount of BZ 1, 4, 8, 10, and 19 lost from the sample. Underestimates can range from about 2 percent in samples with a MDPR of 0.2 and 10 percent loss of the index suite to as much as 17 percent in samples with a MDPR of 0.6 but which has had 50 percent of the index congeners lost from the dechlorinated sample.

As an index to compare dechlorination or other PCB changes, it is better to use a ratio indicating decrease in concentration of two or more peaks selected from chromatograms of the PCBs in the system being studied. Murphy (1989) correlated changes in sediment PCBs from within Waukegan Harbor and with Lake Calumet by changes in the BZ18 / BZ17 ratio. Ideally, however, ratios of more chlorinated congeners having similar chemical characteristics should be used as they are less susceptible to aerobic biodegradation and partitioning into the aqueous phase and at lower concentrations still give a measurable ECD response (see Brown and Wagner ,1990 for ratios used in a study of the Acushnet Estuary sediments).

Also, for both MDPR and MW, Aroclor 1242 is considered as the as the only commercial PCB mixture in the sediments but in some areas, as much as 19 percent Aroclor 1254 was found (pg. 2-19) and Brown et al., (1988) indicate that in the area of RM 194.8, their "hot spot " analysis indicates an average of 94 % Aroclor 1242, 5 % Aroclor 1254 and 1 % Aroclor 1260/1268. Both of the indices should be weighted if they are to be used.

Limits of Dechlorination

The suggestion that dechlorination of PCBs is limited by PCB concentration has been suggested by laboratory dechlorination experiments with natural sediments (Quensen et al. 1988, Risatti,1992, Rhee et al. 1993 and Fish,1996) and discussed by Brown and Wagner (1990) in reference to field observations. Brown and Wagner (1990), state that there are no examples of PCB dechlorination at *isolated* low level (1-3 ppm) sites but that they have seen dechlorination in low concentration PCB samples collected near sites of active dechlorination. Quensen et al. (1988), working with Hudson River sediments found active dechlorination at PCB levels of 700 ppm, less active at 140 ppm and none at 14 ppm. In experiments with Waukegan Harbor sediment cultures (no PCBs added),that there was very little, if any, dechlorination at PCB concentrations of 150 ppm, some dechlorination at 1,500 ppm and very rapid dechlorination at 17,000 ppm (Risatti,1990 and unpublished data). Fish (1996) observed

rapid dechlorination rates in Hudson River sediments spiked with approximately 248 ppm to 25 ppm Aroclor 1242 and slow dechlorination rates at concentrations of about 9.9 ppm. A wide range of dechlorination limits observed have been observed in laboratory cultures and in field studies.

The authors state (page 4-68) that "the distribution of the data strongly suggests that virtually all samples with PCB concentrations greater than 30 ppm are measurably altered with respect to Aroclor 1242." That is, dechlorination is limited at about 30 ppm PCB concentrations. The trend in Figure 4-22 suggests a trend of increasing dechlorination with increased PCB concentration but from the figure the dechlorination threshold limit could be anywhere from 20 ppm to 40+ ppm. Also, Figure 4-23 doesn't support the 30 ppm statement. Sub-sample 10 has approximately 55 ppm PCB but has undergone only 3 percent dechlorination. On the other hand, at horizons 1 and 2, 9 ppm and 6 ppm respectively, dechlorination is 16 percent and 21 percent. The middle horizons seem to be relatively consistent with extensive dechlorination and high PCB levels. The trend in Figure 4-24, indicates, for the most part, dechlorination increasing with both PCB concentration and depth (age), and that sample 1 (approx. 26 ppm PCB) has been dechlorinated by about 21 percent.

Although there is evidence indicating that PCB concentration levels limit the degree of PCB dechlorination in sediments, the threshold concentration seems to vary with the sites examined as well as within the stations sampled including the ones investigated for this report. There does not appear to be a universal PCB dechlorination threshold limit. Given slight changes in conditions (which are as yet unknown), dechlorination may occur rapidly and at lower PCB concentrations; Beddard (1996) has managed to "prime" dechlorination in Housatonic River sediments which had lain dormant for years. However, the factors that induced 98%-99% dechlorination of specific congeners within 30 days from unammended, 15 year old Waukegan Harbor sediment cultures are still unknown. What is interesting about Figure 4-27 is not that it illustrates the contention of poor correlation between time and the dechlorination ratio but that most of the dechlorination in the Upper Hudson occurs within the envelope bounded by approximately 20 percent to 80 percent dechlorination and about 5 cm to 45 cm depth levels. This suggests there is a common factor in the system which influences dechlorination rates. It may be available organic carbon, reducing potential, or flushing of inhibitors or nutrients into or out of the system.

Most of the data presented in the report supporting PCB dechlorination limits is based on the molar dechlorination product ratio (MDPR). This index, as stated above, is not a useful measure of dechlorination and must be calibrated with another set of ratios determined from chromatograms of the samples and which avoid the problems inherent with the MDPR as derived in the report. Consequently, until the degree of error associated with the MDPR data are determined the usefulness of data derived from the MDPR are limited.

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It is much better to use ratios involving the more chlorinated congeners

The less chlorinated congeners used in the MDPR are more subject to aerobic degradation than the

Anaerobic degradation may occur but I'm not convinced that degradation rates are significant *in situ*.

Anaerobic degradation (alteration of the molecule by ring cleavage) here has been some is products is valid but the major problem

ortho-substituted chlorines are more resistant to dechlorination (Brown, 1987, Abramowisz..) and congeners containing ortho-chlorines, such as the suite chosen for the MDPR also can be final products. associated with using mono-, di- and tri-chlorinated congeners is loss into the water column from the sediments or by aerobic degradation. The loss of "light" congeners from the sediment pool of congeners will give a MDPR that underestimates the degree of dechlorination.

Figure 1. Changes in the MDPR at specific dechlorination indices with postulated losses from the sediment of the "lighter" congeners used to determine the index.

Additional comments forthcoming

COMMENTS

Chpt. 1)

P1-2, Sect 1-2: The format should have been organized according to work plan tasks.

Should have a diagram showing tasks in the report and an outline for each chapter.

This chapter should also have for the report a tasks accomplished plot similar to a Gant plot.

1.4.4 - Analytical ChemProgram:

How about a flow sheet showing which samples were analyzed and methods for analyses.

How many congeners were actually identified as occurring in the study ?
Particularly in the sediments ? - chromatograms would have been useful .

Chpt. 2.

P2-3: Air Monitoring for VOCs--were any PCBs detected ?

P2-5: Purchases by GE from 1955-1971 were 97.4% Aroclor 1242, (50.6.106kg) and 2.6% Aroclor 1254 (1.4.106kg)
(Brown et al., 1988--Science, V240,p. 1675)

Chpt.3:

P3-7: Samples should be specified as water samples - grab samples most often imply solid samples and it's hard to visualize grabbing "dissolved PCBs and ...

This paragraph is confusing - if these samples are not "appropriate" (does this mean not useful or not unbiased) why are they discussed and then how can they be "important to reveal possible non-equilibrium... "?

p3-8: Same paragraph as above. State the number of samples used (10 of 18 collected) and refer to the table (Table 1-1). I think the samples from tributaries since they were collected and analysed for PCBs could also have been used.
Last paragraph. "Appear to represent" or are they a representative set ?

Figure 3-2.: A line graph showing change may have been better for POC

P3-10: Perhaps because theoretical values assumed equilibrium conditions - deviations from theoretical should be discussed

P3-12: Last paragraph. "Dissolved concentration (DOC) should be dissolved organic carbon

Figures 3-7 to 3-10: Do these represent single water samples taken at a point in the river at the RM given? Also, it would be helpful to have dates of collection below transect numbers -particularly since figure represents seasonal data

P3-17: Samples were held for four days- were they kept at 4° C ? Were measures taken to inhibit biological activity ?

P3-18: Maybe it should be assumed that disequilibrium in nature is the norm- regarding PCBs: if dechlorination, as an example, is occurring the PCB load is changing- generally from more chlorinated to less chlorinated congeners which in turn would alter the pore water concentration, etc. The process is probably not a slow, continuous reaction throughout the year, but probably goes in spurts as favorable conditions occur.

Figure 3-13: Why is BZ 52 on this figure?

Figure 3-16: At approximately RM196.8--does this suggest that more Mono, Di and Tri-s are being put into the water column from sediments? Could this be related to biological activity in the sediments?

Is this due to input of sediments from Rogers Island?

P3-24: Was this information regarding DOC (4 mg/l) etc. obtained during this study? I don't recall a prior discussion.

P3-27: What is the relationship of Hudson River [POC] and [DOC] to fitting data at Green Bay ?

P3-28: Why was BZ 151 used? It occurs in Aroclor 1254 but not at all in A 1242- Yet the emphasis particularly with MDPR and MW is put on Aroclor 1242.

P3-31 Sect 3.1.3: Makes case for flux of PCBs out of sediments from porewater to H₂O column by diffusion and groundwater advection of DOC and dissolved phases.

P3-35: What specific analytical differences were used by GE and could some of the Congener analyses from the GE study be used?

P3-38: Could reasons for non-equilibrium be due to addition of PCBs from (a) other than sediments and (b) movement of specific congener from the sediments to water column.

P3-39: Lower partition coefficients (K_{oc} and K_{poc}) mono/di CBs concentration is enhanced in porewaters relative to higher C1-congeners facilitating loading to water column from sediments.

P3-40: Were water samples kept on ice or biological activity inhibited in some way?

P3-53: Regarding suspension of fine grained cohesive sediments--could these sediments or a fraction of them, go into suspension (before flows reach the necessary shear stress levels) by impacts and scouring from saltating and suspended particles?

P3-59: Also, Aroclors 1260 and 1268 approximately 1%; Aroclor 1254 approximately 5% (Brown et al 1988)

P3-124: Were water and sediment samples examined by GE or just water samples?

P3-125: Report needs chromatograms.

P3-125: Coelution of BZ 4/10 common with DB-1 and DB-5- but why not group this peak and use in a ratio with other peaks in the chromatogram to measure change?

Figure 3-83: Follow text (p3-128) and put total PCB's on y axis label.

Figure 3-84 to 3-87: I think the y axis labels need to be corrected to fit the figure's legends.

P3-128: From these plots (Fig. 3-83 to 3-87) it would be interesting to determine rates of change between Roger's Island and TI Dam.

Why is there an increase through the winter months. It seems that the curve would flatten out as biological activity decreased as a result of lower temperatures. Also, eventually the curve must become asymptotic - could this possibly be used to get an estimate of the dechlorination rate.

P3-119: Why not use ratios of these congeners (BZ 56, 60, 70 and 74) as a measurement of dechlorination?

