PENOBSCOT RIVER MERCURY STUDY

Chapter 10

Investigation of total and methyl mercury export from Mendall Marsh via south branch of Marsh River, a tributary to the Penobscot River

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1 SUMMARY

Concentrations and fluxes of total suspended solids (TSS), total mercury (Hg) and methyl Hg were measured at Mendall Marsh on the South Marsh River over several tidal cycles in 2009 and 2010 in order to determine whether this marsh system was acting as a source or sink for these constituents with respect to the Penobscot River. One tidal cycle was also characterized on the Orland River and two tidal cycles were characterized on a small tributary channel within Mendall Marsh. Results indicated that the larger Mendall Marsh system (~200 ha) acted always as a sink for TSS, as well as for total Hg, particulate Hg, filter-passing (0.45 micron pore size) total Hg, total methyl Hg and particulate methyl Hg, i.e., more of these constituents were imported into the marsh system by tidal inflow (flood) than were exported by tidal outflow (ebb). The estimated net annual loading (0.6 to 3 g/cm^2/yr) of TSS to the marsh corresponded reasonably well with measured sedimentation rates (0.2 to 1 g/cm^2/yr) for this and similar estuarine marshes. Insufficient temporal data are available to express reliably net fluxes of Hg and methyl Hg on an annualized basis. However, net tidal cycle (12 hr) fluxes per unit area (loading) of the marsh have been calculated and compared. For example, for four well-characterized cycles the net total Hg loading to the marsh ranged from 18 to 94 grams, equivalent to 9.2 to 47 μg/m^2 (0.92 to 4.7 ng/cm^2), for the 200 ha system. The net loading of filter-passing total Hg to the marsh for a single tidal cycle ranged from 0.75 to 2.2 grams, equivalent to 0.38 to 1.1 μg/m^2. Net loadings of total methyl Hg to the marsh per tidal cycle ranged from 0.37 to 2.7 grams, equivalent to 0.18 to 1.4 μg/m^2. The marsh system was also a sink for filter-passing methylmercury during three (May, June and July) of four tidal cycles characterized in 2010 but shifted to being a source of this constituent in September. Stages at tidal high and low water during September sampling was the highest and lowest, respectively, of the four cycles studied and thus stage, or extent of marsh inundation, may explain all or part of this shift. Salinity also increased between May (10.8 ‰) and September (17.2 ‰) and may also have played a role in this shift.

The limited investigation of the Orland River marsh system found no significant differences in concentrations of TSS, or in any Hg and methyl Hg forms, between flood and ebb tidal flows. Compared to tidal flows, river water entering this marsh had comparable or higher concentrations of several Hg forms. The Orland River drainage area includes many upstream wetlands which could account for the comparable or higher concentrations of methyl Hg. In addition, the tidal portion of the Orland contains much less high vegetated marsh than Mendall Marsh and thus has a smaller zone of favorable conditions for production of methylmercury in marsh porewater.

This investigation confirmed that fractions of Hg and methyl Hg that are filter-passing are higher on ebb tide flows than flood tide flows. This observation is consistent with much higher marsh porewater concentrations of these constituents compared with Penobscot River water. Ebb tide flows include increasing proportions of porewater as the stage decreases and the hydraulic gradient increases. This investigation refuted the hypothesis that Hg-contaminated marshes, while still being net sinks for particle-bound Hg, export particles with higher inorganic and methyl Hg content.

Overall, the results of this investigation should allay concern that Mendall Marsh is exporting Hg and/or methyl Hg to downstream/upstream receiving aquatic systems (Penobscot River and Bay). While there is evidence of a small net export of filter-passing methyl Hg under some tidal conditions, the mass involved represents <5% of the mass carried by the Penobscot River. The results do point to a potential concern about biotic exposures within Mendall Marsh, especially within the smaller tidal channels that feed the South Marsh River where concentrations of filter-passing methyl Hg are much higher than in any other surface waters within the estuary.

2 INTRODUCTION

2.1 Background

Marshes (wetlands), and especially estuarine marshes, provide favorable conditions for the conversion of inorganic mercury (Hg) into methyl Hg, a highly bioavailable and toxic form of Hg. Favorable conditions include anoxic sediments, abundant sources of labile carbon and concentrations of sulfate that are neither too low nor too high to inhibit the activities of sulfate reducing bacteria (Gilmour at al. 1992). Marshes with strong freshwater inputs and significant tidal exchange pose these conditions and are known or suspected to act as significant sources of methyl Hg to downstream receiving water bodies (Mitchell et al. 2012; Bergamaschi et al. 2011). Mendall Marsh, within the lower Penobscot River estuary adjacent to Frankfort Flats, is an example of a marsh with such conditions and is even more likely to be a significant active source of methyl Hg to the Penobscot River because of historical deposition of Hg-contaminated sediments within its boundaries (Merritt and Amirbahman 2007, 2008).

This investigation entailed detailed characterization of total Hg and methyl Hg loading (flux) from the South Branch of the Marsh River that drains Mendall Marsh. The primary objective was to determine whether Mendall Marsh is a net source or sink for total and methyl Hg to the Penobscot River. In addition to the main focus on the South Marsh River, a limited investigation of Hg fluxes on the Orland River and a small tidal channel within Mendall Marsh was included.

2.2 Paradigms and Working Hypotheses

Hydrologic transport and geochemical cycling of nutrient solutes and particulate matter in estuarine marshes have been studied throughout the world (e.g., Jordan et al. 1983) with the result that an extensive published literature exists, including for mercury (e.g., Bergamaschi et al. 2011; Mitchell et al. 2011). These studies support the following paradigms and working hypotheses for Penobscot marshes:

- Tidal marshes are net sinks for particle-bound mercury (*Paradigm*).
- Inorganic and methyl Hg are predominantly associated with particles (*Paradigm*) but ebb tide fractions of filter-passing (dissolved) Hg are higher than flood tide fractions (*Hypothesis*).
- Hg-contaminated marshes, while still being net sinks for particle-bound Hg, export particles with <u>higher</u> inorganic and methyl Hg content due to higher ebb tide filter-passing concentrations (*Hypothesis*).
- Ebb tide fluxes of filter-passing inorganic and methyl Hg are greater than flood tide fluxes of these forms (*Hypothesis*) and especially so within smaller tidal channels (*Hypothesis*)

This investigation collected data to <u>confirm</u> these *paradigms* and to <u>test</u> these *hypotheses.* It also intended to assess the relative magnitude of Hg loading from Mendall Marsh to the Penobscot River if a net loading appeared to be present.

2.3 Investigative Approach

We directly measured net fluxes of Hg from the Mendall Marsh over a number of full tidal cycles. From data collected thus far in the Penobscot River Mercury Study (PRMS), river concentrations of filter-passing methyl Hg nearest the marsh (site OB1) appear to be quite low (~0.1 to 0.2 ng/L). Thus, detection of minor changes in concentration upstream and downstream of this marsh within the Penobscot River itself was expected to be difficult. This difficulty would be compounded by the uncertainty involved in trying to quantify potentially very small differences in water discharge upstream and downstream of the marsh such that a net contribution by the marsh could be calculated. There were also important possible interferences from the tributary (North Marsh River) that passes through the town of Frankfort and empties at the northern end of Mendall Marsh. Separating flows originating from this tributary from those from the marsh would have been impossible in an upstream-downstream sampling approach. These uncertainties were greatly reduced by directly quantifying flood and ebb tidal concentrations and discharges within the South Marsh River that drains the Mendall Marsh (~200 ha) and a relatively small upland watershed (~6500 ha). We also measured net tidal fluxes on a small channel within Mendall Marsh that drains ~2-3 ha of high marsh with no upland watershed.

2.4 Study Sites

Hydrologic measurements and sampling for Hg over full tidal cycles in 2009 and 2010 were focused mainly on the South Marsh River (SMR) at two locations (Figure 10-1a), referred to hereafter as “boat launch” (BL) and “peninsula” (P). The BL site was immediately adjacent to the moored water quality and hydrologic monitoring station operated by Woods Hole Oceanographic Institute (WHOI) between April and June 2010. Full tidal cycle sampling and discharge measurements were also conducted in 2010 on a small tidal channel, referred to hereafter as “Cindy’s Slough” (CS) (Figure 10-1b). On one occasion in 2009 limited discharge measurements and sampling were conducted on the Orland River (OR) (Figure 10-1d). Lastly, water samples were collected at numerous smaller tidal channels in 2009 and 2010 (Figure 10-1b and 10-1c). Coordinates of these channel samples are tabulated in the Results section.

Figure 10-1a. Study sites in South Marsh River, Mendall Marsh

Figure 10-1b. Study sites in Cindy's Slough, Mendall Marsh.

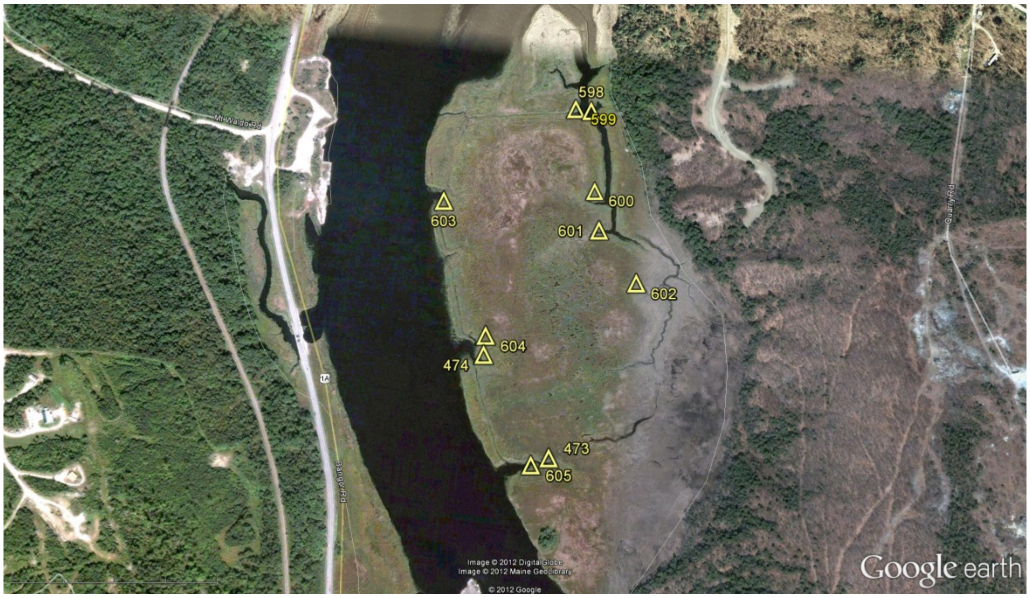


Figure 10-1c. Study sites in northeastern Mendall Marsh.

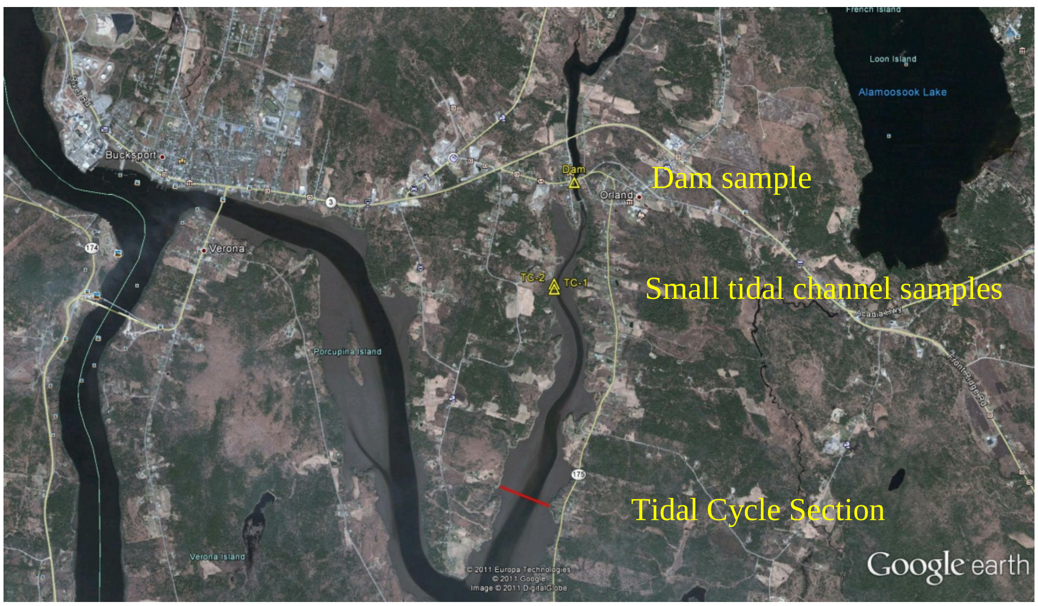


Figure 10-1d. Study sites on Orland River Marsh

3 METHODS

3.1 Hydrology

2009 - With one exception, all current velocities measured in 2009 employed a General Oceanics Model 2135 digital meter attached to a rod. Current velocities were measured at up to four discrete depths at up to three locations across the direction of tidal flow. Discharge within each cell was calculated as the product of cell area and velocity. Channel discharge (Q) for a given event (sampled phase of the tide) was calculated by summing discharges for each cell within the cross section of flow. For one tidal cycle characterized on July 23, 2009 a boat-mounted acoustic Doppler current profiler (ADCP) was used to measure the vertical profile in current velocities at each sampling point. As proof-of- principle several days in 2009 were also dedicated to “indexing” velocity profiles at the peninsula site to channel discharge at the boat launch site. The latter effort involved temporarily installing a SonTek Argonaut SW ADCP at a mid-channel location at the peninsula site and then measuring channel discharges over several full tidal cycles at the boat launch site using a canoe-mounted SonTek RiverCat ADCP (Mueller and Wagner 2009). The canoe was propelled by a trolling motor.

2010 - Moving boat discharge measurements (Mueller and Wagner 2009), using canoe-mounted acoustic Doppler equipment (SonTek RiverCat), were made on multiple occasions over a range of tidal conditions and at the same time as nearby continuous stream bottom-mounted acoustic Doppler velocity measurements to arrive at a velocity index (discharge vs. velocity regression) for the South Marsh River draining the Mendall Marsh area. The continuous measurements of velocity were then applied through the established velocity index to provide channel discharge readings at 5-minute intervals throughout measurement periods of interest (e.g., during water sampling events between April and October 2010).

On March 31, 2010 a SonTek Argonaut SW ADCP was again installed mid-channel at the peninsula location with its data/power cable routed to an instrument shelter on the end of the peninsula. Electronic checks on the operation of the system after a period of high storm flow (freshet) in early April indicated the need to verify the orientation of the bottom-mounted transducer. Divers inspected and adjusted the orientation on April 14, 2010 but electronic checks continued to indicate possible transducer misalignment or other issue. A very low tide on June 17, 2010 finally permitted the transducer’s alignment to be properly checked and adjusted by wading. Thus uncertainty about the quality of the ADCP data for the peninsula site persisted for almost three months. Fortunately this period corresponded with the period during which WHOI was also continuously logging ADCP data near the boat launch site. We developed and compared velocity indices for both sites. Results of this comparison are discussed in the Quality Assurance section below. A Solinst LTC (level-temperature-conductivity) logger was also installed adjacent to the Argonaut for several weeks in September and October 2010 to record longer term bottom water salinity data.

