General Electric Company
Hudson River Project

REVIEW OF THE HUDSON RIVER PCBs REASSESSMENT RI/FS PHASE 2 REPORT VOLUME 2B - PRELIMINARY MODEL CALIBRATION REPORT

Presented to the
U.S. Environmental Protection Agency, Region II

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HydroQual, Inc.
Environmental Engineers and Scientists

MAJOR WEAKNESSES OF THE EPA UPPER HUDSON RIVER MODELS

- The solids balance is fundamentally flawed
- The solids balance errors result in an overstatement of PCB transfer from sediments to the water column
- The solids balances in the PCB fate model and the 100 Year Flood Model are at variance
- The calibration period is inadequate
- Groundwater influx is included as a basis for the TIP load imbalance without supporting evidence
- The 100 Year Flood Model uses different water-sediment shear stresses in its hydrodynamic and sediment transport calculations
- The 100 Year Flood Model does not include coarse-grained sediment
- The bioaccumulation models incorrectly assume steady-state conditions and calculate statistical variability incorrectly

COMPONENTS OF THE EPA MODELING EFFORT

- "Seasonal Scale" PCB Fate Model

  - evaluation of remedial options

- 100 Year Flood Model

  - determine depth of erosion, but not fate of eroded PCBs

- Bioaccumulation Model

  - determine fish PCB levels from predicted water and sediment PCB levels

Salient Features of the EPA Models

- The basic strategy with respect to model structure and study objectives is appropriate
- The general approach is valid
- The time & space scales of the data and the analysis are generally consistent
- 5 PCB congeners and $\sum$PCB are modeled
- The disproportionate rate at which PCBs increase through TIP is partially accounted for by a combination of resuspension and ground water inflow

STATUS OF THE EPA MODELING EFFORT

- PCB fate model has been developed and calibrated to the EPA Phase 2 data set (Jan. to Sept. 1993)

- 100 year flood model has been developed but not calibrated. It has been used to predict the erosion of cohesive sediments in Thompson Island Pool.

- Screening level bioaccumulation model has been developed

MAJOR CONCLUSIONS

EPA	GE
"... relatively high PCB concentrations in sediments of the TIP have a significant effect on Upper Hudson River PCB dynamics."	The sediments of the TIP have a local effect on Upper Hudson River PCB dynamics
Resuspension is more important than upstream sources	Upstream sources are more important than resuspension
Resuspension is the primary mechanism by which sediment PCB concentrations decline	Burial is the primary mechanism by which sediment PCB concentrations decline
Groundwater inflow may be responsible for the disproportionate PCB increase across the TIP	The cause of the disproportionate PCB increase across the TIP has yet to be determined
A 100 yr flood erodes only the top few cm in the TIP depositional areas	A 100 yr flood erodes only the top few cm in the TIP depositional areas
Sediments and water contribute to fish PCBs	Surface sediments and water contribute to fish PCBs

MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

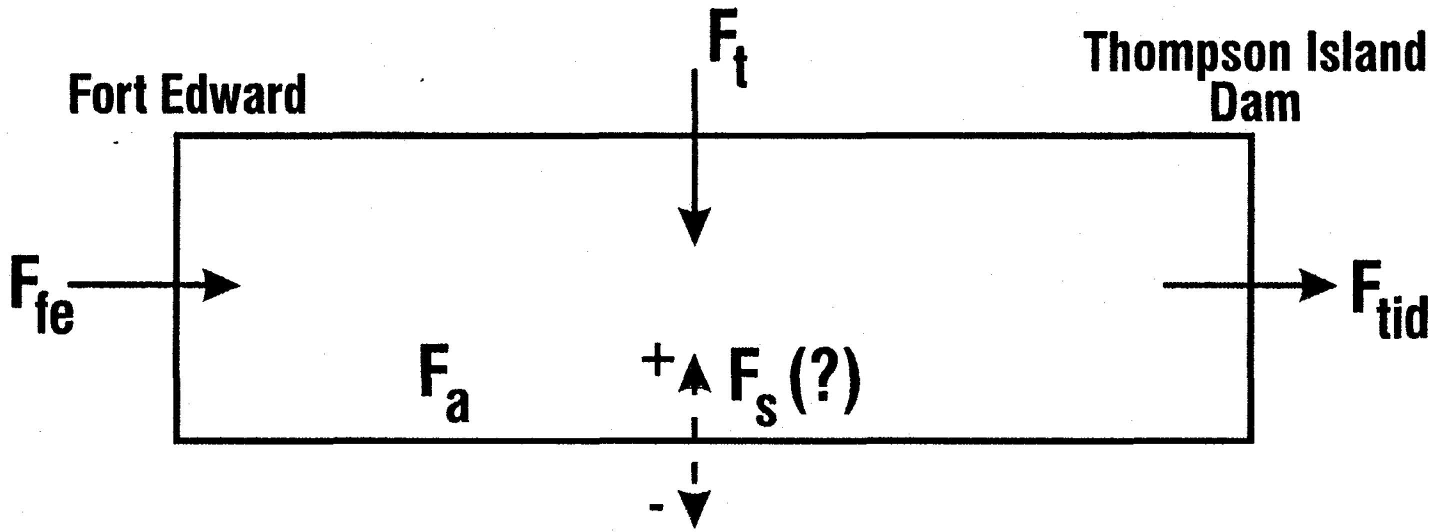
- Solids mass balance is inaccurate

  - loadings from TIP tributaries are underestimated

  - deposition and resuspension rates, particularly at low flow, are too high

  - sedimentation is not integrated into the model as the net of deposition and resuspension, violating the principle of mass balance

SOLIDS MASS BALANCE



$$F_{tid} = F_{fe} + F_t + F_s + F_a$$

$$F_s = F_{tid} - F_t - F_{fe} - F_a$$

(metric tons) $F_s = 38{,}400 - 225 - 35{,}500 - 643$

$F_s = 2{,}032$ (erosion)

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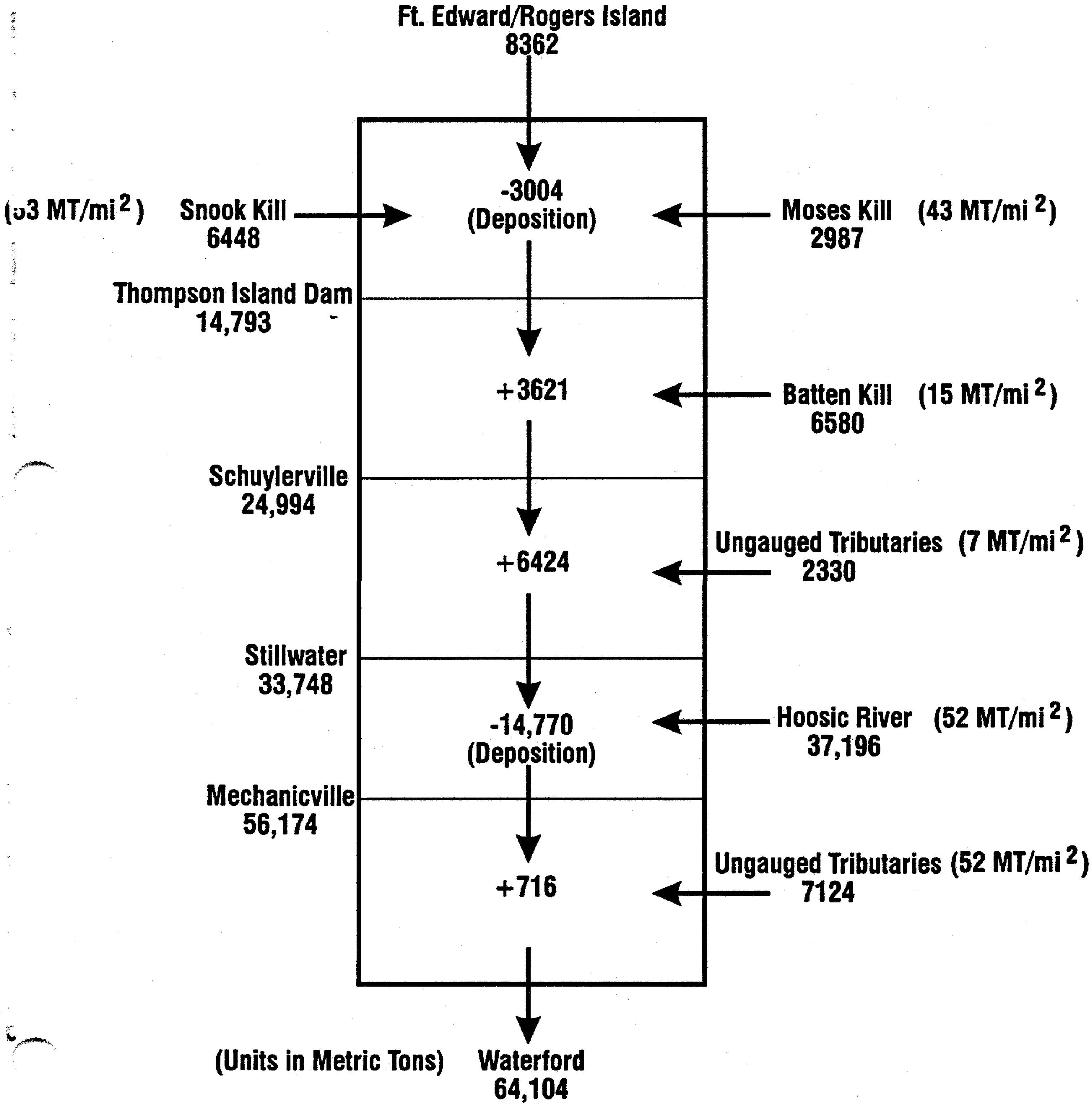
SOLIDS MASS BALANCE FOR 1994 FLOOD
(30 March 1994 - 28 April 1994 - 30 Days)



