PRELIMINARY REVIEW OF EPA'S DATA EVALUATION REPORT

March 21, 1997

I. Introduction

GE agrees with EPA that understanding (1) the sources of PCBs above the Thompson Island Dam ("TID"); (2) the down river fate of PCBs which pass the Dam; and (3) the mechanisms which drive the PCBs from their source to their final repository are critical to selecting a supportable remedy for the Hudson.

EPA has posed appropriate questions; it has not provided sound or persuasive answers. The data do not support EPA's conclusion that the buried sediments in the Thompson Island Pool ("TIP") are the most important source of PCBs to the freshwater Hudson. EPA's report identifies a number of potential sources of PCBs to the freshwater Hudson, concluding that either buried, highly contaminated and dechlorinated sediments within the TIP or pore water from less contaminated and dechlorinated sediments within the TIP are the most likely sources of PCBs to the water column below the TID. However, EPA concludes the former is the source, even though the mechanism for getting the PCBs from those sediments is unclear. In addition, EPA concludes that below the TID, PCBs are transported conservatively to the Lower River, with no substantive additions or losses of PCBs. EPA's report, however, does not test or address the possible mechanisms by which PCBs are made available to the water column. A more persuasive analysis of the data one which incorporates our knowledge of recent source activity in the Hudson River and is based on plausible physical mechanisms demonstrates that recent and continuing PCB releases from the vicinity of GE's Hudson Falls facility are the most significant source of PCBs to the water column at the TID, and that controlling that source should lead to a significant decrease of water column PCB loads to the freshwater Hudson.

Remedy selection requires understanding both the sources <u>and</u> mechanisms responsible for the fate and transport PCBs in the River. GE disputes EPA's identification of the PCB sources and does not believe that EPA can identify mechanisms that support the fate and transport it has postulated. The importance of careful identification of the source of PCBs to remedy selection is easily demonstrated. Putting to one side natural recovery and institutional controls which require separate and thorough consideration, more active remedies are suggested according to the source which supplies PCBs to fish and other biota. If buried sediments are the source of PCBs, capping or removal of the sediments is suggested. If recently contaminated surface sediments or present releases from an upstream source are the source of PCBs, elimination of the external source is suggested. Downstream of the TID, EPA treats the PCBs as running through a conduit, but determining whether the PCBs are subject to settling and volatilization with addition of PCBs to the water column from sediments below the TID is essential to understanding accurately what the effect of a given remedial action in the TIP will be.

The EPA analysis presented in the report illustrates the pitfalls of attempting to over simplify the understanding of complex systems. The interpretations are not constrained by the plausibility of physical mechanisms, nor is the totality of data brought to bear in understanding the behavior of PCBs in the river. It is abundantly clear that the PCB fate and transport model is the best tool to test various hypotheses and EPA must correct the deficiencies in its current model to help resolve the key issues identified.

II. EPA's Analysis and Conclusions are Inconsistent With Existing Data and Known Mechanisms Affecting PCBs

EPA Conclusions 1 and 2:

1. *The area of the site upstream of the Thompson Island Dam represents the primary source of PCBs to the freshwater Hudson*

2. *The PCB load from the Thompson Island Pool has a readily identifiable homologue pattern which dominates the water column from the Thompson Island Dam to Kingston during low flow conditions.*

EPA Evidence:

In most of the Phase 2 monitoring events the PCB mass loading and homologue composition change little between TID and Troy. EPA contends that this indicates the absence of substantial external loads as well as minimal losses from the water column.

GE Response:

Sediments below the TIP are a source of water column PCBs. The lack of a major change in total mass load means that losses approximately balance the additional loading. The PCB load passing TID declines with distance due to flux to the bed (settling) and to the atmosphere (volatilization). This loss is made up by contributions from the downstream sediments. EPA's report supports this view: "sediment-derived loads which originate outside the Thompson Island Pool, indicat[ing] the presence of substantive sediment inventories outside the Pool." (p. E-2).

