Summary Reviews of Select Aspects of the USEPA Upper Hudson River Models

Presented to the USEPA Baseline Modeling Report Peer Review Members
March 27, 2000

Quantitative Environmental Analysis, LLC
Montvale, NJ 07645

Both EPA and GE have developed mass balance models for the Upper Hudson River. These models are the most powerful tools available to evaluate the efficacy of potential remedial options. However, they can always be improved. As have you, we have been reviewing EPA's recently released Revised Baseline Modeling Report (RBMR) to determine if improvements are needed so that the models can reliably predict the efficacy of considered remedial actions. Although our review is not complete, we have highlighted five issues that we hope you will consider as part of your review of the RBMR:

1) Inconsistency between RBMR and LRCR conclusions

We have previously sent to you a memorandum highlighting the importance of peer review charge question 11 and the fundamental inconsistency between the RBMR's conclusion that PCBs are being sequestered and the Low Resolution Coring Report's (LRCR) conclusion that a substantial portion of the PCBs in the fine-grained sediments of the Thompson Island Pool (TIP) have migrated. This inconsistency cannot be reconciled by differences in scale, as EPA suggests, but is the result of the flawed techniques used in the LRCR.

2) Predicted abrupt increase in surface sediment PCB levels

HUDTOX has forecasted abrupt increases in surface sediment PCB levels in the distant future at several locations in the river. These increases have been portrayed as realistic representations of what may happen in areas subject to net erosion. We have determined that these increases are the result of a numerical artifact of the structure of the model of the sediments, in which the depth of the

surface mixed layer is allowed to decline over time and then is abruptly increased. This sudden alteration of the mixed layer depth, which has no biological or physical basis, is responsible for the forecasted abrupt concentration increases.

3) Reduction in Solids Load at Fort Edward after 1990

In the model, the solids load at Fort Edward was reduced by about 40 percent after 1990. The TSS data collected by the USGS between 1977 and 1998 for the purpose of estimating solids load do not support this reduction. The appearance of a reduction comes from the use of TSS data collected by GE beginning in 1991. The GE data was not collected for the purpose of estimating solids load and misses a portion of the heavier particles that constitute an important part of the solids load at high flow.

4) Arbitrary addition of 40 MT/d of solids in the Schuylerville to Stillwater and Stillwater the Waterford reaches of the river

To improve the fit of HUDTOX to TSS and PCB data downstream of the TIP, the solids loads estimated from rating curves were supplemented with an additional load of 40 MT/d. This additional load results in calculated tributary TSS concentrations that exceed a factor of two uncertainty range around the data-based rating curves 83 percent of the time and reach unrealistic levels of several hundred mg/L under low-flow conditions. The need to invoke an unsupportable solids load to achieve model calibration in the region downstream of the TIP is symptomatic of errors in model structure. We believe that the principal structural error is the use of a constant deposition velocity that severely overestimates deposition during low-flow and underestimates deposition during high-flow.

5) Approach to calibration of the bioaccumulation model

Arbitrary statistical optimization of select model parameters was used to achieve a best fit of model to data. The resulting parameter values conflict with site-specific data and vary by location for no apparent biological or physical reason.

More detailed summaries of our analyses of these last four issues are provided in the attached papers. It is our hope that you will review these papers as a supplement to your own analyses and interpretations of the EPA models.

Issue 1: Forecasted "Substantial Increases in PCB Concentrations in Surface Sediments"

USEPA's HUDTOX model forecasts abrupt increases in surface sediment PCB (Tri+) concentrations in several localized areas in the TIP cohesive sediments (Figure 8-4a, Revised Baseline Modeling Report, Vol. 2D-Book 2 of 4) and the non-cohesive sediments of the Stillwater reach (Figure 8-4c, Revised Baseline Modeling Report, Vol. 2D-Book 2 of 4) after 40 to 50 years. EPA contends in the Revised Baseline Modeling Report (RBMR) that these increases are realistic predictions of what may happen in areas subject to net erosion. EPA believes these increases area a demonstration of a process that would "slow or interrupt apparent rates of recovery" (Vol. 2D- Book 1 of 4, Section 8.3.1, p. 160).

This issue is embodied in Peer Review Charge question 8. It is important because the forecasted increases will be considered during the Feasibility Study. However, the increases are not a realistic prediction, but are an artifact of the numerical model used to describe the sediment and the manner in which the model results are presented.

The model employs a 4 cm mixing depth. However, in areas of erosion or deposition, the model inadvertently changes the depth of the surface mixed layer over time (i.e., the depth subject to significant bioturbation) as a consequence of the sediment segmentation scheme and the numerical procedure. Where net erosion is calculated the depth of the topmost segment declines until it reaches some defined minimum value. At that time what remains of the top segment is incorporated in the segment below it and the sediment segments are renumbered by the model (Figure 1). Because particle mixing is calculated for a specified number of segments (e.g., the top two segments in the non-cohesive sediments of the Stillwater reach), the depth of sediment subject to mixing changes. In the case of the non-cohesive area of the Stillwater reach that is calculated to undergo net erosion, the mixed layer declines from 4 cm to almost 2 cm, instantly increases to 4 cm and then begins to decline again. The sudden incorporation of a sediment segment that was previously below the mixing layer and not subject to PCB loss mechanisms results in the calculation of a sharp increase in PCB concentration within the mixed layer (Figure 8-

4c of the RBMR). The reason the increase occurs after 40-50 years is that the net erosion rate is approximately 0.04 cm/year, so it takes about 50 years until that next lower 2 cm thick segment is redefined as part of the "top two segments".

The effect is less dramatic for the cohesive sediments in the TIP because there is mixing in the top 4 segments (8 cm initially). Hence the impact of the third segment suddenly becoming part of the top two segments and the fifth segment being suddenly introduced into the surface mixed layer is dampened. The former third segment was already mixed with the second segment and the former fifth segment is mixed with three segments instead of one segment. Close examination of Figure 8-4a (RBMR) reveals that the increase is more gradual than in the case where there is only mixing in the top two layers. This is expected as mixing slowly brings PCBs from the former fifth segment to the top two segments.

The numerical artifact of declining and then instantaneously increasing the depth of the surface mixed layer is exacerbated by the manner in which the model results are presented. The predicted concentrations in Figures 8-4, (a-e) **do not** represent the top 0-4 cm of sediment as stated in Section 8.3. Instead, they represent an average of the top two sediment segments. Because the depth of the topmost layer changes, the depth of sediment represented in the figures changes also. The presented results in an area of net erosion track a progressively thinner layer of surface sediment (i.e., from 4 to 2 cm) and then instantly a thicker layer (i.e., 4 cm) that again becomes progressively thinner.

Evidence that the predicted increases are due to the model's numerical procedures rather than a real phenomenon can be obtained by examining how the predicted increases change as the resolution of the numerical grid is changed. QEA ran it's bed model using EPA's parameters for particle mass transfer, net erosion, and molecular mass transfer as well as a mixing depth of 4 cm as was used in the Stillwater Reach. The model was run with a segment thickness of 2 cm as well as 0.2 cm to demonstrate that the apparent increase is easily reproducible and a function of layer thickness. We were able to reproduce the sudden increase when using 2 cm layers (Figure 2). As the sediment model

segmentation was refined, the sharp increases due to this numerical artifact began to disappear. As shown in Figure 2, use of segments 0.2 cm thick results in near complete elimination of the increases.

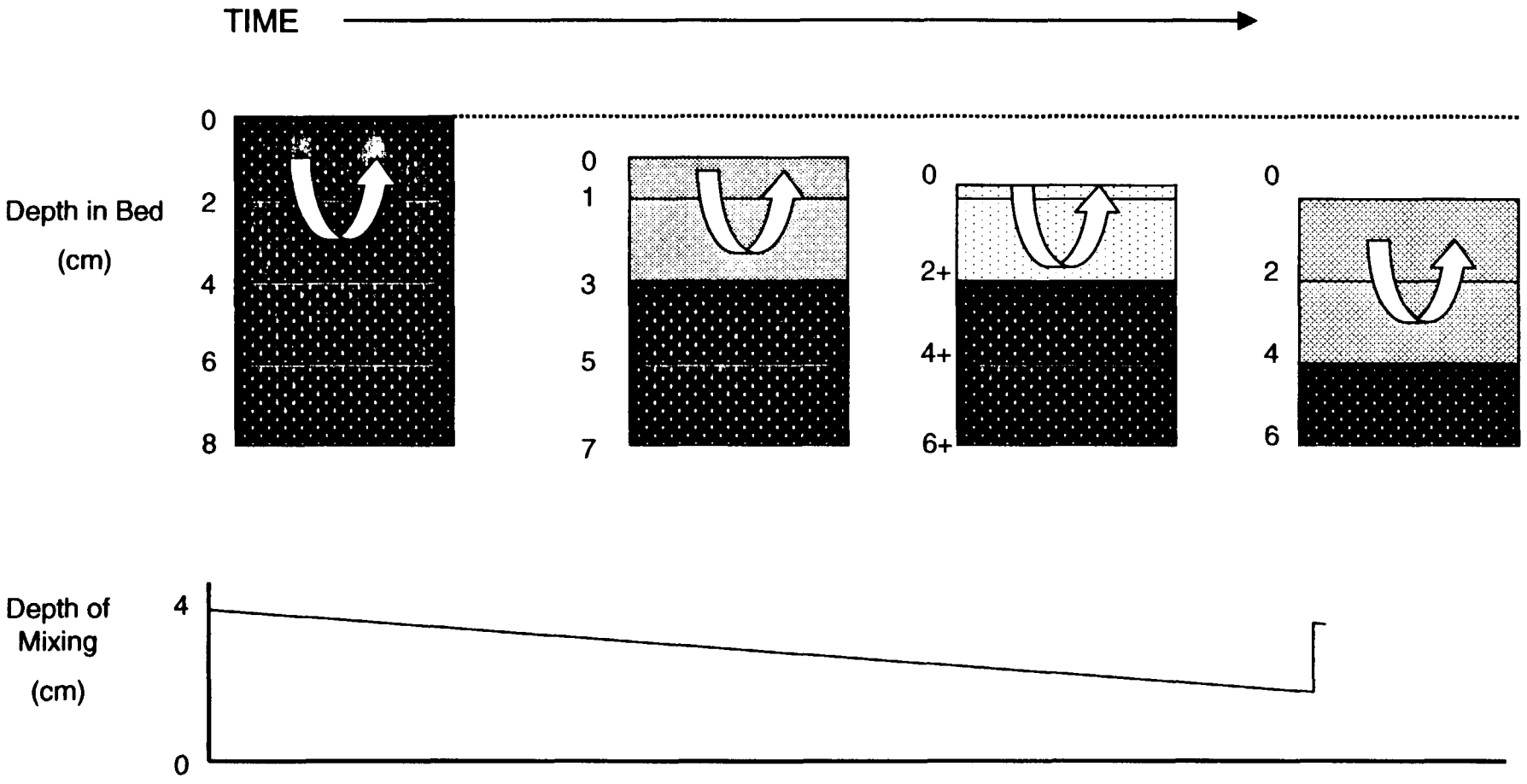


Figure 1. Numerical simulation of erosion in EPA sediment model.

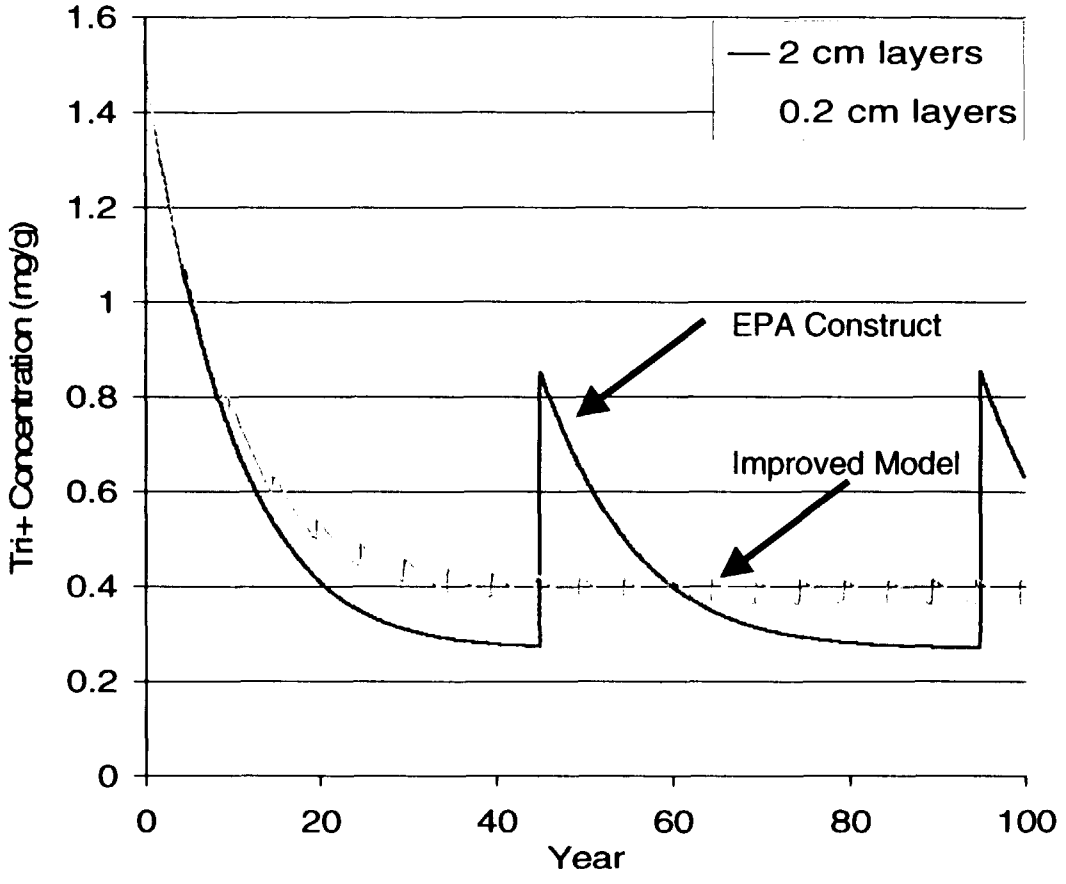


Figure 2. Illustration of error in EPA sediment model.

These comments relate to Charge Question 7 (Are the assumptions for the forecast reasonable?). A critical component of long-term simulations of PCB fate and transport in the Upper Hudson River (UHR), and particularly in the Thompson Island Pool (TIP), is the specification of solids loading at Fort Edward. Sedimentation rates and PCB surficial bed concentrations are directly affected by the Fort Edward solids load. Therefore, the accuracy of the model depends upon an accurate estimation of the Fort Edward solids load.

