HydroQual, Inc.

MEMORANDUM

To: J. Haggard - GE
M. Schweiger - GE
From: J. Rhea
cc. J. Connolly

Date: October 6, 1997
Re: TIP Time of Travel Surveys
File: GECO 0500

This memorandum has been developed by HydroQual, Inc. to document our preliminary evaluation of the Thompson Island Pool (TIP) time of travel studies conducted during September 1996 and June 1997 (HydroQual, 1996; O'Brien & Gere, 1997a). These studies were conducted in an attempt to isolate regions of the river that may be contributing to the anomalous loadings observed in the system since 1991 (HydroQual, 1995). The time of travel survey data exhibited elevated PCB concentrations within water column parcels passing over two regions of the Thompson Island Pool. These areas include:

- eastern shore region across from the Snook Kill, and
- immediately upstream of the Thompson Island Dam.

While the data suggest that these areas may be disproportionately contributing to the water column PCB load, a closer examination of the river along the eastern shore across from Snook Kill suggests that sediment areal fluxes from this area may not significantly differ from other regions of the TIP. Elevated concentrations observed in this region of the TIP can be, at least partially, attributed to changes in river hydrodynamics. Moreover, the increase observed at the Thompson Island Dam (TID) sampling station may be attributed to a bias in data collected from this location (HydroQual, 1997a).

The remainder of this memorandum briefly:

- describes the methodology employed for the TIP time of travel surveys, and
- presents our preliminary analysis of the PCB data.

TIP Time of Travel Surveys

METHODOLOGY

The TIP time of travel surveys were developed to monitor a single volume of water as it traversed the TIP. Lateral transects were established every 0.25 to 0.5 miles between Rogers Island and TID, with sampling stations at three positions across each transect: east shore, west shore, and center channel (Figure 1). Transects were sampled from upstream to downstream so as to correspond with the flow of river water. Stations along each transect were sampled simultaneously. Time of travel between each transect was estimated from flow information retrieved from the U.S. Geological Service's gauging station located in Fort Edward (1996), and by monitoring a pulse of dye injected into the river (1997). A total of four time of travel surveys were conducted: two in September 1996 and two in June 1997.

Samples from each station consisted of vertically stratified composite samples collected from three depths. The samples were submitted to Northeast Analytical, Inc. for PCB analysis by DB-1 capillary column techniques and TSS analysis. The PCB data received from the laboratory were corrected for calibration errors and coelution biases (HydroQual, 1997b).

PRELIMINARY ANALYSIS

The four TIP time of travel surveys exhibited similar spatial trends in total PCB concentration (Figures 2a, 2b, 2c and 2d). PCB concentrations were generally at or near the method detection limit of 11 ng/L at the Rogers Island sampling station and increased gradually to approximately 30 ng/l over the first 2 miles of the TIP, to river mile 193. Downstream of river mile 193, PCB concentrations increased along the eastern and western shoreline as the river flowed over sediment PCB deposits. This increase is particularly pronounced along the eastern shore, across from the Snook Kill (RM 191.5; Figure 2a, 2b, 2c, and 2d).

Despite the variations in total PCB concentrations observed at the various sampling stations during the different surveys, center channel PCB concentrations exhibit a consistent increase with river mile (center panel in Figure 2a, 2b, 2c, and 2d). Over the four mile section of the TIP between river mile 193 and 189, center channel PCB concentrations increase by approximately 40 to 60 ng/L. At average flows of approximately 4,000 cubic feet per second (cfs) observed during the surveys, this increase represents a mass loading rate of 0.4 - 0.6 kg day^{-1}, respectively. These mass loading rates correspond to sediment areal flux rates of approximately 0.3 to 0.4 mg m^{-2} day^{-1} across this region of the TIP. This mass loading rate is consistent with the sediment diffusive load expected from observed 1991 surface sediment PCB

concentrations. It does not appear that any additional load, other than that attributed to surface sediments, is required to achieve the observed water column PCB concentrations between river miles 189 and 193.

IMPORTANCE OF HYDRODYNAMICS

The elevated concentrations observed along the eastern shore across from the Snook Kill can be attributed to a change in hydrodynamics in this region of the river. The elevated concentrations occur downstream of a group of small islands that impede river flow along the eastern shore (Figure 1). Flow predictions using a two-dimensional hydrodynamic model of the TIP indicate that flow rates along the eastern one-third of the river are less than 10% of the total flow rate (Figure 3: 340 cfs at a total river flow of 4,000 cfs). Therefore, surface sediments at the same PCB concentration as upstream areas and exhibiting the same areal PCB flux would produce higher water column PCB concentrations within this area of lower river flow.

For example, consider a section of the river having a sediment area A_s (L^2). Water flows into and out of this section of the river at a rate of Q ($L^3\ T^{-1}$). Assume water flowing in does not contain PCBs and the only water column source is diffusion from contaminated sediments (J_s:$M\ L^{-2}\ T^{-1}$). At steady state, the PCB concentration in water leaving this area (C_{out} :$M\ L^{-3}$) can be calculated as:

$$C_{out} = \frac{J_s A_s}{Q}$$

Given a uniform areal PCB flux rate of 0.4 mg m^{-2} day^{-1} and a sediment area of 100,000 m^2 (the approximate area of the eastern river channel between transects 10 and 12), the PCB concentration in water traveling over this sediment would increase in inverse proportion to the river flow rate, as shown in the table below.

TIP Time of Travel Surveys

Flow Rate (cfs)	C_{out} (ng/L)
10	1635
50	327
100	164
500	33
1000	16

This preliminary analysis does not rule out the possibility that the sediments along the eastern region of the river across from Snook Kill may be contributing a disproportionate PCB flux to the river, but emphasizes the importance of understanding river hydrodynamics when interpreting the water column PCB concentrations observed during the time of travel surveys.

FIELD VERIFICATION/MODELING STUDIES

Additional information on river morphology and hydrodynamics in the region of the islands has been collected by O'Brien & Gere Engineers (O'Brien & Gere, 1997c). These new data will be incorporated into the 2-dimensional hydrodynamic model developed for the upper Hudson River. Flow predictions from this model will then be used to place the time of travel study data within the correct hydrodynamic perspective.