We also used a SonTek FloTracker to manually measure discharge over several tidal cycles on the small channel referred to here as Cindy’s Slough (Figure 10-1b). We installed a 24-ft scaffold plank over the channel to allow hydrological measurements and water sampling to be conducted at all stages of the tide without entry into the channel. The discharge was measured by collecting velocity and water depth data at multiple locations and depths across the width of the channel. The FloTracker's built-in software automatically calculated channel discharge at the end of each series of measurements. A Solinst LTC logger was also installed briefly in the small channel to record longer term data for water level, temperature and conductivity.

NOTE: The SonTek software used to process hydrologic data expects downstream (or ebb) flows to be positive and thus flood (or upstream) flows are carried numerically as negative. For graphical displays of discharge only we have retained this convention. However, for this project the flood fluxes of suspended sediment and mercury into the marsh were considered "positive". Thus, a negative net flux means an export or "loss" from the marsh while a positive net flux means an import or "gain" to the marsh.

3.2 Water Sampling and Analysis

Water sampling employed a 12-volt marine diaphragm pump and C-flex tubing with a plastic-coated weight attached to the intake end. This sampling system was deployed from a canoe anchored in position. The pump and tubing were first flushed for at least one minute with water from the target sampling depth. Bottles (500-mL Teflon for Hg samples, 1-L HDPE for TSS) were then filled with unfiltered water from a short piece of C-flex tubing attached to the pump discharge. The pump was then shut off briefly to allow installation of an inline filter (0.45 µM pore size). The pump was restarted and the filter flushed with ~3x filter volumes (500 mL) before filling a 500-mL Teflon bottle labeled to contain a filtered (dissolved) sample.

A YSI Model 556 multimeter was used to measure water temperature, specific conductance and salinity at several depths including each depth actually sampled for laboratory analysis of TSS and Hg. In some cases these measurements helped to define the target depths to be sampled, e.g., if a salt wedge was present the deepest sample depth was adjusted to target this layer.

Field duplicate (FD) samples were collected periodically to assess homogeneity of water being sampled. Due to the time required to fill bottles several minutes elapsed between collections of field duplicates. Equipment blanks (EB) were collected typically at the end of each event (day) using the same pump and tubing used for the sampling event. Where EB have been prepared with laboratory-cleaned tubing and new filters for other projects, no contamination has ever been detected and thus we focused on detection and quantification of sample carry-over from used tubing. Preparation of these blanks involved flushing the pump and tubing with several liters of bottled spring water (Poland Springs) and then collecting both a filtered and unfiltered sample in the same manner as river water. A separate sample of the spring water was poured directly into a 500-mL Teflon bottle and labeled as a field blank (FB).

All samples were shipped on ice but unpreserved overnight to Battelle Marine Science Laboratory in Sequim, Washington for analysis of total Hg (EPA Method 1631e), methyl Hg (EPA Method 1630) and TSS (Standard Methods, 2450D). Sample abbreviations used hereafter in this report are as follows:

THg = Total (unfiltered) mercury

FTHg = Filter-passing total mercury

MHg = Total (unfiltered) methylmercury

FMHg = Filter-passing total methyl mercury

3.3 Data Processing and Interpretation

While water samples for analysis were collected in the same manner in both 2009 and 2010, hydrologic data collection and processing involved several different methods depending on the year and location of measurements. In 2009 current velocity measurements were taken only at locations and depths where water samples were collected. The area-velocity method (Chow 1964) was utilized in some cases to calculate discharge (Q_i) in each "cell" where cell dimensions were determined by water depth and the number of cells in which velocity (V_i) was measured and a sample collected. The cross-sectional area (A_d) of each the tidal channel cell as a function of water depth was determined from a bathymetric survey at a high tide and graphical integration of areas at successively lower water levels. As shown in Figure 10-2, the relationship between depth and area fit a power function reasonably well and was used in all calculations. The number of cells (N) used in a calculation varied with water depth from 3 (low tide) to 9 (high tide). Discharge (Q_i) for a given cell was calculated as:

$$Q_i = A_d \times V_i$$

Channel discharge (Q) was calculated as:

$$Q = \sum Q_1 + Q_2 + \ldots\ldots Q_N$$

Flux was calculated for each cell (J_i) as the product of cell discharge (Q_i) and cell concentration (C_i):

$$J_i = Q_i \times C_i \quad [i = 1 \text{ to } N]$$

Total channel flux (J) was calculated as:

$$J = \sum J_1 + J_2 + \ldots\ldots J_N$$

Because of the small number of measurement cells relative to the width and depth of the tidal channel the fluxes calculated in the above manner, it was likely that fine-scale cross-sectional heterogeneities in the velocity field may have been missed. This method was used initially for tidal cycles sampled June 26, 2009 and July 23, 2009. However, water balances derived by this method were poor (>20% difference) and thus ebb and flood tidal volumes for similar tidal cycles (i.e., similar high and low tide elevations) characterized in 2010 were substituted to calculate combined tidal phase TSS and Hg fluxes for those two 2009 sample sets. As described subsequently cell discharges were still used to calculate discharge-weighted mean concentrations. As discussed subsequently a more sophisticated approach to hydrologic measurements was taken in 2010.

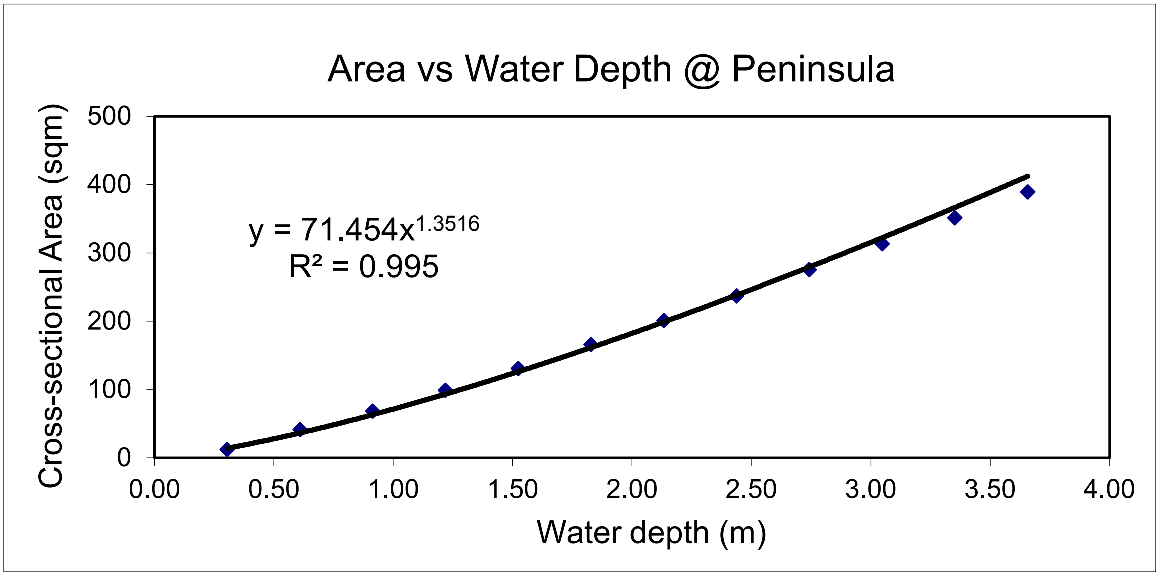


Figure 10-2. Cross-sectional area of peninsula site as a function of water depth.

In 2010, ADCP data (velocities collected in several bins, or depths, at 5-min intervals) from the bottom-mounted sonde (Argonaut) at the peninsula site were uploaded from the Argonaut's built-in memory to a laptop computer at regular intervals. River Cat data (channel depth, velocities, discharge) were collected directly on a laptop and used to develop an index velocity relating average velocity measured by the Argonaut to channel discharge at the boat launch site (Figure 10-3). Channel discharge values for the four 2010 sampling events were merged with the analytical data for salinity, TSS and Hg.

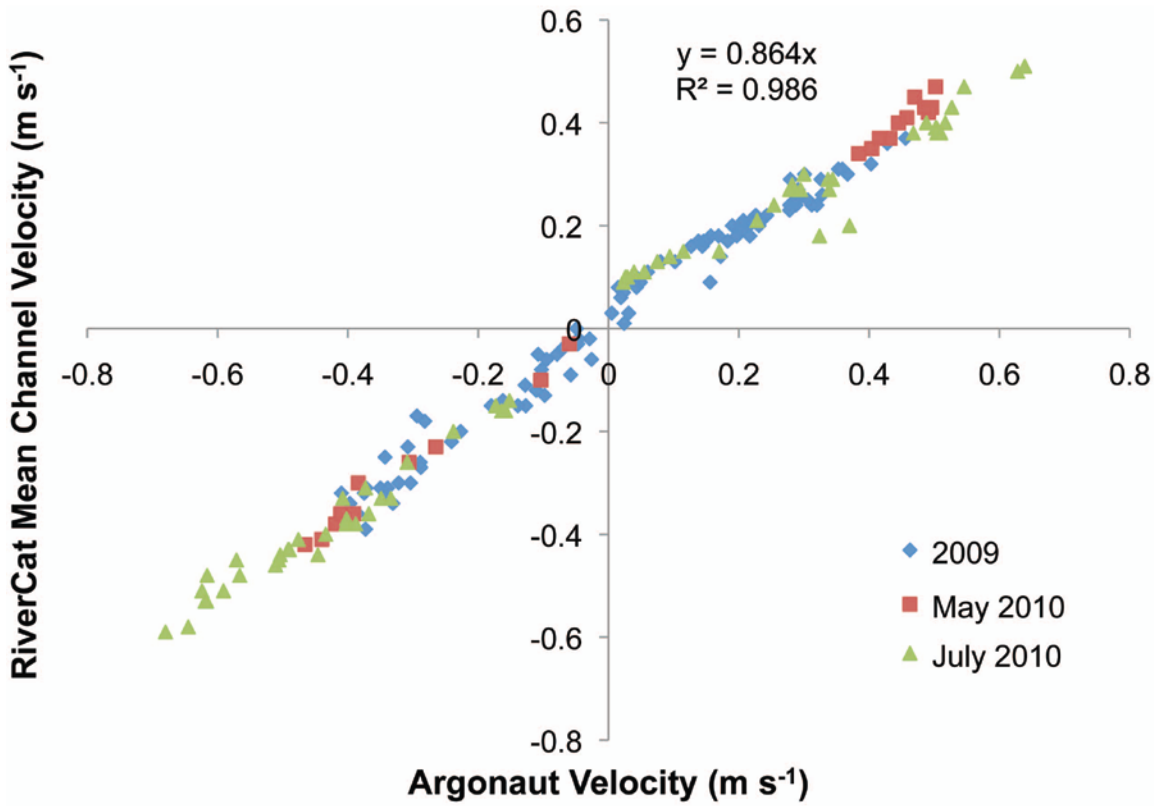


Figure 10-3. Index velocity relating average velocity measured by the Argonaut to channel discharge at the boat launch (BL) site.

Two interpolation routines were applied to concentration data to generate flood and ebb fluxes. The first routine calculated discharge-weighted mean concentrations for samples collected on each tide phase. Flux was then calculated as the product of the weighted mean and total flow for each tide phase. Details of the procedure are given below:

- Sum total flows for flood (Q_F) and ebb (Q_E) tides
- Calculate flood and ebb discharge-weighted means (C_{wgt}) for Salt, TSS, THg, FTHg, MHg and FMHg
- Multiply $Q_{5\text{-min}}$ by C (mass/second) and sum (∑)
- $\sum Q_{5\text{-min}}$
- $C_{wgt} = \sum Q_{5\text{-min}} \times C / \sum Q_{5\text{-min}}$
- Flood flux = $Q_F \times C_{wgt}$
- Ebb flux = $Q_E \times C_{wgt}$

This procedure is not ideal where the discharge values used are for the full channel discharge (2010 data) at each sampling time and not for the same "cells" where samples were collected. Nonetheless it provides a better approximation of fluxes than the product of arithmetic mean concentrations and total flows and was used mainly where good cell discharge and chemical data were available (June and July 2009, August and October 2010 at Cindy's Slough) and could be matched with good ebb/flood tidal volumes (Q_F and Q_E).

The second interpolation routine used a local polynomial fitting approach available as an add-in for Excel (RegionFit). The general type of the fit is referred to as "locally weighted scatterplot smoothing" (Lowess). The user controls the fit by specifying the order of the polynomial and the size of the data region that is used to perform the fit. Input variables consisted of time, concentration, order of polynomial, fit region size, and region edge size. Output consisted of a predicted value for concentration for each target time interval (5-min). Only a second order polynomial was selected while region size and region edge size were adjusted to obtain the closest fit to the actual analytical data as judged visually (e.g., see Figure 10-4).

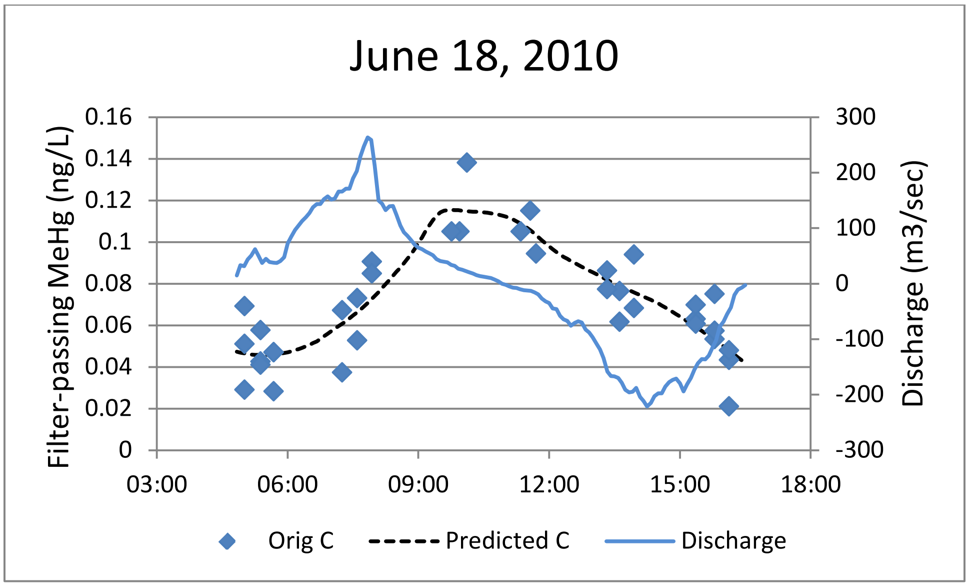


Figure 10-4. Example of data smoothing using RegionFit.