USEPA has hypothesized that a large decrease in the solids loading at Fort Edward occurred after 1990 (USEPA 2000). Various causes for the loading decrease were proposed, including capping of remnant deposits by General Electric (GE) in 1990. Several analyses were presented by USEPA to support their hypothesis that the annual loading rate after 1990 has decreased by 38% when compared to the 1977-90 period.

Both USEPA and GE have estimated Fort Edward solids loading during periods when data are unavailable using rating curves developed from total suspended solids (TSS) concentration and flow rate data collected at the Rogers Island sampling station located at the upstream limit of the TIP (QEA 1999, USEPA 2000). Flow rates are measured by the U.S. Geological Survey (USGS) at the Fort Edward gauging station and are typically reported as daily-average values. The two primary TSS data sources are: 1) USGS, which has collected samples from 1977 to the present and 2) GE, which has collected samples since 1990. There are significant differences in the TSS sampling equipment and procedures used by USGS and GE (Figure 1), and these differences affect the interpretation of TSS concentration data.

There are two reasons that support the use of the USGS data to estimate solids loadings. First, the USGS methodology is specifically designed to measure sediment loads, whereas GE's methodology is not. GE samples are taken at three locations in the water column: 0.2, 0.5 and 0.8 times the depth (e.g., in 2 m of water, the bottom GE sample

would be 40 cm above the sediment bed). The USGS method, in contrast, utilizes a sampler that samples continuously throughout the water column, from the surface to within 6 cm of the sediment bed. Thus, the GE method does not produce a vertically-averaged TSS concentration that adequately samples near-bed sediments, where a major fraction of the suspended sand load is located. In addition, the USGS sampler is a flow-through device that is specifically designed for sampling suspended sediment. A Kemmerer sampler is used by GE to collect TSS samples. The design of this device is such that suspended sands, with relatively high settling speeds, may not be adequately sampled. Second, the USGS methodology has remained constant throughout the relevant period (i.e., 1977 to the present), whereas GE's different methodology was introduced in 1990. It is far preferable to use a consistent data set than to rely on data from two different methodologies. Thus, it is appropriate to rely primarily on the USGS data set to establish solids loading over time at Fort Edward.

The correspondence of the hypothesized loading change and the introduction of a second data source, i.e., GE data, into the loading analysis leads to the necessity to determine whether the change is due to differences in sampling and laboratory analysis between the two data sources. Various techniques can be used to evaluate whether the introduction of the GE data into the loading analysis causes an artifactual reduction in solids loading that is not real. The most direct technique is to determine whether the single data source, i.e., USGS data, that covers both the 1977-90 and post-1990 periods supports the conclusion of a reduction in solids loading. USEPA attempted such a comparison by a paired sample analysis in which the pairs were generated by matching 1977-90 and post-1990 data on the basis of river flow. Few details were provided in USEPA (2000) on how the analyses were conducted or the results of those analyses. However, USEPA concludes that "these results show that the use of time stratification in computing the Fort Edward solids load is supported, at both high and low flows, regardless of whether or not GE data are included." An attempt was made to repeat part of the USEPA analysis, where USGS TSS concentration data from the 1977-90 and post-1990 periods were compared based on flow rate. Unfortunately, exactly how that analysis was performed could not be ascertained because of insufficient information in USEPA (2000). No unique procedure

exists for this analysis and it was found that the results depend upon the assumptions used in the analysis.

A more robust test of the loading-change hypothesis involves comparison of 1977-90 and post-1990 solids rating curves developed from the USGS data. This comparison is critical because,ultimately, rating curves are used to calculate solids loading. Two different methods were used to compare these two rating curves. First, the average annual solids loading for the post-1990 period (1991-1998) was calculated using both rating curves (Figure 2). This approach eliminates any potential effects due to hydrograph variations. The resulting loading rates were 33,300 and 26,600 MT/yr for the 1977-90 and post-1990 rating curves, respectively. Thus, the post-1990 rating curve yields an average annual load that is 20% lower than the 1977-90 rating curve. A large fraction of that difference is attributable to low-flow conditions (post-1990 is 28% lower), whereas the post-1990 high-flow load is only 15% lower than the 1977-90 loading. Second, the two high-flow rating curves were statistically compared and were not significantly different at a 95% confidence level. For the low-flow regime, minimal correlation existed between TSS concentration and flow rate, so, consistent with USEPA's approach, mean values were determined for each period. It was determined that the average low-flow TSS concentrations were statistically different, but the difference was not large, with mean values of 4 and 3 mg/l for the 1977-90 and post-1990 periods, respectively. Therefore, differences exist between the 1977-90 and post-1990 periods in Fort Edward solids loading; statistically significant differences occur under low-flow conditions, with relatively small differences observed during high-flow conditions. It should be noted that high-flow solids loading has a much larger impact on sedimentation than sediment loads brought in during low-flow periods, i.e., episodic deposition occurs in the UHR with most of the annual sedimentation occurring during relatively rare high-flow events. Thus, proper analysis of the USGS data shows that the solids loading during high flow at Fort Edward did not decline after 1990, and only a small drop in solids loading occurred during low flow after 1990.

It appears that USEPA's hypothesized reduction in solids loading after 1990 is due to the Agency's reliance on the GE data, as illustrated by comparing the USGS post-1990 rating curve with the GE post-1990 rating curve. Comparing the two data sets in this manner is crucial because: 1) all of the data are used, not just a limited number of paired measurements and 2) differences in solids loading estimates can be quantified. Large differences between the resulting rating curves, particularly in the high-flow regime, are evident in Figure 3. These rating curves were used to calculate Fort Edward solids loading for an eight-year period, from January 1, 1991 to December 31, 1998 (Figure 2). The rating curve developed from the GE data produced a total solids load for this period that was 24% lower than the USGS rating curve overall, with a much larger difference during high-flow periods (54% lower) than during low-flow periods (17% higher). The apparent low-bias of the GF TSS concentration data during high-flow conditions probably results from the configuration of the sampling device and the sampling procedure, as described previously (Figure 1). Thus, the GE TSS concentration data should not be used for calculating total suspended solids loading at Fort Edward.

This analysis indicates that USEPA's conclusion concerning temporal changes in solids loading at Fort Edward is incorrect. Inclusion of the GE data in the development of the post-1990 rating curve causes an underestimation of Fort Edward solids loading. For example, the USEPA rating curve for the post-1990 period yielded an average annual solids load of 21,500 MT/yr for the 1991-1998 period, which is 20% lower than the load estimated using the post-1990 USGS rating curve (Figure 2). Use of solids loading inputs to HUDTOX that are too low during post-1990 and projection periods will reduce predicted sedimentation rates, affect the calculated rate of natural recovery and may incorrectly skew the efficacy of various remedial actions. Therefore, the use of an artificially low solids load at Fort Edward introduces an error into USEPA's model.

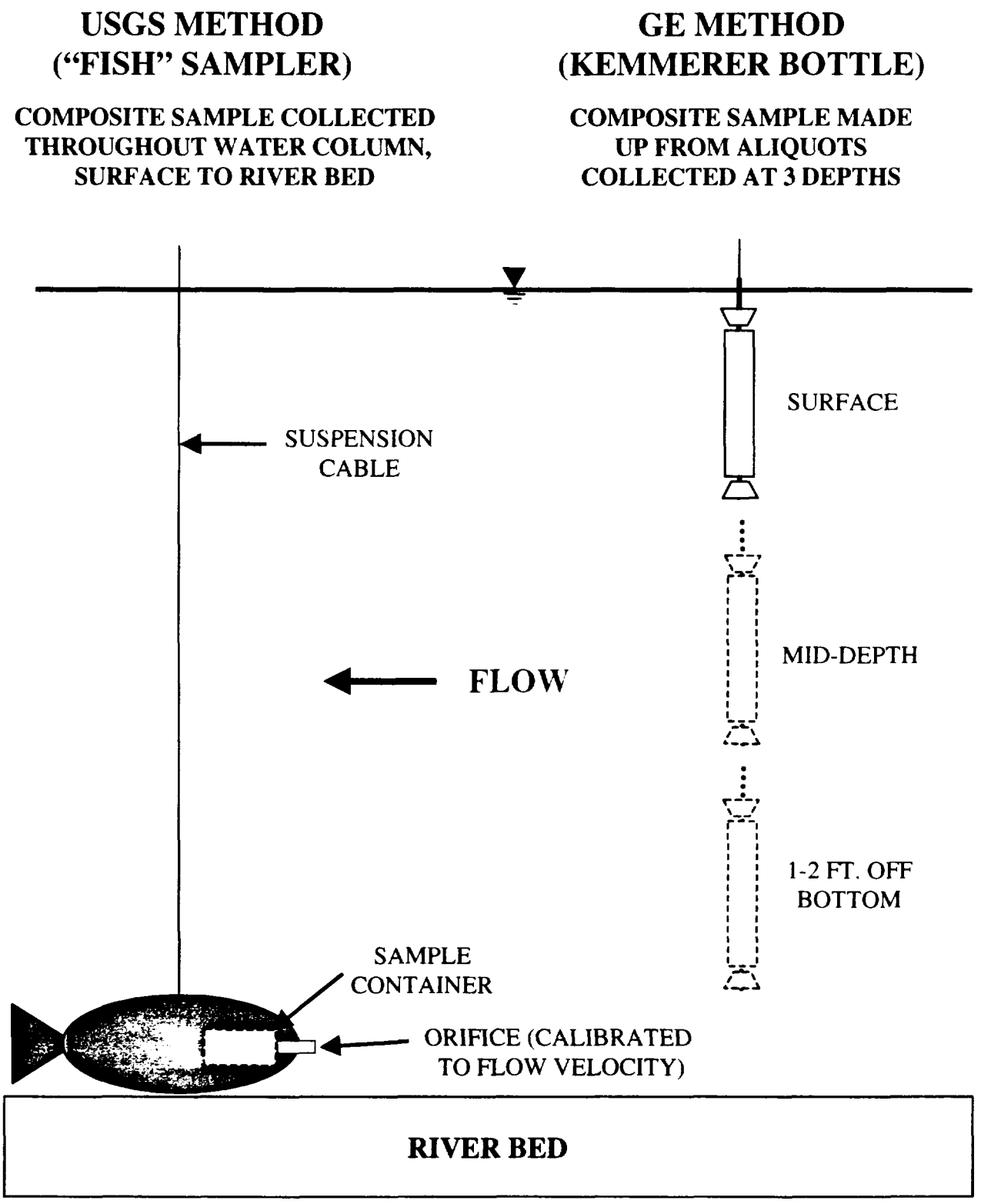


Figure 1. Comparison of USGS and GE solids load sampling methods.

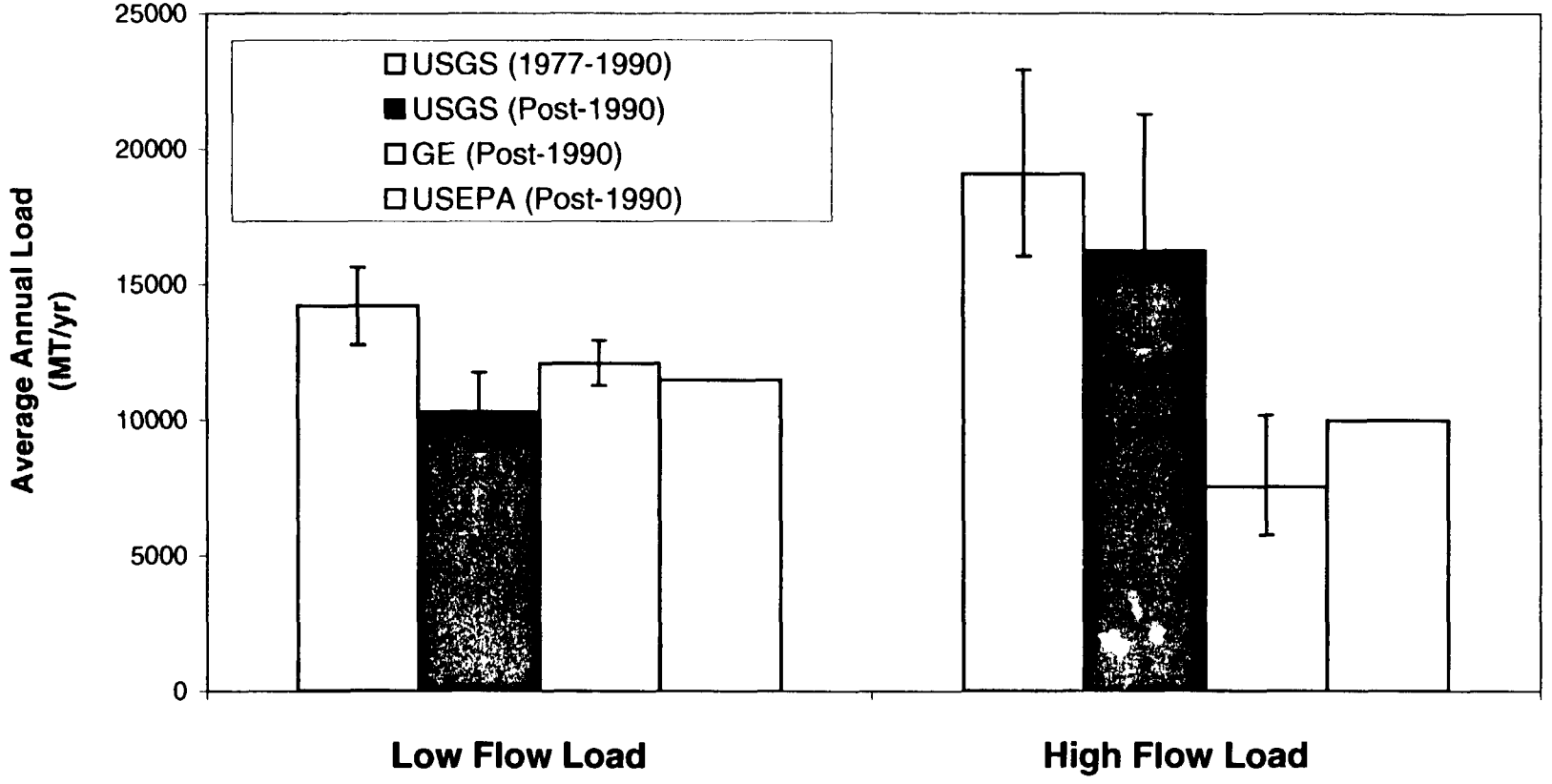


Figure 2. Estimated solids loading at Ft . Edward for post-1990 (1991-1998) period using various rating curves. Error bars represent the 95 % confidence interval.