GE Evidence:

1. Because PCB concentrations in the surficial sediments of Reaches 6 and 7 are similar to those in the TIP (based on sampling in 1977 and 1991), it is probable that PCB fluxes to the water column in these reaches are also similar to those of the TIP.

2. The report states "... the PCB content of the surficial sediment is consistent, both in congener distribution and concentration, with the PCB content of the suspended-matter samples..." (p. 3-105). This finding implies that substantive loads to the water column below the TID will not necessarily cause substantive changes in homologue composition.

3. EPA acknowledges the loss mechanism of volatilization (Section 3. 2. 3), but fails to take this into account.

4. EPA acknowledges that loading and homologue composition changes were observed in the Transect 6 sampling (p. 3-83), but never quantitatively analyzes these changes. As seen in Figure 3-47, a dramatic change occurs for the various homologues despite little change in total PCB flux. For example, the TIP monochlorobiphenyl load of 1 mg/s is reduced to zero by Waterford, whereas the loading of other homologues increased.

5. GE has prepared a preliminary mass balance model for the Upper Hudson River which has been calibrated to the data collected before the occurrence of the Allen Mill event (1977-1991). The model indicates that in 1993, the period in which EPA collected data that 40% of the PCBs passing the TID would be lost from the water column by Waterford, through the well-established mechanisms of settling and volatilization.

EPA Evidence:

EPA argues that changes in the sediment PCB to ^{137}Cs ratio between Stillwater and Kingston can be predicted by simple dilution with tributary sediments. From this EPA concludes that the PCB load passing TID is conservatively transported downstream and accounts for sediment PCB levels throughout this reach.

GE Response:

Simple dilution is an incorrect model for the fate of the PCB load passing TID. This model ignores the processes of settling and volatilization and improperly describes the change in particulate phase PCBs caused by dilution with clean solids. Correcting the model to account properly for these processes demonstrates that the PCB load passing TID constitutes only a fraction of the PCBs in the sediments between Troy and Kingston.

GE Evidence:

1. Preliminary PCB mass balance calculations embodied in the PCB fate and transport model being constructed on GE's behalf indicates that the particulate phase PCBs decline by a factor of 5 to 10 between the TIP and Troy. A simple dilution calculation predicts a decline by only a factor of two. The additional decline occurs because PCBs are lost by settling and volatilization and particulate PCB concentrations are reduced by dilution as water column TSS concentration increases by a factor of two.

2. PCB concentrations in surficial sediments show a decline with distance that agrees with the mass balance calculations.

- 1991 data show a decline in the 0-5 cm layer of about a factor of 11 between the TIP and Waterford (i.e., from 19.4 ppm to 1.7 ppm).
- EPA's own analysis shows a decline in the PCB to ^{137}Cs ratio between the TIP and Stillwater by a factor of 2 to 5, whereas simple dilution predicts a decline of less than 20 percent (see Figures 3-66 and 3-67).

3. As PCBs move from the Upper River to the Lower River additional dilution by cleaner solids occurs because the Mohawk River brings in solids at three times the rate of the Upper Hudson (83.4 MT/km^2 versus 29.6 MT/km^2). This further reduces the PCB load passing TID beyond that computed by simple dilution.

4. The comparison of PCB composition in the Stillwater and Albany high resolution cores provides evidence of other external PCB sources. The report concludes, for 1991 to 1992, that 23% of the PCBs at Albany came from a source other than the Upper River (p. 3-122). The actual percentage is probably higher because the analysis assumed that all of the Aroclor 1242, a commonly used PCB mixture, in the Albany core came from the Upper River. Further, the analysis probably underestimates the current contribution of other sources; the 1991 to 1992 data reflected the elevated PCB flux from the Allen Mill that occurred during this period.

EPA Conclusion 3

> *The PCB load from the Thompson Island Pool originates from the sediments within the Thompson Island Pool*

EPA Evidence:

EPA invokes two mechanisms for moving the historic PCB inventory in the TIP sediments into the water. The first is that the pore water containing relatively undechlorinated PCBs from surficial sediments (0-8 cm) is a potential source of the TID PCBs because its calculated homologue pattern is similar to that observed in the water column at the TID. The second is due to direct resuspension of sediments with dechlorinated PCBs.