REFERENCES

HydroQual, 1995. Anomalous PCB Load Associated with the Thompson Island Pool: Possible Explanations and Suggested Research. Prepared by HydroQual, Inc. for the General Electric Company, Corporate Environmental Programs, Albany, N.Y. October 1995.

HydroQual, 1996. Thompson Island Pool Float Surveys. Letter from J. Rhea of HydroQual, Inc. to J.G. Haggard of General Electric Company, Corporate

Environmental Programs documenting the approach to TIP float survey program. September 13, 1996

HydroQual, 1997a. Memorandum regarding Thompson Island Dam monitoring from J.Rhea of HydroQual, Inc. to J. Haggard and M. Schweiger of General Electric Corporate Environmental Programs dated September 30, 1997.

HydroQual, 1997b. Development of Corrections for Analytical Biases in the 1991 - 1997 GE/Hudson River Database. Prepared by HydroQual, Inc. for the General Electric Company, Corporate Environmental Programs, Albany, N.Y. June 1997.

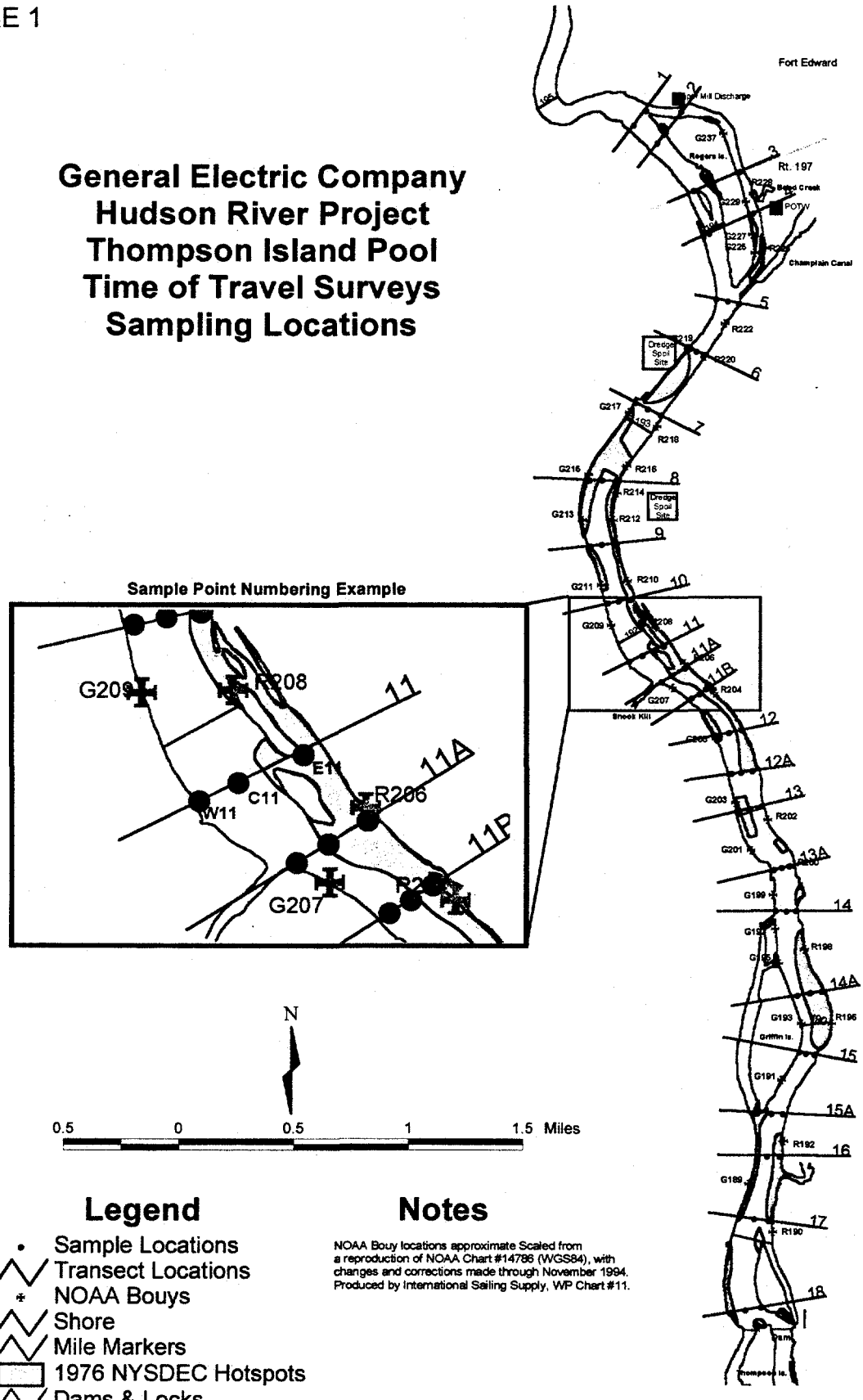
O'Brien & Gere, Inc. 1997a. 1997 Hydro Facility Operations and Thompson Island Pool Monitoring. Prepared by O'Brien & Gere Engineers, Inc. for the General Electric Company Corporate Environmental Programs, Albany, N.Y.

O'Brien & Gere, Inc. 1997b. 1997 Thompson Island Pool Monitoring. Sampling and Analysis Plan Addendum. O'Brien & Gere Engineers, Inc. Prepared for the General Electric Company, Corporate Environmental Programs, Albany, N.Y. August, 1997.

O'Brien & Gere, Inc. 1997c. Memorandum to files regarding Hudson River Hydrologic profiles from M. LaRue of O'Brien & Gere Engineers, Inc. dated September 11, 1997.