Fluxes were calculated by multiplying predicted concentrations by discharge for each 5-min interval and then summing ebb and flood phases of each tidal cycle. Each phase was defined by the time when flow reversed and not by water level as high or low water levels did not always correspond exactly with times of flow reversal.

Data for concentrations of TSS, total Hg (THg), filter-passing Hg (FTHg), total methyl Hg (MHg), and filter-passing methyl Hg (FMHg) were used to calculate the following:

- % Filter-passing Hg = 100 x FTHg / THg
- % Filter-passing MHg = 100 x FMHg / MHg
- % Methyl Hg (Unfiltered) = 100 x MHg / THg

- % Methyl (Filter-passing) = 100 x FMHg/FTHg
- PTHg (ng/L) = THg – FTHg
- PMHg (ng/L) = MHg - FMHg
- TSS-THg (µg/g) = (THg - FTHg) / TSS
- TSS-MHg (µg/g) = (MHg - FMHg) / TSS
- % MHg-TSS = 100 x TSS-MHg / TSS-THg

3.4 Locations and Timing

Sampling of flood and ebb tidal discharges on the South Marsh River was conducted at up to three stations across the direction of flow and at up to three depths (Figure 10-4). In all cases sampling commenced and ended near a high tide or a low tide. In 2009 sampling was conducted at the peninsula location while in 2010 sampling was conducted at the boat launch location. This move was made mainly for convenience: to shorten the distance to the shore access point and to save battery capacity for trolling motor, but it also proved to be useful due to proximity to the WHOI study site.

Typically, sampling at near high tide involved three evenly spaced stations at three depths, three stations at mid-tides at two depths and three stations at near low tide at one depth (Figure 10-4). In most cases sampling commenced near a high tide or low tide. Figure 10-5 illustrates the relative tidal phase positions and sample codes used for sampling a tidal cycle. A similar but abbreviated version of this sampling pattern was used on the Orland River during the one tidal cycle characterized on this river on July 8, 2009. Table 10-1 summarizes times and tide height data for all tidal cycles completely or partially characterized.

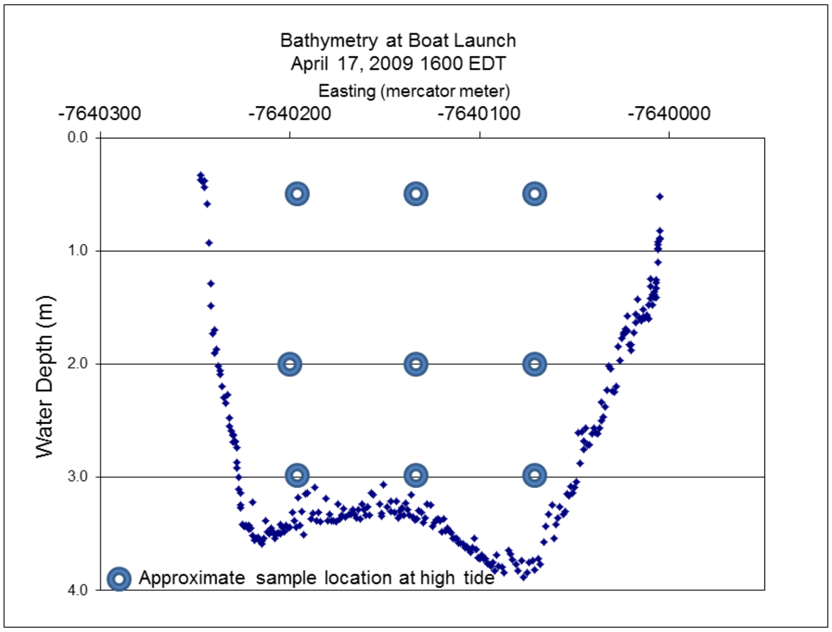


Figure 10-4. South Marsh River cross section at boat launch showing approximate locations and depth distribution of sampling points used for near high tide water sampling.

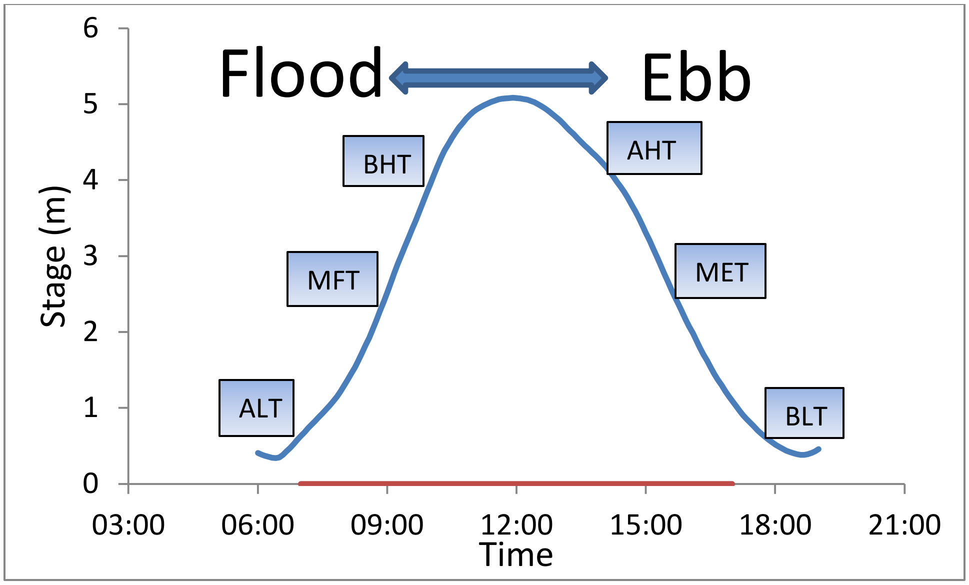


Figure 10-5. Temporal distribution of sampling and sample IDs over typical tidal cycle. ALT=after low tide; MFT=mid flood tide; BHT=before high tide; AHT=after high tide; MET=mid ebb tide; BLT=before low tide.

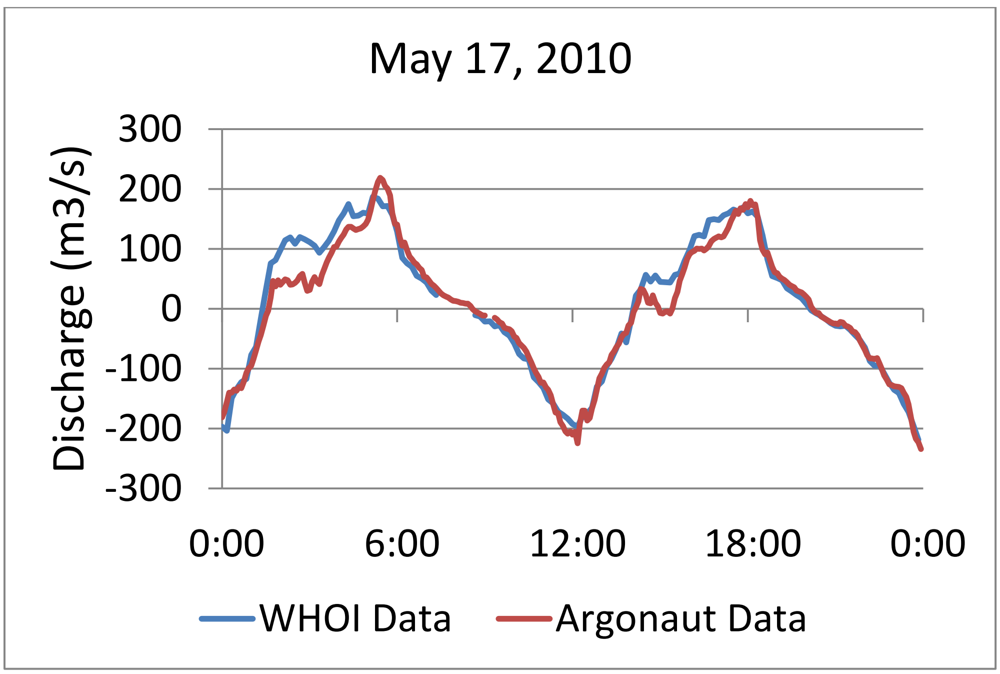
Table 10-1: Times (EDT) and heights of tides for tidal cycles partially or fully characterized. Data from http://tbone.biol.sc.edu/tide

Date	Low Tide		High Tide		Low Tide	
	Time	Level (m)	Time	Level (m)	Time	Level (m)
South Marsh River (Winterport tides)						
June 26, 2009	8:18	-0.41	14:19	3.95	20:38	-0.07
July 23, 2009	6:14	-0.48	12:12	4.02	18:30	-0.20
April 1, 2010	7:08	-0.46	13:06	4.06	19:24	-0.14
May 17, 2010	7:53	-0.19	13:52	3.61	20:04	0.20
June 18, 2010	10:17	-0.17	16:21	3.91	22:49	0.04
July 15, 2010	8:09	-0.41	14:09	4.10	20:33	-0.18
September 9, 2010	5:43	-0.46	11:40	4.38	18:08	-0.48
Orland Marsh (Bucksport tides)						
July 8, 2009	6:31	0.06	12:24	3.07	18:36	0.41

3.5 Quality Assurance

Hydrology – The SonTek ADCP instruments (Argonaut, RiverCat and FlowTracker) used in this study to collect hydrologic data include self-contained software to verify proper operation and calibration. The General Oceanics current meter is a mechanical propeller-style meter with a digital readout. Its accuracy was field verified by dragging it along a measured distance in still water and comparing the distance readout to the measured distance. Manufacturer's instructions were followed with respect to data quality assurance procedures for the ADCP instruments. For example, Argonaut software includes a "beam" checking routine to detect beam misalignment or beam attenuation due to sediment covering without having to conduct a visual inspection of the sonde. After a high discharge event in early April these electronic checks, plus water balance calculations performed on the downloaded data, indicated a possible sonde alignment or other data quality issue. Even after the sonde was visually inspected and adjusted by divers, suspicion persisted based on water balance calculations that the data being generated was possibly compromised by the location of the sonde in the channel or other explanation. To address this concern data from WHOI's ADCP/WQ station located nearby was accessed and compared to that being generated simultaneously by the Argonaut.

For two of the four tidal cycles characterized in 2010, May 10 and June 18, channel discharges could be calculated using both WHOI and our ADCP data. This comparison showed that despite concerns about the quality of our hydrologic data from the Argonaut sonde installed at the peninsula site, WHOI-based calculations of channel area, velocities and discharges were very similar to our areas, velocities and discharges (Figure 10-6).



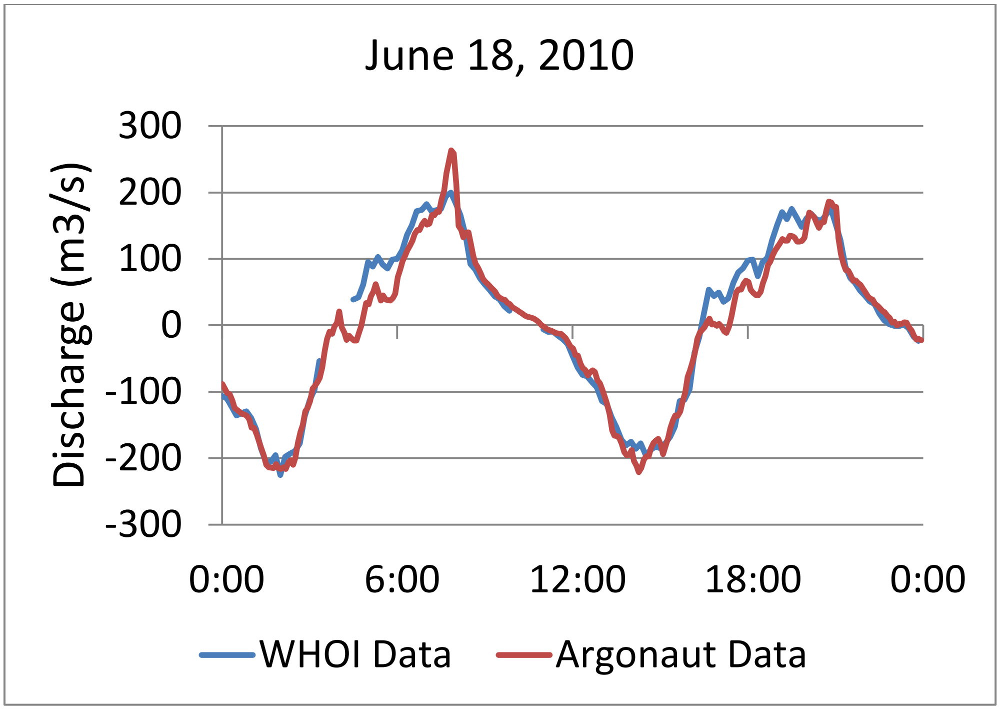


Figure 10-6. Comparison of South Marsh River discharges for two dates derived from ADCP data from Wood Hole Oceanographic Institute sonde located near boat launch and Argonaut SW sonde located at peninsula.

Sampling and Analysis - Results for equipment and FBs are summarized in the appendix. Some equipment blanks showed concentrations slightly higher than the water (Poland Springs) used to generate these blanks. Poland Springs ranged from <0.1 to 0.42 ng/L for total Hg while equipment blanks ranged from 0.11 to 0.66 ng/L. Methyl Hg in Poland Springs water ranged from <0.019 to 0.061 ng/L while equipment blanks ranged from <0.019 to 0.072 ng/L. These analyses suggest the possibility of some slight contamination by total Hg and methyl Hg from sampling equipment but the differences between Poland Springs water and EBs on specific days (e.g., 7/15/2010, Poland Springs methyl Hg = 0.051 ng/L, EBs= 0.056 and 0.072) indicate that the imparted contamination was usually relatively small (total Hg ~ 0 to 0.5 ng/L, methyl Hg ~0 to 0.03 ng/L compared with concentrations in water being sampled). For unfiltered samples with much higher concentrations of Hg and methyl Hg there is no issue with EBs but equipment blanks for filter-passing methylmercury could have resulted in our slightly overestimating flood and ebb tidal fluxes of this form of mercury. However, the effect on net fluxes should be nil.

Complete results of the field and laboratory duplicate analyses are summarized in the Appendix 10-1. FDs were collected for seven tidal cycling events. The overall average relative percent difference (% RPD) for field replicates was 21%. Water quality conditions in the South Marsh River do sometimes vary quickly (minutes) with time and location (depth), making it difficult to collect field replicates that represent the same water mass. Results for filtered samples were better (17%) with several results for filter-passing methyl Hg at near the detection limit and skewing the average.