GE Response:

With respect to the first point, GE agrees that relatively undechlorinated PCBs in the sediments are the source. However, these PCBs cannot be derived from the historic PCB inventory, but rather represent the impact of PCBs from the vicinity of Hudson Falls. The PCB mass in surficial sediments, as estimated from 1984 and 1991 data, is insufficient to sustain the TIP loading. Moreover, for the TIP sediments to provide all of the TIP load would require the implausible conclusion that the sediments in the TIP behave much differently from the sediments below the TIP, despite having similar concentrations and congener patterns. Finally, the homologue and congener pattern calculated from the average composition of TIP surficial sediments does not match that observed in the water column at the TID.

GE Evidence:

1. The magnitude of the sediment source in Reaches 6 and 7 suggests that the sediments in the TIP account for only a small fraction of the observed TIP loading (assuming the sediments in the TIP and Reaches 6 & 7 act in a similar manner).

2. Mass balance calculations indicate that the TIP loading would have depleted the 1984 TIP inventory in the surficial sediments (0-8 cm) by the early 1990s:

TIP Sediment Inventory Depletion if Responsible for the TIP Source

Homologue	TIP Load MT/yr	TIP Surficial Sediment 1984 Mass*	TIP Surficial Sediment Years to Deplete	TIP Sediment Inventory 1984 Mass	TIP Sediment Inventory Years to Deplete
1	0.07	0.65	9	3.16	45
2	0.09	1.59	17	7.74	90
3	0.14	1.14	8	5.55	40
4	0.09	0.45	5	2.21	24
5	0.02	0.14	7	0.69	30
6	0.01	0.04	4	0.20	31

*estimated for average concentration of 28.7 mg/kg

3. If the historic sediments are the source of PCBs to the water column, the appearance of the high resolution core profiles would be substantially different due to the rapid depletion.

4. The report concludes that the high resolution cores indicate that "... PCB loads originating above the TI Dam have leveled off within the last 8 to 10 years." (p. 3-108) Given the rapid depletion of the TIP sediments necessary to sustain the TIP loading and our knowledge of the PCB inventory, these sediments could not sustain a constant depletion over the last 10 years. Other sources are required.

5. The pore water PCB congener pattern calculated using EPA's partition coefficients (as corrected by GE)[1] and reach average sediment PCB composition (from 1991 data) does not match the TIP load. The differences suggest an additional source that is dominated by tri- and tetrachlorobiphenyls.

EPA Evidence:

Older sediments containing the historic PCB inventory (pre-1984) at concentrations greater than 120 ppm have a homologue pattern consistent with that of the TIP load and thus contribute to the TIP load.

[1] GE recalculated the EPA partition coefficients, correcting for an error in specified temperature and allowing congener-specific temperature relationships.

GE Response:

The analysis EPA used to match older sediments to the TIP load assumes that the relationship between PCB molecular weight and the fraction of PCBs in specific congeners is a dechlorination scale that can be used to match sediments and the water column. It is not. Further, no mechanism exists to transfer buried PCBs in older sediment to the water column, and surface deposits at concentrations greater than 120 ppm are incapable of providing the TIP load.

GE Evidence:

1. There are several problems with the EPA – developed index of dechlorination. First, the relationship used to establish the extent of dechlorination is not an exclusive indicator of dechlorination: solubilization and partitioning will result in PCB compositions that also fall on the line because these processes, like dechlorination, enrich the concentration of congeners No. 1, 4, 8, 19 and 20, which EPA used to calculate molar "dechlorination" product ratios. Second, EPA's dechlorination index is flawed because it fails to account for moderate levels of dechlorination by examining only "terminal" dechlorination products. Finally, it would likely completely miss a well documented dechlorination process in the Upper and Lower Hudson that does not produce these products.