Sediment Yield

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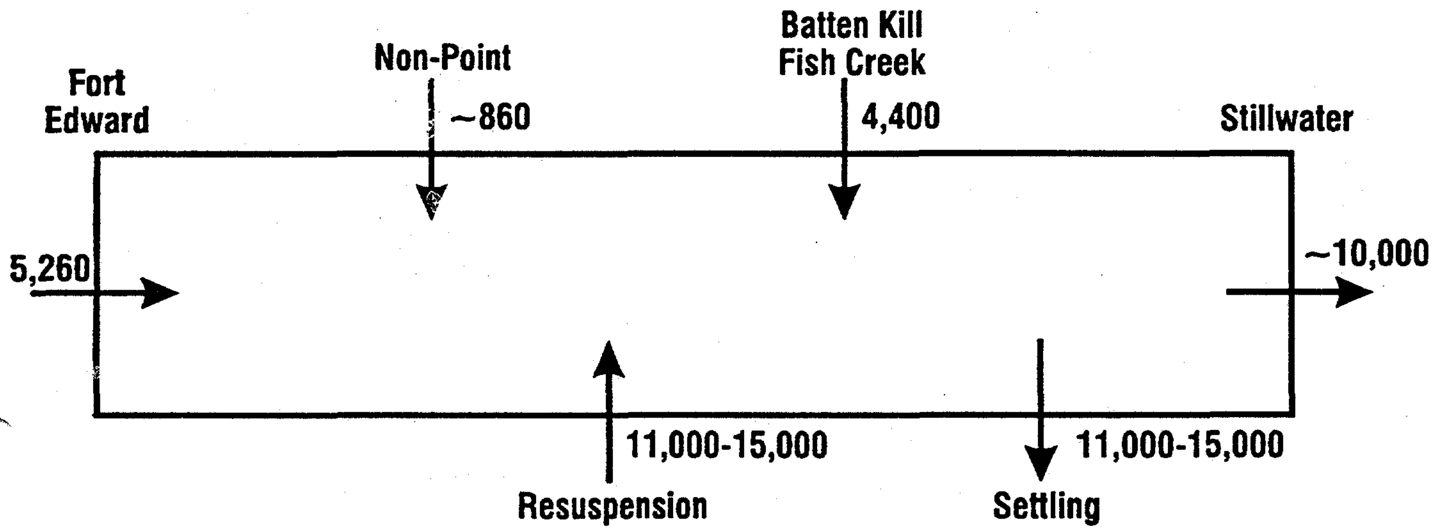
HUDTOX SOLIDS BALANCES

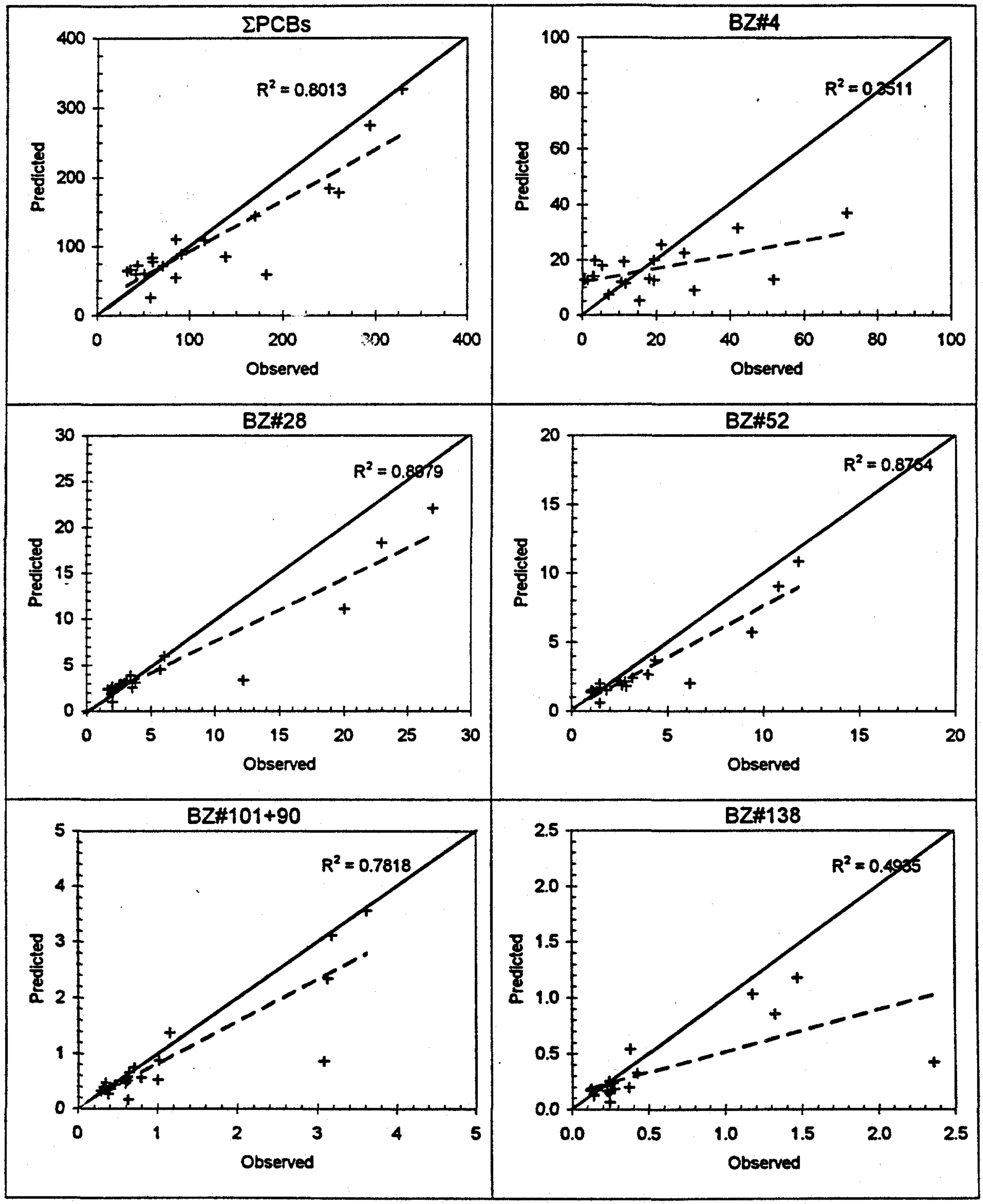
Settling & Resuspension (MT) During Non-Event Period