Laboratory matrix duplicates (MDs) were also run typically at the rate of one per batch of 10 or fewer samples. The grand mean % RPD of these replicates is 5.2% with a range from 0% to 47%. Analyte-specific % RPDs ranged from 2.8% for TSS, 7.1% for total Hg and 5.3% for methyl Hg.

Error Estimation – Measurement uncertainties from laboratory analyses (average = 5%) were combined with those for discharge (assumed conservatively to be ~ 10%) to estimate overall error in calculated fluxes. Cumulative error (~11%) was estimated as the square root of the sum of the squared error from the component measurements in the flux calculations. This method assumes that individual errors are uncorrelated. Water and salt balances were also used as guideposts of uncertainty, i.e., after allowing for any changes in storage water and salt should balance within the estimated error in hydrologic measurements (10%) and salinity measurements (not estimated but assumed to be similar to laboratory analytical error of 5%).

4 RESULTS

Complete results of all sampling and analysis are tabulated in the Appendix 10-2. Selected results are presented and discussed in this section in chronological order as they pertain to the paradigms and hypotheses outlined in the **INTRODUCTION** and the objective of assessing whether Mendall Marsh is a net source or sink for Hg and methyl Hg.

4.1 South Marsh River - 2009

Results for the two tidal cycles characterized in 2009 are summarized in Tables 10-2 and 10-3. Methods used to collect water samples and measure hydrology were still being identified and evaluated in 2009 and thus interpretation of 2009 data is limited. In particular, the June 26, 2009 hydrologic data proved to be inadequate to calculate flood and ebb volumes but could be used to calculate discharge-weighted mean concentrations for flood and ebb flows (Table 10-2). Comparisons of discharge-weighted mean concentrations, as opposed to arithmetic means, are more suggestive of differences in actual fluxes if flood and ebb water volumes are assumed to be equal. The water balance for the July 23, 2009 tidal cycle was better (30% difference) but the potential error in flux calculations was still considered unacceptable. Thus, for both 2009 events we used flood and ebb volumes from two, more accurately measured, 2010 tidal cycles with similar high and low tide elevations.

For both 2009 events discharge-weighted flood means were ~ 2 times the discharge-weighted ebb means for TSS, total Hg and methyl Hg (Table 10-2). Discharge-weighted mean filter-passing concentrations of both total Hg and methyl Hg in flood tide waters were very similar to those in ebb tide waters, while the mean fractions (% filter-passing) of both forms of Hg were substantially higher in ebb tide waters. These patterns suggest significant trapping of particles (TSS) and particle-associated total Hg (PTHg and PMHg) by the marsh with little effect on dissolved concentrations. This leads to an expectation that the fractions of total and methyl Hg that are in dissolved form should be higher in ebb flows than flood flows and the data supports this expectation. The June 26, 2009 data also suggest higher mean values of TSS-THg, TSS-MHg and %MHg-

TSS in flood tide waters than in ebb flow waters, but this difference was absent in July 23, 2009.

Table 10-3 summarizes fluxes and net fluxes of materials for the 2009 tidal cycles. As noted above, 2010 flood and ebb discharge volumes for similar tidal cycles and 2009 discharge-weighted concentrations were used to calculate fluxes in this table. Aside from the significant net flux of salt out of the marsh for the June 26 event, all net fluxes were into the marsh, with largest differences (36% to 69%) associated with TSS and mostly particle-associated Hg. Differences in dissolved fluxes (2.2% to 10.5%) were smaller and probably within the errors of measurement (e.g., water balances are likely no better than ±10%).

Overall the 2009 results for the South Marsh River suggest that Mendall Marsh was a net sink, and not a source, for TSS and all forms of Hg. Tidal cycling of water through the marsh did appear for the June event to slightly change the composition of suspended matter (TSS), i.e., to reduce TSS-Hg and to increase TSS-MHg and %MHg-TSS.

Table 10-2: Mean flood and ebb tide water properties for two tidal cycles characterized in 2009.

	June 26, 2009		**July 23, 2009**	
	Flood	**Ebb**	**Flood**	**Ebb**
Number of samples (N)	10	12	21	15
Salinity (ppth)*	0.93	3.9	8.3	8.6
TSS (mg/L)*	176	78.9	127	68.1
THg (ng/L)*	188	54.5	84.4	49.1
FTHg (ng/L)*	3.56	3.47	1.80	1.75
PTHg (ng/L)*	185	58.8	79.7	46.4
% FTHg	**3.2**	**28.4**	**7.1**	**14.9**
MHg (ng/L)*	5.14	1.72	2.46	1.64
% Methyl Hg	2.6	2.8	2.6	2.6
FMHg (ng/L)*	0.169	0.167	0.098	0.101
PMHg (ng/L)*	4.97	1.72	2.36	1.54
% FMHg	**6.9**	**45**	**14**	**30**
Suspended THg (μg/g)	0.94	0.62	0.64	0.64
Suspended MeHg (μg/g)	0.024	0.013	0.015	0.013
% Suspended MeHg	2.5	2.0	2.2	2.2

*****Discharge-weighted mean

Table 10-3: Water*, salt, TSS and mercury mass balances for two tidal cycles characterized in 2009. Flood and ebb volumes or masses ~ 6 hour fluxes. Net fluxes calculated as Flood minus Ebb (positive values = input to marsh, negative values = export from marsh).

	Water (m^3)*	Salt (mT)	TSS (kg)	THg (g)	PTHg (g)	FTHg (g)	MHg (g)	PMHg (g)	FMHg (g)
June 26, 2009 *Low (-0.41 m) to Low (-0.07 m) High = 3.95 m*									
Flood	2123156	1984	374108	400	393	7.6	10.9	10.6	0.356
Ebb	1972029	7747	155534	107	116	6.8	3.39	3.53	0.330
Net	151128 (3.5 m^3/s)	-5763	218574	293	277	0.80	7.51	7.03	0.026
% Diff[a]	7.1	-290	58	73	70	10.5	69	67	7.3
July 23, 2009 *Low (-0.48 m) to Low (-0.20 m) High = 4.02 m*									
Flood	2356913	19574	298976	199	188	4.2	5.8	5.6	0.232
Ebb	2247222	19307	152993	110	104	3.9	3.7	3.5	0.227
Net	109691 (2.5 m^3/s)	271	145983	89	84	0.30	2.1	2.1	0.005
% Diff[a]	4.7	1.4	49	45	45	7.1	0.36	38	2.2

***Discharge volumes from June 18 and July 15, 2010 with similar high and low tide elevations.
[a] Calculated as *100 x Net / Flood*; Net instantaneous discharge calculated as *Net /43200*

4.2 Orland River – 2009

One tidal cycle was characterized on the lower Orland River marsh (July 8, 2009) with only a limited number (6) of samples collected on each phase of the tide and one sample collected upstream on the river above tidal influence. Although some hydrologic data (velocities) were measured it was not possible to reliably calculate flood and ebb fluxes. As indicated in Table 10-4, mean flood and mean ebb concentrations of TSS and all Hg forms did not differ significantly. Only salinity/specific conductance differed significantly between flood and ebb. River water entering the marsh had comparable or higher concentrations of several Hg forms (DTHg, %DTHg, MHg, DMHg, %DMHg, TSS-MHg and %MHg-TSS) but Particulate THg (ng/L) and TSS-Hg (µg/g) were lower as might be expected. The Orland River drainage area includes many upstream wetlands which could account for the comparable or higher concentrations. In addition, the tidal portion of the Orland contains much less high vegetated marsh than Mendall Marsh and thus a smaller zone of favorable conditions for production of methyl mercury in marsh porewater. For example, dissolved methyl Hg concentrations (0.39 and 0.91 ng/L) in the two samples of small tidal channel water from the upper marsh were lower than observed in similar samples from small channels on Mendall Marsh (1 to 5 ng/L). This difference may be related to where samples were collected in each marsh: lower end of small channels at Orland and drainage from marsh flat at Mendall Marsh.

Table 10-4: Summary of Orland River (N=1), flood tide (N=6) and ebb tide (N=6) concentrations for Orland Marsh, July 8, 2009. Unpaired t-statistic for difference between flood and ebb mean concentrations.								
	Orland River	**Flood**		**Ebb**		**Significance**	**t-statistic**	
		Mean	**Standard Deviation**	**Mean**	**Standard Deviation**		**P**	**t**
Temp (celsius)	18.16	15.11	0.48	15.30	1.70	NS	0.799	0.262
Salinity (ppth)	0.02	11.58	2.60	8.14	2.17	Sig	0.032	2.49
SpecCond (µS/cm)	53	19437	4085	13965	3466	Sig	0.031	2.50
TSS (mg/L)	2.3	9.4	4.6	9.7	5.5	NS	0.921	0.102
THg (ng/L)	2.84	6.85	3.59	8.91	4.32	NS	0.389	0.900
FTHg (ng/L)	2.27	1.90	0.11	1.79	0.29	NS	0.398	0.882
PTHg (ng/L)	0.57	4.95	3.66	7.12	4.42	NS	0.374	0.930
%FTHg	79.9	33.4	14.3	24.9	13.9	NS	0.322	1.04
MHg (ng/L)	0.23	0.257	0.087	0.266	0.083	NS	0.861	0.180
%MHg	8.1	3.25	0.86	4.00	0.71	NS	0.132	1.64
FMHg (ng/L)	0.179	0.110	0.021	0.108	0.030	NS	0.885	0.148
PMHg (ng/L)	0.051	0.147	0.102	0.158	0.085	NS	0.843	0.204
%FMHg	77.8	48.7	22.4	43.5	15.9	NS	0.650	0.469
TSS-Hg (µg/g)	0.25	0.49	0.13	0.77	0.39	NS	0.131	1.65
TSS-MHg (µg/g)	0.022	0.014	0.004	0.017	0.005	NS	0.328	1.03
%MHg-TSS	8.95	2.92	0.91	2.35	0.41	NS	0.189	1.41

4.3 South Marsh River – 2010

Table 10-5 summarizes results for the four tidal cycles at the boat launch site that were fully characterized in 2010. Time series plots of discharge, total Hg and methyl Hg are shown in Figures 10-7 through 10-10. A fifth cycle was partially characterized (Table 10-6) on April 1 with sampling limited to mid-flood (MFT) and mid-ebb (MET) and hydrology to only the flood phase. Qualitative comparison of the latter results suggested that flood tide flows delivered more suspended matter and most forms of Hg to the marsh than ebb tides export. The ebb tide flows had slightly higher percentages of total Hg that was filter-passing (%FTHG) and as well as higher percentages of total mercury that were methyl Hg (% MHg).

Water and salt mass balances (calculated as % difference = 100 x net/flood) for the fully characterized 2010 tidal cycles (Table 10-1) indicate reasonably good balances given expected changes in storage for single cycle measurements. In all cases the water balance reflected slightly (2.5% to 7.1%) more water entering the marsh than exiting, an observation consistent with measured differences in tide levels (low to low or high to high), i.e., levels were always higher (increase in storage) at end of cycle than beginning. Salt balances were not as good (+8.6% to -42%) as for water and reflected more salt exiting (-) than entering (+) the marsh except for the September 9 event. Salt was expected to be more difficult to balance because of presence of a salt wedge within the South Marsh River in some seasons and at some stages of the tide. These balances establish the degree of uncertainty that should be applied to the suspended solids and mercury balances, i.e., differences in the latter balances should be greater than for water and salt to be considered noteworthy.

In all cases the net flux of suspended matter (TSS) was into the marsh with % differences ranging from 21% to 62%. In terms of net loading (kg) to the marsh over a typical 12 hour cycle the values ranged from 16245 to 82243 kg, equivalent to marsh depositions of 8.2 to 41 g/m^2, assuming a marsh area of 200 ha. When converted to sediment thicknesses (bulk density=1500 kg/m^3) these loading values translate into 0.005 to 0.027 mm of new sediment accumulation per tidal cycle, or if annualized, the sedimentation rate would be ~3.65 to 20 mm/year. Published marsh sedimentation rates for the Scheldt Estuary (e.g., Temmerman et al. 2004) range from 4.3 to 32 mm/year. Wood et al. (1989) reported sedimentation rates for Maine coastal marshes as ranging from 0 to 13 mm/year while Goodman et al. (2007) reported values up to 4.2 mm/year. Thus our sedimentation rate estimates for the Mendall Marsh, as derived from the suspended sediment budget, appear to be very reasonable. Further support for the validity of our suspended sediment loading values to the marsh can be found in measurements by Yeager et al. (see Chapter 5) of sediment mass accumulation in Mendall Marsh. Their values range from 0.2 to 0.97 g/cm^2/year depending on marsh location. In equivalent units our values range from 0.6 to 3 g/cm^2/year.

Net fluxes of total Hg were also exclusively into the marsh with % differences ranging from 25% to 69% (Table 10-5). In terms of net loading (g) to the marsh over a typical 12-hour tidal cycle, the values ranged from 18.5 to 94 grams, equivalent to 9.2 to 47 μg/m^2, assuming a marsh area of 200 ha. The lowest value of deposition rate for a single tidal cycle is comparable to the <u>annual</u> (2009) range (5 to 7 μg/m^2) of atmospheric Hg wet deposition rates for Maine (MDN 2009) and thus loading of the marsh by atmospheric deposition is insignificant compared to loading by the Penobscot River. Net fluxes of total filter-passing Hg were also always into the marsh and the % difference values (18% to 36%) were lower than for total Hg. Net loadings of filter-passing total Hg to the marsh ranged from 0.75 to 2.2 grams for a 12 hour cycle. These tidal cycle fluxes can be expressed <u>approximately</u> as daily fluxes per unit area (ng $m^{-2}d^{-1}$) by doubling the values and dividing by the area of the marsh (200 ha). This conversion yields 750 to 2200 ng m^{-2} d^{-1} as the net loading of filter-passing total Hg <u>to the marsh</u>. By way of comparison, Mitchell et al. (2012) found a 40 ng m^{-2} d^{-1} net daily tidal <u>loss</u> of filter-passing total Hg and a 200 ng m^{-2} d^{-1} net daily <u>accumulation</u> of particulate total Hg in a relatively uncontaminated Chesapeake Bay salt marsh.

Net fluxes of total methyl Hg (Table 10-5) were also always into the marsh with % difference values (19% to 78%) similar to those for TSS and total Hg. Net loadings of methyl Hg to the marsh ranged from 0.37 to 2.7 grams for a 12-hour cycle. Net fluxes of filter-passing methyl Hg were into the marsh for three (May, June and July) of the four tidal cycles characterized but out of the marsh for the September cycle. The % difference for September was 61% with the cycle loading (-0.079 g) more than twice as high as for any of the three cycles where fluxes (0.017 to 0.031 g) were inward. These tidal cycle fluxes can be expressed approximately as daily fluxes per unit area (ng m^{-2} d^{-1}) by doubling the values and dividing by the area of the marsh (200 ha). Thus, the net flux out of the marsh of filter-passing methyl Hg for the September event becomes 79 ng m^{-2} d^{-1} while the net flux of particulate methyl Hg into the marsh becomes 880 ng m^{-2} d^{-1}. By way of comparison, Mitchell et al. (2012) found a 3.6 ng m^{-2} d^{-1} net daily tidal loss of filter-passing methyl Hg and a 2.9 ng m^{-2} d^{-1} net daily accumulation of particulate methyl Hg in a relatively uncontaminated Chesapeake Bay salt marsh, resulting in an overall very small source function for methyl Hg from that system. Mitchell et al. (2012) measured net fluxes over an entire year and found the largest discrepancies in filter-passing fluxes during the warmer summer/early autumn period.