Chpt. 4)

P4-9/4-13: The occurrence (persistence) of wood and wood chips at surface and to 30cm depth is interesting--does the wood show any signs of degradation and have PCBs been extracted and analysed from any of the wood debris ?

P4-5: 8. Should this read finer-grained sediments with and without higher total PCB inventories...?

Figure 4-7: Higher PCB levels do correlate with lower DN values, but there is a lot of scatter- In reality, DN values correspond to sediment type and not to PCBs - PCBs are more likely to be associated with finer grained sediments - it is a good approximation tool to help increase the probability of finding sediments with higher PCB levels.

P4-21: Last two lines: "finer sediments tend to be more easily eroded...". Would this also be true with clays or clay rich sediments?

Table 4-3: Check the natural log values.

Table 4-9: Notes: b. Refers to Eq 4-7 and 4-8 for definition of terms. These are not the correct equations (see pg 4-44).

P4-50: 4-3.1: Last line. Dechlorination "reduces" PCB to biphenyl-not "destroys" it because molecule is still intact -although it's nbo longer a PCB.

P4-51: Last paragraph-J. Brown, 1993 is not in reference list.

P4-54: J. Brown, 1987 reports the occurrence of BZ 54 in Hudson River sediments, probably a dechlorination product as according to it doesn't occur in Aroclors 1016, 1242, 1254, 1260, or in Clophen A30, A40, A50, and A60 (Schulz et al 1989).

P4-56: Underestimation could be greater than 5% depending on the amount of light congeners lost and the MDPR ratio.

P4-57: Aroclor 1242 is not primarily a tri-chlorinated biphenyl mixture but instead a tetra- and penta-chlorinated mixture. Tetra-CBs comprise about 31% and penta-CB about 29% of the congeners found in Aroclor 1242 by Frame et al.,(1996) See attached Table I . Table II indicates the Aroclor 1242 congeners listed in the report- (Table 4-8) the differences in the congeners found in the same commercial mixture (Aroclor 1242) Particularly the larger number of Hexa- and hepta chlorinatedbiphenyls.

P4-57-P4-65: See discussion of MDPR.

Figures 4-23. 4-24: the RMs in the text differ from those on in the figures.

P4-71: Brown and Wagner (1990) have found dechlorination in marine sediments of the Acushnet Estuary.

Vol. 2C, Bk 3/3-Data Usability Report

A.5.2.6: Why was OCN used as a recovery standard? Hexachlorobenzene (HCB), among others, would have been a good choice. It gives a good ECD response, and with an HP-5 or Rtx-5 column shouldn't co-elute with any congener. OCN would have better served as an internal standard. This would have facilitated gc peak identifications by enabling comparisons relative retention times determined by Mullin et al.(1984) for all 209 congeners on a similar column. It seems strange that OCN would breakdown during extraction. Was the OCN standard chromatographed to determine if it was pure ?

Holding times: Were sediment and water samples maintained at 4°C after collection and prior to extraction ?

Pg.A-10; B-11: Why was BZ18 used to differentiate Aroclor 1016 from Aroclor 1242? Why not a ratio of BZ 56 Aroclor 1242 to BZ 56 sample? There is about 30X more BZ 56 in A1242 than in A1016.- Even with extensive dechlorination (90%) the ratio would still work and could be used to measure dechlorination.

Table I. Congeners in Arochlor 1242 (wt.% \geq 0.05). Compiled from Frame et al. (1996).

| nCl | IUPAC NUMBER |
|-----|---|
| 1 | 1, 3 |
| 2 | 4, 5, 6, 7, 8, 9, 10, 12, 13,15 |
| 3 | 16, 17, 18, 19, 20, 22, 24, 25 26, 27, 28, 29, 31, 32, 33, 35, 37 |
| 4 | 40, 41, 42, 43, 44, 45,46, 47,48, 49, 51, 52, 53, 55, 56, 59, 60, 63, 64, 66, 70, 71, 74, 76, 77 |
| 5 | 82, 83, 84, 85, 86, 87, 89, 91, 92, 95, 97, 99, 101, 102, 105, 109, 110, 114, 115, 118, 119 |
| 6 | 138, 149, 153 |

**Table II. Congeners (wt.% \geq 0.05) in Arochlor 1242 from
Report Table 4-8**

| nCl | IUPAC NUMBER |
|------------|---|
| 1 | 1, 3 |
| 2 | 4, 6, 8, 9, 10, 12, 15 |
| 3 | 16, 17, 18, 19, 20, 22, 23, 25 26, 27, 28, 29, 31, 32, 33, 37 |
| 4 | 41, 42, 44, 45, 47, 48, 49, 51, 52 53, 56, 60, 63, 64, 67, 70, 74, 75, 77 |
| 5 | 82, 83, 84, 85, 91, 92, 95, 96, 97, 99, 101 105, 107 110, 114, 115, 118, 119, 122, 123 |
| 6 | 128, 129, 136, 137, 138, 141, 149, 153, 156, 157, 158, 167 |
| 7 | 170, 178 |

Premeeting Comments Submitted by Reinhard Bierl

Review of the Data Evaluation and Interpretation Report (DEIR) and Low Resolution Coring Report (LCR) - Hudson River Reassessment Study

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01/03/99

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1. Specific Questions (DEIR)

(1) Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?

I think the data support the assumption that the whole Thompson Island Pool which includes the upper areas are the main source to the water column load during low flow periods. It is not clear which parts of the sediments deliver most of the PCBs, what is the difference between „historically“ deposited PCBs and recent loadings and what happens during high flow events. Additionally we have rise the question whether one year of sampling is representative for the hydrological and geochemical situations in the Hudson River system.

(2) Are two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g. temperature)?

The theoretical background represented in the report expresses mainly the state-of-the-art in the scientific literature. The estimated particulate organic carbon partition coefficients seem to be reasonable. It would have been necessary to see the variability of the constants to comment some of the conclusions

which have been made.

Applying three-phase partitioning coefficients would require a much more detailed analysis of the dissolved organic carbon and colloid contents and properties of pore and surface water. I think this is far beyond the task of this study and should be avoided.

(3) Are the conceptual models based on the transect sampling consistent with the data?

The conceptual models applied to explain the transect data of the 1993 sampling campaign are mainly supported by the data of the Responsiveness Summary. As in some other parts the discussion in the Responsiveness Summary is much more detailed and convincing as in the original DEIR report.

In spite of the quite detailed analysis there remains a kind of unsatisfactory feeling. First most of the corrections concerning flow has to be believed. A detailed analysis of the flow data would require much more time. Second much effort has been spent to present and discuss the transect results but no hint is given towards the variability of the data. Third due to the tremendous variety of data a multivariate approach would have been a useful approach to interpret congener specific data.

(4) Does the sampling at bias of samples collected at the TI Dam-West sampling location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?

As stated in the DEIR Responsiveness Summary, „the net result of combining

and assessing the interpretations of QEA and the phase 2 team is an improved understanding of the TIP sediment PCB source", the arguments put forward in the report appear reasonable. The problem of the sampling bias seems to be compensated by the analytical corrections. Therefore the loadings reported in the DEIR appear to be in the right order.

The implications of higher concentrations along the shoreline would stress different areas: the PCB inventory needs probably be revisited. That means a more detailed geostatistical analysis of the present data emphasizing the shoreline in a more detailed way. Sampling in the future should also consider these areas with a more detailed resolution.

Concerning the transport and the exchange mechanisms it would be necessary to answer a few more questions:

- how are the differences in deposition and resuspension rates between shoreline and center channel,
- is the biological activity very high,
- will you find forms of biofilms during the months with higher temperatures with an influence on sorption processes and sediment stability,
- what are the volatilization losses in the shallow parts of the pool.

(5) Are the geostatistical techniques (polygonal clustering and kriging) correctly applied?

I do not feel as a real expert on geostatistical techniques to say the methods were not correctly applied. Anyway I have a few comments. Fact is that we have data of unequal quality, with a spatial variance of the variograms and with spatial and temporal unfavorable distributed data. In that case it would be useful to use more advanced geostatistical methods, that means unlinear methods. The program GeoEAS which has been used for the analysis does not offer such options. It would be necessary to quantitate the uncertainty of the estimated values. The variograms which are represented have mostly the

character of white noise which reinforces the need for analysis of the estimation uncertainty. I think it would be useful, to express the parameters of the variograms as a function of the spatial coordinates. As far as I understood are the kriging results not only a matter of estimating the PCB-amount in the TI Pool but are also intended to support a redevelopment in the future. Therefore some additional effort would be quite helpful.

(6) Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#1,4,8,10 and 19 (MDPR) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?

The approach to take the change in molecular weight (MW) and molar dechlorination product ratio (MDPR) appears to be reasonable. It gives similar results concerning the accumulation of ortho-substituted mono- and dichloro - congeners as has been reported in several papers working with samples of the Hudson River.

A major restriction to the use of this kind of index is that it depends on the knowledge of the pure original Aroclor-mixture. I'm not sure if this point is completely addressed. A second restriction is that the different mobility of the congeners is neglected that means in reality you will have a chromatographic effect in sediments.

(7) The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?

Even when it is reasonable that the adaptation of microorganisms is connected to certain amounts of PCBs ((1) how comes the PCB-molecule to the microorganism or vice versa; 2) selectivity advantage), there is no indication in the literature that there exists a single threshold. The factors which control the dechlorination process are numerous.

A second point which has influenced my opinion is that I could not proof why quite a huge amount of data have been excluded from this analysis.

2. Specific Questions (LCR)

(1) In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?

Analysis of environmental samples over a period of nearly 20 years will cause differences. This is hardly avoidable due to development of analytical techniques but also due to different sampling techniques and different teams doing the work. There has been much effort to establish a comparable basis especially between the 1984 and 1994 data. Despite the quite detailed work of Butcher (1997) to get a comparison of the non-resolved PCBs I'm not completely convinced about the correctness of the analytical data. I can imagine that much of the variance in the analytical data could be a result of different quantitation methods (e.g. how to draw the baseline in chromatograms which are a result of different matrix of samples etc.) and of problems with the use of the surrogate and internal standards. In the Final Phase Working Plan (1992) it was planned to do some comparable analysis of the older sediment

and water extracts. I haven't seen results to that. When samples (extracts or original sediment material) had been stored in a suitable way (that means at a minimum of -20°C, better -40° to -80°C) I would suggest to do this comparison at least for some of the samples. It would be very interesting to get at least an impression of the lower chlorinated congeners in the 1984 samples. Concerning the internal standards I'm aware that for reasons of keeping methods comparable and perhaps for reasons of cost, OCN and TCMX has been used but why are not at least some samples analysed by using ¹³C-standards to validate the results.

(2) In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sample heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is a loss from most locations supported by the data?