FIGURE 1

General Electric Company
Hudson River Project
Thompson Island Pool
Time of Travel Surveys
Sampling Locations



Legend

- Sample Locations
- Transect Locations
- NOAA Bouys
- Shore
- Mile Markers
- 1976 NYSDEC Hotspots
- Dams & Locks

Notes

NOAA Bouy locations approximate Scaled from a reproduction of NOAA Chart #14786 (WGS84), with changes and corrections made through November 1994. Produced by International Sailing Supply, WP Chart #11.

HydroQual, Inc.

October 1997

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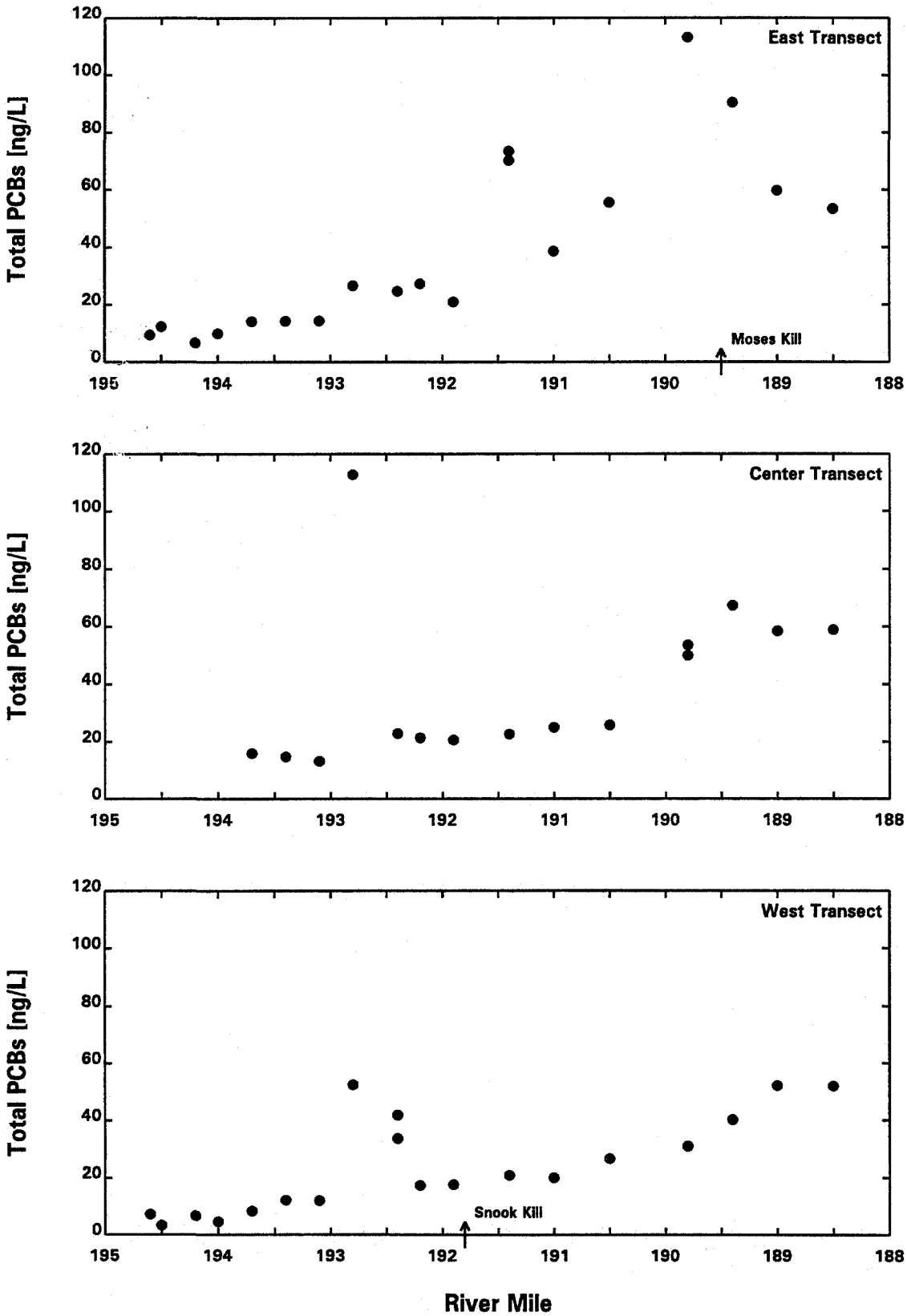


Figure 2a. PCB Concentrations in Water Column Samples Collected During the September 24, 1996 Thompson Island Pool Time of Travel Study