SOLIDS IN = SOLIDS OUT. Therefore, No Calibration Check on Settling & Resuspension

PCB MODEL OVERESTIMATES WATER COLUMN PCB Concentrations at Low Flows, Indicating Settling & Resuspension are Too High

Figure 4-32
HUDTOX Predicted Total PCB Concentrations vs. Observed Values (ng/L)
Phase 2 Transect Data



MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

- High flow resuspension is not inhibited by bed armoring (i.e., resuspension continues as long as velocity exceeds some threshold value)

  - inconsistent with the approach used in the 100 year flood model

  - may exaggerate the transfer of PCBs from the bed to the water column

  - resuspension rate is determined solely by calibration (i.e., no mechanistic basis)

Figure 4-37
TSS Mass Balance for HUDTOX Calibration Period (1/1/93-9/30/93)
Spring Runoff Event Period (3/26/93 - 5/10/93)

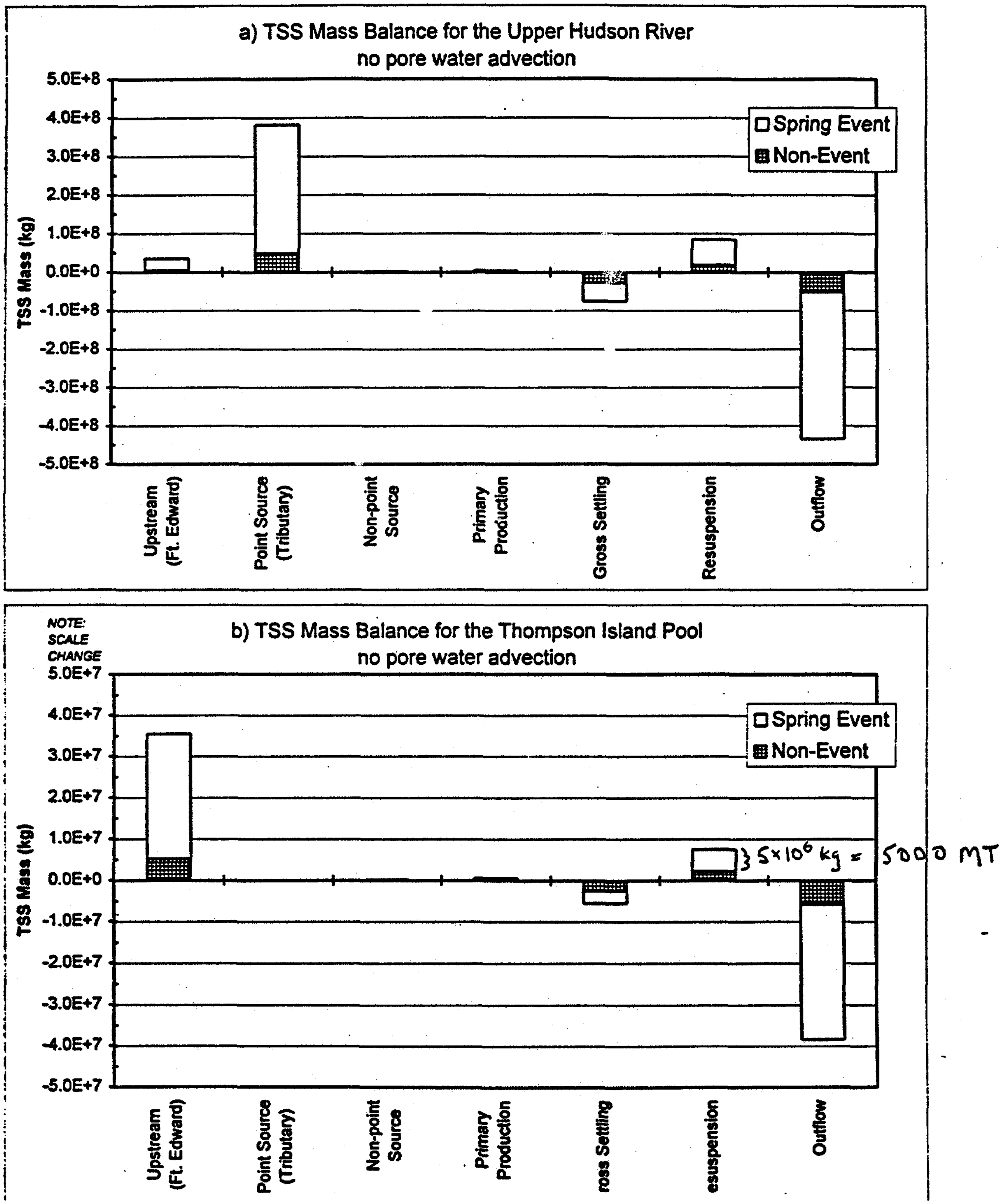


Table 6-5
Mass of Solids and PCBs Eroded from Cohesive Sediments in TIP

Event	Flow (cfs)	Mass of Solids eroded (MT/event)	Mass of PCBs eroded (kg/event)	% of 1984 PCB reservoir eroded [1]	Depth of Scour (cm)		
					Median	5th Percentile	95th Percentile
100 year	47330	834	25.00	0.78	0.16	0.03	0.97
1983	34800	304	8.75	0.27	0.06	0.01	0.32
1994 Spring	28000	220	6.58	0.21	0.04	0.01	0.22
1992 Spring	19000	55.3	1.57	0.05	0.01	0.00	0.05
1991	8000	1.68	0.04	0.00	0.00	0.00	0.00

1 Mass reservoirs based on the Kriging analysis of 1984 NYSDEC data (Butcher et al., 1994)

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MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

- Calibration was limited to the period from January to September, 1993

  - no sediment PCB data to establish initial condition (1991 data were used)

  - time scale is too short to evaluate accuracy of the temporal trend in sediment PCB

MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

- Simultaneous net erosion and net sedimentation

  - a constant sedimentation rate of 0.2 cm/yr is specified independent of the net transfer of solids to the bed

  - over the period of simulation the model has a net erosion of 9,000 MT and a net sedimentation of 31,000 MT