There has been much effort to reoccupy previous sampling locations which indeed has worked out in many locations. But we have to keep in mind the governing factors which are responsible for lateral heterogeneity. Depends it merely on „historical“ deposition, dynamic exchange or predominately on sediment parameters like texture (grain size) and total organic carbon content (TOC). Based on the data in the report and of literature it is obvious that PCB are mostly connected to fine grained sediments especially in the silt fractions with second maxima in coarse fractions. This is due to differences in the properties of the organic matter. The data on organic carbon and nitrogen are neither complete nor are they precise enough but a careful look on the C/N-ratio shows at least a trend that low ratios are followed by high contents of PCBs and high ratios by low contents. Low C/N-ratio expresses organic matter

with less polar hydroxyl and phenolic groups and a more hydrophobic microenvironment which in fact has consequences on partitioning of hydrophobic micropollutants like PCBs.

In the LRC Reassessment analysis most of the cluster areas were determined to be fine-grained sediments. Therefore some of the uncertainty of comparing data on a „point-to-point“ basis was ruled out. Based on the agreement of the mass change estimates between the two methods the data seem to support the general loss of PCBs. But I do not believe that a certain amount of loss can be stated.

(3) What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?

The relative measures of mass change as calculated by the equation 4.1.4

$$\Delta = [(MPA_{94} - MPA_{84}) / MPA_{84}] * 100\%$$

in the LRC is an acceptable means to compensate for some of the uncertainty.

As stated before the uncertainty of the estimated mean values does not allow to represent mass losses as single values. It's definitely a range and should be presented as a range.

(4) In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this „gain“ is primarily due to incomplete characterization in 1977 valid?

I think no other explanation is plausible enough. Comparison of the data from the NYSDEC 1976-78 sediment samples and the TAMS 1994 samples show considerable differences even at near located sampling points. A shift in the hot spot itself is certainly possible. A mass loss at other „hot spots“ of the pool and a mass gain exactly at this location below the dam is not very likely. These would be fundamental events which are not supported by the data of most of the other hot spots.

(5) Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below the TI Dam?

I do agree with this conclusion that significant losses have occurred from hot spots below the dam. Again I think it is not possible to calculate overall mass changes but it is sufficient to estimate trends. A more rigorous (geo)statistical analysis of the data would be perhaps more persuasive. The question however what mechanism has caused this losses has still to be answered. Losses of more than 10% in my opinion can only occur due to resuspension and advective transport during the major runoff events.

(6) The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?

The aspect of burial depends to a certain part on the values for deposition and resuspension rates which are not known exactly in the different zones. Depending on the PCB concentration profiles given in the reports there is no indication that large fractions of the PCB inventory are buried very deeply. This is supported by the high-resolution cores, by the loss of PCB inventory and by

the fact that a redistribution of sediment-bound PCBs is consistent with the water-column data.

(7) Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?

I have no personal experience with sidescan sonar data but the results are very convincing and the comparison of the SSS-data and the other grain-size data show that valuable spatial data could be gained.

3. General Questions

(1) Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?

The data set is very comprehensive and I think it is enough to get a quite good impression of the transport behavior of PCBs in the Upper Hudson. Nevertheless some points - already discussed in the Responsiveness Summary - concerning for example the exact influence of the Thompson Island Pool to the overlying water still remain. It would be interesting to see how good the transport models are working.

Concerning the fate of PCBs I would state the data set it is **not** sufficient. USEPA/TAMS suggest some additional work in the modeling and (eco)toxicology part of the Hudson Reassessment study but these data are not the basis for this review. There are some compartments which seem to be addressed only theoretically in the DEIR. To determine exact volatilization rates of PCBs is certainly a very difficult task but some measurements of atmospheric PCB contents along the Hudson River would be very helpful. Due to the frequent situations with pools (very low flow velocity) and dams (spray) volatilization could be an essential process of PCB removal. Photochemical destruction of PCBs (both in the surface water and in the atmosphere) is an important fate mechanism but the overall rate limiting steps are diffusion from sediments and the transfer at the water/atmosphere boundary.

Another point of concern is the fate of the coplanar congeners. In respect of the enormous amounts of PCBs in the Hudson River system the toxicological importance of the coplanar PCBs can not be ignored. Are there any data on these congeners and perhaps some recent data on dioxins and furans besides

the data given in Brown et al. (1988)?

Nevertheless I have the feeling that the important issues have been addressed and mostly answered. Combining all the available and most recently data from USEPA/TAMS, GE, USGS and the other involved organizations the database should serve as a qualified basis for the further reassessment study. So to my opinion the DEIR and LRC are acceptable.

(2) Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?

Some of the points have already been addressed in the preceding questions. I would have liked some additional work on the geostatistical techniques and the statistics as a whole. In certain parts a multivariate approach would have been the better choice to come to qualified results. Particularly it could have been useful to trace sources of the PCBs by a multivariate fingerprinting approach as well as to analyze the dechlorination patterns.

In general it's a pity that the study didn't use a more multivariate approach determining for example the main nutrients and metals which could serve as additional indicators of the system behavior.

I would suggest to do some additional analysis in the estimation of the sampling and analytical error. The described sampling program for river water rises some questions. How are the 17 L water results comparable to the 1 L results taken by GE? How big are the deviations concerning the filtering of water samples in a dissolved and particulate phase? Is the colloidal phase of minor importance to transport and is it adequately addressed by the DOC-content?

As stated earlier I would also suggest, if the storage of the extracts and samples has been done in an adequate manner, to do some re-analysis of the old extracts or samples. It could be (or not) a confirmation of the results done by estimation of the packed column analysis and it could give some indication of the low-chlorinated congeners in the 1984 samples.

APPENDIX D

LIST OF REGISTERED OBSERVERS OF THE PEER REVIEW MEETING



United States
Environmental Protection Agency
Region 2

Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Data Evaluation and Interpretation Report Low Resolution Sediment Coring Report

Albany Marriott
Albany, New York
March 16 - 18, 1999

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APPENDIX E
AGENDA FOR THE PEER REVIEW MEETING



Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Data Evaluation and Interpretation Report Low Resolution Sediment Coring Report

Albany Marriott
Albany, New York
March 16 - 18, 1999

Agenda

Meeting Facilitator: Jan Connery, Eastern Research Group, Inc.
Meeting Chair: Ken Reimer, Environmental Sciences Group, The Royal Military College of Canada

TUESDAY, MARCH 16, 1999

- 7:15AM Registration/Check-in
- 8:15AM Welcome Remarks and Panel Introduction
Jan Connery, Eastern Research Group, Inc.
- 8:40AM EPA Overview and Background Remarks
Doug Tomchuk, U.S. Environmental Protection Agency
- 8:55AM Observer Comments
- 9:45AM B R E A K
- 10:00AM Presentation on Responsiveness Summary for the Low Resolution
Sediment Coring Report
Ed Garvey, TAMS Consultants, Inc.
- 11:00AM Charge to the Panel/Summary of Pre-meeting Comments
Ken Reimer, Chair
- 11:30AM L U N C H (on own)
- 12:45PM Discussion on Data Evaluation and Interpretation Report (DEIR)
Questions 1 & 2



TUESDAY, MARCH 16, 1999 (Continued)

2:15PM **B R E A K**
2:30PM **Discussion of DEIR Questions 3, 4 & 5**
4:00PM **Adjourn**

WEDNESDAY, MARCH 17, 1999

8:30AM **Discussion of DEIR Questions 6 & 7**
10:30AM **B R E A K**
10:45AM **Summary of Discussion of DEIR Questions**
11:45AM **L U N C H (on own)**
1:00PM **Discussion of Low Resolution Sediment Coring Report (LRC)
Questions 1 & 2**
2:30PM **B R E A K**
2:45PM **Discussion of LRC Questions 3 & 4**
4:15PM **B R E A K**
4:30PM **Discussion of LRC Questions 5 & 6**
5:15PM **Adjourn**

THURSDAY, MARCH 18, 1999

8:00AM **Discussion of LRC Question 7**
8:45AM **Summary of Discussion on LRC Questions**
9:30AM **B R E A K**
9:45AM **Discussion of General Questions 1 & 2**
10:45AM **Summary of Discussion on General Questions**
11:15AM **B R E A K**
11:30AM **Observer Comments**
12:15PM **L U N C H (on own)**
1:30PM **Recommendations and Chair's Summary**
3:15PM **Closing Remarks**
3:30PM **Adjourn**

APPENDIX F
SUMMARIES OF OBSERVERS' COMMENTS

List of Observers Who Made Comments

Day 1 (March 16, 1999):

George Hodgson, Saratoga County Environmental Management Council
John Connolly, Quantitative Environmental Analysis
Jim Rhea, Quantitative Environmental Analysis
Kirk Ziegler, Quantitative Environmental Analysis
John Haggard, General Electric

Day 3 (March 18, 1999):

George Hodgson, Saratoga County Environmental Management Council
Marilyn Pulver, Town of Fort Edward
William Ports, New York Department of Environmental Conservation
Mel Schweiger, General Electric
John Connolly, Quantitative Environmental Analysis
Jim Rhea, Quantitative Environmental Analysis
John Haggard, General Electric Company

The remainder of this appendix summarizes the comments made by the observers listed above. Comments are summarized in the order in which they were presented. As the meeting agenda in Appendix E shows, observer comments were scheduled only for the first and third day of the meeting.

Appendix F—Summaries of Observers' Comments

Day 1, Comments from George Hodgson, Saratoga County Environmental Management Council

Mr. Hodgson opened his comments by stating that the Saratoga County Environmental Management Council is very supportive of the peer review process. He noted that the council had recommended that EPA conduct an independent peer review for all scientific aspects of the site reassessment project. Mr. Hodgson then commented that EPA's responses, as presented in the reports and their responsiveness summaries, should be carefully reviewed because he thought some findings were "not well-founded and sometimes misleading." Mr. Hodgson then provided the following examples of findings that he encouraged the reviewers to evaluate critically. Most of these examples are from the LRC.

First, Mr. Hodgson commented that EPA did not adequately justify that the number of sediment core samples collected in the 1994 sampling effort were sufficient for estimating changes in PCB inventory. Mr. Hodgson noted that comparing results from "matched pairs" of sediment cores was not an acceptable approach for evaluating changes in inventory among the 1,200 samples collected by NYSDEC and the 60 samples collected by EPA. Rather, Mr. Hodgson advocated using a statistical comparison of the means of these sampling efforts (e.g., by conducting an analysis of variance using an F-test). Mr. Hodgson indicated that such statistical analyses are critical for determining whether the amount of PCBs in the Hudson River sediments have truly changed between 1984 and 1994.