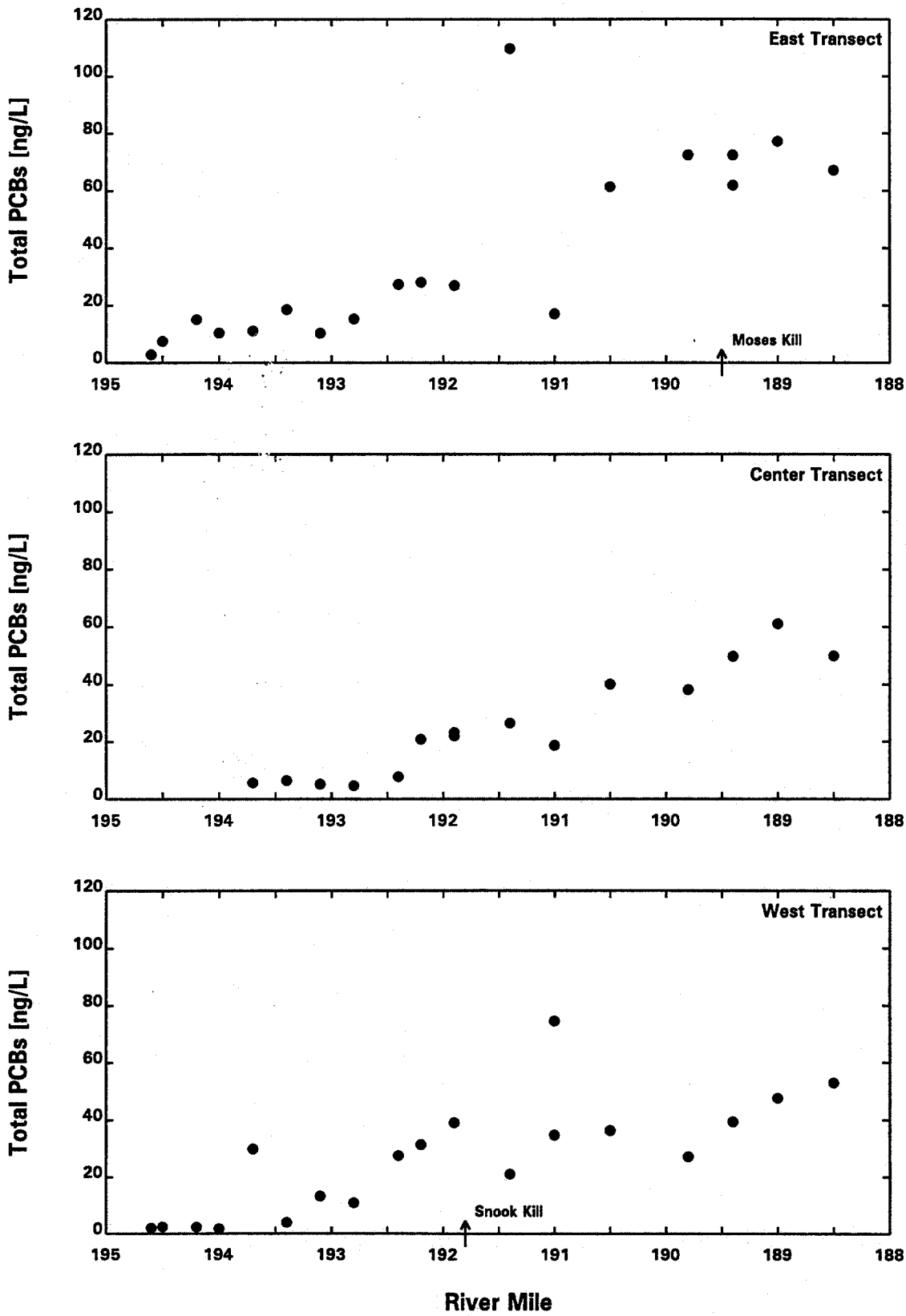


Figure 2b. PCB Concentrations in Water Column Samples Collected During the September 25, 1996 Thompson Island Pool Time of Travel Study

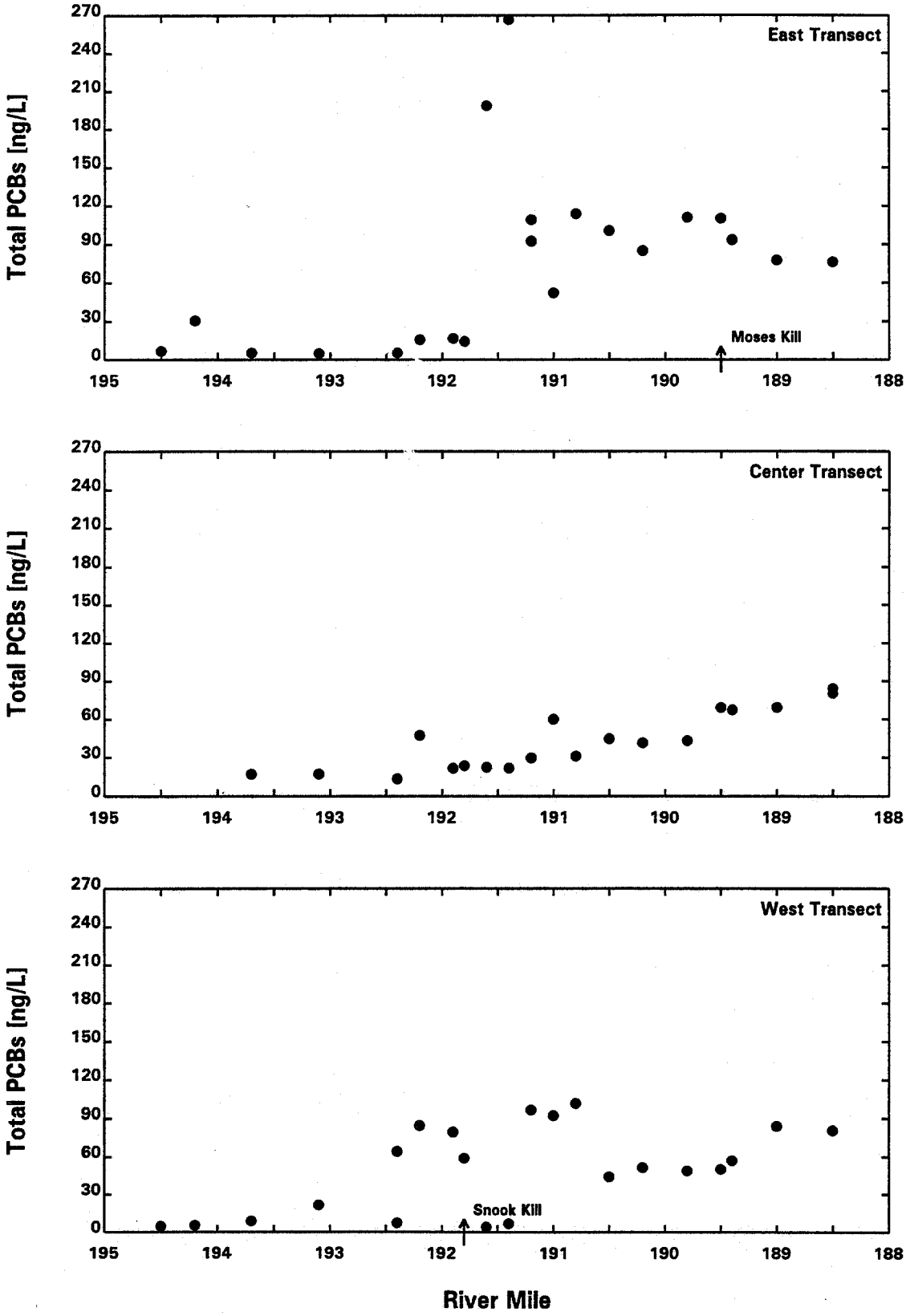


Figure 2c. PCB Concentrations in Water Column Samples Collected During the June 4, 1997 Thompson Island Pool Time of Travel Survey