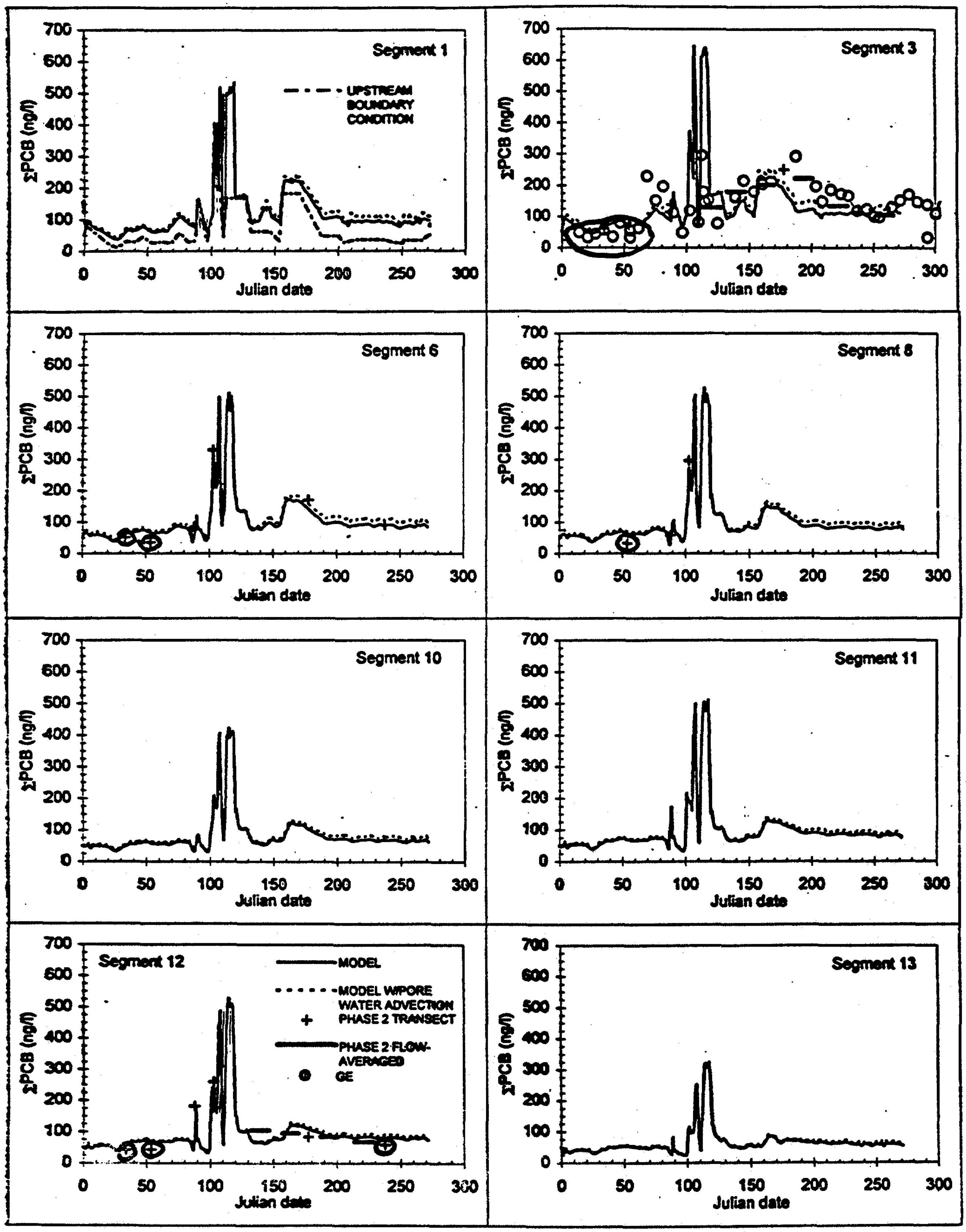
MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

- Model is unable to achieve a PCB mass balance across TIP, despite resorting to hypothesized mechanisms for which there is no factual demonstration

  - groundwater flux of buried PCBs was applied

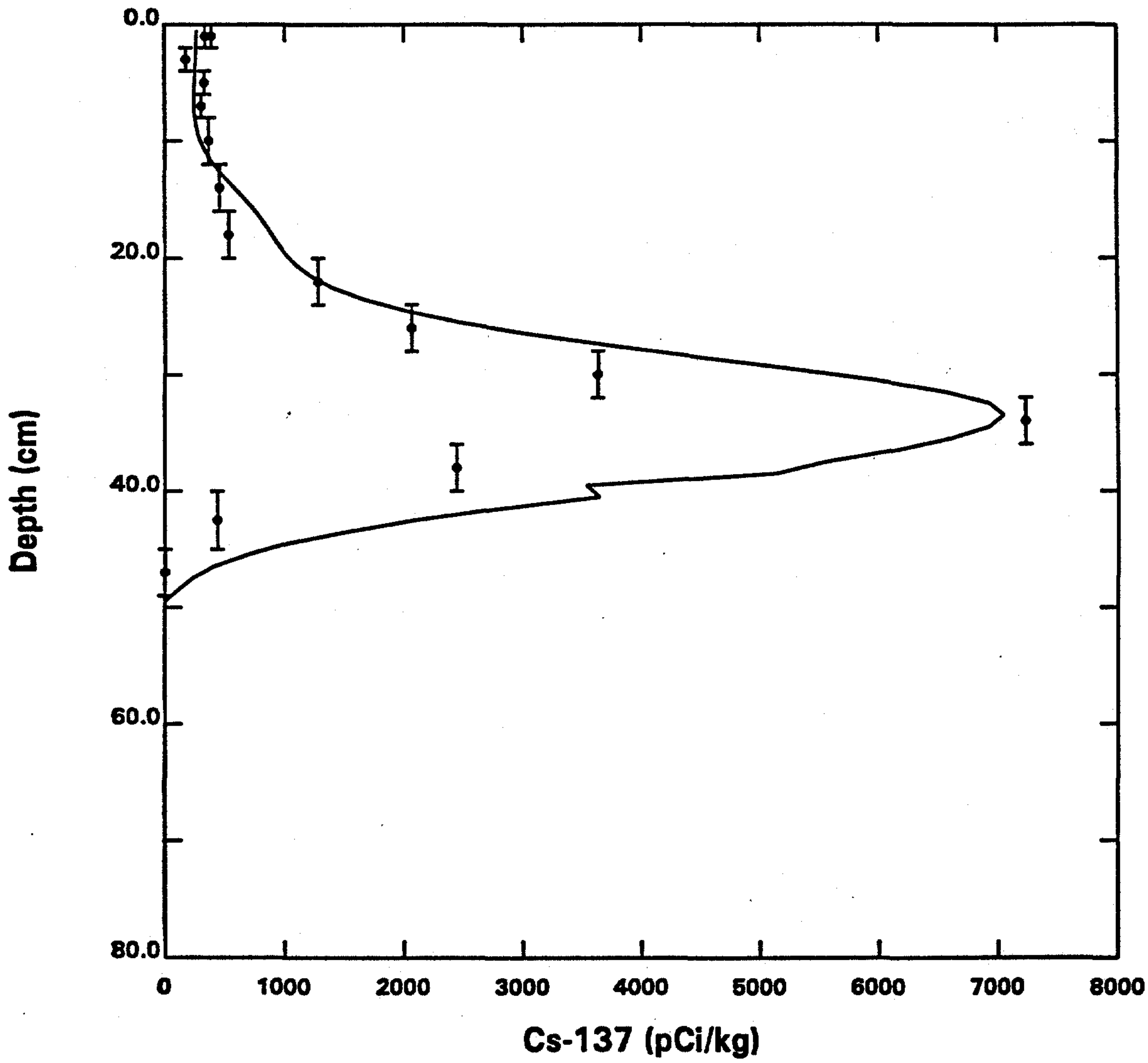
  - model over predicts PCBs in winter and under predicts PCBs in summer