Overall the detailed characterization of four tidal cycles in 2010 showed that Mendall Marsh was trapping suspended sediment as well as total Hg, particulate Hg, filter-passing total Hg and methyl Hg. For three of the four cycles the marsh was also retaining more filter-passing methyl Hg than it was exporting. However, in September the latter pattern reversed with the marsh acting as a net source for filter-passing methyl Hg. It is noteworthy that average salinities in the South Marsh River increased from May to September (10.8, 12.8, 15.4 and 17.2 ppth) and that the September tidal cycle was the only one in 2010 for which the net flux of salt (Table 10-5) was into the marsh. The September cycle also had the highest high tide, 4.38 m, and lowest low tide, -0.46 m, among the four cycles characterized: others were 3.61, 3.91 and 4.10 m, respectively, and -0.19, -0.17, and -0.41 m, respectively. Water temperatures were actually highest in July (19.9°C) and only slightly lower in September (18.8°C). Whether salinity, temperature or high/low tide elevations played roles in the net release of dissolved methyl Hg in September is unclear but a case can be made for the highest tides, which fully inundate the high marsh, acting to flush/extract more sediment pore fluid with high filter-passing methylmercury concentrations than lower tides that do not flood the high marsh or flood only the margins. Jordan and Correll (1991) highlighted the tendency of high marshes to export nutrients while low marshes tended to be zones of deposition (import). Alternately, the especially low tides that accompany spring tides could act to allow longer and deeper drainage of the marsh due to the larger hydraulic gradient associated with especially low tides. Both especially high tides and especially low tides likely work in concert to facilitate net export of filter-passing methyl Hg from the marsh.

It is important to assess the probable frequency of the export of filter-passing methylmercury and compare it to the flux in the nearby Penobscot River. Frequency analysis of 2010 tides at Winterport (Figure 10-11) indicated that high tides >4.1 m accounted for about 15% of all high tides. If filter-passing methyl Hg is only exported from Mendall Marsh when high tide exceeds 4.1 m, as it did during the September event, the annual loading to the Penobscot River would amount to ~55 days x 0.16

g/day = 8.8 grams of filter-passing methyl Hg. In contrast a reasonable estimate of the range of annual loads carried by the Penobscot River would be 600 to 6000 grams (assumes range of discharge from 100 to 1000 m^3/s and mean filter-passing methyl Hg concentration of 0.2 ng/L). Thus, the Mendall Marsh loading would represent <5% of the river loading.

Table 10-5: Water, salt, TSS and Hg mass balances for four tidal cycles characterized in 2010. Flood and ebb volumes or masses ~ 6 hour fluxes. Net fluxes calculated as Flood minus Ebb (positive values = input to marsh, negative values = export from marsh).

	Water (m^3)	Salt (mT)	TSS (kg)	THg (g)	PTHg (g)	FTHg (g)	MHg (g)	PMHg (g)	FMHg (g)
May 17, 2010 *Low (0.518 m) to Low (0.902 m) High = 4.24 m*[b]									
Flood	1675194	19342	131733	137	134	3.66	3.42	3.28	0.12
Ebb	1633276	27394	49540	43	40	2.91	0.74	0.66	0.10
Net	41918 (0.97 m^3/s)	-8052	82243	94	93	0.75	2.68	2.62	0.025
% Diff[a]	2.5	-42	62	69	69	20	78	80	21
June 18, 2010 *High (4.39 m) to High (4.42 m) Low = 0.601 m*[b]									
Flood	2123156	25101	75887	77.9	73.3	4.60	1.64	1.28	0.154
Ebb	1972029	27326	59642	43.5	39.7	3.78	0.90	0.82	0.137
Net	151128 (3.5 m^3/s)	-2224	16245	34.4	33.6	0.82	0.74	0.46	0.017
% Diff[a]	7.1	-8.9	21	44	46	18	45	36	11
July 15, 2010 *Low (0.313 m) to Low (0.603 m) High = 4.63 m*[b]									
Flood	2356913	34211	116611	74.6	68.2	6.22	1.95	1.77	0.18
Ebb	2247222	37508	76462	56.1	53.2	4.01	1.58	1.43	0.15
Net	109691	-3293	40150	18.5	15.9	2.21	0.37	0.34	0.031
% Diff[a]	4.7 (2.5 m^3/s)	-9.6	34	25	23	36	19	19	17
September 9, 2010 *Low (0.340 m) to Low (0.456 m) High = 5.08 m*[b]									
Flood	3018591	50765	115779	101	96.3	5.14	1.90	1.76	0.13
Ebb	2935399	46414	84683	60.9	59.9	4.02	1.06	0.88	0.21
Net	173192	4351	31096	40.5	36.4	1.12	0.84	0.88	-0.079
% Diff[a]	5.7 (4.0 m^3/s)	8.6	27	40	38	22	44	50	-61

[a] Calculated as *100 x Net / Flood*; Net instantaneous discharge calculated as *Net /43200*

[b] Tide elevations are from Mendall Marsh Argonaut station

Table 10-6: Results of analysis of mid-flood (MFT) and mid-ebb (MET) tidal samples from boat launch site on April 1, 2010. Low tide @ 7:08 = -0.46m high tide @ 13:06 = 4.06m

	MFT		MET		Difference*
Sample depth (m)	0.5	2.5	0.5	2.7	-
Time	10:35	10:35	16:42	16:42	-
Discharge (m^3/s)	155	155	-	-	-
Salinity (ppth)	0.08	0.08	0.07	0.07	Not different
TSS (mg/L)	85.6	80.6	39.4	76.4	Higher flood
THg (ng/L)	95.6	70.6	30.1	49.6	Higher flood
FTHg(ng/L)	2.84	2.82	2.22	2.36	Higher flood
Particulate THg (ng/L)	92.8	67.8	27.9	47.2	Higher flood
% FTHg	2.97	3.99	7.38	4.76	Lower flood
MHg (ng/L)	1.64	1.25	0.564	0.907	Higher flood
% MHg	1.72	1.77	1.87	1.83	Lower flood
FMHg (ng/L)	0.11	0.17	0.093	0.105	Higher flood
Particulate MHg (ng/L)	1.53	1.08	0.471	0.802	Higher flood
% FMHg	3.87	6.03	4.20	4.45	Not different
TSS-THg (μg/g)	1.08	0.84	0.71	0.62	Higher flood
TSS-MHg (μg/g)	0.018	0.013	0.012	0.011	Higher flood
% MHg-TSS	1.65	1.59	1.69	1.70	Not different

***Qualitative comparison of MFT and MET mean values only, no statistical significance intended**

Tributary Sampling - As noted in the **INTRODUCTION** the South Marsh River includes drainage from a relatively large (6500 ha) upland watershed. No hydrological monitoring stations are known to exist in this watershed and we did not make any hydrological measurements. We have assumed that except perhaps during freshet and large storms the freshwater flow volume from this upland area is small compared to the tidal exchange volumes. For example, in 2010 our most accurate estimates of average tidal discharges range from 69 to 139 m^3/s and all four net discharges (4.7 to 7.1 m^3/s) were into and not out of the marsh. For a slightly smaller (3730 ha) nearby gauged watershed (Ducktrap River, Waldo County) average annual discharge varied from 0.57 to 1.61 m^3/sec between 1998 and 2010 and was 1.19 m^3/s in 2010. Thus an estimate of the average discharge for the upland tributaries to the South Marsh River would be in the range 1 to 3 m^3/s (~2 m^3/s in 2010), or <5% of the mean tidal discharges. However, at low tide water in the channel of the South Marsh River would likely be composed of significant amounts of upland drainage and there was a possibility that upland tributaries could be contributing significant amounts of methyl Hg to the Mendall Marsh due to fluxes from upstream wetlands. Accordingly, stream samples were collected in these tributaries in 2009 (April, July and September) and 2010 (April and July) for analysis (Table 10-7). In order to estimate the flux of suspended matter (kg/day) and Hg (g/day) from these tributaries we assumed a mean freshwater discharge into the marsh of 3 m^3/s and then multiplied by the arithmetic average concentrations. As expected the estimated daily tributary fluxes of TSS, total Hg and methyl Hg were small (<10%) compared to net tidal fluxes but tributary fluxes of filter-passing total Hg and filter-passing methyl Hg fluxes could have accounted for significant fractions of net tidal fluxes. This was especially true for filter-passing methyl Hg where the tributary flux (0.055 g/day) was similar to or exceeded the net tidal fluxes (0.025, 0.017, and 0.031 g/tide) when the marsh was apparently a net sink for filter-passing methyl Hg and could have accounted for ~1/3 of the net tidal flux (i.e., 2 times -0.079 g/tide = 0.16 g/day) when the marsh was a net source of filter-passing methyl Hg. With regard to the later flux, our estimate of the relative contribution of the occasional net flux of filter-passing methyl Hg on spring tides to the Penobscot could originate in part from upland tributary flux and not from Mendall Marsh, thus further reducing this contribution.

Table 10-7: Estimated concentrations and fluxes of suspended matter and Hg for upland tributaries (assuming Q = 3 m^3/s) to Mendall Marsh compared to net tidal fluxes at SMR boat launch site. Tributary data (N = 10) from 2009-2010.

	TSS	THg	FTHg	MHg	FMHg
	(mg/L)	(ng/L)			
Mean tributary concentrations	6.0	2.93	2.25	0.237	0.211
	(kg/day)	(g/day)			
Tributary flux	1553	0.76	0.58	0.061	0.055
	kg/tide*	g/tide*			
SMR Net flux @ BL 2010	16245 to 82243	18 to 94	0.75 to 2.2	0.37 to 2.7	-0.079 to 0.031

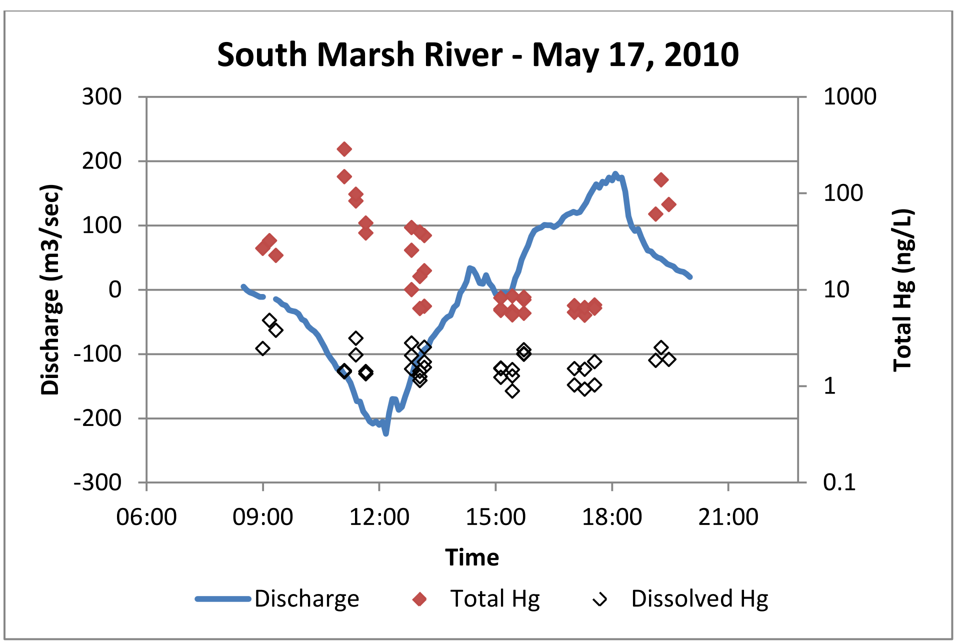
*Values from Table 5, multiply by 2 for comparison to tributary fluxes

To allow a more rigorous comparison of selected properties (Table 10-8) of flood and ebb flows we merged all data from 2009 and 2010 and ran unpaired t-tests for differences in mean values. Ebb flows were characterized by ~2 times higher fractions of both total Hg and methyl Hg in filter-passing form and the fraction of filter-passing total Hg that was methyl Hg was also higher in ebb than flood flows (Table 10-8). Concentrations of both total and methyl Hg on suspended matter were also slightly, but significantly, higher on flood than ebb flows. Although higher in flood flows the fraction of total Hg on suspended matter that was methyl Hg was not significantly different between flood and ebb flows. These patterns support or refute two of the hypotheses posed at the beginning of this investigation:

- Ebb tide fractions of filter-passing Hg are higher than flood tide fractions (*Hypothesis*) – **Supported**
- Hg-contaminated marshes, while still being net sinks for particle-bound Hg, export particles with higher inorganic and methyl Hg content (*Hypothesis*) – **Refuted**

Table 10-8: Comparison (unpaired t-test, df=204) of mean values for selected flood and ebb flow properties.