Second, Mr. Hodgson noted that EPA did not adequately address concerns raised about spatial variability of PCB concentrations in the river sediments, particularly in "hot spots." Mr. Hodgson explained that EPA had identified "large variations" in PCB concentrations in one hot spot (area H7) but had concluded that this area did not represent most of the other hot spots. To support the claim that the hot spots are relatively homogeneous, he recommended that EPA conduct sampling on a fine grid (1- to 2-foot spacing). Mr. Hodgson also noted that EPA did not respond to comments on the large spatial variations in PCB concentrations depicted in plates 4-21 through 4-28 of the LRC, particularly in plate 4-23.

Third, Mr. Hodgson felt that EPA did not provide a convincing argument to support that burial of PCBs is not occurring. Mr. Hodgson noted that low resolution sediment coring samples, which mix the top 9 inches of sediments, are incapable of characterizing how PCB concentrations vary with sediment depth. Nonetheless, Mr. Hodgson noted that EPA, when responding to comment 4-1.7 on page LRC-20, stated that peak PCB concentrations are "only a few inches" below the surface. Mr. Hodgson did not think the LRC data could support such a finding. He continued by stating that the high resolution coring actually shows peak PCB concentrations at 6 inches or more below the surface—a depth Mr. Hodgson thought was "likely well below the active surface layer." Mr. Hodgson also noted that EPA disputes the use of high resolution coring data to characterize PCB concentrations with depth in areas of the river without fine-grained sediments. After expressing his concerns about the concentration profiles with depth, Mr.

Appendix F—Summaries of Observers' Comments

Hodgson recommended that EPA obtain data proving that the peak PCB concentrations occur within the "active surface layer" of the sediments, rather than inferring this finding from the low resolution sediment coring results.

Fourth, Mr. Hodgson commented on the mechanisms EPA proposed in the DEIR for how PCBs transport from the sediments to the water column. Regarding advection of groundwater through hot spots as a possible mechanism, Mr. Hodgson thought EPA's sample calculations (i.e., those that showed "breakthrough" occurring in 25 years) used an assumed advection flow that is much higher than actual field data generated by GE. Mr. Hodgson noted that the calculated "breakthrough" time would be an order of magnitude different had EPA used GE's data. Though he acknowledged that EPA considered GE's field data to be "too meager" for this calculation, Mr. Hodgson still wondered why EPA chose not to use the only data set that is available on groundwater advection. Mr. Hodgson concluded by recommending that EPA collect data to support its sample calculations on groundwater advection.

Day 1, Comments from John Connolly, Quantitative Environmental Analysis

Mr. Connolly opened his comments by introducing himself as a consultant for GE and by noting that he has worked in the field of contaminated sediments for more than 20 years—some of this experience was gained as an EPA employee. Mr. Connolly then listed several sites on which he has worked and continues to work. Regarding the Hudson River PCBs site, Mr. Connolly first congratulated EPA on completing a "very thorough" study of the river and sediments. Mr. Connolly indicated, however, that some of the conclusions in the DEIR and LRC are incorrect. Mr. Connolly explained that he and two of his colleagues from Quantitative Environmental Analysis (QEA) would explain what these incorrect conclusions are.

Mr. Connolly stated that EPA attempted to address "four major issues" in the two reports under review: (1) identifying the sources of PCBs that pass over the Thompson Island Dam; (2) determining the fate of PCBs that pass over the Thompson Island Dam; (3) determining the fate of PCBs in the fine-grain river sediments; and (4) attributing the PCBs in the freshwater portion of the lower Hudson River to specific sources. Mr. Connolly's comments addressed the second of these four major issues. In giving his comments, Mr. Connolly referred to a pie diagram that Doug Tomchuk (EPA) had used during the opening remarks. Mr. Connolly commented that the pie diagram suggests that the PCB concentration passing Thompson Island Dam constitutes the "vast majority of the PCBs passing through the freshwater Hudson." Mr. Connolly noted that this diagram implied that most of the PCBs moving through the freshwater Hudson could be eliminated by removing the sources of PCBs upstream of the TID. Mr. Connolly offered several reasons why he thought such a finding is incorrect.

Appendix F—Summaries of Observers' Comments

First, Mr. Connolly noted that the pie diagram was based on 1991 sampling data—the last time a comprehensive sediment survey was conducted. He explained that this data set found, on average, that the surface sediments in the 5.9 miles of the TIP contained 19 parts per million (ppm) of PCBs; he then explained that the same data set found, on average, that surface sediment in the 34 miles immediately downstream of the TID contained 5 ppm of PCBs. Based on these average values, Mr. Connolly presented a simple analysis that weighted PCB concentrations by the lengths of the river over which they were measured. Using this analysis, Mr. Connolly suggested that 5 ppm of PCBs for 34 miles ($5 \times 34 = 170$) contributes 1.5 times the amount of PCBs to the water table as 19 ppm of PCBs for 5.9 miles ($19 \times 5.9 = 112$). Therefore, Mr. Connolly concluded that contaminated sediments in the 34 miles downstream of TID could contribute more PCBs to the water column than the contaminated sediments in the TIP. Though he acknowledged the shortcomings of this simple analysis of PCBs in the Hudson River, Mr. Connolly stated that the simple model shows that remediating sediments in the TIP would probably not solve the PCB contamination problem for the entire river system.

Second, Mr. Connolly commented that the pie diagram used in EPA's opening remarks at the peer review meeting is based upon "simple accounting." The pie diagram evaluates PCB concentrations at TID and at Waterford, notes that the concentration profiles of PCB congeners are similar, and then assumes that the PCBs observed in Waterford must be the PCBs that left the TID. He compared this reasoning to examining a bank account and concluding that no transactions had occurred simply because the ending balance is similar to the beginning balance. Mr. Connolly emphasized that this is flawed logic and explained that one must look at all of the sources and sinks to understand the fate and transport of PCBs in the Hudson River system. Mr. Connolly noted that it is a "naive conclusion" to suggest that PCBs transport conservatively from the TID to Waterford.

Third, in commenting on the transport of PCBs in the freshwater portion of the Hudson River, Mr. Connolly again questioned the idea of conservative transport of PCBs. He noted a contradiction in the reasoning of EPA's reports: Mr. Connolly explained that PCBs could not both be conservatively transported through the river and be responsible for contaminating the river sediments.

At the end of his comments, Mr. Connolly noted that two of his colleagues would address other findings in the DEIR and LRC that QEA questioned. He also noted that a statistician from Stanford University who was unavailable to attend the peer review meeting provided comments on the statistical analyses in EPA's reports. These comments were distributed later in the meeting.

Appendix F—Summaries of Observers' Comments

Day 1, Comments from Jim Rhea, Quantitative Environmental Analysis

Mr. Rhea first acknowledged the difficult task the reviewers face in evaluating the reports, given their limited experience with this particular site, unlike many of the observers at the meeting who have spent around 10 years working on the problem of contaminated sediments in the Hudson River. Mr. Rhea then added that the sediments of the Hudson River are probably the "most studied" sediments of any site in the United States, by virtue of the various EPA and GE sampling efforts. Mr. Rhea then commented that he has some concerns regarding the "broad-based conclusions" drawn by EPA. The remainder of Mr. Rhea's comments focused on the source of PCBs that pass TID. (This was the first of the four issues raised by Mr. Connolly.)

Referring to a pie chart that EPA had displayed earlier in the meeting, Mr. Rhea stated that 1.7 parts per billion (ppb) of PCBs were measured in the water passing the TID (or in the water flowing through the TIP). Mr. Rhea then questioned whether PCBs passing the TID were associated with recently deposited sediments or with sediments that had been in the TIP for a long time period. Mr. Rhea indicated that the similar PCB congener profiles between the water column and the sediments suggests that the sediments likely act as a source of PCBs. He indicated further that EPA's reports postulated two mechanisms that might account for the PCBs in the water column: pore water diffusion and resuspension of contaminated sediments. Regardless of whether the underlying mechanisms are ever fully understood, Mr. Rhea noted that a more "relevant question" is determining whether the PCBs detected in the water column originated from contaminated sediments deposited in the last couple of years or from sediments deposited more than 20 years ago. Mr. Rhea indicated that the answer to this question could have "tremendous implications" on the effectiveness of source control and sediment remediation in the Hudson River.

Mr. Rhea noted that the available data suggest that upstream sources have been "a major factor" in contaminating surface sediments with PCBs. He explained that much of the data are consistent with "large-scale, external" loads of PCBs to the Hudson River. Mr. Rhea identified some of these external loads, such as the Allan Mill event in the early 1990s and more recent loadings of dense nonaqueous phase liquids (DNAPL) from the GE plant to the river, despite GE's remediation efforts to eliminate such releases. Mr. Rhea indicated that EPA's water column transects indicate that "plant site loadings" account for half of the total PCBs entering the Hudson River system. He indicated further that EPA's study shows that most of the PCB loadings are as "particulate phase PCBs." Mr. Rhea noted that the particulate phase PCBs that enter the TIP settle in that stretch of the river. Mr. Rhea also indicated that a study conducted by GE found that DNAPL releases from the GE facilities also would remain confined within the TIP.

In concluding his comments, Mr. Rhea noted that the congener profile of PCBs in the water column throughout the TIP closely matches the congener profile of the surface sediments. He emphasized that, because of this, surface sediments are critical for understanding the source of

Appendix F—Summaries of Observers' Comments

PCBs in the river, regardless of whether PCBs enter the water from diffusive sources or resuspension. Mr. Rhea maintained that the extent to which upstream sources have impacted levels of PCBs in surface sediments has important implications for the "final remedy" for the contaminated sediments.

Day 1, Comments from Kirk Ziegler, Quantitative Environmental Analysis

Mr. Ziegler opened his comments by indicating that his expertise is in the fate and transport of cohesive sediments and that he has worked in this field for more than 15 years and has studied more than 20 river systems. He noted that he has worked on the contaminated sediments in the Hudson River for 8 years, during which he focused on sediment transport within the TIP. Mr. Ziegler indicated that his comments would primarily address EPA's findings regarding the fate and transport of PCBs in the fine-grained sediment areas. (This is the third of the four issues raised by Mr. Connolly.)

Before critiquing EPA's findings, Mr. Ziegler first restated several of the main conclusions of the DEIR and LRC (e.g., that PCBs were "somewhat unstable" in the fine-grained sediments with 40 to 80 percent of the PCB mass lost from selected hot spots over a 10-year period). Mr. Ziegler then noted that he and his colleagues had done a "tremendous amount of analysis" that showed that some of the main conclusions are incorrect. He then presented arguments to support this statement.

First, Mr. Ziegler addressed the stability of the sediments in the Upper Hudson River. Mr. Ziegler noted that "a very good" side-scan sonar study had been conducted by EPA contractors in 1993. He then indicated that the results of this 1993 bed mapping study were largely consistent with a 1978 study by NYSDEC to identify hot spots in the river. Mr. Ziegler indicated that the similarity between these studies, which were conducted 15 years apart, suggests that areas of fine-grained sediments in the Upper Hudson River are "fairly stable."