Figure 4-14
Total PCB Calibration - ΣPCBs for January - September 1993

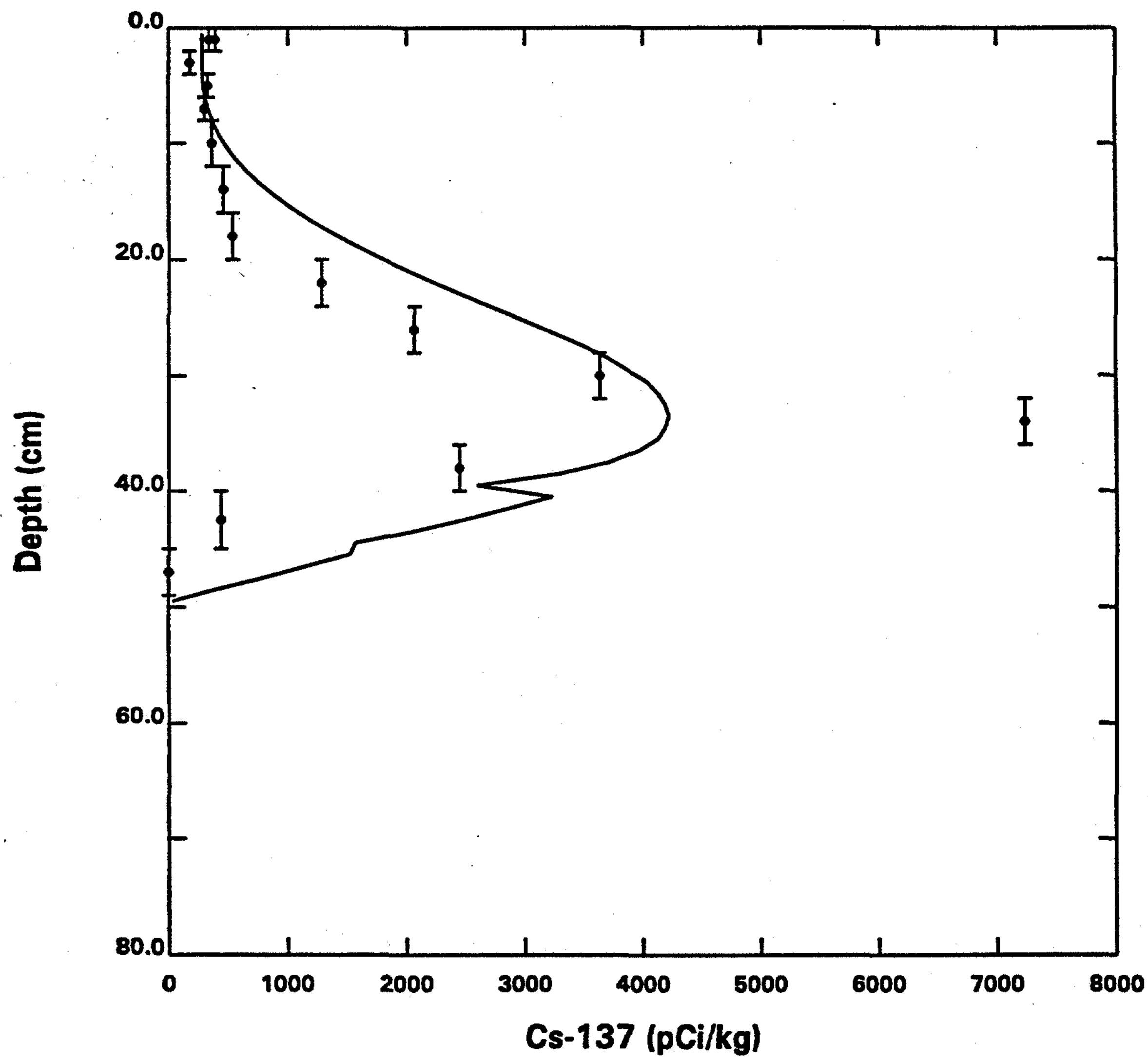


MAJOR WEAKNESSES OF THE UPPER HUDSON RIVER PCB FATE MODEL

- The ground water inflow hypothesis is inconsistent with the radiotracer and PCB profiles in sediments from depositional areas



Cesium-137 Calibration with Sedimentation Rate of 1.1 cm/yr Without Groundwater Flow



Cesium-137 Calibration with Sedimentation Rate of 3.5 cm/yr
With Groundwater Flow

WEAKNESSES OF THE 100 YEAR FLOOD MODEL

- No attempt to calibrate model to data from previous floods

- Sediment transport calculation does not use the bed shear stresses used in the hydrodynamic model

  - correcting this error will increase erosion by about 30 percent

- Model does not include coarse grained sediment

BIOACCUMULATION MODELS

1. Bivariate statistical model

   Purpose: predict average PCB levels in fish

   Status: essentially complete

2. Probabilistic food chain model

   Purpose: estimate variation in fish PCB levels for use in risk assessment

   Status: in development

3. Gobas model

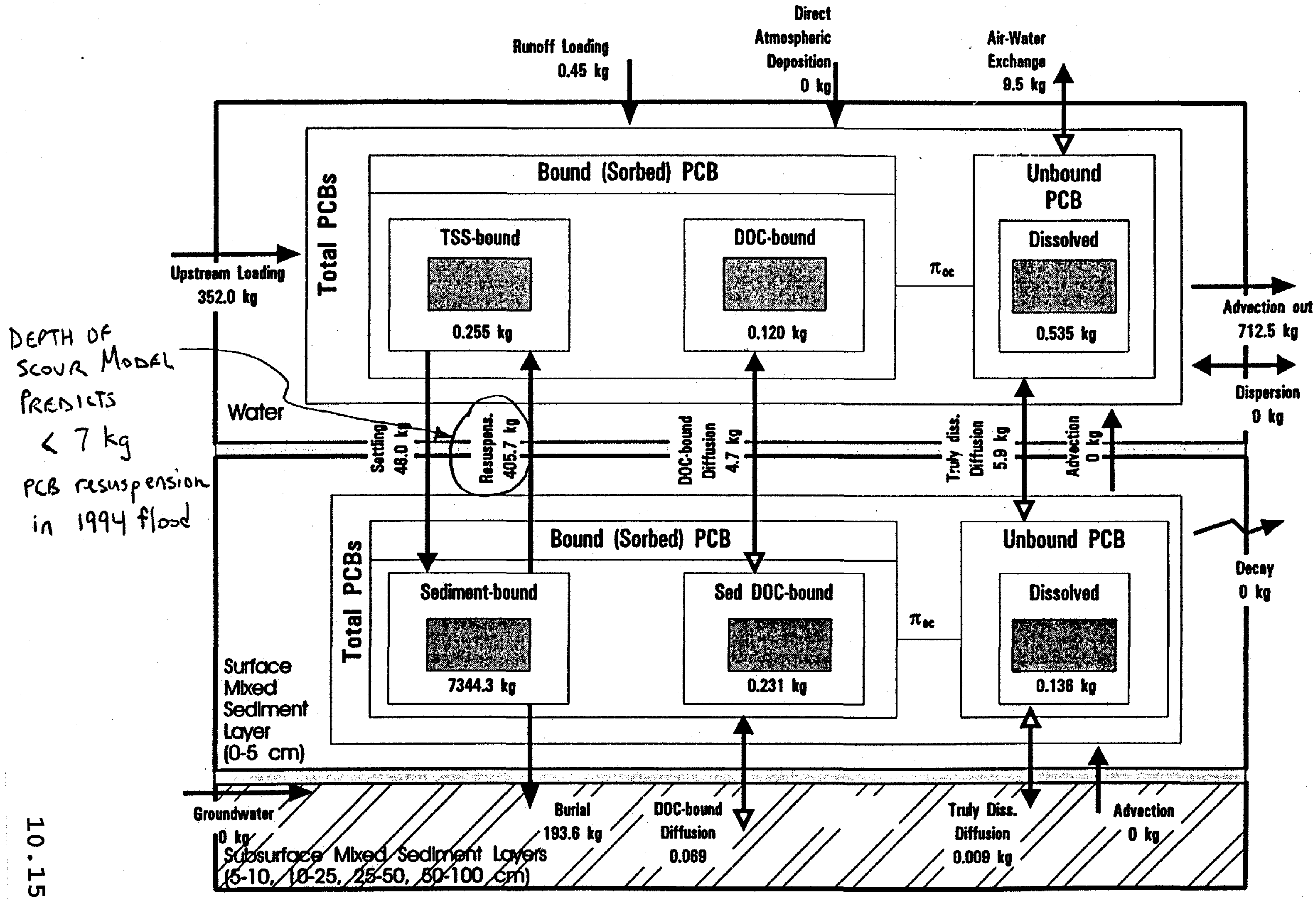
   Purpose: check models 1 and 2 and provide further insight into issue of water vs. sediment exposure

   Status: planned effort

WEAKNESSES OF THE BIOACCUMULATION MODELS

- Bivariate statistical model (BSM) and the probabilistic model (PM) assume steady-state conditions
- BSM over predicts PCBs at low water and sediment concentrations
- PM is circular, requiring the answer (i.e., variability of PCB levels among individual fish) to do the problem
- PM confuses variability and uncertainty