	Flood Mean	Ebb Mean	Significant Difference?	P	t
Aqueous Phase					
% FTHg	9.88	18.1	Yes	<0.0001	5.3263
% FMHg	14.5	32.2	Yes	<0.0001	7.5806
% MHg (unfiltered)	2.34	2.25	No	0.4298	0.7912
% FMHg (filtered fraction)	3.74	4.32	Yes	0.0066	2.7463
Suspended Matter (TSS)					
TSS-THg (μg/g)	0.72	0.62	Yes	0.002	3.1252
TSS-MHg (μg/g)	0.017	0.011	Yes	0.0376	2.0
% MHg-TSS	2.19	1.64	No	0.01018	1.6437



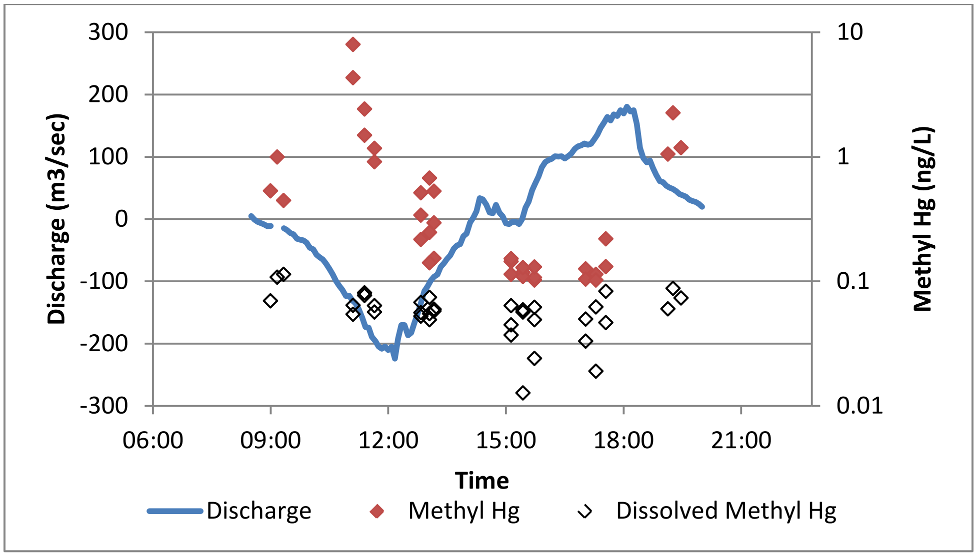
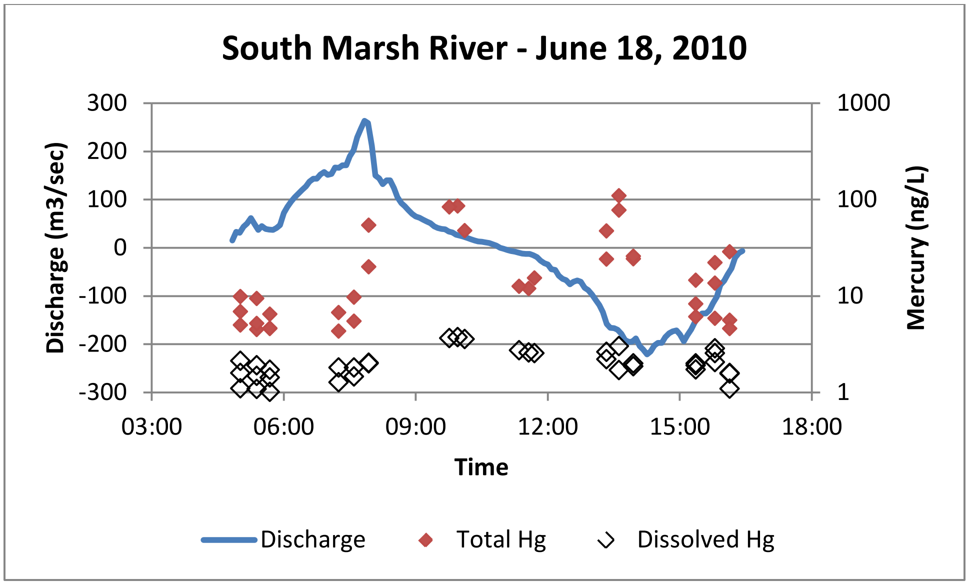


Figure 10-7. Time series discharge, Hg and methyl Hg data for tidal cycle on the South Marsh River characterized on May 17, 2010. (Negative discharge = flood tide; positive discharge = ebb tide)



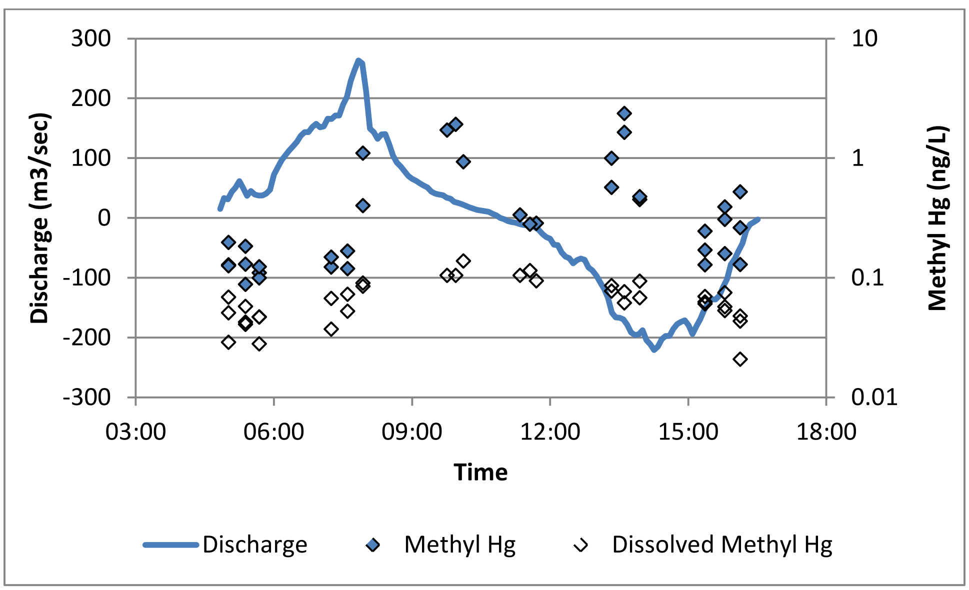
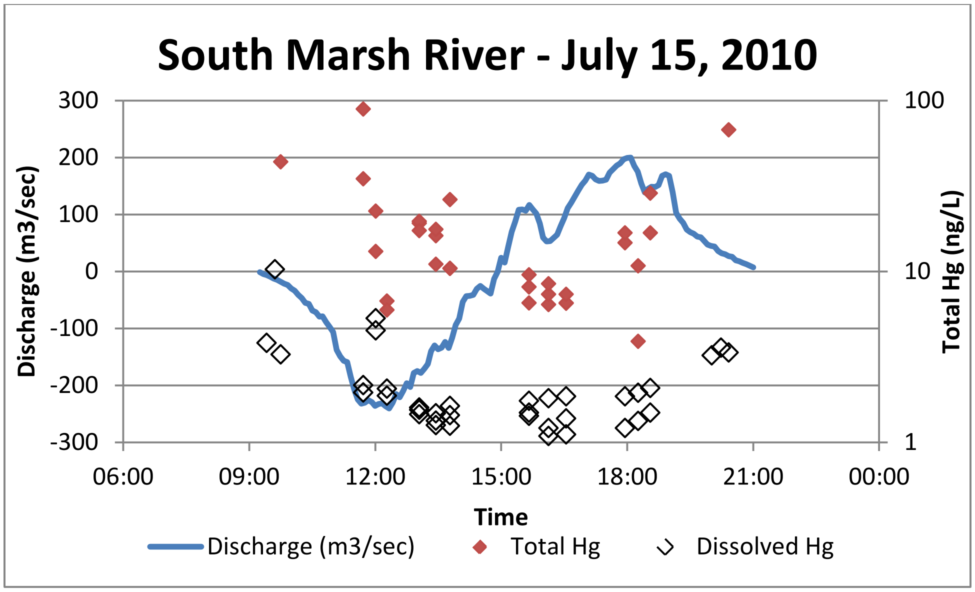


Figure 10-8. Time series discharge, Hg and methyl Hg data for tidal cycle on South Marsh River characterized on June 18, 2010. (Negative discharge = flood tide; positive discharge = ebb tide)



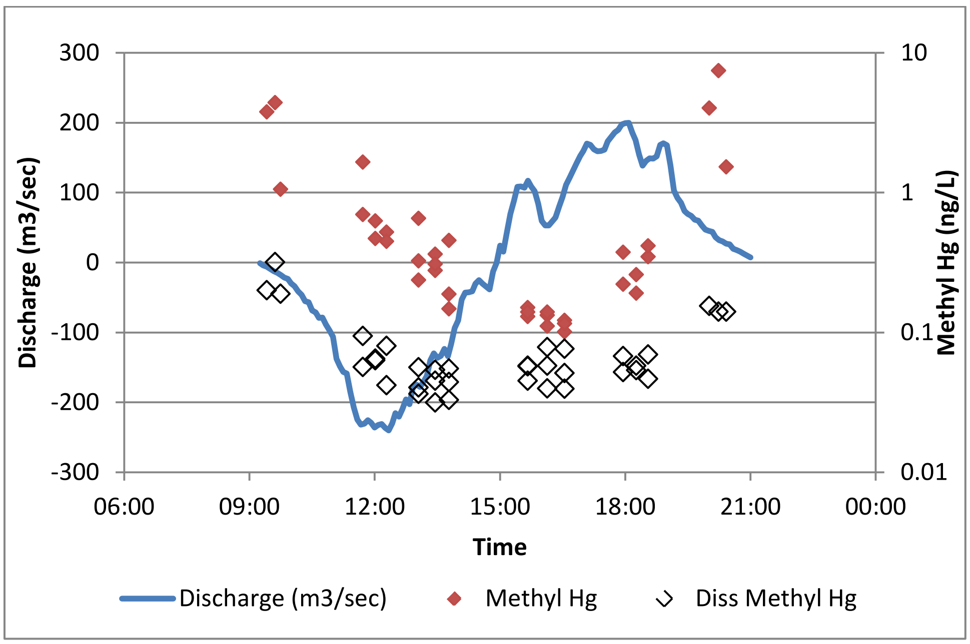


Figure 10-9. Time series discharge, Hg and methyl Hg data for tidal cycle on South Marsh River characterized on July 15, 2010. (Negative discharge = flood tide; positive discharge = ebb tide)

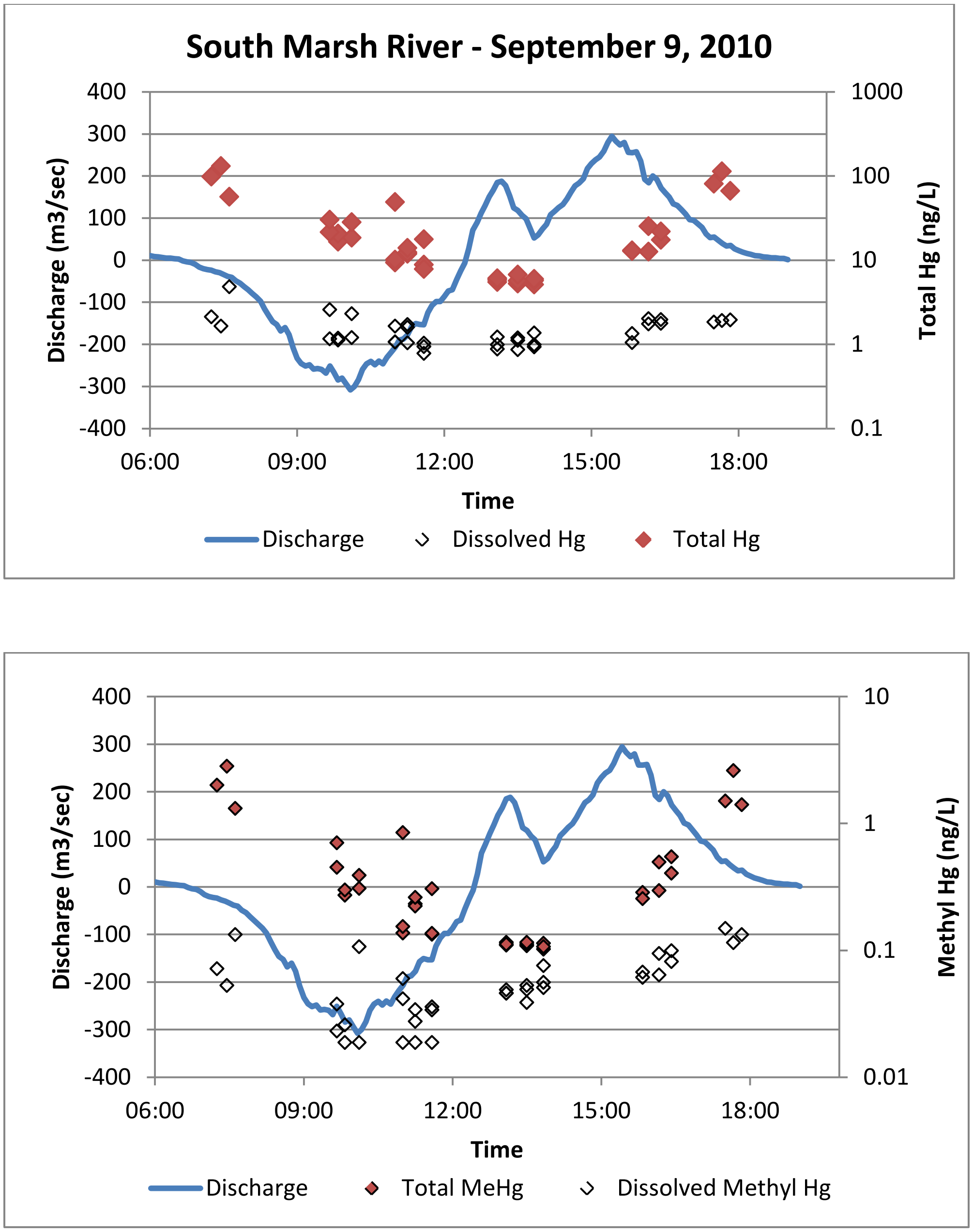


Figure 10-10. Time series discharge, Hg and methyl Hg data for tidal cycle on South Marsh River characterized on September 9, 2010. (Negative discharge = flood tide; positive discharge = ebb tide)

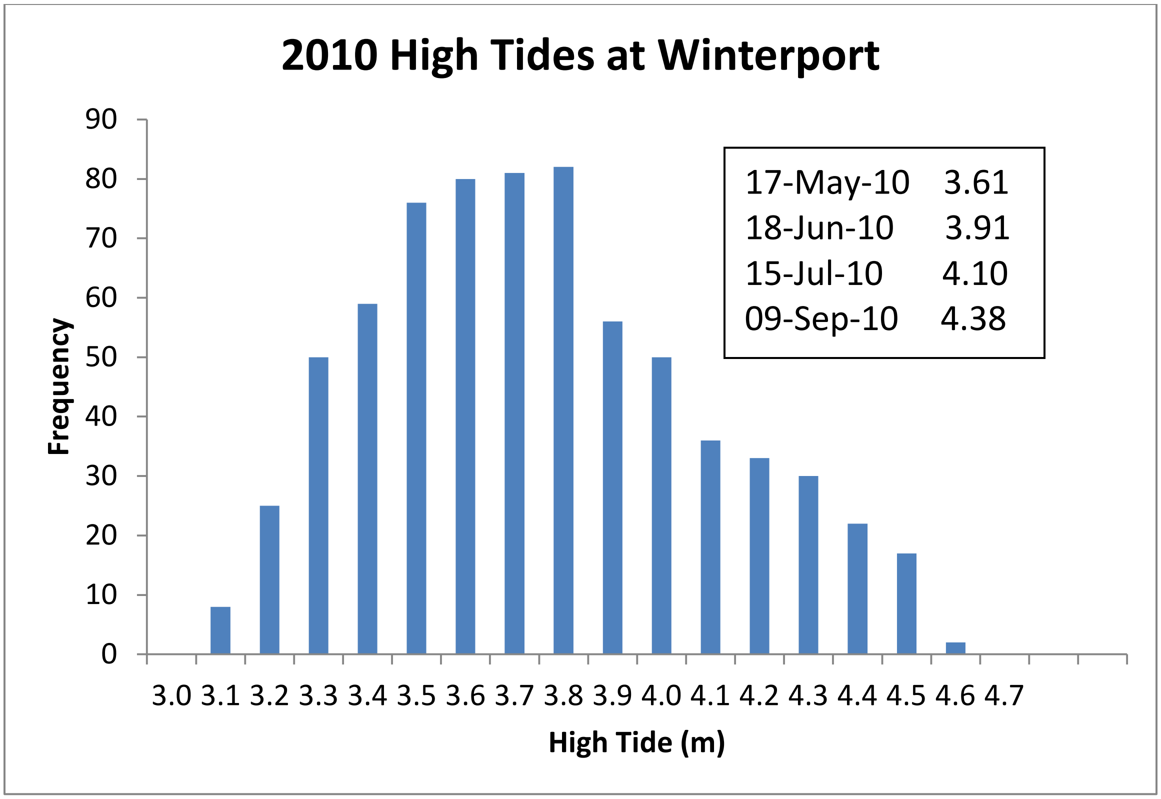


Figure 10-11. Frequency distribution of high tides at Winterport in 2010

4.4 Small Tidal Channel Investigations

Longitudinal Patterns - Over the course of this investigation we collected water samples from several small tidal channels that contribute flow to the South Marsh River. Locations are shown in Figures 10-1c and 10-1d while complete analytical results are given in Appendix 10-2. This effort was exploratory in the sense that we desired to understand what was happening at the interface between marsh porewater and the South Marsh River. Small tidal channels intersect the high marsh at variable intervals along the banks of the South Marsh River. On Mendall Marsh these channels are deeply incised and often penetrate deeply into high marsh areas that exhibit some of the highest concentrations of methyl Hg in porewater observed in the Penobscot Estuary. These channels provide hydrologically favorable pathways for rapid transport of filter-passing total Hg and methyl Hg to the South Marsh River during ebb tidal flows, as well as providing a “reaction” zone where geochemical transformations, such as adsorption, oxidation and photochemical degradation can occur.