Second, Mr. Ziegler addressed EPA's finding that "widespread burial" of PCBs is not occurring in areas of the Hudson River with cohesive sediments. He stated that this finding is counterintuitive because the Upper Hudson River is a "reservoir" system that has many dredged channels. He noted further that no "strong perturbations" had occurred in the Upper Hudson River for many years. Mr. Ziegler thought these observations were inconsistent with a hypothesis that net burial of sediments is not occurring. Mr. Ziegler then reviewed some of the data presented in the DEIR and LRC to refute EPA's finding regarding net deposition of sediments. For example, Mr. Ziegler thought cesium profiles in high resolution sediment cores indicated that sediments were depositing at a rate between 0.5 and 1 centimeters per year in some areas. Furthermore, Mr. Ziegler indicated that the peak PCB concentrations in many of the high

Appendix F—Summaries of Observers' Comments

resolution cores "are buried at depth." He also noted that about 70 percent of the sediment cores that detected certain beryllium isotopes (Be^7) were consistent with sediment burial.

Mr. Ziegler concluded by stating that reviewing water column and sediment sampling data is not sufficient for understanding the fate and transport mechanisms in the Hudson River. Rather, he suggested that EPA evaluate the data in conjunction with a mass balance modeling approach that includes the various physical processes as constraints. By this approach, Mr. Ziegler claimed that he and his colleagues found that net burial is occurring in the river, particularly in the TIP. Their studies estimated a net sedimentation rate of approximately 0.8 centimeters per year among the fine-grained sediments of the TIP. Mr. Ziegler noted that his analyses have suggested that approximately "85 percent of the net sedimentation" occurs within the TIP—a result that he thought was consistent with the behavior of cohesive sediments in "low energy" areas of rivers.

Day 1, Comments from John Haggard, General Electric Company

Mr. John Haggard, an engineering program manager with GE, began his comments by noting that EPA had denied his request for making a "lengthy presentation" during the peer review meeting. Mr. Haggard indicated that he and his colleagues would be available throughout the peer review meeting to answer any questions the reviewers might have.

The remainder of Mr. Haggard's comments focused on the conclusion from the LRC that there had been a 40 percent loss of PCBs from the sediments in the TIP over a 20-year period. Mr. Haggard indicated that EPA based this conclusion on statistical and inferential arguments. To comment on these arguments, GE hired a statistician, Dr. Paul Switzer of Stanford University, to review the report. Mr. Haggard indicated that Dr. Switzer basically found that the statistical basis for EPA's conclusion was not supported by the data. Though Mr. Haggard acknowledged that he believes a loss of PCBs from the TIP has occurred over the last 20 years, he questioned EPA's estimates of this loss (40 percent) and wondered how this finding would be used to predict future conditions in the Hudson River. He indicated that the methods used by TAMS Consultants to estimate loss of PCBs are not useful for evaluating how PCB levels might change in the future. Mr. Haggard suggested that the best method for evaluating changes in inventories would be to use modeling or additional data collection to test hypotheses drawn from the existing data. Mr. Haggard reiterated that he thought the estimate of 40 percent loss of PCBs in the TIP was incorrect.

Mr. Haggard continued by reading written comments attributed to Dr. Switzer, who was unable to attend the meeting. Mr. Haggard noted that he would not read the entire set of Dr. Switzer's comments, but he quoted some passages, such as the "responses to my earlier comments were disappointing" and "some responses that invoke statistic concepts are inarticulate

Appendix F—Summaries of Observers' Comments

and meaningless as understood by statisticians, suggesting that responsibility for replying to my earlier questions and criticisms may not have been entrusted to a professional statistician." Mr. Haggard stated that Dr. Switzer seemed frustrated that many times his criticisms "were waved away" when EPA responded to his original comments. Mr. Haggard submitted Dr. Switzer's written comments to the peer reviewers.

Day 3, Comments from George Hodgson, Saratoga County Environmental Management Council

Mr. Hodgson opened his comments by commending the peer reviewers for their work during the meeting. Mr. Hodgson's comments, which he made on behalf of the Saratoga County Environmental Management Council, primarily addressed the peer review process and the adequacy of the data in the DEIR and LRC for understanding PCB dynamics. Regarding the peer review, Mr. Hodgson first noted that he was disappointed that the EPA charge did not allow reviewers to "wrap their arms around" the main issues of PCB dynamics in the Hudson River, particularly in the TIP. Mr. Hodgson thought understanding the mechanisms of PCB fate and transport is critical for selecting appropriate remediation alternatives. He felt strongly that no remedial decisions should be made until these mechanisms are understood.

Mr. Hodgson then addressed several issues regarding data interpretations in the DEIR and LRC. First, he questioned the reliability of estimates that 40 percent of the PCBs in the TIP were lost to the water column over a 20-year period. He thought the uncertainties associated with upstream sources of PCBs, groundwater advection, and depositional and scour areas of the riverbed prevented such a firm estimate of PCB loss from the sediments. Mr. Hodgson indicated that the Hudson River is "too important a resource" to make remedial decisions without "having all the facts" regarding PCB dynamics in the river.

Mr. Hodgson then stated that he and the Saratoga County Environmental Management Council advocate collecting additional data to understand the system dynamics better. He noted two specific examples where additional data might be useful: reviewing chromatograms to put the historical data into perspective; and using "congener fingerprinting" to determine the extent to which surface sediments, buried sediments, and upstream inputs act as sources of PCBs to the water in the TIP. Mr. Hodgson commented that these examples raise important questions that need to be answered.

Mr. Hodgson then returned to his earlier comments on the peer review process. He again noted that the peer reviewers had "a very strict charge" that limited their evaluations of the DEIR and LRC. Mr. Hodgson thought this was unfortunate since his organization had recommended that EPA's peer reviews consider all available data, not just a "snapshot or one side of the picture." Mr. Hodgson believed that the limited scope of the peer review did not serve the public interest well. To determine the extent of interaction between GE and EPA on the peer review

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process and other issues, Mr. Hodgson asked Bill McCabe (EPA) if meetings between GE and EPA, as discussed in January 1998, had been scheduled. [Mr. McCabe responded that EPA and General Electric were trying to schedule meetings, but none had been conducted to date.] Mr. Hodgson responded that he believed "an open dialogue" between the two parties was essential for reaching scientifically defensible solutions.

As a final comment, Mr. Hodgson stated that the Saratoga County Environmental Management Council does not think the available data for the Hudson River provide convincing evidence that the major source of PCBs to the water column is the hot spots in the TIP. He emphasized that additional data or scientific studies are needed to prove this point to the Council.

Day 3, Comments from Marilyn Pulver, Town of Fort Edward

Ms. Pulver introduced herself as a councilwoman from the town of Fort Edward and as a farmer. She indicated that she has "been directly involved" with the Hudson River PCBs site for 20 years. Ms. Pulver began her comments by commending the independent reviewers for their efforts during the meeting and noting that the peer reviewers focused much of their discussions on what she thought was "the greatest weakness" in EPA's reports: the data uncertainty.

Ms. Pulver continued her comments by indicating that many people who live near the Upper Hudson River believe the peer reviewers offer the only truly independent evaluation of EPA's work. She urged the reviewers to make strong recommendations to EPA about reporting firm conclusions and acknowledging associated uncertainties, instead of misleading the public with unsupported claims. Ms. Pulver thought such strong recommendations would help others make sense of the many conflicting studies published to date. She also thought that EPA still has not provided compelling evidence to support a "20-year-long dredging project."

Ms. Pulver then expressed several concerns regarding the peer review process. After noting that the reviewers evaluated only those data collected by EPA's contractors, she indicated that the public would prefer to know "the facts" about the Hudson River, regardless of whether they were derived from data collected by EPA, GE, or NYSDEC. Ms. Pulver thought a "truly informed interpretation" of the Hudson River PCBs site must consider data from all available relevant studies. Ms. Pulver then indicated that she thought the reviewers might have felt obligated to answer only the questions asked by EPA. Ms. Pulver thought the community members in the Upper Hudson River area deserved a more open peer review process, and she indicated that the consequences of remediation were too great to have anything less than a completely open peer review. Ms. Pulver ended her comments by confirming with Bill McCabe (EPA) that the observers' comments would become part of the peer review record.

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Day 3, Comments from William Ports, New York State Department of Environmental Conservation

Mr. Ports introduced himself as a project manager from NYSDEC, and he then commented on the reviewers' discussions about the comparison of results from a 1984 sediment survey to EPA's 1994 coring studies. According to Mr. Ports, NYSDEC asked a contractor with extensive experience with the Hudson River to review EPA's comparison of the two studies. This contractor reportedly reviewed the two data sets and examined in detail one sediment core from 1983. Mr. Ports noted that some of the contractor's interpretations were limited since they were based on only one sediment core. Nonetheless, Mr. Ports indicated that NYSDEC's contractor recommended a more detailed evaluation of chromatograms from 1984—a recommendation that the peer reviewers had made during the second day of the meeting. Mr. Ports then submitted the contractor's written comments and thanked the reviewers for their efforts during the meeting.

Day 3, Comments from Mel Schweiger, General Electric

Mr. Schweiger introduced himself as the manager of the "Hudson River research and remediation project" for GE. Mr. Schweiger then noted that he and his colleagues were frustrated during the peer review meeting because they were not given the opportunity to take part in the deliberations among the reviewers. Nonetheless, he commended the reviewers for their efforts and began to offer technical comments.

Mr. Schweiger indicated that GE has been asking EPA to conduct scientific peer review of its research for the last 8 years. Mr. Schweiger considered independent peer review to be an important facet of scientific studies. He then praised the review process by providing an example of how the reviewers identified critical flaws in the LRC. More specifically, Mr. Schweiger noted that EPA, shortly after releasing the LRC, claimed that 40 percent of the PCBs had "washed out of hot spots" in the TIP over a span of 10 years. Mr. Schweiger indicated that EPA said this 40 percent loss was a "rock solid" estimate and that the loss of PCBs to the water column might necessitate immediate emergency actions. On the other hand, Mr. Schweiger noted that two scientists hired by GE concluded that EPA had "no factual basis" for its estimated loss of PCBs from the river sediments—a finding that was presented to EPA. Mr. Schweiger then acknowledged that the reviewers reached a similar conclusion as GE: some PCBs were lost from the sediments, but the 40 percent loss estimate was unfounded.