2. To account for the TIP load by resuspension from the areas of the TIP in which sediment concentrations exceed 120 ppm ("pre-1984") at the surface would require sufficient erosion to deplete the total historic inventory in these areas of the TIP in a relatively short time.

3. While on a homologue level, there is an apparent match in composition, on a congener level there is not. The congener pattern of the "pre-1984" sediments does not match the congener pattern of the TIP load.

4. GE's preliminary sediment transport model indicates that erosion in the TIP under low flow conditions is substantially less than the erosion of >120 ppm sediments needed to account for PCB loads at the TID (i.e., approximately 0.1 MT/d versus 5 MT/d). Such erosion of sediments would only be expected during large flood events.

EPA Conclusion 4

Sediment inventories will not be naturally "bioremediated" via dechlorination

EPA Evidence:

The extent of dechlorination appears to be related to the total PCB concentrations and does not consistently occur at concentrations less than 30 ppm.

GE Response:

Natural recovery processes in the river which include PCB dechlorination and burial are significant processes and will result in lower PCB levels in fish and water in the future. With respect to dechlorination, EPA has come to a number of unsupportable conclusions. EPA's dechlorination index is flawed and does not accurately measure actual levels of dechlorination. In addition, although mass loss does not occur, dechlorination reduces risk by even a greater extent by reducing the extent of bioaccumulation and the concentrations of the most toxic, highly chlorinated congeners.

GE Evidence:

1. EPA's dechlorination index is flawed because other physical processes can account for enrichment of lower chlorinated congeners, and it is insensitive because it only measures terminal dechlorination products. EPA's index cannot detect partial dechlorination, which has been demonstrated to occur in the Hudson, and which attacks higher PCB congeners (i.e., those with 4-7 chlorine atoms per biphenyl), but produces very little of the lower homologues (i.e., those with only 1-2 chlorines).

2. Dechlorination has been shown to occur at concentrations less than 30 ppm; the rate of dechlorination simply decreases at these lower concentrations. This has been confirmed in laboratory as well as direct field measurements. (See Abramowicz, D.A., et al., "In situ anaerobic PCB dechlorination and aerobic PCB biodegradation in Hudson River sediments," *Biotechnology in Industrial Waste Treatment and Bioremediation*, ed, R.F. Hickey and G. Smith, Lewis Publishers, CRC Press, 1996)

3. Dechlorination reduces the bioaccumulation potential of PCBs. The dechlorinated PCB congeners found in the sediments display approximately a 10-40 fold reduction in their tendency to bioconcentrate in fish, as compared to the more highly chlorinated tri- and tetra-chlorinated PCBs present in the original Aroclor 1242 mixture. The dissolved PCBs in the water column passing the TID which are derived from dechlorinated sediments will have an even lower bioaccumulation potential. Moreover, apart from dechlorination, studies show that as PCBs age and remain in sediments, they become markedly less available to the water column. Thus, dechlorination and aging of PCBs reduce risk by markedly reducing the potential for exposure.

4. Dechlorination also reduces risk by reducing the toxicity of PCBs. EPA recently revised the PCB cancer potency sharply downward over 100 fold for PCB mixtures containing only mono-through tetrachlorinated biphenyls. Dechlorination also removes the coplanar higher chlorinated congeners, thereby reducing the dioxin-like toxicity of PCBs. Finally, EPA recently concluded that there is no conclusive evidence showing that PCBs cause adverse health effects in humans through endocrine disruption.

III. A More Persuasive Analysis of the Data Demonstrates the Importance of the Hudson Falls Source

The water column data collected over time clearly shows that the amount of PCBs entering the river in the TIP are in excess of what is expected from the inventory of PCBs present in the pool and known physical mechanisms. One potential mechanism to account for this is that oils containing PCBs denser than water enter the TIP undetected and are deposited in the surface sediment of the pool. These PCBs are then diffused into the water column and transported with the measured load entering the pool, downstream. As these PCBs are transported downstream some are lost through sedimentation and volatilization, and local downstream sediments which also contain historic deposits of PCBs contribute to the PCB levels further downstream. The PCBs passing the TID are not transported like "pipe flow" to Kingston, New York as alleged by EPA.