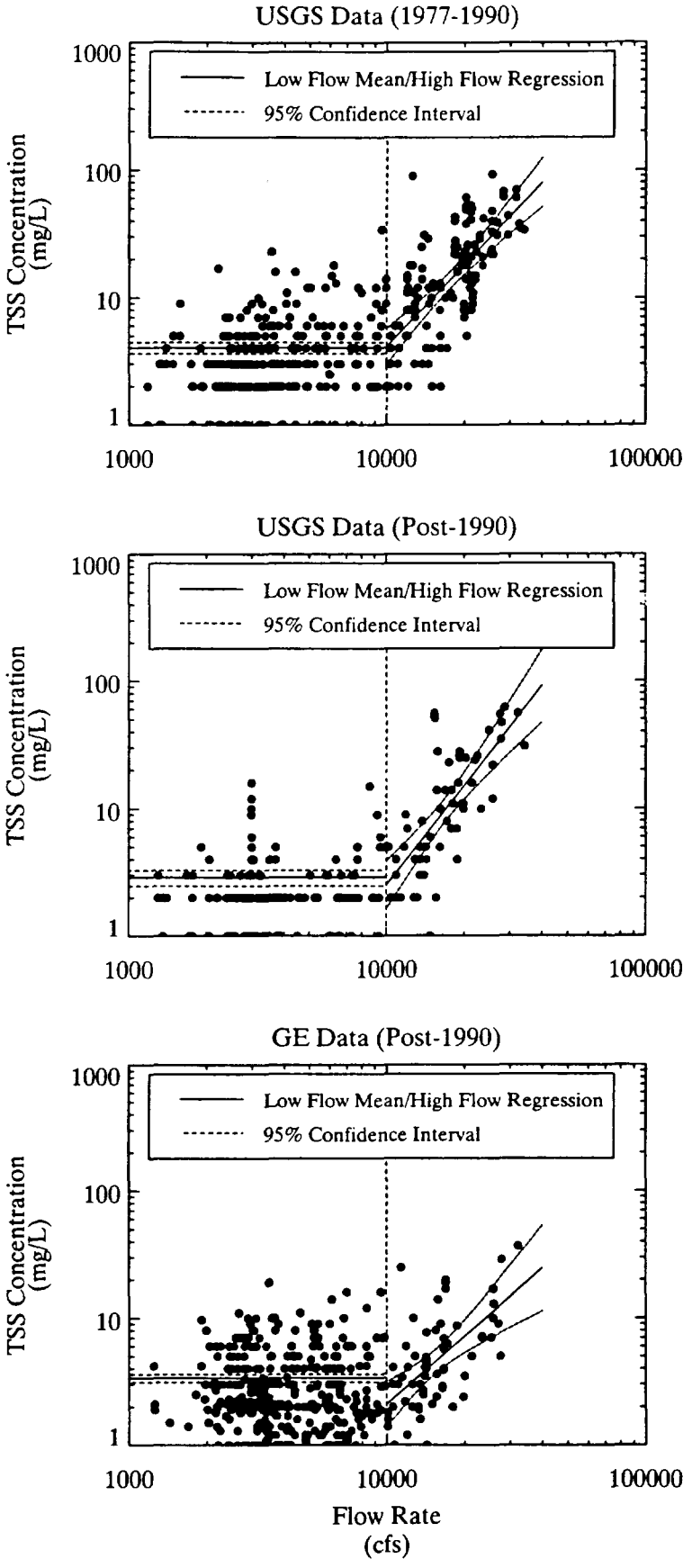


Figure 3. Fort Edward solids rating curves using three different data sets.

These comments relate to Charge Question 4 (Is the model calibration adequate?). Sediment resuspension and deposition are primary controlling factors in determining PCB fate and transport in the Upper Hudson River (UHR). Accurate simulation of these processes is essential in the development and application of an UHR PCB fate model. USEPA's sediment transport model suffers from weaknesses that undermine its accuracy, particularly downstream of the Thompson Island Pool (TIP). This inaccuracy apparently led USEPA to add an arbitrary tributary solids loading downstream of the TIP. A more realistic representation of solids dynamics, particularly downstream of the TIP, is feasible and, we believe, will improve the accuracy of model projections.

Similar deposition formulations were applied to cohesive and non-cohesive bed areas in HUDTOX. Effective settling speeds used in HUDTOX were temporally constant and spatially variable, with a higher value in cohesive areas than in non-cohesive areas. This approach overlooked three important phenomena that affect deposition: 1) variable bottom shear stress or, equivalently, flow rate (i.e., probability of deposition effects); 2) changes in composition of water column solids (i.e., relative amounts of clay, silt and sand in suspension); and 3) flocculation of clay and silt particles. An example of these effects on effective settling speed is illustrated in Figure 1, which shows results from the GE sediment transport model (a mechanistic model that USEPA has accepted) for a cohesive bed area in the TIP (QEA 1999). The effective settling speed relationship shown on Figure 1 is typical for the UHR, with relatively low settling speeds during low-flow conditions due to most of the suspended load being composed of flocculating clay and silt particles. During high-flows, significant increases in suspended sand content occur, causing the effective settling speed to increase by more than an order of magnitude. Even though the HUDTOX effective settling speed for cohesive bed areas (4.15 m/day) may approximate a long-term average value, it is too high during low-flow and too low during high-flow (Figure 1).

Accurate estimation of tributary sediment loading to the UHR is important for any analysis of long-term PCB fate in the river. USEPA and GE made considerable efforts to construct accurate solids mass balances for the UHR and develop credible methods for estimating tributary solids loading (QEA 1999, USEPA 2000). While there is some uncertainty in the estimated tributary solids loads, the estimation techniques appear to produce reasonably accurate tributary loads (QEA 1999).

To calibrate its model, USEPA adjusted solids loadings from the tributaries downstream of the TIP (USEPA 2000), especially during low-flow conditions. Unfortunately, the RBMR does not provide sufficient information to determine the cause and extent of the initial calibration difficulties. Thus, USEPA input an additional tributary solids load of 40 metric tons/day (MT/day) to both the Schuylerville-Stillwater and Stillwater-Waterford reaches during the final calibration. Although USEPA portrays this load increase as being within the uncertainty range of the estimated tributary loads (USEPA 2000), a closer examination reveals that the magnitude of the supplemental solids loading was not trivial during low-flow periods, i.e., below mean tributary flow rate. While the increase in long-term solids loading was about 26 and 17% for the two reaches, respectively (USEPA 2000), the relative increase in tributary solids loading was much greater during low-flow conditions. Figure 2b shows a temporal comparison of the tributary loading for the Schuylerville-Stillwater reach specified by: 1) time-variable rating curves (developed from the solids load analysis referenced above and used during initial model calibration) and 2) constant load of 40 MT/day. During low-flow conditions, the supplemental load is significantly greater than the original rating curve load. The magnitude of this disparity in the Schuylerville-Stillwater reach is illustrated in Figure 2c, which shows the temporal variation of the ratio of the final calibration rating curve loading (initial rating curve load plus supplemental load) to the initial rating curve loading. This ratio increases as the flow decreases, with maximum values of about 70X and 12X for the Schuylerville-Stillwater and Stillwater–Waterford reaches, respectively. The ratio is greater than two 83% of the time between 1977 and 1999 for the Schuylerville–Stillwater reach. Assuming that uncertainty about the rating-curve-estimated loading is about a factor of two, then this percentage represents the portion of

time during which the assumption of a constant supplemental solids loading of 40 MT/day is **not** within the assumed uncertainty range of the tributary solids loading.

Analysis of tributary TSS concentrations required to produce an additional load of 40 MT/day provides a further illustration that this loading was unrealistic during low-flow conditions. With the additional load, low-flow TSS concentrations were as high as 500 and 190 mg/l for the Schuylerville-Stillwater and Stillwater-Waterford reaches, respectively. These concentrations are much higher than observed TSS concentrations during low-flow periods for UHR tributaries. Further illustration of the unrealistically high TSS concentrations resulting from the additional tributary load is presented on Figure 3 for the direct drainage area in the Schuylerville-Stillwater reach. This figure shows TSS concentration as a function of flow rate determined from three sources: 1) original rating curve (with factor of two uncertainty range); 2) additional constant load (18 MT/day for this tributary); and 3) low-flow TSS data for Snook and Moses Kill. Clearly, the additional load produced unrealistically high TSS concentrations during low-flow conditions.

Adjustment of tributary sediment loading to achieve adequate calibration of the model is an indication that HUDTOX does not accurately simulate sediment transport in the UHR, particularly downstream of the TIP. Sediment resuspension and deposition dynamics were incorrectly represented in the model, primarily due to the use of formulations that are too simplistic and inaccurate.

Non-cohesive suspended load transport in rivers has been studied extensively and is relatively well understood. Numerous mechanistic models, of varying levels of complexity, have been developed to simulate resuspension and bed armoring processes for non-cohesive beds. These models have been successfully developed and applied to various rivers, including the GE model of the UHR (QEA 1999). Instead of using these formulations, USEPA selected a non-mechanistic formulation that is not based on any site-specific or experimental data nor based on a peer-reviewed theoretical framework. Problems with the USEPA approach are: 1) neglect of bed armoring processes that can

significantly affect erosion rates during a flood; 2) omission of effects of bottom shear stress variation on erosion rate, i.e., non-cohesive erosion rate is a non-linear function of bottom shear stress (flow rate); and 3) spatial and temporal variations in non-cohesive bed properties were not adequately addressed.

While the above discussion highlights problems in the sediment transport formulations used in HUDTOX, part of the problem results from USEPA's use of two separate model frameworks for the UHR: one for the TIP and another one for the seven reaches downstream of the TIP. The TIP model appears to produce reasonable results, even though some of the processes (as discussed above) are not properly described. The model's success in the TIP is due primarily to: 1) use of TIP-specific erosion data and bottom shear stress information; 2) use of GE sediment transport model results to calibrate/validate HUDTOX; and 3) use of a hydrodynamic model to generate realistic cohesive resuspension functions. In contrast, in the reaches downstream of the TIP, USEPA did not use site-specific erosion data, even though such data were available. Significant variability exists in reach-average cohesive resuspension parameters for the seven reaches downstream of the TIP; up to an order of magnitude difference in resuspension parameters was observed for the downstream reaches (QEA 1999). USEPA also did not develop and apply a hydrodynamic model(s) for the reaches below the TIP; a hydrodynamic model is needed to calculate bottom shear stresses, a critical parameter for the Lick equation and calculation of cohesive resuspension. Although USEPA claims that the simplified transport model used downstream of the TIP is warranted because of data limitations and uncertainties in those reaches, GE's model demonstrates that it is possible to develop a defensible, mechanistic sediment transport model for the **entire** UHR.

Realistic and accurate simulation of sediment transport processes is crucial for understanding the long-term fate of PCBs in the UHR. USEPA's sediment transport model for the UHR suffers from several problems, primarily downstream of the TIP. These problems can be addressed and should improve the accuracy of model projections.

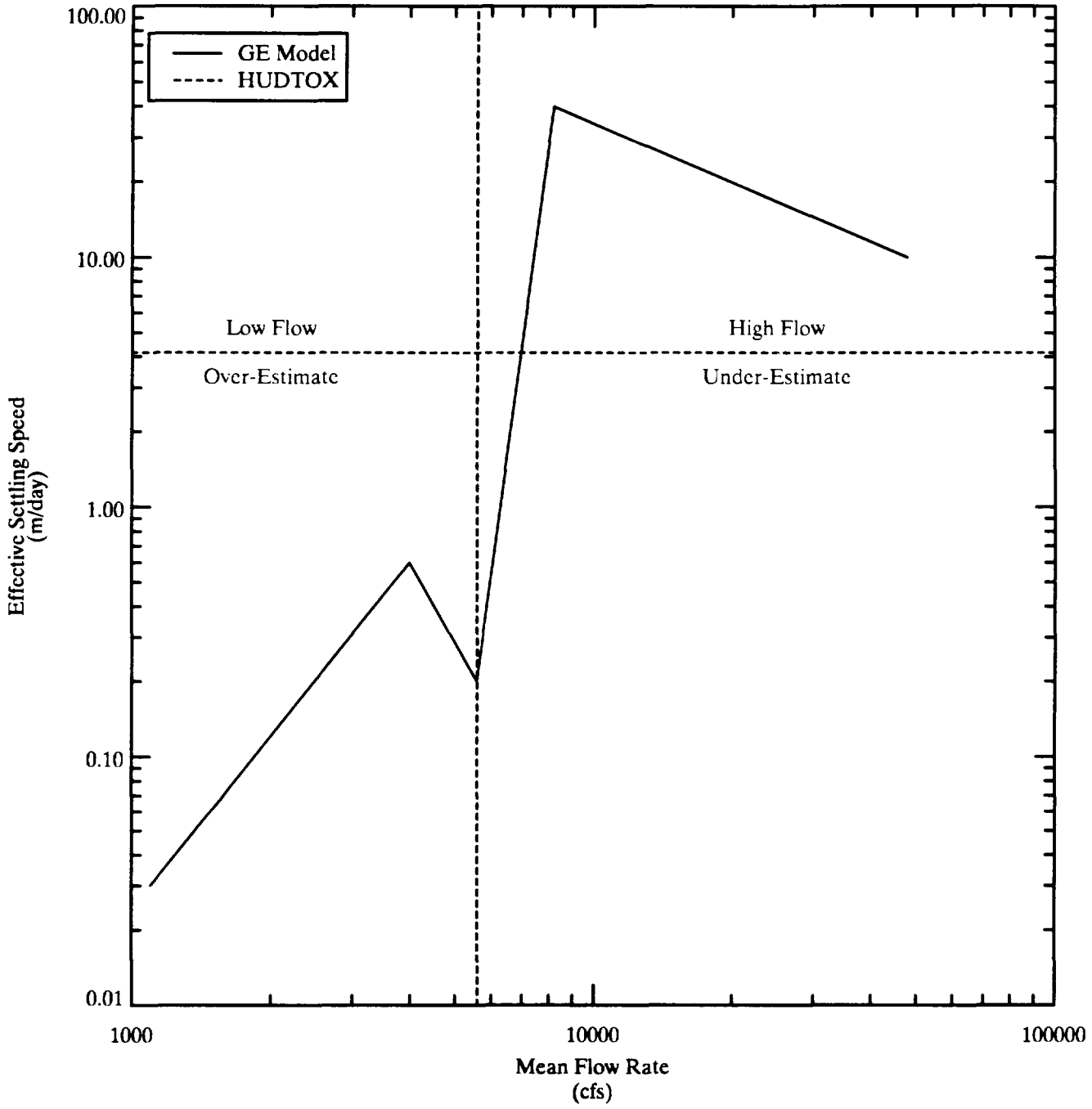


Figure 1. USEPA (specified) and GE (calculated) relationships between effective settling speed and flow rate for the cohesive bed in the TIP.