Figure 4-39
Total PCBs Component Diagram for Thompson Island Pool without Pore Water Advection (1/1/93 - 9/30/93)



EROSION EXCEEDS BURIAL

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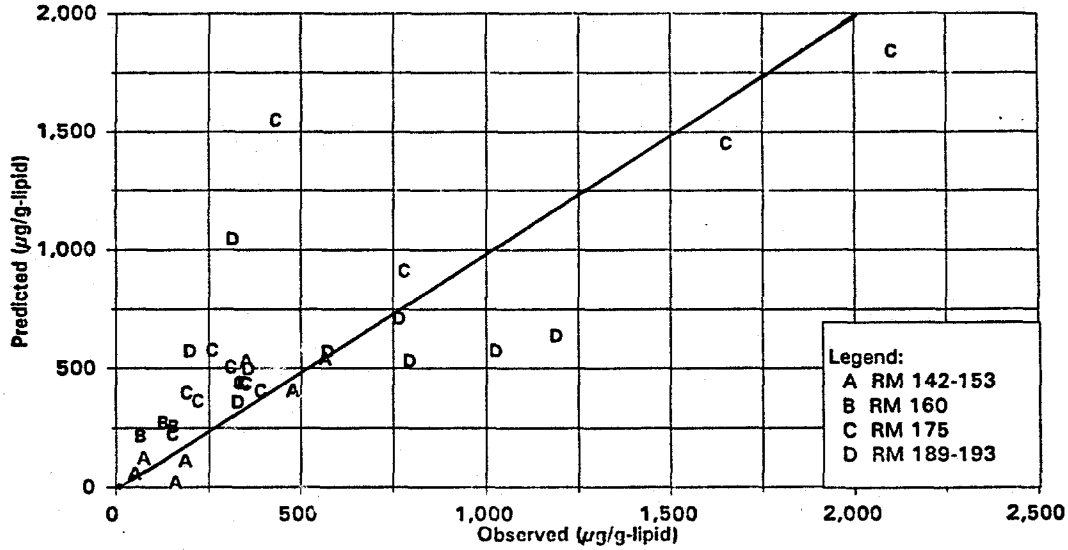
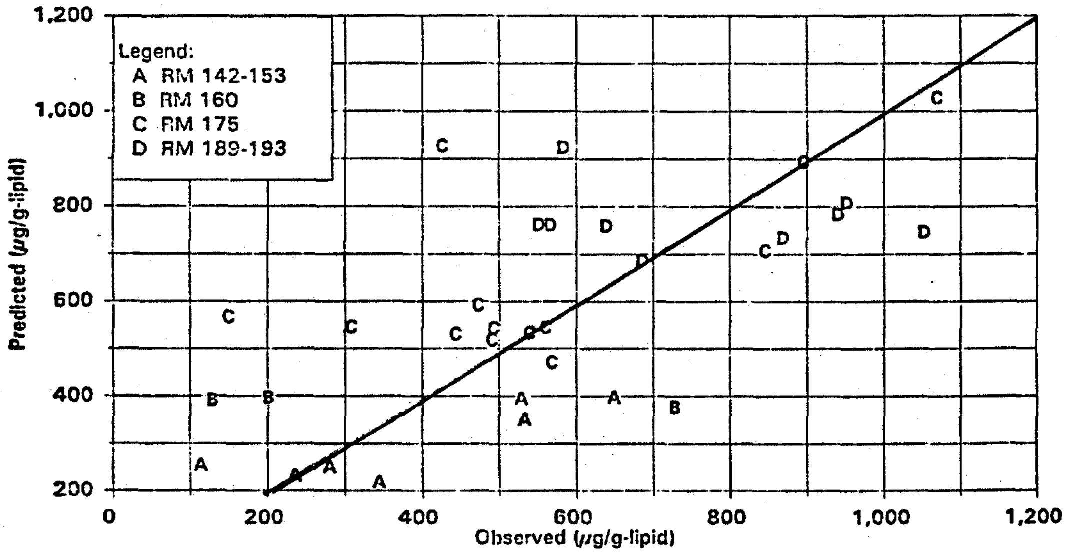
Figure 9-9
Comparison of Observed and Predicted Aroclor 1016 Concentrations in
Hudson River Largemouth Bass (Corrected to NYSDEC 1983 Quantitation Basis)



Source: TAMS/Gradient Database, Release 3.1

Figure 9-12
Comparison of Observed and Predicted Aroclor 1254 Concentrations in
Hudson River Largemouth Bass (Corrected to NYSDEC 1983 Quantitation Basis)



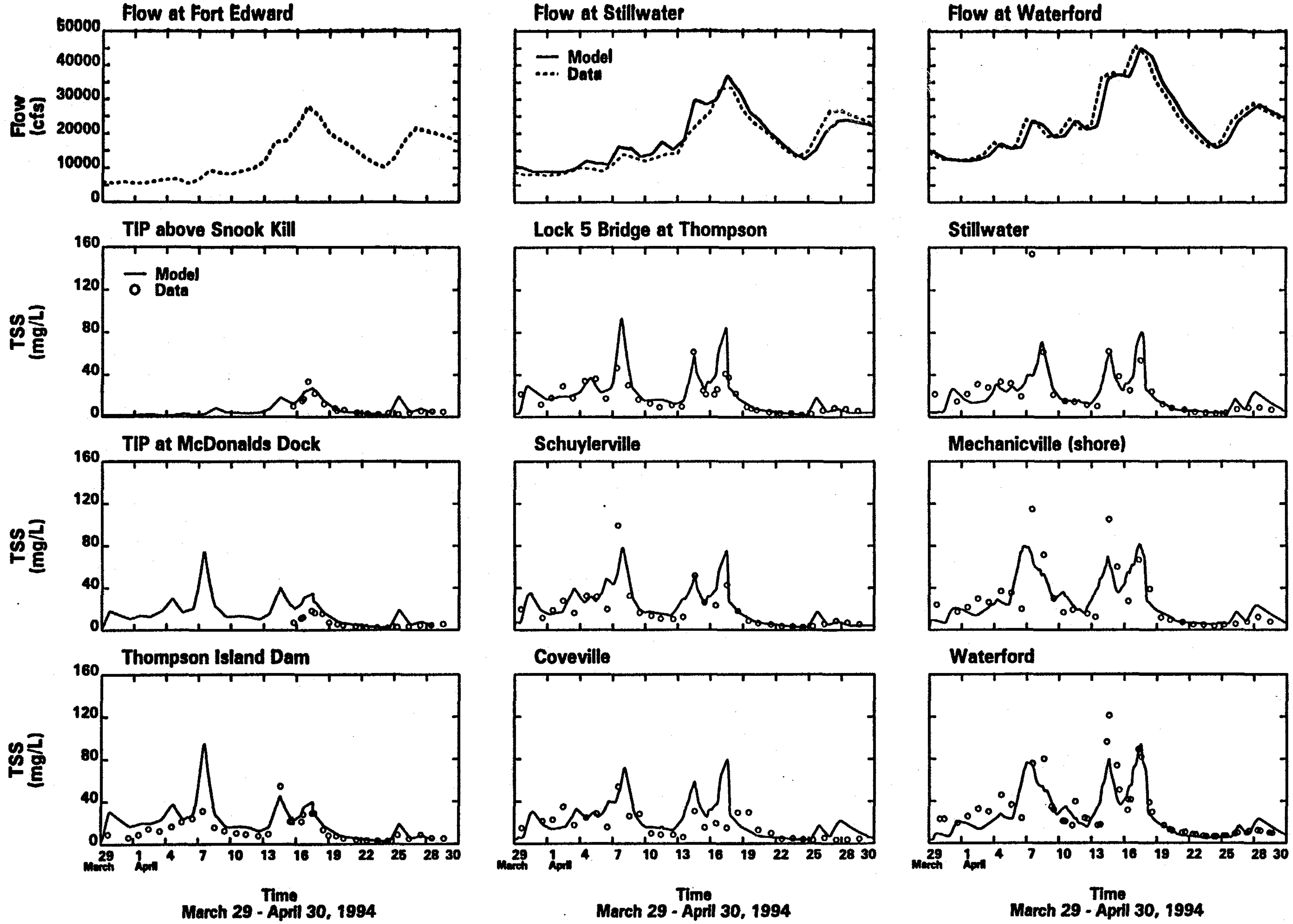
Source: TAMS/Gradient Database, Release 3.1