In August 2010 we collected a series of water samples along Cindy’s Slough from the mouth to the head of several first order channels covering a maximum distance along tidal channels of almost 500 meters. All samples were collected on low ebbing tide and included samples for TSS as well as for total Hg and methyl Hg.

It might be expected that filter-passing forms of Hg in marsh porewater, where redox conditions favor higher solubility than in more oxic surface water, would tend to partition to solids (TSS and bed sediments) during transport in tidal channels. As shown in Figures 10-12 the percent of filter-passing total Hg decreased with decreasing distance from the mouth. The same longitudinal pattern for percent filter-passing methyl Hg (Figure 10-13) was not as obvious, if present at all. As indicated in Figure 10-14 inorganic Hg exhibited higher partition coefficients than methyl Hg in this sample series and thus the tendency of methyl Hg released from pore water to bind to channel bed and suspended sediments was reduced compared with inorganic mercury, i.e., filter-passing methyl Hg was more stable in tidal channels as it was transported towards the river.

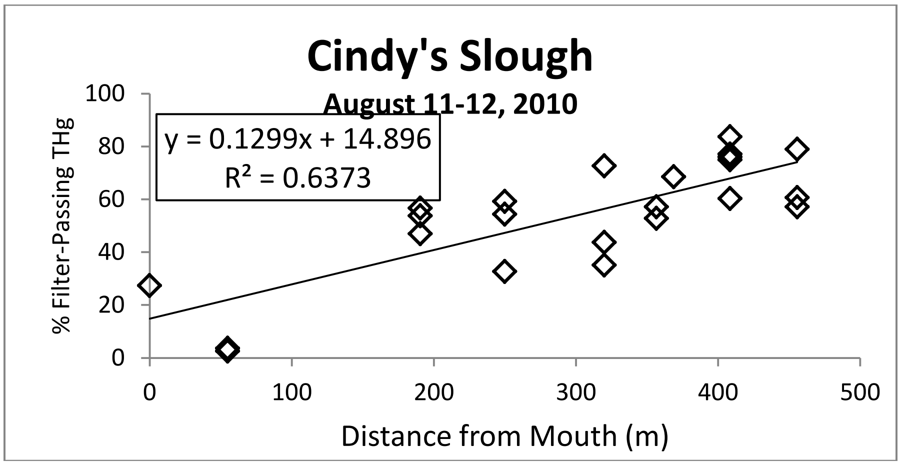


Figure 10-12. General decrease in percent filter-passing Hg with decreasing distance to mouth of Cindy's Slough.

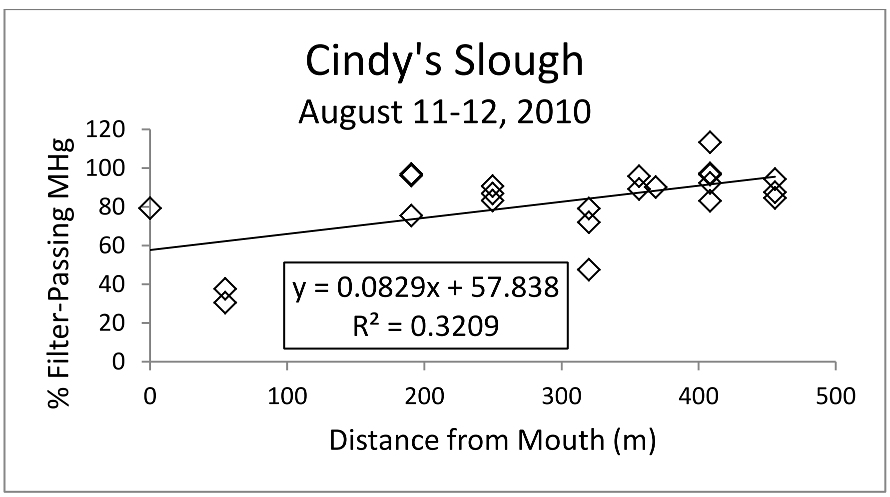


Figure 10-13. Percent filter-passing methyl Hg as a function of distance from mouth of Cindy's Slough.

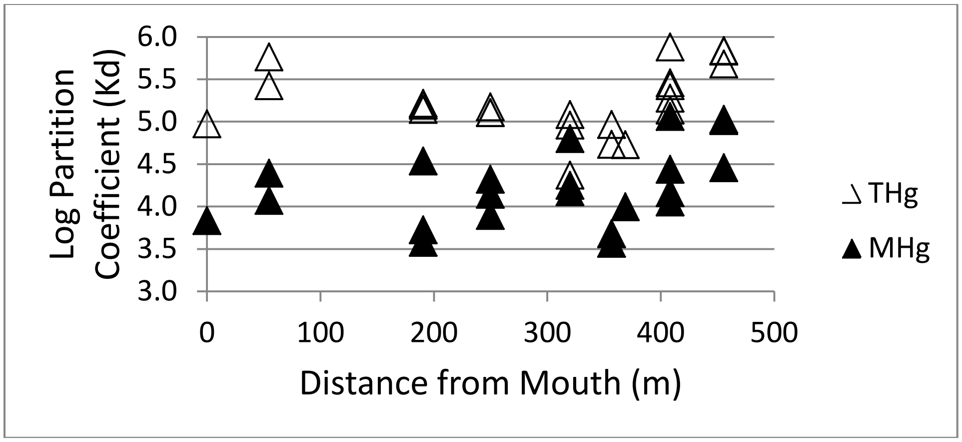


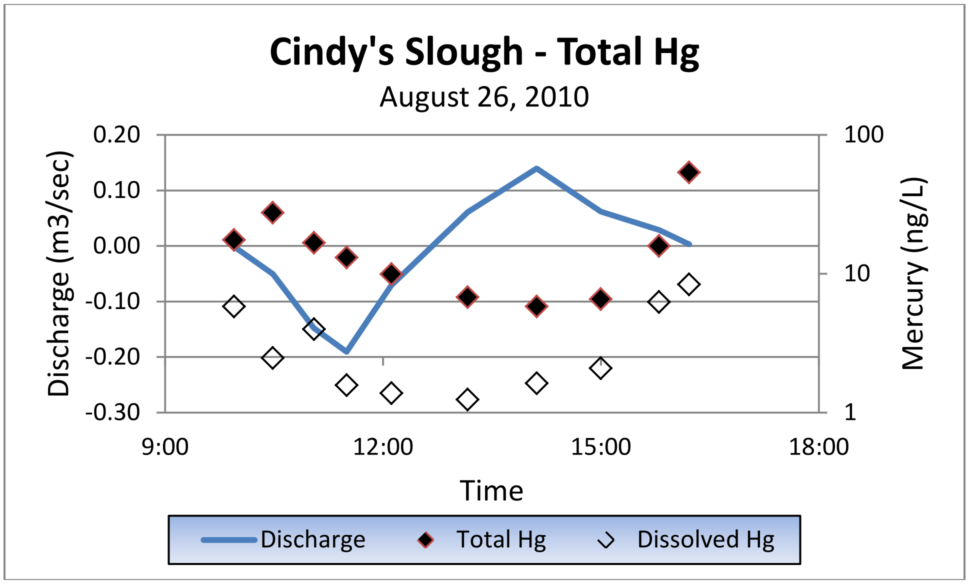
Figure 10-14. Partition coefficients (log values) for inorganic Hg and methyl Hg as function of distance from mouth of Cindy's Slough. Partition coefficients calculated as ((particulate Hg $_{ng/L}$)/(TSS $_{mg/L}$))/ (filter-passing Hg $_{ng/L}$)

Cindy's Slough Flux Measurements – Three tidal cycles at the hydrological station (CS, Figure 10-2) were characterized (Figures 10-15 and 10-16) at the lower end of Cindy's Slough in 2010 (June 23, August 26 and October 9). Only the data from the last two events are presented and discussed here due to FlowTracker failure during the June event. Partial results for the June event are given in Appendix 10-2 The October 9 event was a spring tide (high tide = 4.48 m) and caused inundation of the entire high marsh area while the August 26 event (high tide = 3.62 m) only filled and drained the incised channel. Measured water balances (Table 10-9) for both events were reasonably good (9.6% and 12 % differences) but the apparent good balance for the October event may be misleading as more water certainly would have entered and drained from the marsh than was captured by our monitoring station located on the channel. The Hg fluxes (Table 10-9) for these hydrologically contrasting events again demonstrated the property of the marsh to capture and retain TSS and particle-associated Hg (PTHg and PMHg) even with a ~10-fold increase in tidal water volume. Filter-passing total Hg may also have been weakly retained by the marsh during the smaller August tide but the % difference (11%) in filter-passing Hg flux was similar to the water balance difference (-9.6%) and thus the apparent net retention may not be significant. The marsh was clearly a source for filter-passing total Hg during the October event and was also a source for both total methyl Hg and filter-passing methyl Hg during both events. Net loadings (export) of total methyl Hg (2.7 g) and filter-passing methyl Hg (3.4 g) to the South Marsh River during the October event were much higher than those for August (0.7 and 0.09 g) as might be expected due to likelihood of significant marsh porewater introduction into ebb tide flows following full inundation of the high marsh and deep drainage during this spring tide. Expressing these exports on a unit area basis is difficult because the actual contributing drainage area is highly uncertain and would have changed or become meaningless during the October 9 spring tide. The maximum area can be somewhat bracketed under the assumption that drainage area boundaries are defined by the traces of nearest channels and obvious non-marsh upland. This approach yields ~9 ha while using boundaries defined by traces that bifurcate the distance between Cindy's Slough channel and the nearest channels and non-marsh upland yields ~3 ha. Using these areas yields 30 to 90 $\mu g/m^2$ for total methyl Hg export and 38 to 113 $\mu g/m^2$ export for filter-passing methyl Hg for the October event. The estimated export (3.4 g) of filter-passing methyl Hg by Cindy's Slough during the October spring tide (high tide = 4.48 m) event is approximately two orders of magnitude higher than export (0.079 g) of filter-passing methyl Hg by the South Marsh River during the September event (high tide 4.38 m). The export (0.090 g) of filter-passing methyl Hg by Cindy's Slough during the August event (high tide = 3.62 m), while much lower than for October event, also exceeded the export by the South Marsh River during the September event. These comparisons of exports suggest strongly that filter-passing methyl Hg does not behave conservatively after entering the tidal channels, i.e., redistribution of methyl Hg to non-filter-passing forms occurs before entry to the main river channel.

Table 10-9: Water, salt, TSS and Hg mass balances for two tidal cycles characterized at Cindy's Slough. Flood and ebb volumes or masses ~ 6 hour fluxes. Net fluxes calculated as Flood minus Ebb (positive values = input to marsh, negative values = export from marsh).