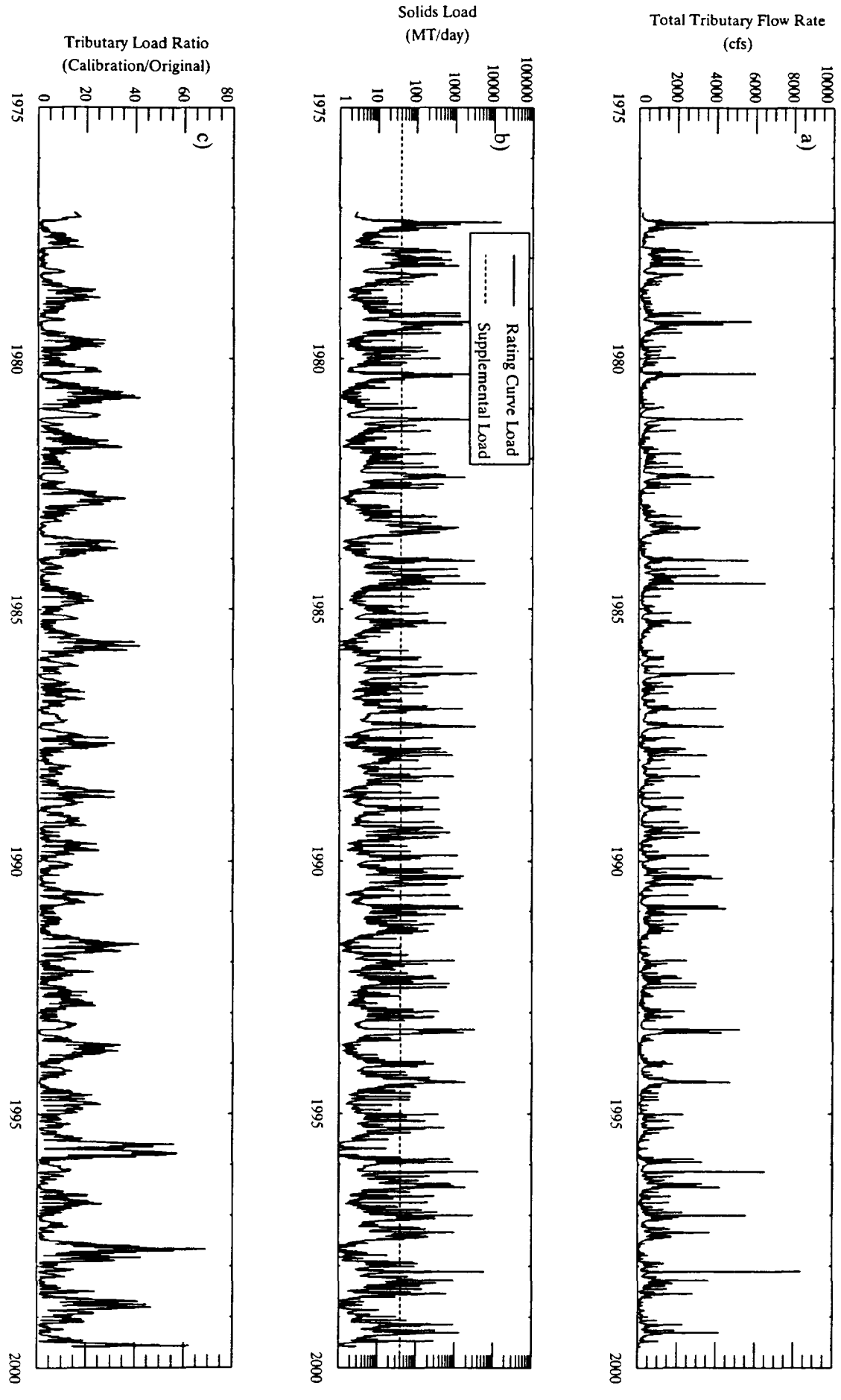


Figure 2. Total discharge and sediment loads input to tributaries in Schuylerville - Stillwater reach.

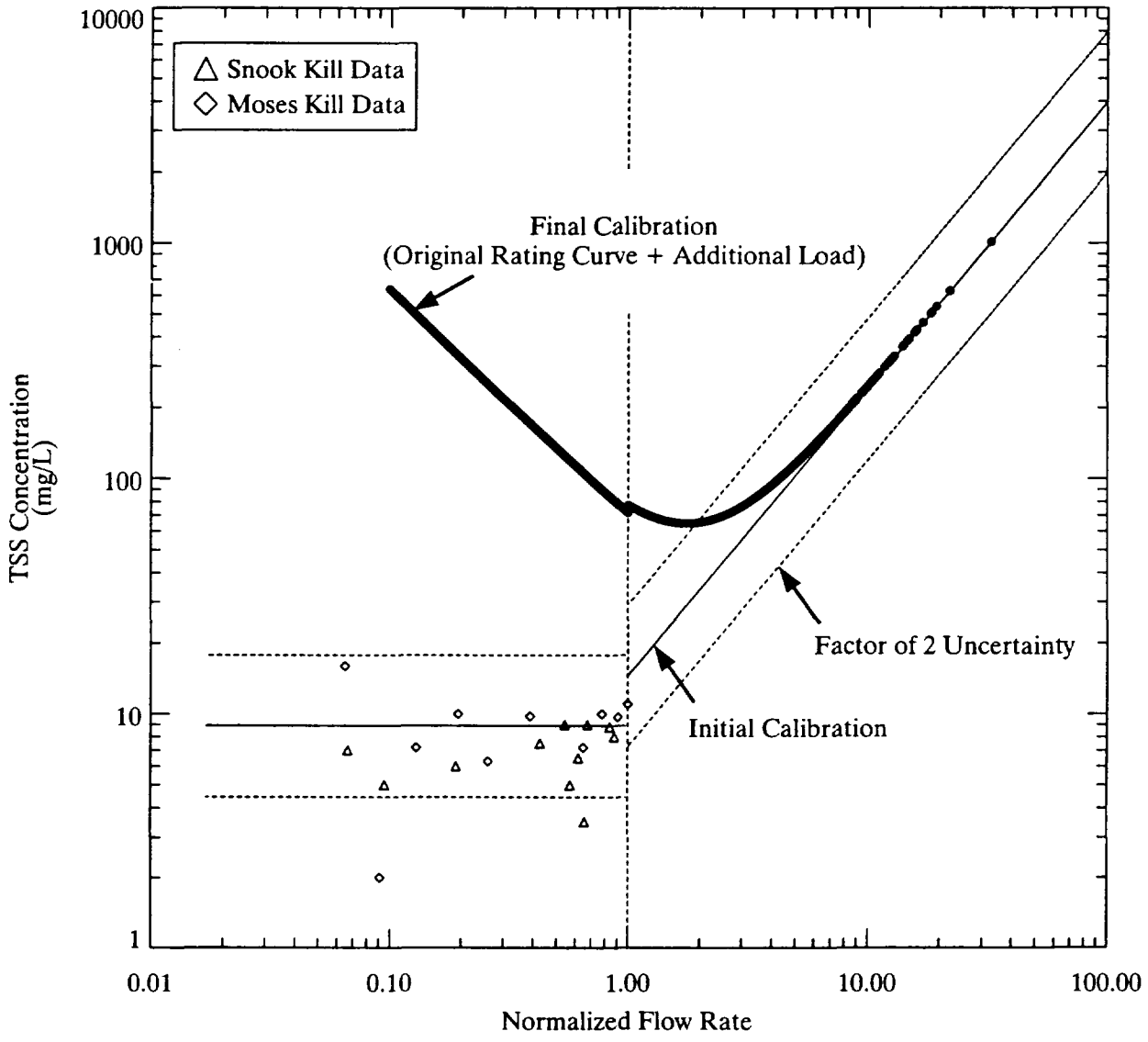


Figure 3. Comparison of supplemental load effects to original rating curve and TIP tributary data for direct drainage area in Schuylerville - Stillwater reach. Flow rates are normalized with respect to mean flow in tributary.

The USEPA developed three bioaccumulation models as part of the Further Site Characterization of the Upper Hudson River: the Bivariate Statistical Model, the Probabilistic Bioaccumulation Food Chain Model, and the mechanistic FISHRAND Model. Of the three models, FISHRAND is the only model that mechanistically describes PCB transfer through the food web and was appropriately used in the risk assessment. Unfortunately, this model inaccurately represents the physiology and bioenergetics of the fish species it simulates and the characteristics of the PCBs and sediments to which the fish are exposed. The inaccuracies result from the approach USEPA used to calibrate the model, and consequent use of values for several key model parameters that are inconsistent with the available site data.

The USEPA apparently chose calibration parameters on the basis of a statistical optimization without proper reference to site-specific data, and as a result the parameter values are inconsistent with these data. Although USEPA's Bayesian approach is appealing conceptually, its application has led to parameter distributions that are at variance with data and biological understanding. Thus, while the calibration may appear satisfactory based on the relationship between calculated and measured fish PCB levels, final estimates for some key parameters are not consistent with data collected throughout the Upper Hudson River, because much of the site-specific data was not considered during calibration. Consequently, the ability of FISHRAND to predict future PCB concentrations in fish is compromised.

FISHRAND CALIBRATION

Fish growth rate, fish lipid content, organic carbon in the sediment, and K_{OW} were selected as calibration parameters and were adjusted to optimize the fit of the model to Upper Hudson River PCB measurements in the fish. Site-specific data are available to constrain these parameters, and these data conflict with the final values used in the

model. In addition, values for these parameters were chosen independently for each reach of the river, resulting in independently calibrated models for each reach that are inconsistent with each other.

Fish Growth Rate

USEPA's model framework includes a default weight-based relationship for estimating growth rates. During calibration, USEPA modified a default parameter of this relationship on a species- and reach-specific basis, with no supporting analyses. USEPA did not consider site-specific growth data collected by the NYSDEC and others in the Upper Hudson River. The calibration adjustments result in largemouth bass growth rates in Thompson Island Pool and Stillwater that are 6 and 19 times greater, respectively, than indicated by the data. (Figure 1; Volume 2D, Book 4, Tables 6-2 and 6-3). Thus, not only are the growth rates at variance with the data, they were determined independently for each reach of the river. Growth rates of the other modeled species were modified in a similar manner (Volume 2D, Book 4, tables 6-2 and 6-3).

Lipid Contents in Fish

There are three problems with USEPA's estimation of fish lipid contents. First, calibration resulted in lipid contents different from the best estimates based upon the data collected by NYSDEC in during their PCB monitoring program. For example, the fraction lipid in the largemouth bass used at Stillwater (geometric mean = 0.006 g lipid/g wet weight) is less than ½ of the mode of the data (0.014). In contrast, a value more similar to the data (0.011) is used in Thompson Island Pool. Lipid contents for the other modeled species are also modified independently of the data and independently for each reach, for example spottail shiner (Figure 1).

Second, USEPA uses a constant lipid fraction for each species throughout the simulation, even though the data indicate that lipid content varies considerably. USEPA states that it

is possible to obtain close to perfect agreement between model predictions and observed body burdens by inputting the observed lipid concentrations for each year. However, the Agency does not use this method, because, it claims, it limits the ability of the model to forecast fish tissue PCB concentrations, since future variation in lipid content is unknown (Volume 2D, Book 3, p. 36). This is incorrect. Historical lipid contents are known; therefore they should be used. Ignoring existing historical data does not make predictions more robust.

Third, the lipid contents used for largemouth bass and brown bullhead in FISHRAND are based on fillet samples collected by NYSDEC. However, FISHRAND simulates bioaccumulation of whole fish, and therefore, lipid contents for fillet samples must be converted to whole-body equivalents prior to incorporation into the model; the lipid content on a whole-body basis is approximately 2.5 times the fillet lipid content (QEA, 1999). This error results in the overestimation of PCB elimination in the modeled fish.

Organic Carbon Content of Sediment

The organic carbon contents of the sediments (f_{OC}) used in the calibrated model differ from the values used in HUDTOX, which are based upon the 1991 GE sediment data (Volume 2D, Book 1, p. 109; Book 2, Table 6-32). The f_{OC} values used in Thompson Island Pool and Stillwater are approximately twice and ½ the average values used in HUDTOX, respectively (Figure 1). Using a lower carbon content at Stillwater increases the carbon-based PCB concentration, resulting in greater accumulation throughout the food web and a greater contribution of sediment-based PCBs to the food web. In effect, PCBs in Thompson Island Pool and Stillwater sediments are assumed to be ½ and twice as bioavailable as the organic carbon data indicate, respectively.

Octanol-Water Partition Coefficient

USEPA incorrectly uses one average partition coefficient (K_{OW}) value to describe both

accumulation at the base of the water column food web and elimination in fish. This ignores differences in congener composition in the two media and processes. The average K_{OW} values used in the two media are likely to differ, and values should be based upon the available site data.

Calibration results in log (K_{OW}) values of 6.60 and 6.47 for Thompson Island Pool and Stillwater, respectively (Volume 2D, Book 4, Tables 6-2 and 6-3). The average Log(K_{POC}) value used by USEPA to describe PCB_{3+} partitioning in the water column is 5.85 (Book 2, Table 7-4). This value is based upon an analysis of data collected by USEPA in the Upper Hudson River. Thus, the K_{OW} values used in FISHRAND are 4 to 6 times greater than the value used in HUDTOX, resulting in an unrealistically large degree of bioaccumulation from the water column. Because K_{OW} does not apparently affect bioaccumulation from the sediments in FISHRAND, this inaccuracy causes an unrealistic overestimation of the importance of water column-based PCBs to the food web.

The K_{OW} values used in FISHRAND in Thompson Island Pool and Stillwater differ by approximately 35 percent. The lower K_{OW} value at Stillwater results in lower bioaccumulation at the base of the food web and faster elimination of PCBs in the fish, both of which act independently to reduce computed PCB levels in the fish in Stillwater relative to Thompson Island Pool.