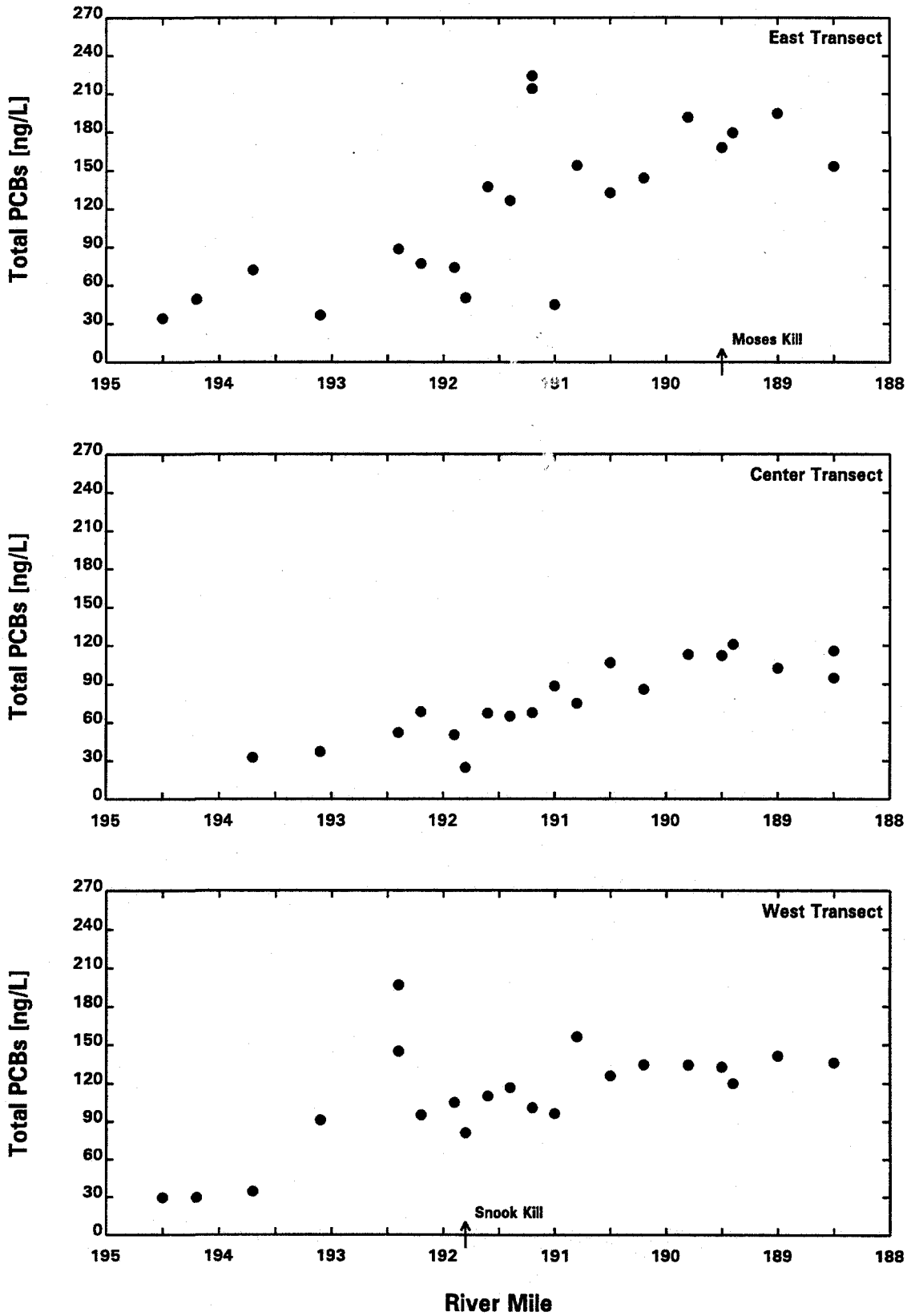
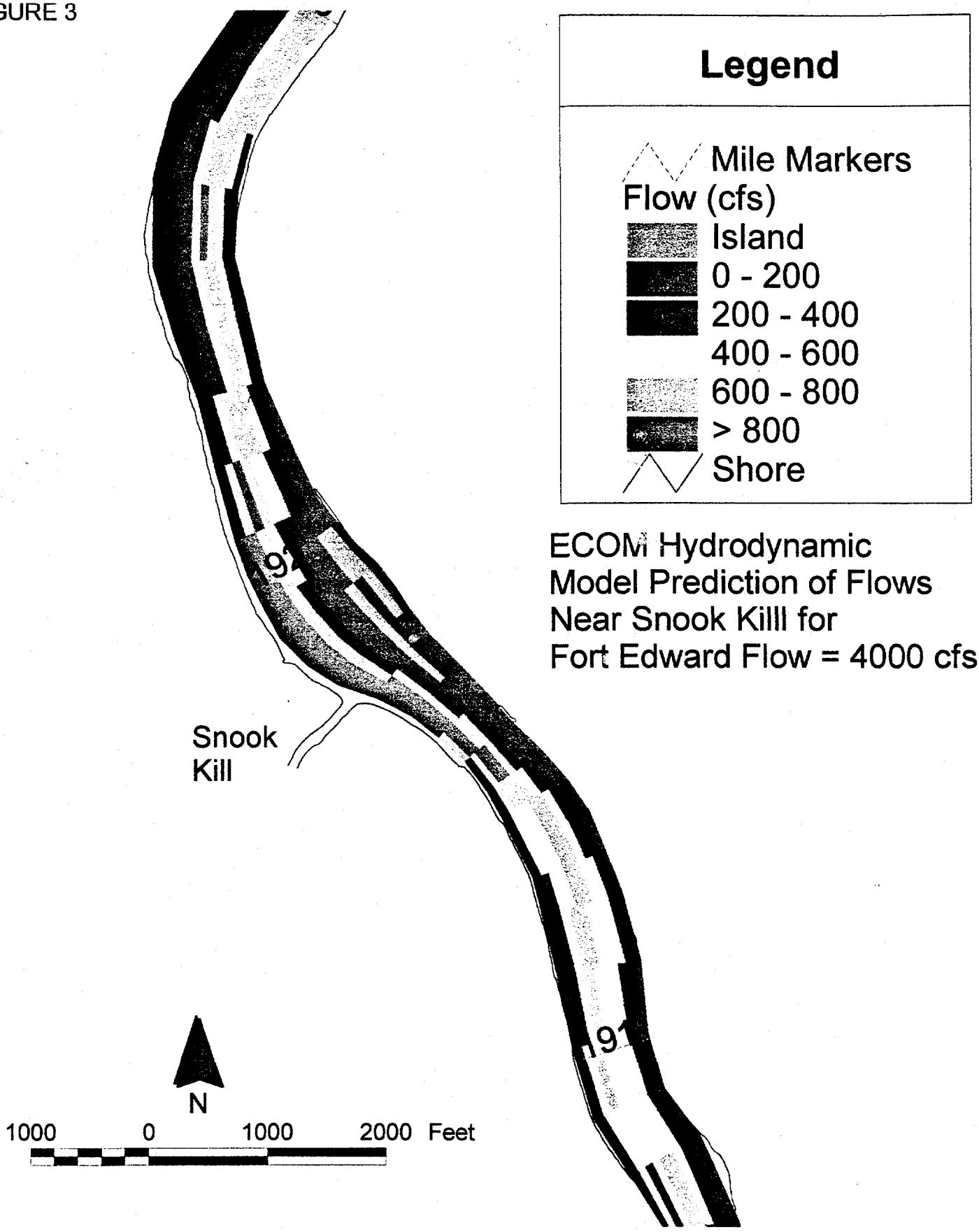