A. *PCBs enter the River at Hudson Falls as DNAPL*

1. In September, 1996, GE located and controlled a seep of PCB oil, Seep 13, entering the River below water level at the base of the cliff in the vicinity of Hudson Falls.

2. GE's investigations in the vicinity of the Hudson Falls facility have found evidence of other small sources of PCB oil along the cliff face and in the riverbed below the Bakers Fall Dam

B. *PCB DNAPL oils are transported to the TIP by pulse loadings associated with river high flow events and possibly daily flushing of the Bakers Falls plunge pool associated with operation of the new AHDC hydroelectric facility.*

1. Spring high flow events in 1992 and 1993 mobilized large quantities of PCBs from the Hudson Falls area:

- Instantaneous loadings at the Fort Edward station in 1992 increased from less than 5 kg/day to approximately 40 kg/day along the rising limb of the spring flow event hydrograph.

- Instantaneous loadings during the spring 1993 high flow event were approximately 18 kg/day (EPA Transect sampling event 4 conducted along the falling limb of the event hydrograph).

2. Annual PCB transport from Hudson Falls during high and low flow periods exceeds that contributed by in-place sediments of TIP:

- EPA estimates the 1993 Hudson Falls source contribution at 370 kg/yr (p. 3-90).

- EPA estimates the TIP source at 225 kg/yr (p. 3-90).

3. PCBs mobilized during these flow events had congener and homologue patterns identical to that of oils collected from Hudson Falls.

4. GE's PCB DNAPL transport study conducted by discharging and collecting plastic beads in the River under moderate flow conditions during the fall of 1996 indicates:

- Greater than 95% of PCB DNAPL entering the river at Hudson Falls would be retained in the river upstream of the TID.

- PCB DNAPL droplets (<100 um in diameter) are readily transported downstream from Hudson Falls to Fort Edward but are retained within the TIP.

- Coarse PCB DNAPL droplets (>100 um in diameter) are retained within the river downstream of the plant site but upstream of Fort Edward and would presumably be mobilized under higher flow conditions.

5. Sediment bed load samples collected along the rising limb of a moderate flow event during the 1996 DNAPL transport study showed a PCB homologue and congener pattern characteristic of PCB oils from Hudson Falls.

6. Water column monitoring timed to follow the volume of water flushed from the Bakers Falls plunge pool during routine maintenance of the AHDC hydroelectric facility suggests that such activity may increase PCB transport downstream.

C. *Water column PCBs at the TID are derived mainly from upstream sources through two mechanisms: (1) direct water column contribution from Hudson Falls; and (2) pore water diffusion from the surface sediments in the TIP (which contain PCBs recently deposited from Hudson Falls).*

1. A combination of the sediment diffusive source and a source with an Aroclor 1242 homologue pattern matches the TIP load.

2. The TIP load varies seasonally and annually in a pattern inconsistent with simple flux from in-place sediments, but consistent with a high-flow activated source. It is highest after the spring flood and declines to a minimum in winter. It was substantially reduced in 1995 when no high flow occurred.

3. The 1993 high flow sampling showed a significant input of PCBs from upriver and probably underestimated the total load because sampling was done on the down leg of the hydrograph.

4. The EPA analysis found that the composition of the surface sediment matched that of TSS, particularly for TSS during the high flow Transect. The analysis concludes that pulse inputs from upstream are responsible for the PCB contamination in the surface sediments (p. 3-106). Thus, the component of the TIP load that comes from surface sediment originates largely from recent pulse inputs from upstream.

5. The GE Upper River model indicates that sources external to the TIP are the reason that recovery of the system has not occurred at a greater rate. Without external source contributions from 1977 to the present, the summer average water column PCB concentration in 1989 would have been about 13 ng/l rather than the 30 to 40 ng/l measured and about 9 ng/l by 1994, rather than the 120 ng/l measured.