Finally, the USEPA states correctly that average K_{OW} for PCBs in fish can be estimated using PCB congener composition data measured in fish, and this would have been a reasonable approach (QEA 1999).

ALTERNATIVE CALIBRATION PARAMETERS

In order to match the fish PCB data, USEPA had to choose values for its calibration parameters that are inconsistent with the site data. These parameters can and should be constrained by site data. There are other parameters that are relatively unconstrained by

site data that are therefore more appropriate choices for calibration (QEA 1999), in particular dietary composition and PCB elimination rate.

Dietary Composition

The proportion of benthic and water column invertebrates in the diet of the forage fish is estimated qualitatively by USEPA, using "best professional judgement and a careful analysis of all the available data" (Volume 2D, Book 3, p. 79). The site-specific diet and community composition data do not permit the diets of the important fish to be constrained tightly. In developing the GE bioaccumulation model, QEA (1999) estimated bounds for the dietary composition based upon a quantitative analysis of the field data, and then calibrated the model by adjusting diet within those bounds.

PCB Elimination Rate

FISHRAND calculates gill elimination as a diffusive process, which probably overestimates the true elimination rate in chronically exposed fish (QEA 1999). The true elimination rate cannot at this point be tightly constrained by the available experimental data, and therefore is an appropriate calibration parameter. For example, QEA (1999) introduced a multiplier in the diffusion formulation which was adjusted in the process of calibration.

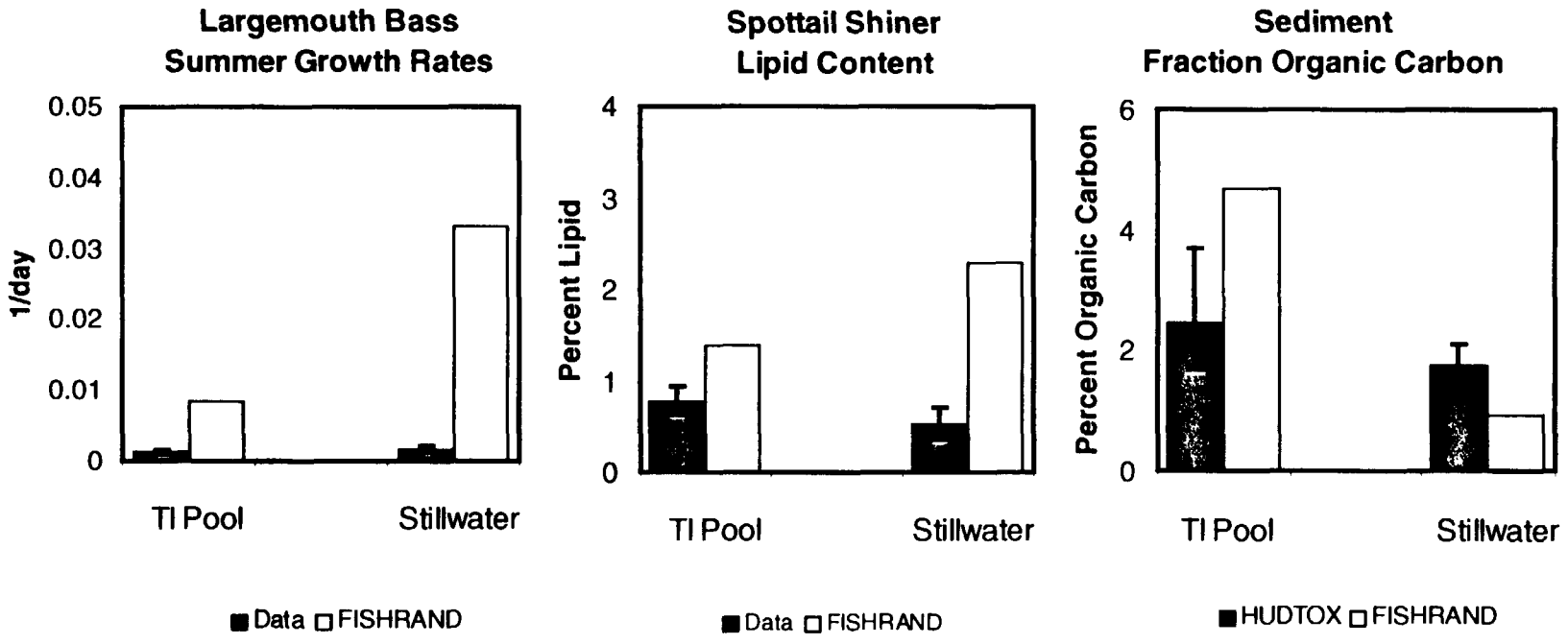
MODELING IMPLICATIONS

FISHRAND appears to be a well-calibrated model, judging from the relationship between computed and observed fish PCB levels. However, the values chosen for key parameters conflict with site data and differ among reaches. In essence, USEPA has developed two completely different models, calibrated independently in the two locations.

The calibration results presented in the original Baseline Modeling Report (BMR) and the

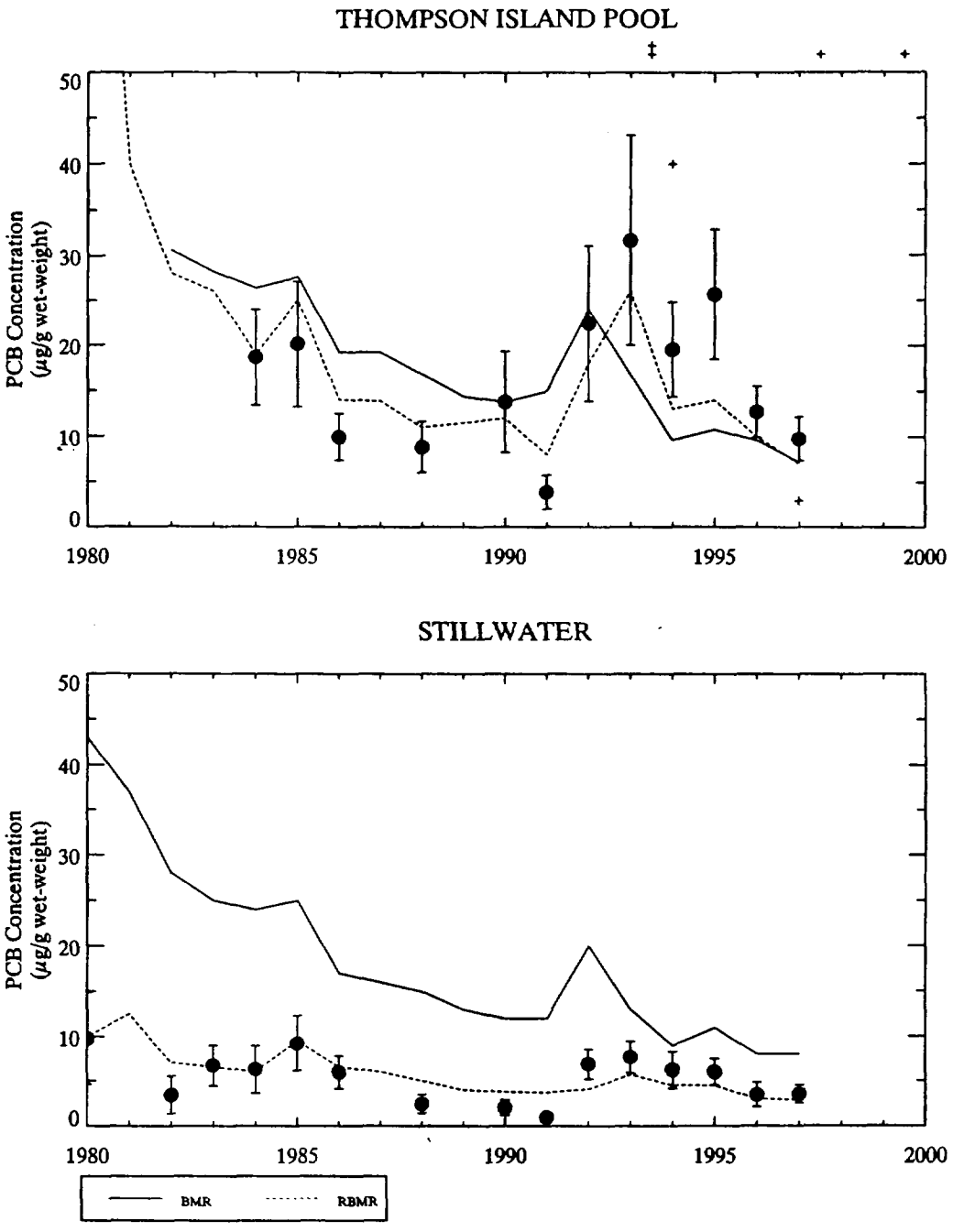
Revised Baseline Modeling Report (RBMR) demonstrate the impact these differences have on model results. Calibration simulations from the BMR and the RMBR are presented in Figure 2. In the original BMR calibration, predicted PCB concentrations in largemouth bass in Thompson Island Pool and Stillwater were similar. In contrast, in the RMBR, computed largemouth bass levels are lower at Stillwater than in the Thompson Island Pool, and closer to measured PCB levels in Stillwater. The dietary compositions did not change from the BMR to the RBMR and are the same throughout the river. However, as mentioned above, different values were used for several parameters. Thus, the improvement in the calibration was achieved by changing the process of bioaccumulation and the bioavailability of PCBs in these two locations, in ways for which there is no support. As a result, both the degree of bioaccumulation and the relative importance of sediment and water column PCB to the food web appear to be incorrect. This means that projected fish PCB levels are likely to be incorrect.

The reliability of the model could be significantly improved by recalibrating in a consistent fashion in all locations using parameter values that are consistent with all of the available site data. Recalibration would provide a model that more accurately estimates the extent of bioaccumulation, as well as the relative importance of sediment and water column-based PCBs to the food web. This, in turn, would provide a more reliable model.



Data: mean +/- 2 standard errors
HUDTOX: average and range of segment-specific values, based on 1991 data

Figure 1. Comparison of fish growth rates, fish lipid content and sediment organic carbon contents used in FISHRAND with measured values.



DATA SOURCES: NYSDEC (circles); GE (diamonds)
Data are arithmetic means +/-2 standard errors
Crosses indicate values excluded from annual averages

Figure 2. Comparison of FISHRAND calibration results for largemouth bass presented in the Original and Revised Baseline Modeling Reports.

John G. Haggard, Manager
Hudson River Program

General Electric Company
320 Great Oaks Office Park, Ste: 323
Albany, NY 12203
Fax: (518) 862-2731
Telephone: (518) 862-2739
Dial Comm: 8 232-2739*
E-Mail:John.Haggard@corporate.ge.com
Pager: 518-484-3177

March 20, 2000

Dr. Per Larsson
Assistant Professor
Ecotoxicology, Dept. of Ecology
Solveg 37
Lund, Sweden 22362

RE: Hudson River PCBs Superfund Site: Baseline Modeling Report Peer Review

Dear Dr. Larsson:

In anticipation of the upcoming peer review of EPA's Baseline Modeling Report, I enclose for your consideration a short report concerning Charge Question 11. The report was prepared by Dr. John Connolly of the firm Quantitative Environmental Analysis (QEA) on GE's behalf, and addresses the apparent inconsistency between the conclusions in EPA's Baseline Modeling Report and Low Resolution Coring Report.

I am sending you this Report because I believe it will assist you in your deliberations on Charge Question 11. These inconsistencies are important and potentially lead to different remedial approaches. As a result, the apparent discrepancy should be resolved, but I also appreciate that it is up to you whether to consider the information in this Report.

If you have any questions, please do not hesitate to contact me or John Connolly at (201) 930-9890.

Yours truly,

John G. Haggard

JGH/bg

Enclosure

Critical Issues Imbedded in Fate and Transport Model Peer Review Charge Question 11

To evaluate remedial options to reduce PCB levels in fish of the Upper Hudson River one must understand the degree to which humans and key animal species might be exposed to the PCBs in the water and sediments. This, in turn, raises the question of the long-term fate of the sediment PCB inventory. Do burial processes sequester and isolate PCBs from humans and animals or do other physical and biological processes make the bulk of the PCB inventory potentially available for exposure to humans and animals?

All of the charge questions you have been directed to answer are important to the evaluation of USEPA's models. However, one question is of paramount importance to the issue of remedy selection because it is directed to the long-term fate of the PCB inventory in the sediment. Question 11 raises the possibility that a conflict exists between the results of the fate and transport model and the results of separate data analyses presented in the Low Resolution Coring Report (LRCR: USEPA, 1998). A key conclusion of the model is that burial is sequestering PCBs in the sediment (as stated in charge question 11 and by Vic Bierman of LimnoTech in his presentation to you). In contrast, a key conclusion of the LRCR is that PCBs in the most highly contaminated areas are not being buried, but are being redistributed by unidentified means within the system (as stated in charge question 11 and in the LRCR). Although these conclusions are plainly inconsistent, EPA has suggested that the different conclusions result from the differing spatial scales of the two analyses. This implies that the redistribution suggested by the LRCR analysis (presumably caused by net erosion) is occurring at a smaller spatial scale than is discernable by the model.

Question 11 raises two fundamental issues:

- First, although it is possible that areas deemed depositional by the model contain regions of net erosion, is the scale of the model so crude that it fails to identify erosional areas which contribute important quantities of PCBs to the water column and biota?

- Second, which analysis is better suited to support remedial decisions – the model's mass balance approach which incorporates all relevant data into a mechanistically-based framework or the LRCR's geochemical approach which examines one type of data without mechanistic or mass balance constraints?

The answers to these questions are fundamentally important in the remedial analysis. If, as the LRCR's analysis would suggest, a major fraction of the PCBs entering the water column comes from cohesive sediment areas whose PCB inventory is being made available through mechanisms such as net erosion, then the PCBs in those areas could be a target for a form of remediation different from that selected for depositional areas. Conversely, if, as the model concludes, the bulk of the PCB inventory is sequestered and the dominant sources are upstream inputs and surface sediments in general, then targeting the buried PCB mass for remediation is likely to be ineffective.

We believe the answers to these two questions are straightforward. Although EPA's model has its limitations and could be improved, the model's inherent conceptual view is correct. The model accounts for the important sources and sinks of PCBs within the Thompson Island Pool, as evidenced by its ability to replicate the PCB concentration trends in the sediment and water column. It does so by burying PCBs in the sediment, principally in the cohesive sediments; the highest concentrations of PCBs typically occur below the bioturbated surface layer in the cohesive sediments. All of the cohesive sediment areas are subject to deposition and there is no indication from EPA's modeling analyses that a significant fraction of the PCB inventory has been mobilized and redistributed from any of these areas.