Mr. Schweiger used the following quote from the LRC Responsiveness Summary as evidence that EPA concurs with the findings of GE and the peer reviewers regarding the loss of PCBs from contaminated sediments: "EPA acknowledges that there is considerable uncertainty surrounding the loss values in these estimates, but stresses that there is statistically significant loss despite this uncertainty." Mr. Schweiger paraphrased the statement, finding that what EPA

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presented as fact previously, it now presents as very uncertain. Mr. Schweiger then emphasized that he presented this example not as a criticism of EPA, but as praise of the peer review process in causing EPA to revisit its conclusions.

Mr. Schweiger concluded his comments by asking the peer reviewers to consider carefully the comments that his colleagues (John Connolly and Jim Rhea) were about to present. He noted in particular that his colleagues would address the extent to which the TIP sediments contribute to PCBs in the freshwater Hudson and whether widespread burial of PCBs occurs in the TIP. Mr. Schweiger indicated that EPA's own data, as well as data not yet presented at the meeting, suggest that widespread burial of PCBs does occur.

Day 3, Comments from John Connolly, Quantitative Environmental Analysis

Mr. Connolly's comments addressed what he considered one minor issue (uncertainty in EPA's data) and one major issue (whether "widespread burial" of PCBs occurs). Regarding the data uncertainty, Mr. Connolly acknowledged that the reviewers discussed this issue extensively, but he wanted to clarify another aspect of the issue. His overall point was that EPA's reported value of PCB loss from the TIP did not fully account for the uncertainty among the data. To illustrate this point, Mr. Connolly detailed step by step the method EPA used to estimate losses of PCBs. He explained that EPA's estimates of PCB loss did account for the uncertainty associated with calculating mean inventory levels from individual sediment coring measurements; he also noted, however, that EPA's estimates did not consider the variability inherent in each individual measurement. By ignoring this uncertainty, Mr. Connolly thought EPA's range of estimated PCB loss (4 to 59 percent) likely understated the actual range of PCB loss indicated by the data. Mr. Connolly indicated that, when all uncertainties are considered in calculations, changes in PCB inventory over time might actually range from 100 percent loss (complete loss of PCBs in the sediments) to a 50 percent gain (an increase in PCBs in the sediments). He thought this broader range underscored an important finding: EPA's reports "considerably underestimate the uncertainty" associated with estimates of PCB mass loss.

Regarding EPA's conclusion that "widespread burial" of PCBs did not occur in the TIP, Mr. Connolly provided a series of arguments to refute this finding. Mr. Connolly addressed this issue by first defining two criteria that he thought must be met to reach conclusion in scientific documents: a conclusion must be stated as clearly as possible to avoid misinterpretations, and a conclusion must be supported by the available data. On the topic of the clarity of EPA's conclusions, Mr. Connolly indicated that the terms "widespread" and "burial" are both subjective and open to many different interpretations. Using an analogy of flu epidemics, Mr. Connolly indicated that "widespread" could be carefully defined (e.g., 25 percent of a population is affected) or the term could be vaguely defined, thus causing observers to have different interpretations. He reiterated that EPA's use of the term "widespread" in the LRC was open to

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multiple interpretations. Mr. Connolly then explained several possible interpretations of "burial": new sediments gradually bury old sediments with time or new sediments have moved PCBs to depths below "some bioavailable layer." Noting that these two interpretations have considerably different implications, Mr. Connolly concluded that EPA used a subjective term ("burial") in presenting a major conclusion of the LRC. Overall, Mr. Connolly indicated that the vaguely defined terms in EPA's conclusions violated his first criterion for making conclusions in scientific documents.

Mr. Connolly then provided two arguments to suggest that the conclusion of "widespread burial" is not supported by the data—his second criteria for accurate, scientific conclusions. First, Mr. Connolly critiqued EPA's interpretations of the beryllium measurements. He explained that these measurements can indicate deposition of sediments, but only when beryllium is detected; he noted that no conclusions regarding sediment deposition can be made when beryllium is not detected. Mr. Connolly continued by indicating that beryllium was detected in the sediments at 70 percent of the locations that EPA sampled. Since beryllium is an indicator of sediment deposition, Mr. Connolly thought this frequency of detection offered "definitive evidence" that sediments are depositing in the Upper Hudson River.

Second, Mr. Connolly reviewed EPA's interpretations on how PCB concentrations varied with sediment depth and offered an alternative interpretation that he thought was better supported by the data. To address this issue of PCB "burial," Mr. Connolly first provided an overview of the LRC results: in 60 percent of the samples, the highest PCB concentration was observed to be in the top 9 inches of sediment; in the remaining 40 percent of the samples, the highest PCB concentration was observed in deeper sediments. Mr. Connolly asked the reviewers whether they could truly infer that "widespread burial" occurs when roughly half of the samples had maximum PCB concentrations at depths more than 9 inches below the surface. Using the profile of PCB concentrations for a single high resolution sediment core, Mr. Connolly showed how EPA's low resolution cores might not be sufficient for commenting on burial: a high resolution core might show a maximum PCB concentration between 8 and 9 inches below the surface, but a low resolution core taken at the same location would only show that the maximum occurred within the top 9 inches. In short, he emphasized that the low resolution cores cannot distinguish sediments with maximum PCB concentrations that occur up to 9 inches below the surface from those where maximum concentrations occur at the surface layer. Mr. Connolly thought this shortcoming was very important to future evaluations on the bioavailability of the PCBs. He concluded this discussion by presenting what he thought was a more accurate summary of the LRC data: in 60 percent of the samples collected, the highest concentrations of PCBs, which presumably were deposited in the 1970s, occurred within the upper 9 inches of the sediments.

As a final point, noting that EPA's finding of "no widespread burial" has potentially important implications, Mr. Connolly indicated that additional studies are first needed to verify EPA's findings. He thought such studies might include collecting additional high resolution

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sediment cores, evaluating the depth over which bioturbation affects mixing of sediments, and more thoroughly characterizing the stability of the sediments. Mr. Connolly concluded his comments by urging the reviewers to consider his many concerns regarding EPA's conclusion that "widespread burial" of PCBs does not occur.

Day 3, Comments from Jim Rhea, Quantitative Environmental Analysis

Mr. Rhea's comments focused on clarifying two interpretations of the water column sampling data: the extent to which the sediments of the TIP act as a source of PCBs to the freshwater Hudson River and the impact EPA's correction factors had on monitoring data collected at stations with sampling biases. Mr. Rhea indicated that he tried to offer the following remarks during the peer reviewers' discussions.

First, Mr. Rhea noted that EPA based its conclusion that the sediments of the TIP were a primary source of PCBs to the freshwater Hudson strictly on the water column transect data from 1993. He noted further that a large volume of water column data have since been collected, including weekly sampling results from stations at Fort Edward, the TID, and another downstream location. Mr. Rhea said the more recent data collected by GE suggest a different spatial profile of PCB concentrations than reported in the DEIR, and he suspected this difference was largely due to a sampling bias in EPA's work (which he explained in greater detail later in his comments). In short, Mr. Rhea thought the GE data show that the sediments downstream of the TIP are just as much a source of PCBs to the water column as are the sediments within the TIP itself. To support this claim, Mr. Rhea presented a chart summarizing a subset of monitoring results from GE's sampling stations, which he indicate are operated as part of a consent decree with oversight by EPA. The chart showed a roughly linear increase in PCB concentrations in the water from the Fort Edward station all the way to the Schuylerville station. Mr. Rhea reiterated that this gradual increase suggests that the sediments within the TIP as well as the sediments immediately downstream of the TIP act as comparable sources of PCBs to the water. Mr. Rhea did not find this result surprising, since river sediments from the TIP through Schuylerville are known to be contaminated with PCBs. Based on his arguments, Mr. Rhea asked the reviewers to clarify in their final comments the extent to which sediments in the TIP act as a source of PCBs.

Second, Mr. Rhea discussed the corrections that EPA made to its transect study, as presented by Ed Garvey during the peer review meeting. Before commenting in detail on the correction factors, Mr. Rhea first presented a map of the various sampling stations that had been operated in the vicinity of the Thompson Island Dam. He pointed out the location of GE's former sampling station at the dam's "Western Wing Wall" (a station that was found to have a sampling bias) as well as GE's current sampling station at a downstream location (a station that is believed to be unbiased). Mr. Rhea then explained how EPA's contractors derived a correction factor based on data from the two GE sampling stations and applied this factor to data collected at

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EPA's sampling station, which was approximately one-quarter mile upstream from the TID. Mr. Rhea thought an implicit assumption in applying this correction factor was that the PCB concentrations at the EPA sampling station must be similar to those at GE's former sampling station. After presenting limited sampling data indicating that PCB concentrations at these two locations are indeed different, Mr. Rhea concluded that EPA's contractors had not appropriately applied the correction factor that they derived. He noted further that he did not think enough data were available to derive an appropriate and defensible correction factor for the EPA sampling station. To summarize the significance of the correction factors, Mr. Rhea presented a slide showing an EPA water column transect based on the correction factor and he then showed a different slide showing water column PCB concentrations that were "unbiased." The data presented on the slides had notably different implications as far as what sediments acted as sources of PCBs to the water column.

In closing his comments, Mr. Rhea commended the peer reviewers for their efforts in critiquing EPA's reports. He acknowledged that the reviewers had a difficult task, especially considering that many scientists at the meeting have worked on the Hudson River PCBs site for more than 10 years.

Day 3, Comments from John Haggard, General Electric

Mr. Haggard introduced himself as the technical program manager for a GE team that conducts research on the Hudson River. As a general comment on the peer review process, Mr. Haggard expressed his frustration that GE was not allowed to present material during the peer reviewers' discussions. He indicated that many people associated with GE had potentially valuable contributions to the peer review by virtue of their many years of experience working on the Hudson River. Mr. Haggard thought GE's exclusion from the peer review discussions hurt the overall process.

Before providing his comments on the DEIR and LRC, Mr. Haggard pointed out that some of the reviewers' findings were consistent with "key issues" that GE had raised with EPA. As an example, he indicated that both GE and the reviewers had concerns about the statistical techniques used to compare sediment inventories from different years and the conclusions stated in the reports (particularly the estimates of PCB loss from the sediments) without "proper qualifications." The remainder of Mr. Haggard's comments focused on three technical issues.

First, Mr. Haggard addressed the issue of PCB loss from sediments downstream of the TID. He noted that only two sets of data are available (data from 1977 and data from 1994) for estimating PCB loss for this stretch of the river. Mr. Haggard recalled that the reviewers were skeptical about the reliability of the 1977 data set, and he thought the reviewers should comment further about what this unreliability means in terms of estimating losses of PCBs from sediments.

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In short, Mr. Haggard felt that estimated losses of PCBs for the area downstream of the TID might be "somewhat unreliable," given the concerns the reviewers had about the 1977 data set. Mr. Haggard requested the reviewers to reconsider this issue in their final deliberations.