6. The TIP load appears to have been reduced following the control of Seep 13 and other recent remedial actions at the plant site. The average load at the TID has been about 0.75 l b/d (3.9 mg/s) from October 1996 through January 1997. Between 1993 and 1995 the load averaged between 1.5 and 2.3 lb/d (7.9 to 12.1 mg/s) for the same seasonal period.

D. *The fraction of the PCB load attributable to sources above the TID declines as water flows down stream: (1) PCBs are lost to the sediments through volatilization; and (2) PCBs are added through pore water diffusion, resuspension and other external sources.*

1. As set out above, surficial sediment PCB concentrations decline downstream of the TIP at a rate much greater than would occur by simple dilution. This greater decline reflects losses from the water column due to settling and volatilization. The GE model indicates that settling and volatilization reduce the TIP loading by about 40 percent by the time it reaches Waterford. The Transect 6 data show that the TIP monochlorobiphenyl load is completely lost by Waterford (see Figure 3-47).

2. The GE model indicates that sediments downstream of the TIP accounted for about one-third of the low flow PCB loading at Waterford in 1993 (i.e., 0.6 lb/d out of 1.9 lb/d).

E. *If the Hudson Falls source is contained, the PCBs in the sediment in the TIP and elsewhere will be covered through the deposition of clean sediment.*

1. The high resolution cores indicate burial rates of greater than 1 cm/yr in the depositional areas (i.e., fine sediment areas) of the Upper River (see Table 3-18).

2. Analysis of the TSS data collected by EPA in 1994 indicates that burial occurs in portions of the river even under high flow conditions.

3. The EPA and GE modeling of the 100-year flood indicates that rare flood events erode only the top centimeter or so of the sediment.

IV. To Resolve Open Factual Issues, Additional Data Must Be Collected

The difference in view between what EPA suggests as the primary source of PCBs in the river, and what is supported by the data is more than just a curiosity. Knowledge of this source must be obtained so the correct remedy can be selected, one that reduces surface sediment and water PCB concentrations which are the PCBs ultimately showing up in fish. To accomplish this, additional data collection will be undertaken by GE this year. Additionally, it is essential that a more robust data interpretation mechanism be employed, one that utilizes all of the data and has internal controls such as plausible physical mechanism and mass balance concepts. The EPA fate and transport model is the correct tool if it is corrected, recalibrated and then used to test the various hypotheses being proposed to evaluate the sources in the river. Only after this is done can predictions of future PCB levels in fish be made under various source control options and the full analysis of remedial options undertaken. With respect to data collection the following program is being pursued:

A. *Groundwater Seepage Investigation.*

Objective: Test the hypothesis that ground water seepage is responsible for observed increased load at the Thompson Island Dan.

Scope: Develop, test and deploy ground water seepage meters in Thompson Island Pool (Reach 8) and Reach 6 during summer low flow conditions.

B. *High Flow Water Column Monitoring.*

Objectives: Test the hypothesis that PCBs enter TIP as pulse loading during high flow events.

Scope: Sampling and analysis at water column monitoring stations upstream and downstream of TIP during rising and falling limb of event hydrograph and collection of sediment bed load samples during spring high flow.

C. *Thompson Island Pool Float Survey*

Objective: Identify regions of TIP contributing to anomalously high PCB loads observed during summer low flow periods.

Scope: Injection of dye within Bakers Falls plunge pool, collection of water column samples for PCB analysis at three locations across dye front at 18-20 lateral transects as dye travels downstream through TIP.

D. *Bakers Falls Plunge Pool Flushing Surveys*

Objective: Quantify the PCB mass loading from the Bakers Falls Plunge Pool associated with routine hydroelectric facility operations.

<u>Scope</u>: Collection of samples at the Bakers Falls Plunge Pool and Fort Edward monitoring stations before, during and after inundation of falls and flushing of the plunge pool. Timing of sampling will be determined based upon time of travel estimates from Bakers Falls to Fort Edward.