The only condition under which the conclusions of the modeling and the geochemical analysis might not be contradictory is one in which the locations targeted in the geochemical analysis deviate from the average condition represented by the model in a manner that would yield net erosion. Such deviation would be possible if the locations targeted in the geochemical analysis experienced velocities (and shear stresses) that: 1) were higher than the average for the model area; and 2) were of sufficient magnitude to cause an erosion flux that exceeded the depositional flux.

EPA has made no attempt to determine whether such deviation exists. Such a determination can be made using the EPA hydrodynamic and sediment erosion model, which has spatial resolution comparable to, or finer than, that of the geochemical analysis (see Figures 3-2 and 3-3 of the RBMR; USEPA, 2000). The General Electric hydrodynamic and sediment transport model, whose results were used by EPA in calibrating its model, also has sufficient resolution to examine conditions on the scale of the geochemical analysis. As shown for each of the 1994 sampling clusters on which the geochemical analysis relies (see attached figures), the GE model indicates that the targeted locations are **not** erosional and tend to have greater deposition rates than the averages for the larger areas represented by the HUDTOX model.

As both EPA's and GE's models conclude and as all of the field data show, the bulk of the buried PCB mass in the most highly contaminated areas has not migrated to the sediment surface where it could be released and redistributed:

- Water column mass balance analyses around the Thompson Island Pool show no evidence of PCB flux from sediments beyond that indicated by the models (GE, 1998; page 31)
- Sediment sampling throughout the Thompson Island Pool shows no evidence of a spatial shift in the distribution of PCB mass within the pool. Instead, the data indicate a continuous decline over time in both areas of high and low contamination that is replicated by the GE and EPA models (Figures 4-44 and 4-45 of the GE model report - GE, 1999; Figure 7-15 of the RBMR- USEPA, 2000).
- 1998 sediment data contradict the conclusion that the areas targeted in the geochemical analysis are subject to a significant and ongoing process of mass loss (GE, 1998; pages 32-34)
- No surface sediments have the high ^{137}Cs concentrations characteristic of material deposited in the 1960s and 1970s and shown to be associated with the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; page 48)
- Almost all finely sectioned sediment cores show that maximum concentrations and bulk of the PCB mass remain buried below the surface sediments (GE, 1998; p.40)

- The PCB composition in the water column shows no evidence of a major contribution from the dechlorinated PCBs characteristic of the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; pages 46-48)
- The PCB composition in fish indicates that they have not been exposed to the dechlorinated PCBs characteristic of the bulk of the PCB mass in the most highly contaminated areas (GE, 1998; page 47)

An obvious question is why did the LRCR conclude that PCBs in the most highly contaminated areas are not being buried if the modeling and the data cited above are at variance with such a conclusion? The answer lies in the flawed methodology of the LRCR analysis (GE, 1998). The analysis relies on comparisons between sediment PCB data collected in 1984 and 1994. Unfortunately, the comparisons are not valid because the 1984 samples chosen for the comparison were not randomly picked from all the data lying within designated areas, but were chosen because they had among the highest PCB levels in the data set. Further, the ability to see statistically meaningful differences between the 1984 and 1994 samplings was severely impaired because of the extreme variability among samples and the relatively small sample size. Finally, the statistical analysis of the data did not account for all of the sources of variance and may have underestimated the uncertainty of the estimated mass change[1]. The reported uncertainty is already so large (4 to 59 percent) that the analysis has little power to determine what has occurred to the PCB inventory between 1984 and 1994.

In sum, question 11 invites acceptance of the untenable attempt to reconcile two irreconcilable conclusions. Either the conclusion reached applying the mechanistically-based, mass-balance approach used by the models is correct (that is, that the vast bulk of the PCBs in the cohesive sediments are being buried) or the LRCR's non-mechanistic and limited geochemical analysis is correct (that is, that a substantial fraction of the PCBs in the cohesive sediments are not being buried). This is a central issue that should be resolved in order to aid the decision-making process at this site.

[1] USEPA could have obtained an appropriate confidence interval for the year-to-year change by conducting an analysis of variance using a two-way classification by cluster and by year.

Given the weakness inherent in the statistical data comparison approach and the methodology errors, the LRCR conclusions are too unreliable to be used to understand PCB fate within the sediments of the TIP. The best overall tool to use is the mechanistically-based models that reconcile all the data available for each media.

REFERENCES

[GE] General Electric Company. 1998. *Comments of the General Electric Company on Phase 2 Report - Review Copy, Further Site Characterization and Analysis, Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* Hudson River PCBs Reassessment RI/FS developed for the USEPA Region 2 by TAMS Consultants *et al.* July 1998.

[QEA] Quantitative Environmental Analysis, LLC. 1999. *PCBs in the Upper Hudson River, Volume 2 - A Model of PCB Fate, Transport, and Bioaccumulation.* Prepared for General Electric Company. May, 1999.

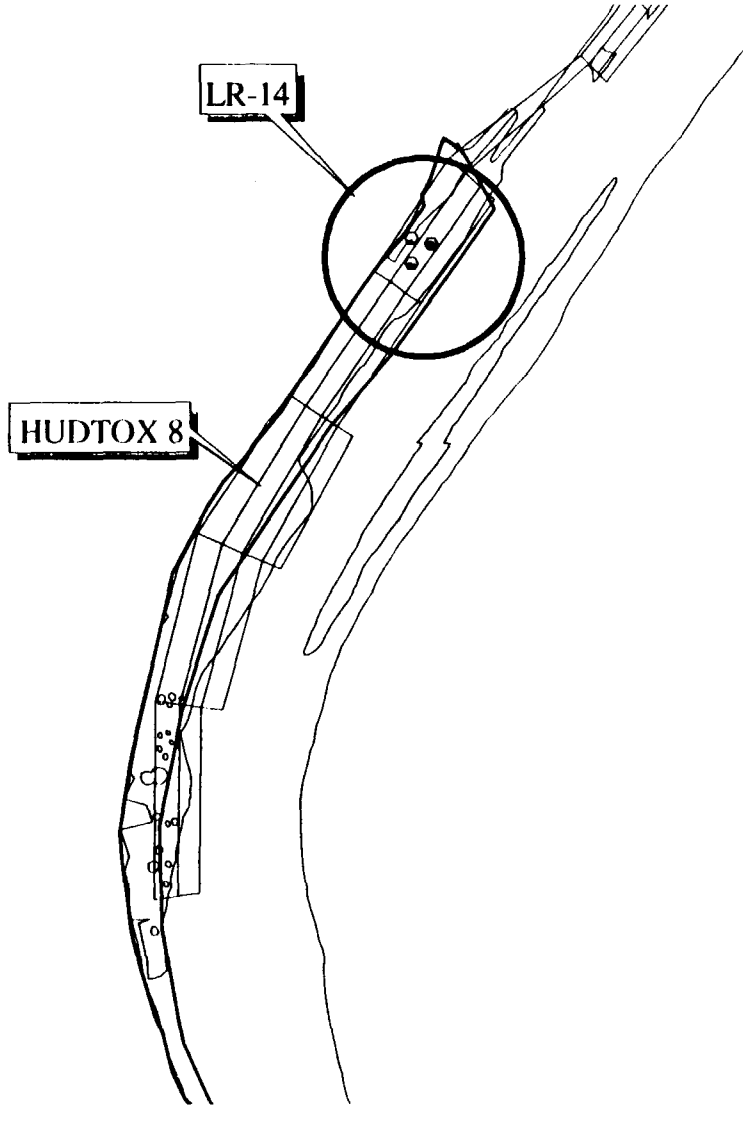
Sokal, R.R. and Rohlf, F.J., 1995. *Biometry: The principles and practice of statistics in biological research.* 3rd Edition, W.H. Freeman and Company, New York. 887 p.

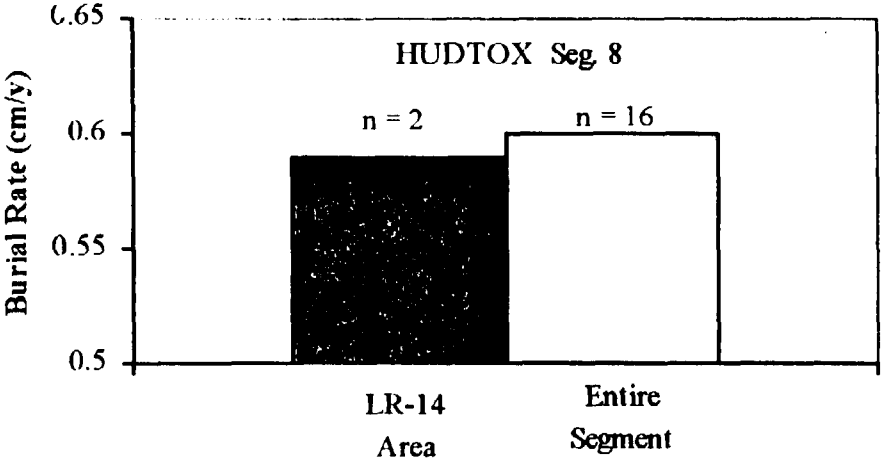
[USEPA] U.S. Environmental Protection Agency, 2000. *Phase 2 Report – Review Copy: Further Site Characterization and Analysis – Volume 2D – Revised Baseline Modeling Report.* Hudson River PCBs Reassessment RI/FS, January 2000.

[USEPA] U.S. Environmental Protection Agency. 1999. *Hudson River PCBs Reassessment RI/FS Responsiveness Summary for Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* February 1999.

[USEPA] U.S. Environmental Protection Agency. 1998. *Phase 2 Report - Review Copy, Further Site Characterization and Analysis, Volume 2C-A - Low Resolution Sediment Coring Report, Addendum to the Data Evaluation and Interpretation Report,* Hudson River PCBs Reassessment RI/FS developed for the USEPA Region 2 by TAMS Consultants *et al.* July 1998.

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Area 14 and in the larger area represented by Segment 8 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.1 0 0.1 0.2 Miles

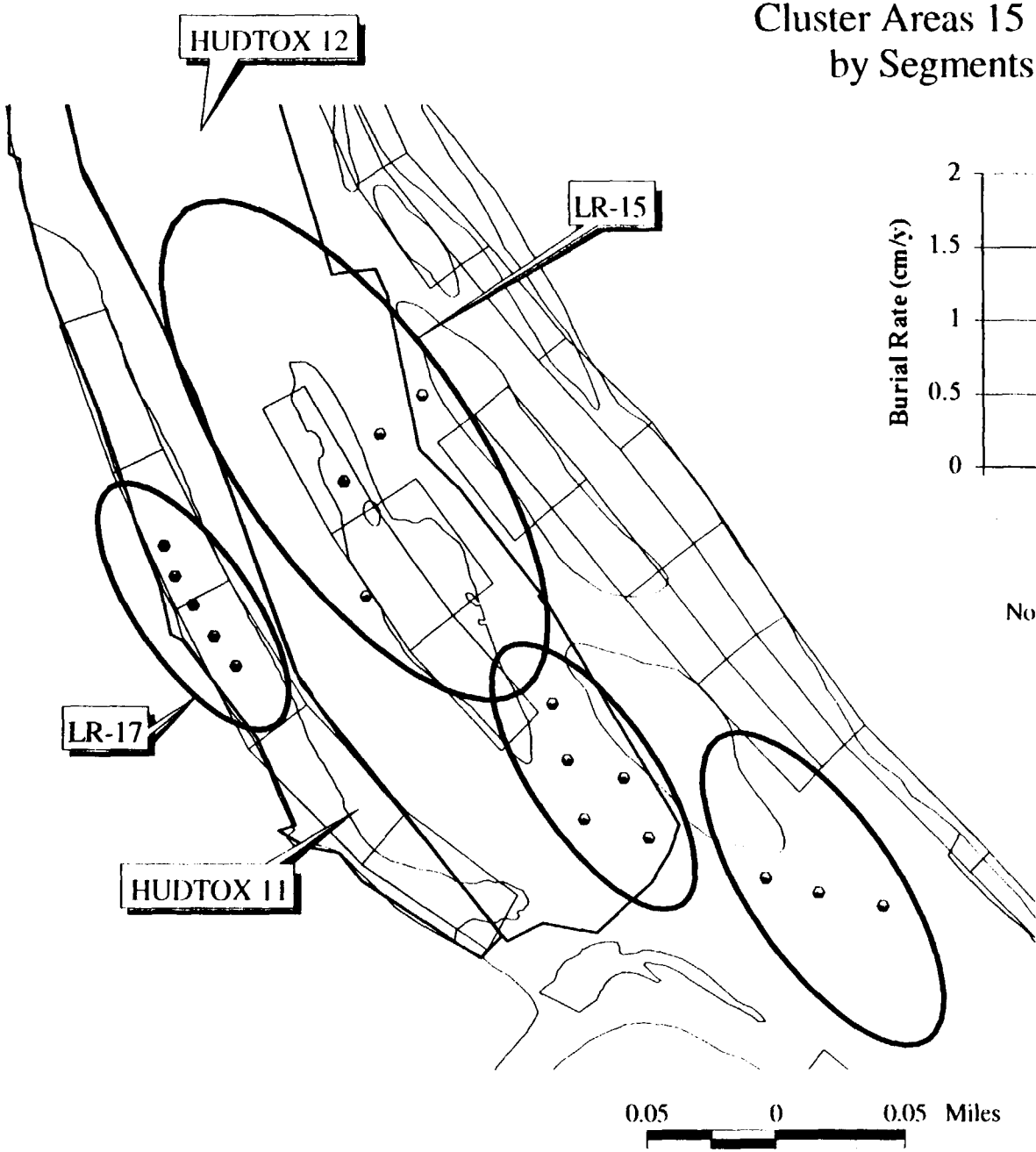
N

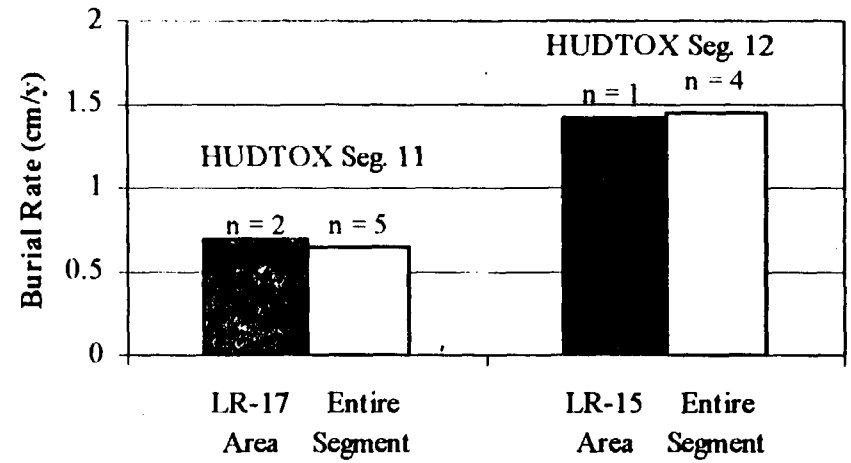
Emily - D:\GE\Nhud\model\cluster_analysis\depos_avg.apr