Second, Mr. Haggard addressed EPA's conclusions regarding losses of PCBs from the sediments in the TIP. Mr. Haggard acknowledged that even GE's reports have concluded that surface sediments in this part of the river clearly add PCBs to the water column; however, he found EPA's quantitative estimates of PCB losses from sediments to be unconvincing. Since the reviewers suggested that EPA's estimates should be reported as ranges instead of point estimates, Mr. Haggard wondered whether a range of 5 to 59 percent would be really meaningful. More specifically, he explained that this range spans virtually no PCB loss (5 percent loss) to more than half of the PCBs being lost (59 percent loss). Rather than relying on this range, Mr. Haggard instead recommended an analysis of fate and transport processes and water column measurements to complete a "real mass balance" for the PCBs. He thought this type of analysis would generate a less uncertain estimate of PCB losses from the river sediments.

Third, Mr. Haggard asked the reviewers to consider in their final discussions how the conclusions of the LRC and DEIR will be used in the future—an issue that was raised by Dr. Ron Mitchum (a peer reviewer) during the meeting. Mr. Haggard recalled that the peer reviewers did not discuss this topic thoroughly during the meeting because it was not part of the charge. Noting that the reviewers' conclusions might eventually be used to make press statements and remedial decisions, Mr. Haggard urged the reviewers to state their conclusions with appropriate qualifiers.

Mr. Haggard closed his comments by commending the reviewers for evaluating EPA's reports and managing to complete the peer review during the 3-day meeting.

APPENDIX G
MINUTES FROM THE JANUARY 1999 BRIEFING MEETING

**Minutes from the Briefing and Site Visit for the Peer Review of the
Data Evaluation and Interpretation Report and the Low Resolution
Sediment Coring Report for the Hudson River PCBs Superfund Site**

On January 11–12, 1999, Eastern Research Group, Inc. (ERG), conducted a meeting to provide six independent reviewers with background information on two reports that were prepared for the Hudson River PCBs Superfund site, and ERG organized a site visit of the Upper Hudson River to familiarize the reviewers with the site. The reports of concern were the Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC). A copy of the agenda of the meeting and site visit is among the Attachments to these minutes. The meeting, which was open to the public, was facilitated by ERG and attended by the reviewers, representatives from the U.S. Environmental Protection Agency (EPA), representatives from EPA's contractors, and approximately 20 observers. The Attachments to these minutes list the meeting attendees. Though observers were invited to attend the site visit of the Upper Hudson River, none did so. The remainder of these minutes briefly summarizes the presentations made during the meeting and site visit, in the order that the presentations were given.

Ms. Jan Connery (ERG), meeting facilitator, welcome remarks and introduction. Ms. Jan Connery opened the meeting by welcoming the observers and describing the purpose of the briefing and site visit: to provide background and context for the reviewers such that they understand the site history and the scope of the reports. Ms. Connery emphasized that the briefing was not the actual peer review of the documents; she noted that the peer review was scheduled to take place in March 1999. Ms. Connery then reviewed the agenda for the two-day meeting. During Ms. Connery's presentation, the reviewers, representatives from EPA, and representatives from EPA's contractors introduced themselves.

Mr. Doug Tomchuk (EPA), overview presentation. Mr. Doug Tomchuk's presentation outlined the history of EPA's involvement with the Hudson River PCBs Superfund site. As means of introduction, Mr. Tomchuk presented a series of slides that showed the setting of the Upper Hudson River. He then discussed historical releases of PCBs to the river, as well as controls that have been implemented to minimize them. Mr. Tomchuk explained that EPA has been involved with this site for many years and indicated that, in 1984, the Agency reached an interim "No Action" decision for the contaminated sediments of the Upper Hudson River. He noted that current work on the site is part of EPA's Reassessment of the previous decision.

Mr. Tomchuk then gave an overview of the purpose and organization of the Reassessment. He explained that the Reassessment is being conducted in three phases and that the DEIR and LRC were prepared as part of Phase 2. To provide additional context for the reviewers, Mr. Tomchuk described the scope of the six reports that comprise Phase 2 of the Reassessment. Focusing specifically on the DEIR and LRC, Mr. Tomchuk reviewed the four major conclusions of both reports. He also reviewed the schedule for completing the Reassessment.

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Mr. Tomchuk closed his presentation by describing relevant aspects of the Superfund process, such as EPA's criteria for selecting remedies for a given site and EPA's general decision making process for Superfund. The reviewers did not have any questions about the presentation.

Mr. Damien Hughes (EPA), overview of the charge to the reviewers. Mr. Damien Hughes stepped through the charge to the reviewers, a copy of which is included in the Attachments to these minutes. Mr. Hughes explained the purpose of the peer review and the charge to the reviewers, and he indicated that EPA will likely not collect more data for this site as part of the Reassessment. During his presentation, Mr. Hughes reviewed every question in the charge and answered several of the reviewers' questions regarding the charge. These questions addressed the meaning of "conceptual models" (see Question 3 in the charge), the need to address data quality during the peer review, and the process by which reviewers should ask questions in the time between the briefing meeting and the actual peer review.

Dr. Ed Garvey (TAMS Consultants, Inc.), presentation on the DEIR and LRC. Dr. Ed Garvey, an author of the DEIR and LRC, provided a detailed overview of the content of the reports. Starting with the DEIR, Dr. Garvey first reviewed the four major conclusions of the report. For background purposes, he listed the various data collection efforts (i.e., water column monitoring, sediment coring, geophysical surveying) that were considered in the Phase 2 reports. Dr. Garvey then gave an overview of six subject areas covered by the DEIR. A summary of this overview follows:

- *Water column sampling data.* Dr. Garvey noted that EPA, General Electric Company (GE), and the United States Geological Survey (USGS) have all collected water column samples in the Hudson River. Dr. Garvey then explained the scope and monitoring locations of the transect sampling and flow-average sampling performed for the DEIR, during which he provided background information on the sampling and analytical methods. Dr. Garvey then showed selected figures from the DEIR to provide an overview of the water column sampling results. Dr. Garvey informed the reviewers that some of the data presented in the DEIR has been modified in the Responsiveness Summary—a document that was distributed to the reviewers later in the meeting.
- *High resolution sediment coring.* Dr. Garvey indicated that high resolution sediment coring was performed to establish a time history of PCBs in the river sediments and to characterize spatial variations in PCB concentrations. Dr. Garvey then described the sampling and analytical methods used to measure sediment concentrations and explained how selected radionuclides were analyzed to "date" the sediments. To illustrate the main findings derived from the high resolution sediment coring results, Dr. Garvey presented a series of figures from the DEIR and commented on selected data trends. In response to a

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reviewer's question, Dr. Garvey indicated that he did not have a slide that showed PCB concentration profiles for sediments in the Thompson Island Pool.

- *Equilibrium partition coefficients.* Dr. Garvey indicated that part of the scope of the DEIR was to derive equilibrium partition coefficients for PCBs in the water column. He presented some of the coefficients that were calculated from the water column monitoring data, and indicated that the DEIR presents additional sets of coefficients, including those with corrections for temperature and those with corrections for dissolved organic carbon.
- *Geophysical analyses.* Dr. Garvey reviewed the geophysical analyses (the sidescan sonar characterization of the river bed) that were documented in the DEIR. He explained how these analyses helped generate a two-dimensional map of the river sediments and how sediment "confirmation cores" were collected to verify the findings of the sidescan sonar data. Dr. Garvey presented some results from the geophysical analyses and explained how the acoustical signal from the sidescan sonar study relates to PCB concentrations in sediments.
- *Anaerobic dechlorination.* Dr. Garvey opened his discussion on anaerobic dechlorination by briefly describing the microbial processes that are believed to occur in the Hudson River. After defining the two measures used in the DEIR to characterize the extent of anaerobic dechlorination, Dr. Garvey showed a series of plots from the report that illustrate its main findings with respect to anaerobic dechlorination.
- *Geostatistical analyses.* Dr. Garvey indicated that geostatistical analyses, namely polygonal declustering and kriging, were used to estimate PCB inventory from sediment samples collected in 1984 by the New York State Department of Environmental Conservation (NYSDEC). Dr. Garvey then gave some background information on the techniques and how they were applied to the NYSDEC sampling effort. Finally, he presented some results of the geostatistical analyses that were cited in the DEIR.

After elaborating on these six topics, Dr. Garvey reiterated the four major conclusions of the DEIR. Dr. Garvey informed the reviewers that some of the analyses in the report had been revised in a Responsiveness Summary—a topic that he would revisit later in the meeting.

Following the presentation on the DEIR, Dr. Garvey provided background information on the LRC. Dr. Garvey first explained that the LRC focuses primarily on estimating PCB inventory in the river sediments. Dr. Garvey then reviewed the four major findings of the LRC and described salient features of the sampling and analytical methods used to collect and analyze low resolution sediment cores. He also reviewed some aspects of the data quality from this study, such as relative percent differences (RPDs) from the coring samples, and answered a reviewer's questions

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about how the RPDs were calculated. Dr. Garvey then gave an overview of three subject areas covered by the LRC. A summary of this overview follows:

- *Consistency with findings of the DEIR.* Dr. Garvey presented two examples of how the findings documented in the LRC were, to a certain extent, consistent with those documented in the DEIR. First, he presented a graph which showed that the extent of anaerobic dechlorination observed in the low resolution sediment cores was consistent, in a general sense, with that observed in the high resolution sediment cores. Second, he presented some data that suggested that the low resolution sediment coring data were generally consistent with the sidescan sonar data.
- *Change in PCB inventory in the sediments in the Thompson Island Pool.* Dr. Garvey described the methods by which changes in PCB inventory were calculated for the sediments in the Thompson Island Pool; he also indicated that the Responsiveness Summaries will document additional methods for calculating these changes. Dr. Garvey then presented a series of slides illustrating the calculation methods and their findings. Though he noted that the Responsiveness Summary which had not yet been released might modify the findings, Dr. Garvey indicated that the LRC reported an estimated 40 percent loss of PCBs from hot spots in the Thompson Island Pool, and he noted that this estimate has considerable uncertainty associated with it.
- *Change in PCB inventory in the sediments downstream of the Thompson Island Pool.* Dr. Garvey gave an overview of the procedure documented in the LRC for comparing the 1977 sediment coring results to the 1994 sediment coring results. Dr. Garvey presented several figures that indicated a statistically significant loss of PCBs from several hot spots downstream of the Thompson Island Pool. Dr. Garvey also presented data suggesting that hot spot 28 gained a large mass of PCBs between 1977 and 1994; however, he noted that the LRC provides evidence that this apparent gain is likely due to incomplete characterization of the hot spot during the 1977 sampling effort.