Figure 2d. PCB Concentrations in Water Column Samples Collected During the June 17, 1997 Thompson Island Pool Time of Travel Survey

FIGURE 3



GENERAL ELECTRIC COMPANY - Hudson River Project

HydroQual, Inc.

October, 1997

312534

From: Mark LaRue MDL
Re: Hudson River Hydrologic Profiles
File: 612.226.497
Date: September 11, 1997

cc: W.A. Ayling
J.K. Farmer
J.G. Haggard (GE)
J.R. Rhea (HydroQual)
K. Ziegler (HydroQual)

The purpose of this memorandum is to present the results of field activities conducted on the Hudson River during the week of August 25, 1997. The scope of these activities was based on the results of reconnaissance activities performed in the vicinity of Snook Kill within the Thompson Island Pool by Jim Rhea and Mark LaRue on August 21, 1997. The field activities included mapping approximately 3,000 feet of the Hudson River shoreline, and collecting bathymetric and flow velocity data along transects across the river. The field activities were conducted by Tee Tong-Ngork and Mark LaRue using the 24 foot pontoon boat. Surveying support was provided by Richard Rybinski Land Surveying. Dick performed surveying along the river during the 1991 sediment survey, and was able to locate control points that he established for that effort within our work area, resulting in the saving of a significant amount of time. We elected not to use a GPS system to perform the survey work due to the presence of numerous trees which hang over the water, particularly in between the islands, which typically block the satellite signals that GPS systems rely on.

The shoreline mapping began at a point upstream of the group of islands east of Snook Kill, and extended south to a point just downstream of where Black House Creek enters the river on the east shore (Figure 1). The shorelines of the islands were also located. There are actually four islands in this reach of the river; only three are depicted on the USGS Fort Miller quadrangle map. As the shoreline mapping was conducted, the locations of five transects oriented from east to west across the river were staked out and located (Figure 1).

Upon completing the shoreline mapping, water depth and flow velocity measurements were obtained at selected points along each of the five transects. Hydrologic data was collected along transect 5 on August 27, 1997, and along transects 1 - 4 on August 28, 1997. The locations of the data collection points were spaced more closely in areas where the bottom was irregular, and were spaced further apart in areas where the elevation of the river bed was relatively even. To assist in the selection of data collection points, the shape of the bottom was observed using a Humminbird bottom profiling depth finder. When a data collection point was selected, the boat was held in position using spuds (where depths permitted) or anchors. The boat was positioned as close to the transect line as practical in the current and wind conditions encountered. The locations of the data collection points were obtained by the surveyor at the time the data was collected. The surveyor was positioned with an instrument at a control point on shore and obtained the angle and distance to a prism which was mounted on the boat adjacent to the point where the depth and velocity measurements were made. The water depth was measured at each data collection point by probing with a calibrated rod and verified with the depth finder. Flow velocity was measured at approximately 25% and at 75% of the water depth at each point with a Marsh-McBirney model 201 water velocity meter. An instantaneous stage height at the Ft. Edward USGS gaging station was obtained prior to starting and upon completion of each transect.

Hydrologic profiles for each transect have been developed by using the bathymetric data and velocity measurements. Transect locations, data collection points, and river bed spot elevations are illustrated in Figure 1. The hydrologic profiles are presented in Figure 2. Flow estimates have been developed based on dividing the transect cross-sectional area into sub-sections, as indicated in Figure 2, and using the measured velocity and the

cross-sectional area of each sub-section to calculate flow. A summary of water depth, flow velocity data, and estimated flow is presented in Table 1. The islands have been designated as 1 - 4, as indicated in Figure 1. The estimated flow through the channels between the islands, and the percentage of the total flow which flows through the channels are presented in Table 2. A back current was observed at transect 5 along the east shore. This back current was observed visually and verified with the velocity meter. At the time of the survey, the upstream extent of the back current appeared to terminate in the vicinity of transect 4. The downstream extent (or point of origin) of the back current is unknown; it may originate near the next downstream bend in the river. The characteristics of the back current likely changes under different flow conditions in the river. The total estimated flow for transect 5 has been calculated by subtracting the portion of flow that was observed to be flowing upstream from the flow measured across the remainder of the transect.