Privileged & Confidential

308037

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 15 and 17 and in the larger areas represented by Segments 11 and 12 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

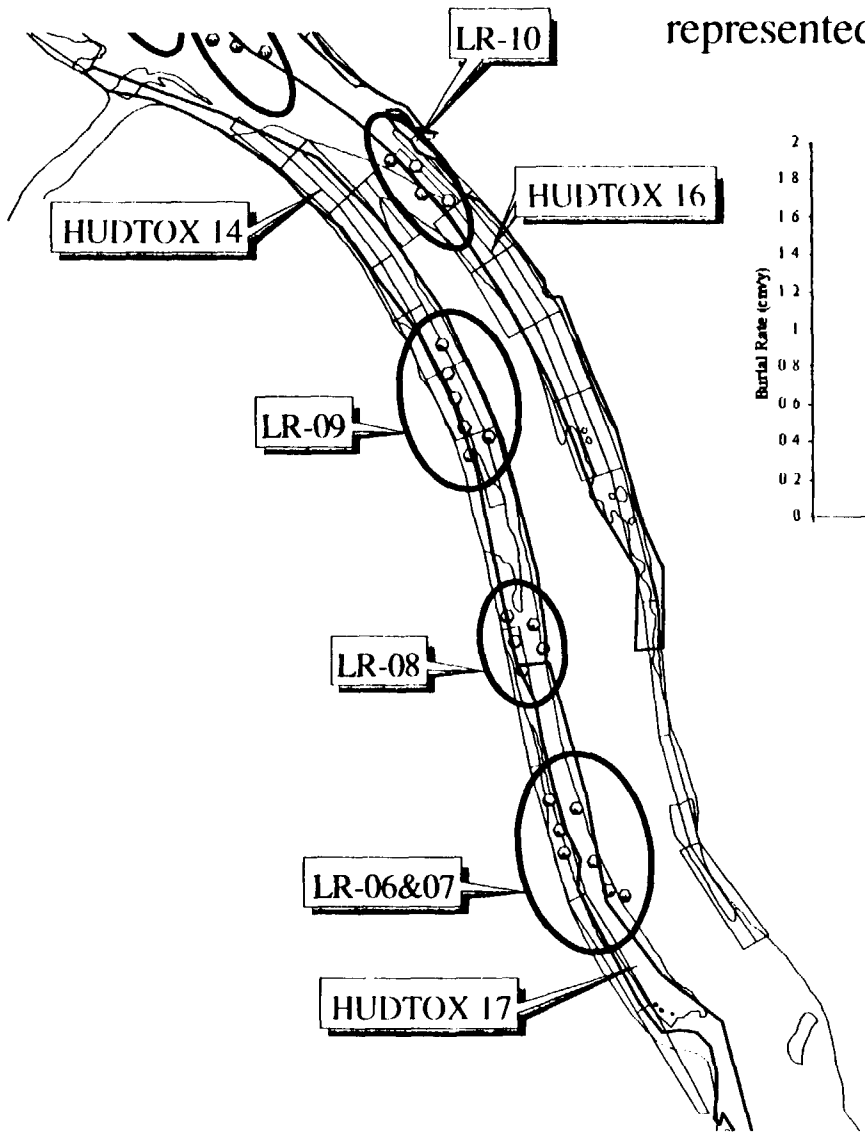
- EPA Low Resolution Core Clusters
- EPA HUDTOX Segments
- 1994 Low Resolutions Cores
- GE Model Cohesive Grid Elements
- Shoreline
- Cohesive Sediments

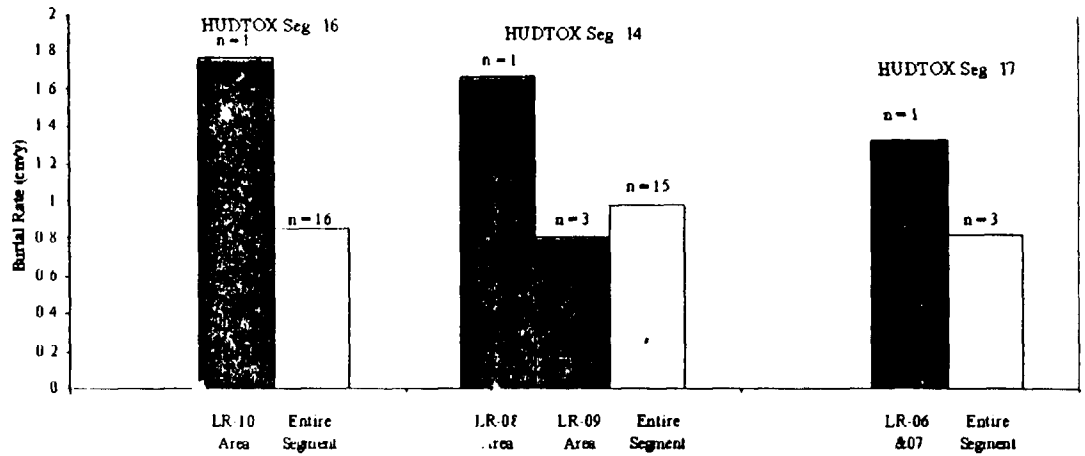
308038

Emuly - D:\GE\Nhud\model\cluster_analysis\depos_avg.apr

Privileged & Confidential

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 06&07, 08, 09, and 10 and in the larger cohesive sediment areas represented by Segments 14, 16, and 17 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.1 0 0.1 0.2 Miles

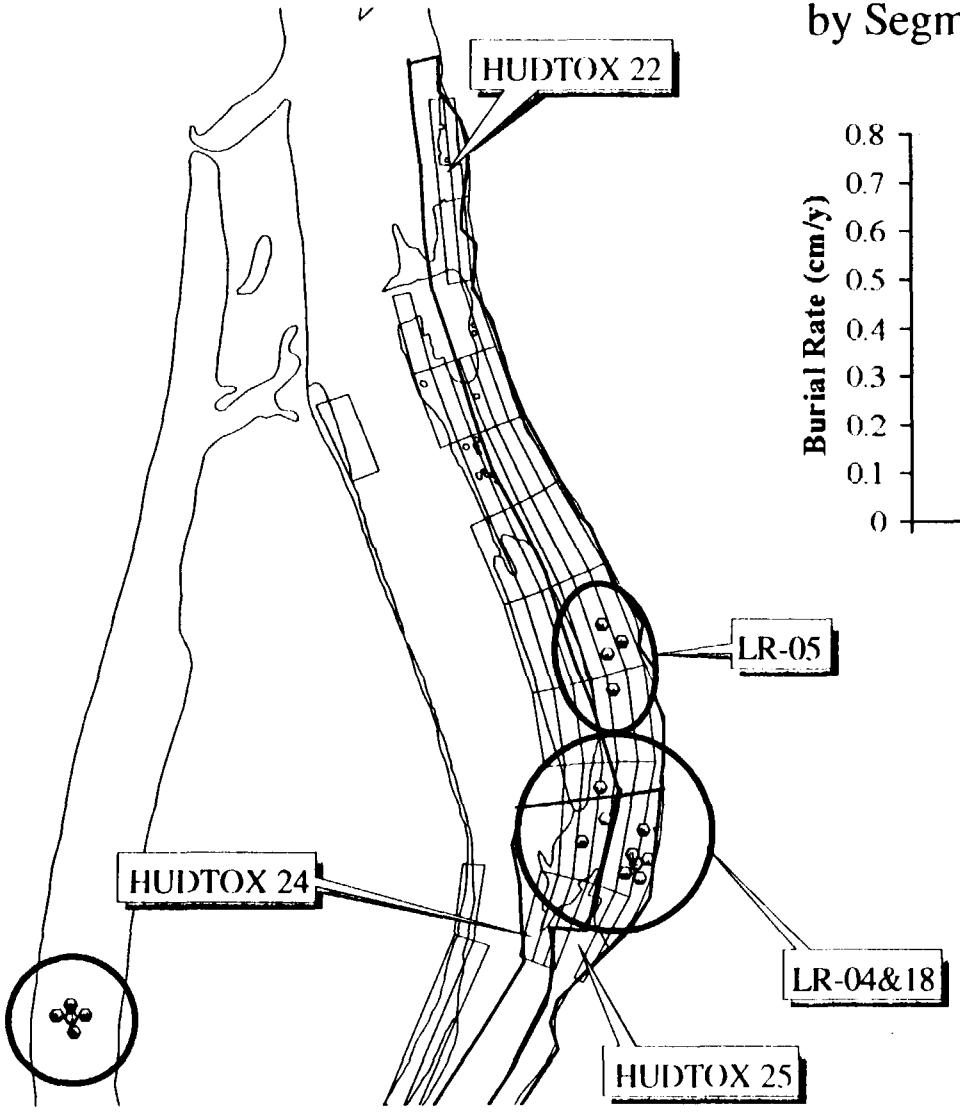
N

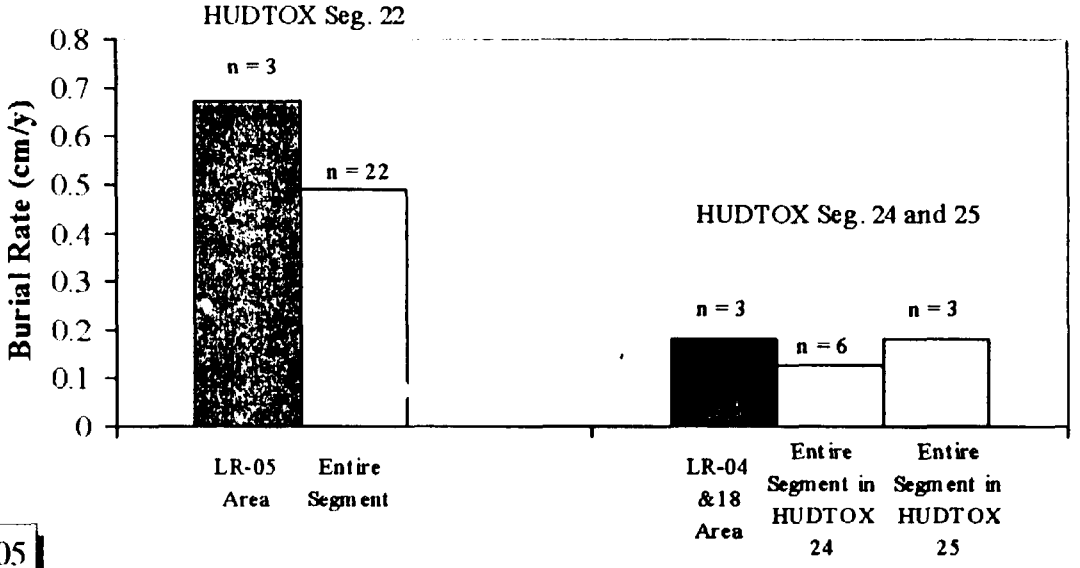
Emily - D:\GE\Nhud\model\cluster_analysis\depos_avg.apr

Privileged & Confidential

308039

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 04&18 and 05 and in the larger areas represented by Segments 22, 24, and 25 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.07 0 0.07 0.14 0.21 Miles

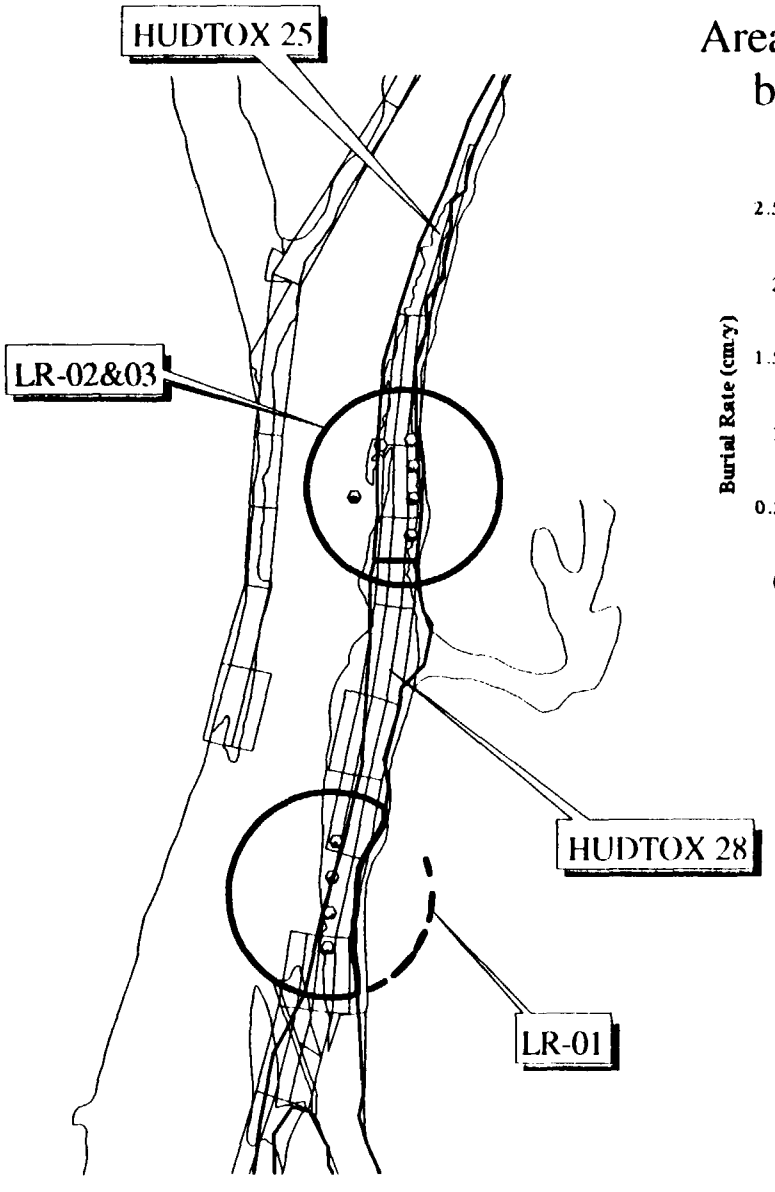
N

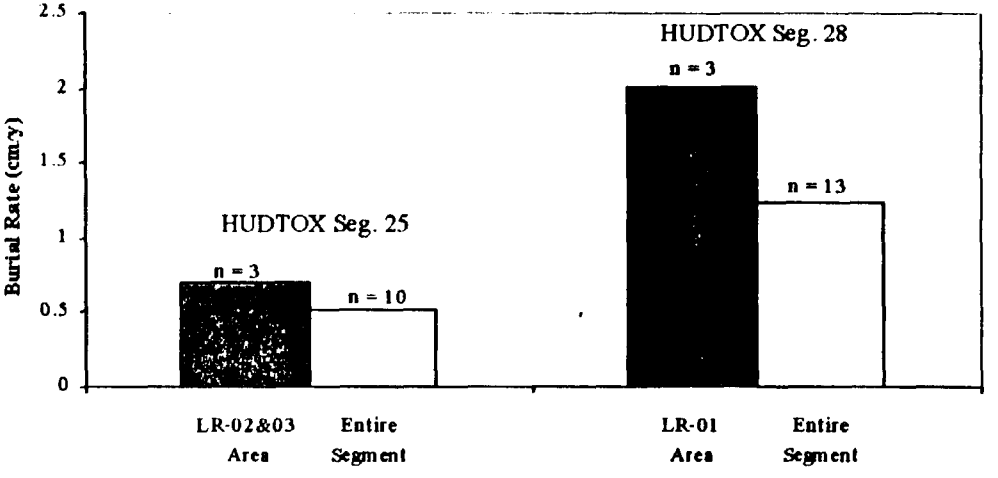
Emily - D:\GE\Hud\model\cluster_analysis\depos_avg.apr