After reviewing these topics addressed in the LRC, Dr. Garvey identified several subjects in the reports that will likely be revised in the Responsiveness Summary expected to be released in February 1999. Dr. Garvey then answered reviewers' questions regarding the availability of data characterizing grain size distribution for the river sediments, measurements of biphenyl or other compounds in the sediment cores, and consideration of aerobic degradation in the reports.

Mr. Doug Tomchuk (EPA), additional comments. Following the first half of Dr. Garvey's presentation, Mr. Tomchuk informed the reviewers that some conclusions in the DEIR and LRC were slightly modified, and these modifications were documented in Responsiveness Summaries for the reports. For additional background on the documents, Mr. Tomchuk also informed the

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reviewers of EPA's extensive "community interaction program" for the Hudson River PCBs site. As examples, he noted that all documents go through both extensive internal reviews and reviews by other agencies (e.g., NYSDEC), as well as public comment periods, and he explained that "peer input" has occurred throughout the process through use of a "scientific and technical committee." Mr. Tomchuk indicated, however, that these various reviews and peer inputs are not necessarily independent.

Mr. Damien Hughes (EPA), additional comments. Prior to Dr. Garvey's final presentation, Mr. Hughes indicated that independent peer review was an important part of the Reassessment, since the peer review would help ensure that the reports prepared for EPA were based on sound scientific principles. Mr. Hughes reminded the reviewers that they should feel free to comment on all aspects of the reports during their peer review, including topics that may not be addressed in the specific questions in the charge. Finally, Mr. Hughes urged the reviewers to maintain their independence during the review process and to contact ERG directly with any inquiries they might have prior to the peer review meeting.

Dr. Ed Garvey (TAMS Consultants, Inc.), presentation on the Responsiveness Summaries for the reports. Dr. Garvey's final presentation addressed revisions that were made, or that were being made, to the DEIR and LRC in the documents' Responsiveness Summaries. He discussed several reasons why revisions were necessary: analytical corrections that were made to GE's data set; corrections for sampling biases at a sampling location near the Thompson Island Dam; corrections to the river flow data that were originally used in the DEIR; and revisions to selected statistical analyses presented in the reports. Dr. Garvey noted that the overall impact of these revisions is to be documented in the two different volumes of Responsiveness Summaries. Dr. Garvey closed his presentation by answering reviewers' questions, which addressed quality assurance, methods for collecting water samples, sedimentation rates, consideration of air sampling, annual loads of PCBs in the water column, and ranges of suspended solid concentrations.

Mr. Doug Tomchuk (EPA), site tour of the Upper Hudson River. The briefing meeting closed with Mr. Tomchuk outlining the itinerary for the site visit of the Upper Hudson River. Mr. Tomchuk identified the six locations that the reviewers would see. Observers were invited to follow on this site visit, but none did so. After Mr. Tomchuk's brief presentation, the reviewers boarded a bus and visited the following six locations along the Upper Hudson River:

- An observation point immediately downstream from Bakers Falls and directly across the Hudson River from GE's Hudson Falls plant.
- An overlook of the Hudson River, near a former outfall from GE's Fort Edward plant.

**Minutes from the Briefing and Site Visit for the Peer Review of the
Data Evaluation and Interpretation Report and the Low Resolution
Sediment Coring Report for the Hudson River PCBs Superfund Site**

—Continued—

- An overlook of the Hudson River, directly across from capped remnant deposit #4, and upstream from the former Fort Edward Dam and Rogers Island.
- The northern tip of Rogers Island.
- The western wall of the Thompson Island Dam.
- Lock #5 on the Hudson River.

The briefing and site visit for the peer review of the DEIR and LRC ended after the reviewers visited these six locations.

**Minutes from the Briefing and Site Visit for the Peer Review of the
Data Evaluation and Interpretation Report and the Low Resolution
Sediment Coring Report for the Hudson River PCBs Superfund Site**

ATTACHMENTS

1. *Meeting agenda*
2. *Peer reviewers*
3. *ERG onsite conference support staff*
4. *EPA and contractor participants*
5. *Observers*
6. *Charge to the reviewers*



Briefing and Site Visit for the Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Holiday Inn Turf on Wolf Road
Albany, New York
January 11-12, 1999

Agenda

MONDAY, JANUARY 11, 1999

- 11:00AM Lunch (on own)
- 12:00N **Registration/Check-In**
- 12:30PM **Welcome Remarks and Introduction**
Jan Connery, Eastern Research Group, Inc. (ERG)
- 12:45PM **Overview Presentation**
Doug Tomchuk, U.S. Environmental Protection Agency (EPA)
- 1:45PM **Presentation on Data Evaluation and Interpretation Report (DEIR) and the
Low Resolution Coring Report (LRC)**
Ed Garvey, TAMS Consultants, Inc.
- 3:00PM B R E A K
- 3:15PM **Presentation Continues**
- 4:30PM Adjourn

TUESDAY, JANUARY 12, 1999

- 8:30AM **Presentation on Responsiveness Summaries: DEIR and LRC**
Ed Garvey
- 11:30AM Adjourn
- 11:35AM Lunch (on own)
- 12:30PM **Site Tour and Briefing (Albany to Hudson Falls to Albany)**
- 4:30PM **End of Site Tour at Holiday Inn Turf, Albany**





Briefing and Site Visit for the Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Holiday Inn Turf on Wolf Road
Albany, New York
January 11-12, 1999

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United States
Environmental Protection Agency
Region 2

Briefing and Site Visit for the Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Holiday Inn Turf on Wolf Road
Albany, New York
January 11-12, 1999

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United States
Environmental Protection Agency
Region 2

Briefing and Site Visit for the Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Holiday Inn Turf on Wolf Road
Albany, New York
January 11-12, 1999

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Briefing and Site Visit for the Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Holiday Inn Turf on Wolf Road
Albany, New York
January 11-12, 1999

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Peer Review of Hudson River PCBs Reassessment RI/FS Phase 2 Reports

Data Evaluation and Interpretation Report Low Resolution Sediment Coring Report

**Albany Marriott
Albany, New York
March 16 - 18, 1999**

Charge

Members of this peer review will be tasked to determine whether the scientific analyses conducted for U.S. EPA's Data Evaluation and Interpretation Report (DEIR) and the Low Resolution Sediment Coring Report (LRC) are credible, the conclusions valid, and whether the findings are appropriate to use to support the decision-making process for the Hudson River PCBs Site Reassessment study. The peer reviewers will base their assessment on the review of the DEIR and LRC, as well as additional information found in the Responsiveness Summary issued in December 1998 (responding to several documents including the DEIR) and the Responsiveness Summary for the LRC (which will be released in February 1999). The peer reviewers will also have available for their review the Hudson River Reassessment database, which contains all of the data used in the preparation of the above documents, along with other data.

The DEIR and LRC present the results of the geochemical analyses conducted on the water-column and sediment data collected for the Reassessment, as well as data collected by a number of other agencies and General Electric. It should be noted that there have been several changes in the available data since the time of the release of the DEIR in February 1997. These changes include a better estimate of flow for several reaches of the river, a recalculation of GE's PCB data due to an analytical bias, and the discovery of a sampling bias at the Thompson Island Dam monitoring station. These changes are discussed in the Responsiveness Summaries, and the analyses in the Responsiveness Summaries should supersede those conducted in the reports, as appropriate.

It is important to realize that the geochemical analysis conducted in the DEIR and LRC will be complemented by mass balance modeling and human health and ecological risk assessments to provide a thorough understanding of the fate and transport and impacts of PCBs in the Upper Hudson River. These other reports will address questions regarding the mechanisms that release PCBs from the sediment, toxicity, and bioavailability/biouptake. A peer review was previously conducted for the approach proposed to conduct the modeling for the Reassessment. After the modeling and the risk assessment reports are released, the Agency will also have those documents peer reviewed.

Specific Questions

Data Evaluation and Interpretation Report (DEIR)

1. Is the documented PCB load, which originated from the TI Pool, consistent with a source consisting of historically deposited PCB-contaminated sediments?
2. Are the two-phase and three-phase partitioning coefficients, derived in the DEIR, appropriate and do they properly address the physical parameters of the system (e.g., temperature).
3. Are the conceptual models based on the transect sampling consistent with the data?
4. Does the sampling at the TI Dam-West location impact EPA's conclusion that the sediments of the TI Pool are the major source of PCBs to the freshwater Hudson during low flow conditions considering the analytical corrections made to GE's PCB data? What are the other implications of finding higher concentrations along the shoreline than in the center channel?
5. Are the geostatistical techniques (polygonal declustering and kriging) correctly applied?
6. Are the methods applied in the DEIR (change in molecular weight (MW) and evaluating concentrations of BZ#s 1, 4, 8, 10 and 19 (MDPR)) appropriate standards for determining extent of dechlorination? Are there any significant problems with this approach, or more appropriate approaches?
7. The DEIR finds that the degree of anaerobic dechlorination is primarily a function of original concentration rather than time, and accordingly that there is not significant predictable dechlorination in sediments containing less than approximately 30 mg/kg PCB. Is this reasonable?

Low Resolution Sediment Coring Report (LRC)

1. In the LRC, EPA compared sediment data from cores taken in 1977, 1984 and 1994, which had the PCB analysis conducted by different laboratory methods. How valid are the methods used to establish a consistent basis for comparison?
2. In the upper Hudson River system, it has been well established that there is significant lateral heterogeneity in sediment concentrations. While it was attempted to reoccupy previous locations, some uncertainty is added with respect to the actual sampling location. While the statistical techniques help compensate for this, how does the sediment heterogeneity affect the comparison of cores from two different years? Given the spatial variability, is the finding that there is loss from most of the locations supported by the data?

3. What is the impact of the difference between replicate samples in the 1994 sampling effort (36 percent average variability) on the finding that there was a 40 percent loss of PCB inventory from the highly contaminated sediments in the TI Pool?
4. In the LRC, it was found that Hot Spot 28 contained much more mass than previous estimates. Is the conclusion that this "gain" is primarily due to incomplete characterization in 1977 valid?
5. Does the data set and its interpretation support the conclusion that significant losses have occurred from hot spots below TI Dam?
6. The LRC found that the historically contaminated sediments in the TI Pool were not universally being buried and sequestered from the environment. How much confidence would you place in the LRC evidence against widespread burial?
7. Is the interpretation of the sidescan sonar data appropriate and supported by the analysis of the associated sediment properties?

General Questions

1. Is the data set utilized to prepare the DEIR, LRC and Responsiveness Summaries sufficient to understand the fate and transport of PCBs in the Upper Hudson?
2. Are there any additional analyses that should be done to verify certain findings of the DEIR and LRC?

Recommendations

Based on your review of the information provided, please identify and submit an explanation of your overall recommendation for both the DEIR and LRC.

1. Acceptable as is
2. Acceptable with minor revision (as indicated)
3. Acceptable with major revision (as outlined)
4. Not acceptable (under any circumstance)