Overall, the quality of the flow data appears to be good. The variability in flow rates between the Ft. Edward gaging station and the flows measured at the transects is likely due to the local effects of tributary flow on total river flow, changes in river flow during the collection of velocity data, the use of a mean water elevation of 118.7 during the study, and the potential errors inherent to measuring open channel flow. Several inches of rain were received as a result of a heavy rain storm that passed through the area during the late afternoon and evening of August 27. On the morning of August 28, the Hudson River at Ft. Edward and throughout the Thompson Island Pool was very turbid (water column visibility was reduced to less than one foot), apparently due to storm water runoff. The flow at the Ft. Edward gaging station did not increase appreciably as a result of the storm; therefore, the heavy rain may have been localized. Thompson Island Pool tributaries, including Bond Creek and Snook Kill, were flowing significantly. The river remained turbid throughout the day.

Hydrologic data was collected along transect 5 on August 27, 1997, prior to the storm event. There was minimal flow in the tributaries prior to the storm. Flow at this transect was calculated to be within approximately 2% of the mean flow at the Ft. Edward gaging station during the data collection period (Table 1). The effects of tributary flow on flow in the Thompson Island Pool after the storm event are likely indicated by the increase in flow observed on August 28, 1997 between Ft. Edward and transects 1, 2, and 3, as indicated in Table 1. This increase was approximately 500-600 cfs, and was likely due to flow from Bond Creek and other small unnamed tributaries which enter the river downstream of the gaging station and upstream of transect 1. There also appears to have been an increase in flow between transects 3 and 4, if the flow measured at each transect is compared with the mean flow at the gaging station during the respective data collection periods (approximate increase between the gaging station and transect 3 was 650 cfs; 1,000 cfs for transect 4). This apparent increase is likely due to flow from Snook Kill, which enters the river just upstream of transect 4.

Bathymetric data was also obtained along a series of east/west oriented transects located between the group of islands and the east shore of the river (Figure 1). These data were obtained to fill in a data gap, as bathymetric data was not collected in this area during the 1991 bathymetric survey. The river bed spot elevations obtained in this area are included in Figure 1. The elevation of the Hudson River varied during the survey approximately 0.4 ft, with flow at the Ft. Edward gaging station varying from approximately 3,300 to 4,700 cfs. A mean river elevation

of 118.7 has been used to represent river conditions at the time of the survey. The bathymetric data is in AutoCAD 12 format, and will be transmitted electronically to Kirk Ziegler of HydroQual.

Table 1. Hydrologic data summary.

					Shallow			Deep							
Date	Time	Transect	Point I.D.	Water Depth (ft)	25% Depth Velocity (ft/sec)	Flow area (ft2)	Flow (cfs)	75% Depth Velocity (ft/sec)	Flow area (ft2)	Flow (cfs)	Transect Total Flow (cfs)	Instantaneous Stage @ Ft. Edward	Instantaneous Flow @ Ft. Edward (cfs)	Mean Flow @ Ft. Edward for transect (cfs)	Diff. Between Mean Flow @ Ft. Edward and Transect (cfs)
08/28/97	13:21	1	A	3.4	0.1	153	15.3	0.1	162	16.2	-	21.54	3934	-	-
08/28/97	13:28	1	B	8.5	0.4	329	115.2	0.4	303	121.2	-	-	-	-	-
08/28/97	13:40	1	C	13.0	1.1	634	697.4	1.1	649	713.9	-	-	-	-	-
08/28/97	13:44	1	D	15.5	1.1	953	1048.3	1.2	931	1117.2	-	-	-	-	-
08/28/97	13:50	1	E	13.0	0.3	601	180.3	0.5	632	316.0	-	-	-	-	-
08/28/97	14:08	1	F	12.0	0.2	420	84.0	0.3	364	109.2	-	-	-	-	-
08/28/97	14:12	1	G	5.5	0.0	190	0.0	0.0	182	0.0	4534 (1)	21.58	4063	3999	536
08/28/97	14:34	2	A	1.5	0.3	10	2.9	0.3	13	3.8	-	21.54	3934	-	-
08/28/97	14:39	2	B	3.7	0.4	35	12.3	0.4	29	10.2	-	-	-	-	-
08/28/97	14:45	2	C	3.8	0.2	59	11.8	0.2	32	6.4	-	-	-	-	-
08/28/97	14:50	2	D	3.3	0.2	107	21.4	0.2	78	15.6	-	-	-	-	-
08/28/97	14:53	2	E	3.9	0.3	146	43.8	0.2	161	32.2	-	-	-	-	-
08/28/97	15:00	2	F	5.8	0.2	264	52.8	0.2	276	55.2	-	-	-	-	-
08/28/97	15:04	2	G	8.3	0.7	467	326.9	0.9	509	458.1	-	-	-	-	-
08/28/97	15:08	2	H	13.0	1.3	748	972.4	1.2	713	820.0	-	-	-	-	-
08/28/97	15:13	2	I	16.0	0.9	780	702.0	0.8	695	556.0	-	-	-	-	-
08/28/97	15:21	2	J	11.9	0.2	387	77.4	0.4	411	143.9	-	-	-	-	-
08/28/97	15:25	2	K	7.5	0.2	131	26.2	0.2	116	23.2	4374 (1)	21.44	3620	3777	597
08/28/97	15:41	3	A	3.6	0.1	73	7.3	0.1	56	5.6	-	-	-	-	-
08/28/97	15:45	3	B	5.7	0.3	112	33.6	0.2	122	24.4	-	-	-	-	-
08/28/97	15:49	3	C	9.5	0.2	204	40.8	0.2	114	22.8	-	-	-	-	-
08/28/97	15:54	3	D	1.5	0.1	51	5.1	0.1	60	6.0	-	21.71	4498	-	-
08/28/97	16:00	3	E	4.8	0.1	182	18.2	0.1	187	18.7	-	-	-	-	-
08/28/97	16:05	3	F	7.8	0.4	343	137.2	0.3	339	101.7	-	-	-	-	-
08/28/97	16:09	3	G	10.4	0.9	451	405.9	0.8	481	384.8	-	-	-	-	-
08/28/97	16:14	3	H	16.0	1.4	564	789.6	1.2	509	585.4	-	-	-	-	-
08/28/97	16:19	3	I	16.5	1.4	574	803.6	1.3	503	628.8	-	-	-	-	-
08/28/97	16:23	3	J	10.0	1.1	428	470.8	1.0	428	428.0	-	-	-	-	-
08/28/97	16:28	3	K	4.0	0.3	139	41.7	0.2	172	25.8	-	21.77	4706	-	-
08/28/97	16:55	3	AA	4.1	0.0	56	0.0	0.0	34	0.0	-	21.67	4362	-	-
08/28/97	16:59	3	BB	5.0	0.2	48	9.6	0.2	42	8.4	-	-	-	-	-
08/28/97	17:03	3	CC	3.6	0.2	40	8.0	0.2	40	8.0	-		-	-	-
08/28/97	17:06	3	DD	2.2	0.1	86	8.6	0.1	43	4.3	5033 (1)	21.54	3933	4375	658