Privileged & Confidential

308040

Comparison of GE model computed cohesive sediment burial rates in Low Resolution Coring Analysis Cluster Areas 01 and 02&03 and in the larger areas represented by Segments 25 and 28 of the EPA Hudtox Model





Note: n indicates number of GE model grid elements

EPA Low Resolution Core Clusters
EPA HUDTOX Segments
1994 Low Resolutions Cores
GE Model Cohesive Grid Elements
Shoreline
Cohesive Sediments

0.05 0 0.05 0.1 0.15 Miles

N

Emily - D:\GE\Nhud\model\cluster_analysis\depos_avg.apr

Privileged & Confidential

SARATOGA COUNTY

ENVIRONMENTAL MANAGEMENT COUNCIL

PETER BALET
CHAIRMAN

GEORGE HODGSON
DIRECTOR

March 13, 2000

Dr. Per Larsson, Assistant Professor
Lund University
Exotoxicology, Department of Ecology
Solveg 37
Lund, Sweden 22362

RE: Charge for Peer Review 3
Specific Question 11

Dear Dr. Larsson:

This letter is written to express my concern over Specific Question 11. The question appears innocent enough but must be taken in the context of several concerns about the Low Resolution Coring Report (LRC). Because I am not sure you have been provided with the LRC report and EPA's response to comments on the report, I am sending you this letter to assist in your review. Serious questions have been raised about the conclusions EPA presented in the LRC report. Further, the EPA response to these questions has been less than adequate. Finally, there is the inadequate attempt by EPA to justify the differences between the LRC report and the Revised Baseline Modeling Report (RBMR) on pages 140 and 141 of the RBMR.

Examples of the more significant comments I submitted on the LRC and a discussion of the inadequacy of the EPA responses are shown in the attachment to this letter. The examples are taken from my letter of October 1, 1999 to John Wanska of the GAO. This letter was in response to a request from the GAO for examples of what I considered to be failures on EPA's part to reply responsibly and completely to comments. The thrust of these comments is that EPA had insufficient data to draw conclusions about movement of PCBs from the hot spots in the Thompson Island Pool (TIP), and EPA used what data it had improperly. Also, that EPA improperly used a homogenized 9in. upper core segment to draw the conclusion that burial of PCBs is not occurring.

These inadequacies of the LRC report are then compounded by the discussion in Section 7.4.4 on pp. 140 and 141 of the RBMR. First, on p. 140, EPA maintains that a direct comparison of HUDTOX and LRC findings is impossible due to different assumptions and spatial scales (the LRC dealt only with cohesive sediment while HUDTOX considers both cohesive and non-cohesive areas). But HUDTOX considers the two types of sediment separately so it is not at all clear why HUDTOX results for the cohesive sediment can not be compared to the LRC conclusions. Second, on p. 141, EPA maintains the 9% loss of PCBs from the TIP calculated by HUDTOX shows consistency with the LRC best estimate of 45% from the hotspots because the 9% is within the 4 to 59% range in the LRC. To say 9% and 45% are consistent on this basis seems amazing. What would be the probability that the value in the LRC would truly lie at one extreme of the range? Finally, in the last paragraph, EPA repeats the same misleading type

50 WEST HIGH STREET BALLSTON SPA, N.Y. 12020 (518) 884-4778

statement used in the LRC about the poolwide change in sediment bed depth. This change has no bearing on the question of burial because burial is only expected in the cohesive sediments. The increase in the cohesive sediment of 6.5 cm. in 10 years from the HUDTOX model is in reasonable agreement with the 0.8cm/yr. value calculated by the GE/QEA model. (As an aside, I hope you have had the time to review GE's model so we can have the benefits of your thoughts on how the models compare.) EPA states that the 6.5cm. increase is small compared to the "surface" layer depth of 23 cm., the depth of the upper 9 in. layer in the LRC. Simply because EPA used a 23cm. upper layer in the LRC does not make this the "surface" layer, at least not in the important sense of what is the active surface layer for PCB interchange with the water column. This active layer is much more likely in the range of 5cm. or 2in., making a change of 6.5cm. quite important and indicative that burial is occurring. Burial, of course, would be consistent with the continued presence of hotspots. Without burial, how could the hotspots continue to exist?

Coming back to the original concern over Question 11, one must wonder if EPA is seeking vindication of the conclusions reached from EPA's geochemical approach as set forth in the Data Evaluation and Interpretation report and the LRC report. These reports showed a distinct bias towards remedial action based on lack of burial in the TIP hotspots and these hotspots being the major source of PCBs to the food chain. These conclusions are in direct contradiction to the results from HUDTOX. The HUDTOX results show burial is occurring, all of the contaminated sediment contributes PCBs to the food chain, and long term PCB levels are governed by the input of PCBs from upstream of the TIP. EPA's geochemical approach has discounted the importance of upstream PCB inputs. To conclude that the geochemical-based conclusions are correct for the present situation would seem to require EPA to refute its own model. This would then raise the question of how EPA can justify saying its model is inadequate to model the present situation but is satisfactory to predict the future, something the geochemical model can not do. It is very important that Question 11 be given close scrutiny.

Sincerely,

David D. Adams, PE mp

David D. Adams, P.E.
Member-At-Large, SCEMC
Member, Government Liaison Committee, C.

Enc.

cc: Mr. Doug Tomchuk, Project Manager, USEPA
Mr. Darryl Decker, Chr; Government Liaison Committee, CIP
SCEMC Members

ATTACHMENT

Selected Comments By David D. Adams From Letter To John Wanska, GAO, Dated October 1, 1999.

Following are EPA's responses to SCEMC comments on EPA's Low Resolution Coring Report (LRCR) which are followed by SCEMC's discussion of why EPA's response was inadequate. The complete text of EPA's responses can be found in EPA's Responsiveness Summary for Volume 2C-A, Low Resolution Sediment Coring Report dated February, 1999.

Comment #2. ***P.1-7 & P.2-1: Before any conclusions can be drawn from the low resolution coring (LRC) data, a statistical analysis must be done which predicts the ability of the small number of samples taken by EPA in only a few locations to adequately estimate the PCB mass over a large area with very large spatial variations in PCB concentrations. This analysis should include consideration of the fact that the mean values from the NYSDEC data are based upon an order of magnitude greater number of samples than the EPA data. Page 1-7 states the LRC program wasn't designed to duplicate the extensive spatial coverage of the NYSDEC program. Page 2-1 dramatically quantifies this statement by showing that EPA had only 60 core sampling sites in the TIP in the vicinity of the 1984 NYSDEC locations vs. 1200 NYSDEC core sites. The meager number of EPA cores hardly seems sufficient to quantify the PCB inventory (and therefore changes to the inventory as put forth later in the report) in the face of existing data which show very large spatial variation in PCB concentrations over very short distances in the TIP. EPA's data also shows this variation as can be seen in Plate 4-23 which indicates a 100:1 difference in concentration in nearby samples and variations of 10:1 in most, if not all, of Plates 4-21 to 4-28. Certainly, the scope of the EPA sampling program is not sufficient to justify the "alarming" statements made by EPA to the public which accompanied the release of the report and called for a study of immediate remedial action.***

EPA's response to this comment is found on pp. LRC-40 & 41 of the Responsiveness Summary, Responses LL-1.2 & 1.3. These responses completely miss the major thrust of our comment which is that before drawing conclusions about differences between individual samples taken in 1984 and in 1994 and by inference differences in PCB inventory it is first necessary to show statistically that the 1984 and 1994 populations are different. This can be evaluated by a statistical method, such as the analysis of variance, which can compare two populations of different sample size. Considering the known large spatial variation in PCB concentration over very short distances in the Thompson Island Pool (TIP), it is first necessary to show that the total 1994 data set is significantly different from the 1984 data set before conclusions can be drawn (as EPA does in Vol. 2C-A) about changes in PCB inventory in the TIP. This same comment was made by one of the peer reviewers of Vol. 2C-A. Also, the EPA responses contradict the LRC report itself. The responses say the LRC study was not "designed to create a 1994 inventory" (Response to LL-1.2) and later in LL-1.3 "the LRC for the TI Pool inventory is a point-to-point comparison between sixty 1984 cores or grabs and sixty 1994 cores, not a Thompson Island Pool inventory estimate comparison." However the point-to-point comparisons are used in the LRC report to calculate the change in the PCB inventory in the TIP "hotspots" between 1984 and 1994, precisely the purpose EPA said in the responses was not the purpose of the 1994 data.

Comment #6. ***P.2-16: The statement that the presence of PCB maxima in the top-most core layer shows that PCB burial is not occurring is not justified. High resolution core profiles have shown relatively low PCB concentrations in the first few inches of sediment with the PCB concentration then rising rapidly to a peak before declining to a low level or zero. Inspection of Fig. 2-7 shows that most of the PCB mass in both of these cores would occur within the top 9 inches (about 23 cm) of the cores but yet relatively low PCB concentrations within 2 plus inches of the sediment-water interface. Burial may or may not be occurring (the presence of "hot spots" would seem to indicate it is) but reasoning from the presence of a maximum PCB concentration in an upper 9" core segment cannot be used to make such a conclusion.***

EPA's response first says (Response to LL-1.7 on p. LRC-20) that not all the cores from fine grained areas of the Hudson River have a profile of PCB concentration which peak at depth below the water/sediment interface. However, all of the high resolution cores taken by EPA in the fine grained areas show this profile of the peak PCB concentration at depth and EPA fails to show any high resolution core data to support their position that the peak is not always at depth, making EPA's response little more than speculation. EPA presents only speculation and not facts to refute the fact that what high resolution core data are available show that the peak PCB concentrations occur several inches below the surface and well below what even EPA today admits is the "active" sediment depth (~ 2") involved in PCB interchange between sediment and the water column. EPA also does nothing factual to refute the observation in the comment that the PCB concentration profiles in the high resolution cores are such that mixing the top 9" in these cores would result in the maximum PCB concentration in this top 9" segment even though the PCB concentration in the top 2" of the cores is relatively low and the peak concentrations are well below this depth. EPA presents no factual information in its response to refute the comments contentions that EPA has misused the LRC data to draw conclusions not supported by the LRC data. Instead, EPA repeats the conclusions from the LRC report our comment takes issue with and brings in other extraneous statements, again not substantiated by facts, such as the effect of prop wash disturbance of sediment.

Comment #15. ***P.4-21: The discussion on P. 4-21 about corrections needed for the grab samples is another illustration of uncertainty in the EPA comparison of 1994 data to earlier data. There is no way of knowing if the extrapolation to 12" is valid or not. It is suggested the grab samples not be included in the analysis. Also, using the concentration of the second layer of the 1994 LRC samples to extend 9" cores to 12" is questioned. Based upon the sharp PCB concentration gradient in the range of 9-12" seen in the high resolution cores, this method of extending from 9" to 12" may greatly underestimate the LWA (Length Weighted Average) in the 1994 data.***

EPA's response, LL-1.17, on p. LRC-65 does not address the suggested deletion of the grab samples from the data analysis due to the inability to know if the extrapolation from the unknown depth of the grab samples (presumed to be 4") to 12" sediment depth is valid. Also, no data or calculations are presented to support EPA's contention that the LWA PCB concentration values calculated by extrapolating the 9" core concentrations to 12" using the data from the next deeper core segment are acceptable since "the PCB maxima are typically found in the uppermost core segment." This statement needs justification not provided by EPA because high resolution core data shows high concentration gradients in the 9 – 12" range of sediment depth and not in the 0-9" range.

Comment #17. ***P.4-22: Any comparison of PCB inventory based upon the 1976-78 and 1994 data is made uncertain by the lack of solid specific weight (SSW) data for the 1976-78 data. The statement here that total PCBs and SSW show very strong correlation is in contradiction to the statement on P. 3-18 that SSW showed a weak trend with PCB concentration. Also the range of variation in the data in Fig. 3-15 and 4-17 is very large making conclusions about correlations uncertain and no 2σ or 3σ values are given for the SSW to PCB values shown in Table 4-3. EPA needs to do more to show why the SSW values used for the 1976-78 data are reasonable to use, including a level of uncertainty, to make comparisons of PCB inventories between 1976-78 and 1994 meaningful.***

EPA's response, LL-1.19, is on p. LRC-66 of the Responsiveness Summary. While the response acknowledges the validity of the comment about the correlation of total PCBs and SSW, EPA fails to provide any information on uncertainty ranges. EPA's reliance on LWA comparisons for support is questionable given the issues raised in Comment #15 above.