RECOMMENDATIONS TO EPA

- Develop and test by data collection, if necessary, the range of hypotheses that might explain the TIP load imbalance
- Refine the solids loading estimates for all tributaries; particularly for Snook and Moses Kills
- Eliminate low flow resuspension and incorporate the concept of bed armoring. Also refine settling rates based on solids composition
- Include sedimentation within the mass balance
- Recalibrate the model using the full historical data set
- Develop a time-variable bioenergetics-based food web model
- Reissue the calibration report prior to making predictions

GE's Modeling Efforts Could Aid the Agency in Rapidly Attaining Necessary Model Accuracy

- Sediment transport model consistent with the EPA Depth of Scour model has been developed and calibrated to data from 1977 to the present
- Technical issues regarding integration of sediment transport model and PCB fate model have been resolved
- PCB fate model has been calibrated through the historical data to 1991, prior to the Alan Mill release and the TIP load imbalance
- Data collection and analysis efforts are providing insights regarding the TIP load imbalance
- Time variable food web bioaccumulation model has been developed and calibrated to the historical data


Flow at Fort Edward
Flow at Stillwater
Flow at Waterford
Flow (cfs)
Model
Data
TIP above Snook Kill
Lock 5 Bridge at Thompson
Stillwater
TIP at McDonalds Dock
Schuylerville
Mechanicville (shore)
Thompson Island Dam
Coveville
Waterford
TSS (mg/L)
March
April
Time
March 29 - April 30, 1994

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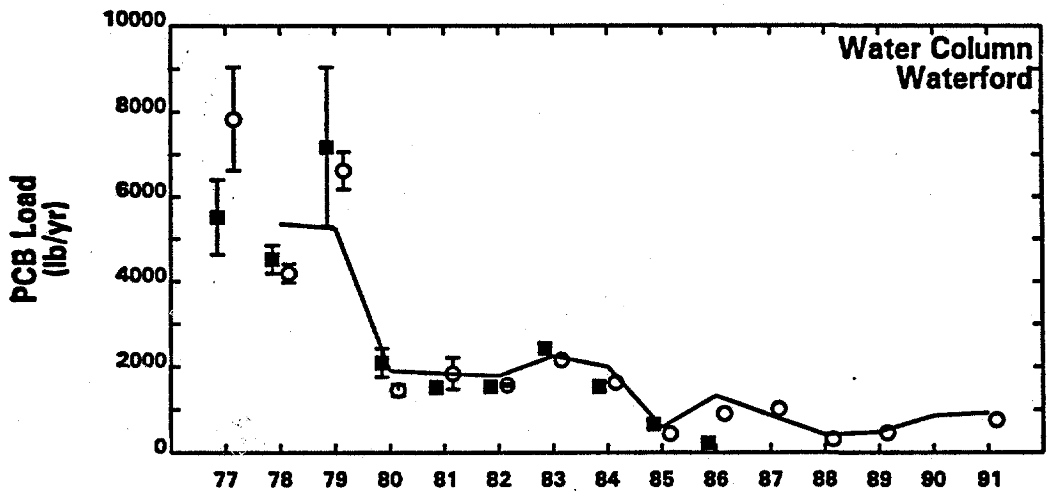
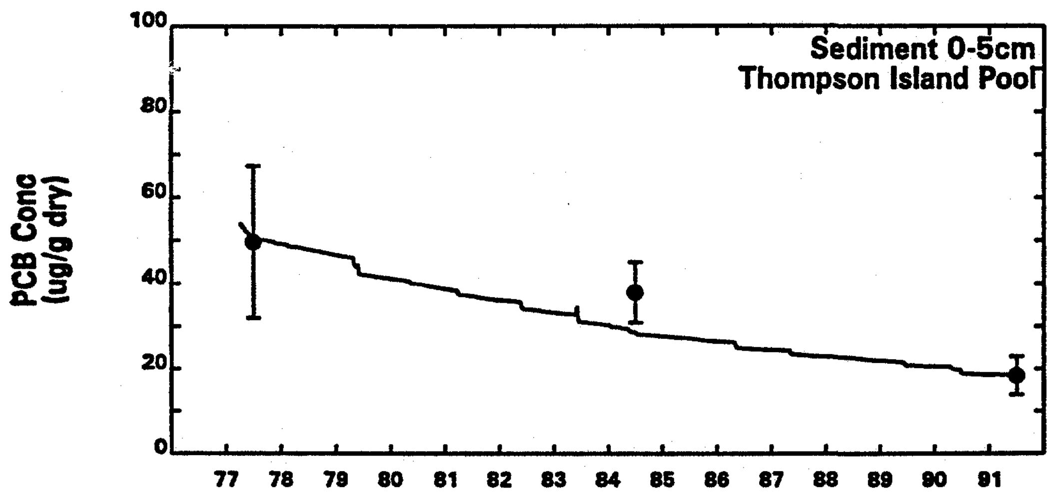
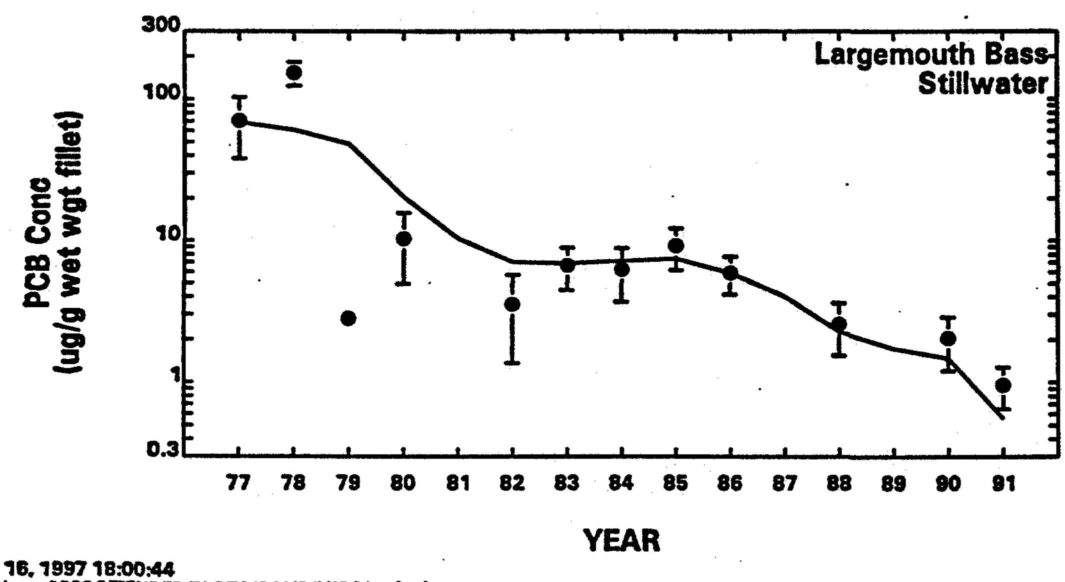
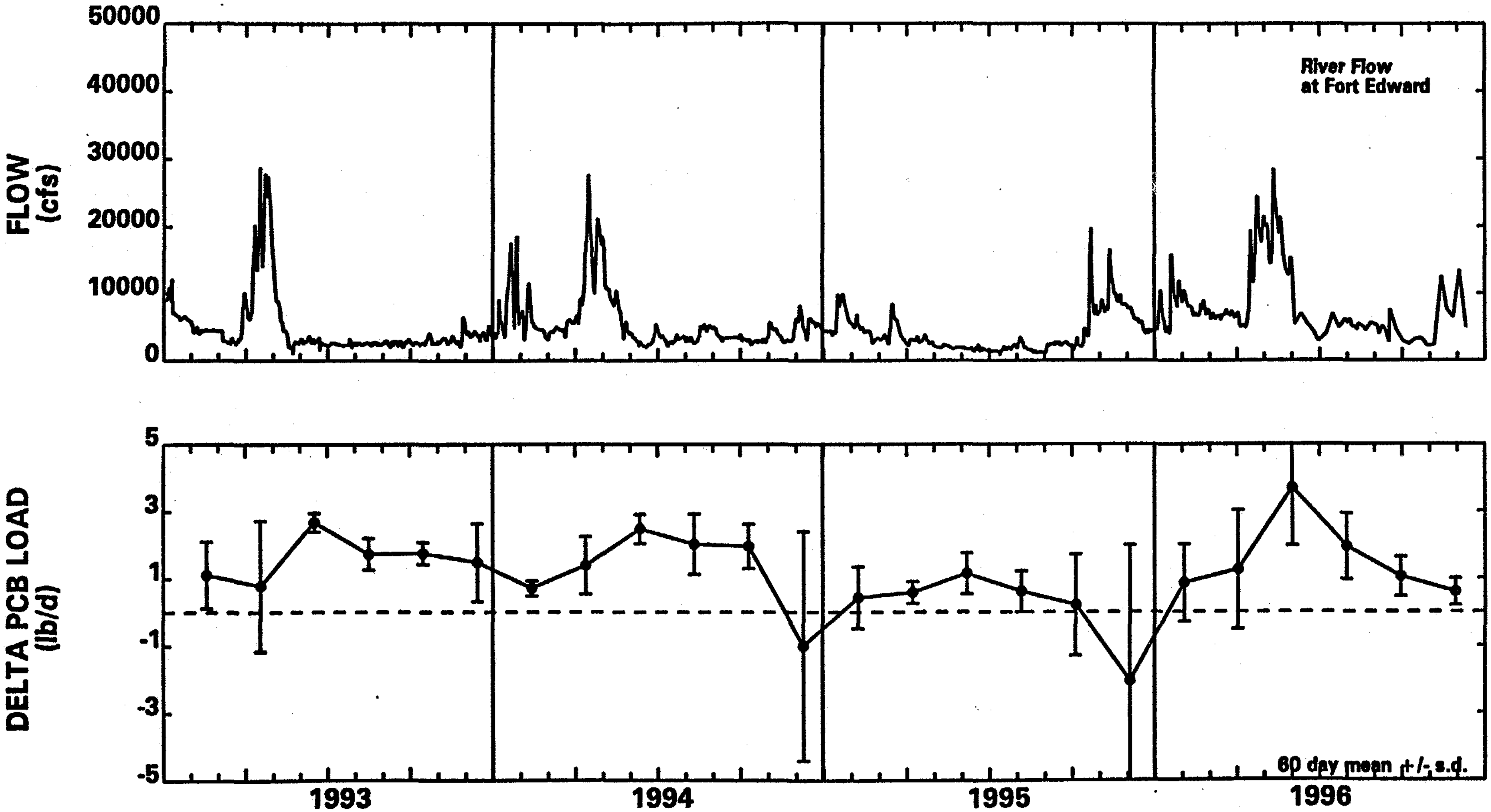
Upper Hudson River Water, Sediment, and Fish PCB Levels 1977-91