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Table 1. Hydrologic data summary.

					Shallow			Deep							
Date	Time	Transect	Point I.D.	Water Depth (ft)	25% Depth Velocity (ft/sec)	Flow area (ft2)	Flow (cfs)	75% Depth Velocity (ft/sec)	Flow area (ft2)	Flow (cfs)	Transect Total Flow (cfs)	Instantaneous Stage @ Ft. Edward	Instantaneous Flow @ Ft. Edward (cfs)	Mean Flow @ Ft. Edward for transect (cfs)	Diff. Between Mean Flow @ Ft. Edward and Transect (cfs)
08/28/97	11:35	4	A	1.8	0.0	26	0.0	0.0	26	0.0	-	21.35	3350	-	-
08/28/97	11:47	4	B	5.5	0.2	105	21.0	0.2	90	16.2	-	-	-	-	-
08/28/97	11:51	4	C	6.2	0.3	134	33.5	0.3	118	35.4	-	-	-	-	-
08/28/97	11:54	4	D	4.3	0.2	86	17.2	0.2	96	14.4	-	-	-	-	-
08/28/97	11:58	4	E	3.6	0.1	87	8.7	0.1	50	5.0	-	-	-	-	-
08/28/97	12:05	4	F	7.7	0.6	270	148.5	0.7	235	152.8	-	-	-	-	-
08/28/97	12:10	4	G	14.0	1.0	578	549.1	1.1	539	566.0	-	-	-	-	-
08/28/97	12:15	4	H	15.5	1.4	674	943.6	1.2	642	770.4	-	-	-	-	-
08/28/97	12:20	4	I	14.0	1.6	382	611.2	1.3	176	228.8	-	-	-	-	-
08/28/97	12:27	4	J	10.5	1.6	182	282.1	1.4	176	246.4	-	-	-	-	-
08/28/97	12:31	4	K	6.6	1.4	167	233.8	1.3	121	157.3	5041 (2)	21.77	4706	4028	1013
08/27/97	15:48	5	A	4.2	-0.1	163	-16.3	-0.2	108	-16.2	-	21.39	3469	-	-
08/27/97	16:03	5	B	5.3	-0.1	104	-10.4	-0.1	107	-10.7	-	-	-	-	-
08/27/97	16:07	5	C	11.0	0.1	153	15.3	0.2	173	34.6	-	-	-	-	-
08/27/97	16:12	5	D	17.5	0.2	392	58.8	0.3	374	112.2	-	-	-	-	-
08/27/97	16:20	5	E	19.5	0.5	439	219.5	0.6	436	270.3	-	-	-	-	-
08/27/97	16:25	5	F	21.5	0.8	645	516.0	0.8	645	483.8	-	-	-	-	-
08/27/97	16:31	5	G	22.5	1.0	872	872.0	0.7	783	548.1	-	-	-	-	-
08/27/97	16:38	5	H	14.0	0.6	385	231.0	0.5	423	211.5	-	-	-	-	-
08/27/97	16:45	5	I	4.5	0.2	107	21.4	0.1	103	10.3	3551 (3)	21.50	3806	3638	-86

(1) - includes flow from Bond Creek and other tributaries located between Ft. Edward gaging station and transect. Tributary flow was significant on August 28, 1997 due to heavy rain on previous evening.

(2) - includes flow from upstream tributaries and Snook Kill.

(3) - transect data obtained prior to storm event, minimal flow observed in tributaries.

Table 2. Flow analysis at transects.

Transect	Channel	Points	Estimated Flow (cfs)	Percent of Total Flow
1	Main Channel	A-G	4534	100.0
	Transect total	A-G	4534	100.0
2	Between East Shore and Island 1	-	- (1)	-
	Between Island 1 and Island 2	A-C	47.4	1.1
	Main Channel	D-K	4327	98.9
	Transect total	A-K	4374	100.0
3	Between East Shore and Island 2	AA-DD	46.9	0.9
	Between Island 2 and Island 4	A-C	135	2.7
	Main Channel	D-K	4851	96.4
	Transect total	AA-K	5033	100.0
4	Between East Shore and Island 4	A-E	151	3.0
	Main Channel	F-K	4890	97.0
	Transect total	A-K	5041	100.0
5	Main Channel	C-I	3605	101.5
	Back Current	A-B	-53.6	-1.5
	Transect total	A-I	3551	100.0

(1) - measureable flow was not observed on the east side of Island 1 or Island 3.

THE MAP IS AVAILABLE FOR REVIEW AT THE FOLLOWING LOCATION:

HUDSON RIVER PCBS ADMINISTRATIVE RECORD

U. S. EPA, REGION 2 SUPERFUND RECORDS CENTER,
290 BROADWAY, 18TH FLOOR, NEW YORK, NY 10007

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