Thu Jan 16, 1997 18:00:44
/power2/geco0320/XTENDED/PLOTS/CALIB/MISC/wsf.gdp



FLOW (cfs)
50000
40000
30000
20000
10000
0
River Flow at Fort Edward
DELTA PCB LOAD (lb/d)
5
3
1
-1
-3
-5
60 day mean +/- s.d.
1993
1994
1995
1996

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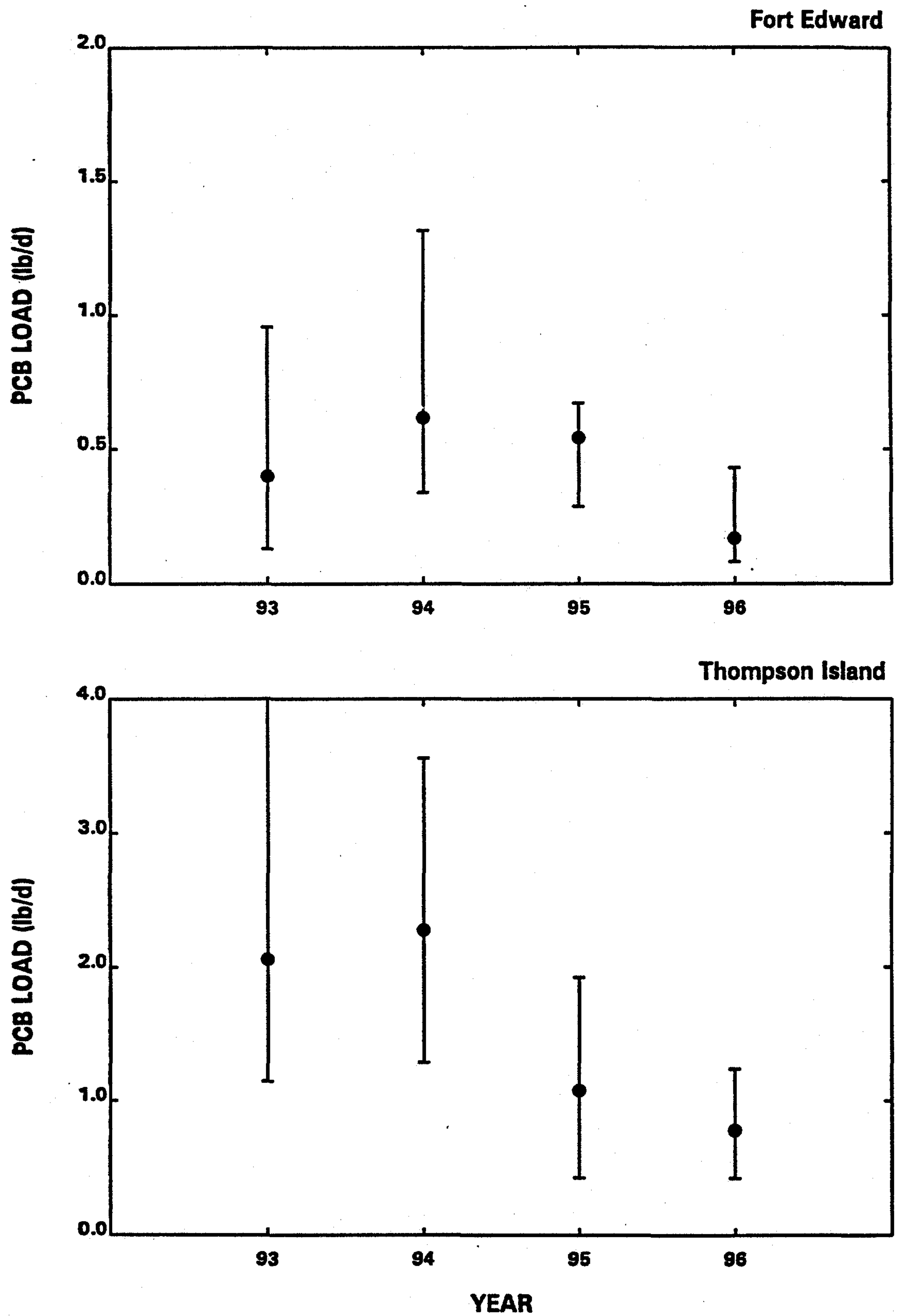

Average Oct-Dec 93-96 PCB Load Passing Fort Edward and Thompson Island
data source: ge/obg flow < 10,000 cfs