	Water (m^3)	Salt (mT)	TSS (kg)	THg (g)	PTHg (g)	FTHg (g)	MHg (g)	PMHg (g)	FMHg (g)
August 26, 2010 ***High = 3.62 m***									
Flood	858	12.3	20.0	13.2	11.1	2.08	0.279	0.166	0.112
Ebb	940	13.3	9.24	6.5	4.7	1.85	0.349	0.117	0.202
Net	-82	-1.0	11.2	6.7	6.4	0.23	-0.70	0.049	-0.090
% Diff[a]	-9.6 (0.002 m^3/s)	-8.1	53.4	50.4	58	11.0	-25.3	30	-79.7
October 9, 2010 ***High = 4.48 m***									
Flood	7276	34.2	222	167	153	14	2.6	2.08	0.55
Ebb	8170	41.0	84	79	58	21	5.4	1.45	3.9
Net	-894	-6.8	138	88	95	-7	-2.7	0.63	-3.4
% Diff[a]	-12 (0.021 m^3/s)	-20	62	53	62	-52	-103	30	-612

[a] Calculated as *100 x Net / Flood*; Net instantaneous discharge calculated as *Net /43200*



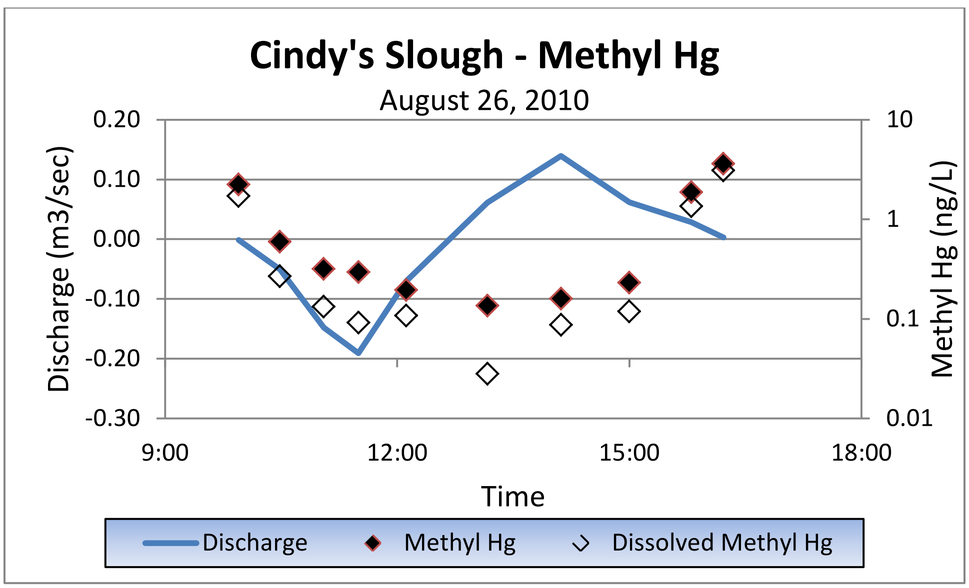
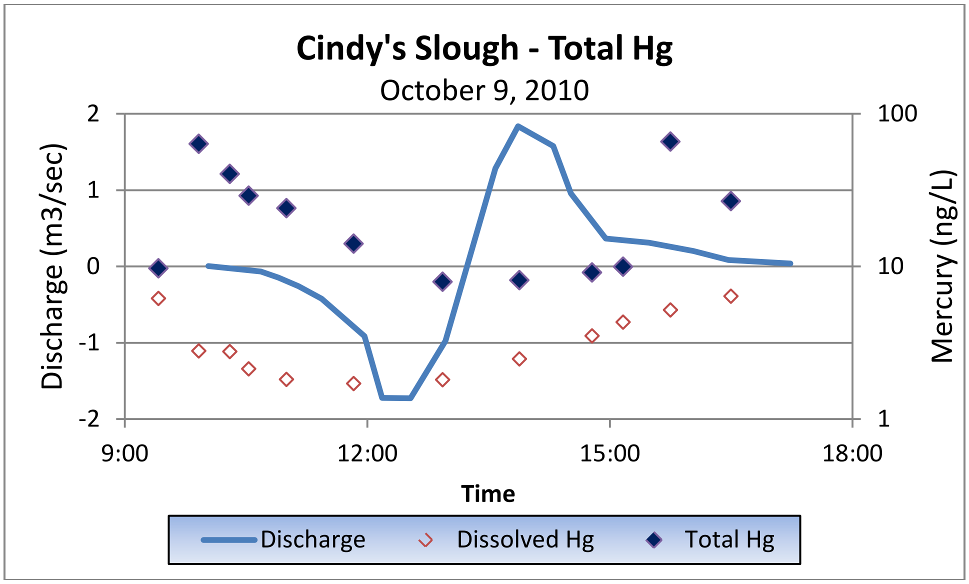


Figure 10-15. Time series discharge, mercury and methylmercury data for tidal cycle on Cindy's Slough characterized on August 26, 2010.



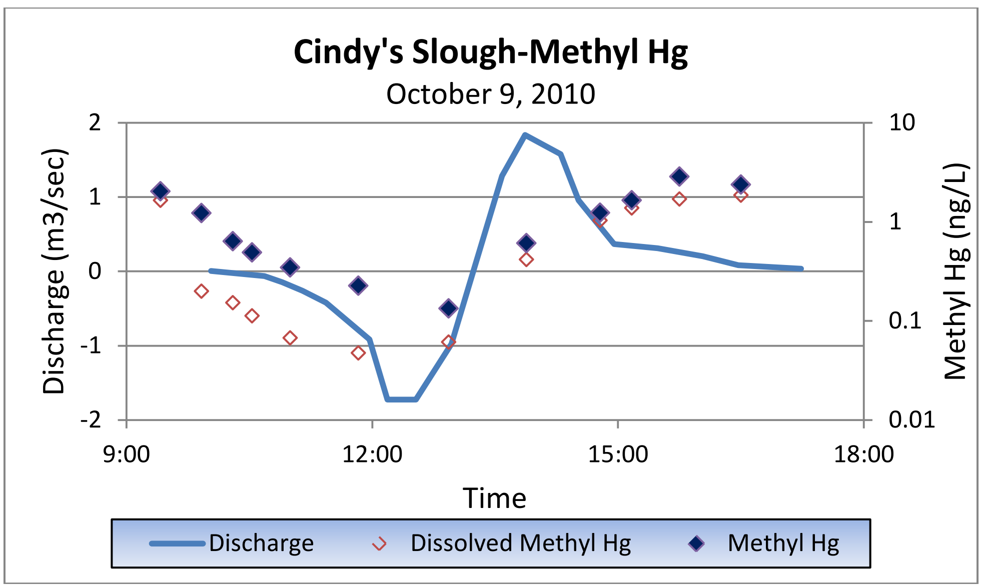


Figure 10-16. Time series discharge, mercury and methylmercury data for tidal cycle on Cindy's Slough characterized on October 9, 2010.

5 CONCLUSIONS

Mendall Marsh as a whole, as well as smaller areas within it, appear to be significant sinks for TSS, Hg and methyl Hg brought into these on flood tides. Comparison of ebb and flood concentrations and net fluxes consistently showed capture of TSS, as well as unfiltered and particulate Hg phases, by the marsh. Filter-passing total Hg was captured by the larger marsh to a lesser extent than particulate total Hg, but the net flux of this form of Hg was seaward during one of two tidal cycles characterized on a smaller area within Mendall Marsh. The net flux of filter-passing methyl Hg varied from inward (import) to outward (export) among the tidal cycles and locations characterized. For five of the six tidal cycles characterized Mendall Marsh was a sink for filter-passing methyl Hg. Mitchell et al. (2012) also observed changes from sink to source behavior in a Chesapeake Bay marsh, Maryland. The one cycle where the marsh was a source for this form of Hg was unique in being a spring tide that fully inundated the high marsh and also produced a very low tide. Results for both tidal cycles characterized on the smaller area within Mendall Marsh revealed net outward fluxes of filter-passing methyl Hg with a 38-fold increase in this flux between a neap and spring tide. Although Mendall Marsh appears under some circumstances to export filter-passing methyl Hg, the magnitude of this export (~0.2 g/day) is estimated to be <5% of that of the Penobscot River (5 to 20 g/day).

This investigation also demonstrated that ebb tide fractions of filter-passing Hg were higher than flood tide fractions. Filter-passing Hg is considered more bioavailable than particulate Hg. Mendall Marsh, while being a net sink for particle-bound Hg, did not export particles with <u>higher</u> inorganic and methyl Hg content.

Overall the results of this investigation should allay concern that Mendall Marsh is exporting Hg and/or methyl Hg to downstream/upstream receiving aquatic systems (Penobscot River and Bay). While there is evidence of a small net export of filter-passing methyl Hg under some tidal conditions, the mass represents <5% of the mass carried by the Penobscot River. The results do point to a potential concern about biotic exposures within Mendall Marsh and especially within the smaller tidal channels that feed the South Marsh River.

6 REFERENCES

Bergamaschi, B.A., J.A. Fleck, B.D. Downing, E. Boss, B. Pellerin, N.K. Ganju, D.H. Schoellhamer, A.A. Byington, W.A. Heim, M. Stephenson, and R. Fujii. 2011. Methyl mercury dynamics in a tidal wetland using in situ optical measurements. Limnology and Oceanography. 56(4):1355-1371.

Goodman, J.E., M.E. Wood, W.R. Gehrels. 2007. A 17-year record of sediment accretion in the salt marshes of Maine (USA). Marine Geology. 242:109-121.

Jordan, T.E., D.L. Correll, D.F. Whigham. 1983. Nutrient flux in the Rhode River-Tidal exchange of nutrients by brackish marshes. Estuarary Coast Shelf Science. 17:651-667.

Merritt, K.A. and A. Amirbahman. 2007. Mercury dynamics in sulfide-rich sediments: Geochemical influence on contaminant mobilization within the Penobscot River estuary, Maine, USA. Geochimica et Cosmochimica Acta. 71:929-941

Merritt, K.A. and A. Amirbahman. 2008. Methylmercury cycling in estuarine sediment pore waters (Penobscot River estuary, Maine, USA). Limnology and Oceanography. 53(3):1064-1075.

Mitchell, C.P.J. and C.C. Gilmour. 2008. Methylmercury production in a Chesapeake Bay salt marsh. Journal of Geophysical Research – Biogeosciences. 113:G00C04.

Mitchell, C.P.J., T.E. Jordan, A. Heyes, C.C. Gilmour. 2012. Tidal exchange of total mercury and methylmercury between a salt marsh and a Chesapeake Bay sub-estuary. Biogeochemistry. doi:10.1007/s10533-011-9691-y (currently “Online First”).

Mueller, D.S. and C R. Wagner. Measuring discharge with acoustic Doppler current profilers from a moving boat. Chapter 22 of Book 3, Section A. Techniques and Methods 3-A22. US Geological Survey.

Temmerman, S., G. Govers, S. Wartel, P. Meire. 2004. Modeling estuarine variations in tidal marsh sedimentation: Response to changing sea level and suspended sediment concentrations. Marine Geology. 212:1-19.

Wood, M.E., J.T. Kelley, D.F. Belknap. 1989. Patterns of sediment accumulation in the tidal marshes of Maine. Estuaries. 12(4):237-246.

APPENDIX 10-1:

Quality Assurances Data

Table A1. Quality control/assurance results for field and equipment blanks.

Date	Location	Type	Equipment	THg (ng/L)	MHg (ng/L)	Notes
7/23/2009	SMR	Field	na	<0.1	<0.020	Poland Springs
7/23/2009	SMR	EQ-Unfilt	Pump/Tubing	0.15	<0.020	Used equipment
7/23/2009	SMR	EQ-Filt	Pump/Tubing/Filter	0.28	0.027	Used equipment
7/23/2009	SMR	EQ-Unfilt	Pump/Tubing	0.23	<0.020	Used equipment
7/23/2009	SMR	EQ-Filt	Pump/Tubing/Filter	0.17	<0.020	Used equipment
5/17/2010	SMR	Field	na	0.11	<0.019	Poland Springs
5/17/2010	SMR	EQ-Unfilt	Pump/Tubing	0.12	<0.019	Used equipment
5/17/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.19	0.021	Used equipment
5/17/2010	SMR	Field	na	0.12	<0.019	Poland Springs
5/17/2010	SMR	EQ-Unfilt	Pump/Tubing	0.11	<0.019	Used equipment
5/17/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.11	0.025	Used equipment
6/18/2010	SMR	Field	na	0.16	0.029	Poland Springs
6/18/2010	SMR	EQ-Unfilt	Pump/Tubing	0.39	0.025	Used equipment
6/18/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.66	0.033	Used equipment
6/18/2010	SMR	Field	na	0.16	<0.019	Poland Springs
6/18/2010	SMR	EQ-Unfilt	Pump/Tubing	0.16	0.019	Used equipment
6/18/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.27	0.036	Used equipment
7/8/2010	OR	Field	na	0.19	<0.021	Poland Springs
7/8/2010	OR	EQ-Unfilt	Pump/Tubing	0.13	0.030	Used equipment
7/8/2010	OR	EQ-Filt	Pump/Tubing/Filter	0.20	0.028	Used equipment
7/15/2010	SMR	Field	na	0.20	0.051	Poland Springs
7/15/2010	SMR	EQ-Unfilt	Pump/Tubing	0.23	0.072	Used equipment
7/15/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.28	0.056	Used equipment
7/15/2010	SMR	Field	na	0.12	0.061	Poland Springs
7/15/2010	SMR	EQ-Unfilt	Pump/Tubing	0.21	<0.019	Used equipment
7/15/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.22	0.042	Used equipment
8/11/2010	SMR	Field	na	0.12	0.050	Poland Springs
8/11/2010	SMR	EQ-Unfilt	Pump/Tubing	0.17	0.037	Used equipment
8/11/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.26	0.048	Used equipment

Table A1. Quality control/assurance results for field and equipment blanks.						
Date	**Location**	**Type**	**Equipment**	**THg (ng/L)**	**MHg (ng/L)**	**Notes**
8/12/2010	SMR	Field	na	<0.1	<0.019	Poland Springs
8/12/2010	SMR	EQ-Unfilt	Pump/Tubing	0.11	0.029	Used equipment
8/12/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.14	0.020	Used equipment
8/26/2010	SMR	Field	na	0.12	0.019	Poland Springs
8/26/2010	SMR	EQ-Unfilt	Pump/Tubing	0.13	0.041	Used equipment
8/26/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.28	0.052	Used equipment
10/11/2010	SMR	Field	na	0.42	<0.019	Poland Springs
10/11/2010	SMR	EQ-Unfilt	Pump/Tubing	0.34	<0.019	Used equipment
10/11/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.40	<0.019	Used equipment
10/11/2010	SMR	EQ-Unfilt	Nalgene filter	0.33	<0.019	TSS <0.5 mg/L
9/9/2010	SMR	Field	na	<0.10	<0.019	Poland Springs
9/9/2010	SMR	EQ-Unfilt	Pump/Tubing	0.12	<0.019	Used equipment
9/9/2010	SMR	EQ-Filt	Pump/Tubing/Filter	0.19	<0.019	Used equipment
9/9/2010	SMR	Field	na	<0.10	<0.019	Poland Springs
9/9/2010	SMR	EQ-Unfilt	Pump/Tubing	0.13	<0.019	Used equipment
9/9/2010	SMR	EQ-Filt	Pump/Tubing/Filter	<0.10	<0.019	Used equipment

Table A2. Laboratory Matrix Duplicates - Total Suspended Solids (TSS)							
Date	**Sample ID**	**Type**	**Analyte**	**Replicate 1**	**Replicate 2**	**%RPD**	**ABS[%RPD]**
6/26/09	SMR-BLT-W-TSS	MD	TSS	1143	1128	1.32	1.32
6/26/09	SMR-LT-C-TSS	MD	TSS	132	133	-0.75	0.75
6/26/09	SMR-DUP-TSS	MD	TSS	131	136	-3.75	3.75
7/08/09	OR-TC-2-TSS	MD	TSS	818	834	-1.94	1.94
7/23/09	SMR2-BLT-C-TSS	MD	TSS	643	649	-0.93	0.93
7/23/09	SMR2-MFT-W-L-TSS	MD	TSS	240	245	-2.06	2.06
7/23/09	SMR2-BHT-W-L-TSS	MD	TSS	214	220	-2.76	2.76
7/23/09	SMR2-TC4-TSS	MD	TSS	685	700	-2.17	2.17
5/17/10	SMR3-MFT-E-L-TSS	MD	TSS	263	270	-2.63	2.63
5/17/10	SMR3-BHT-W-LD-TSS	MD	TSS	39.5	39	1.27	1.27
5/17/10	SMR3-BLT-E-L-TSS	MD	TSS	68.7	70.6	-2.73	2.73
5/17/10	SMR3-BLT-W-L-TSS	MD	TSS	77.3	78.4	-1.41	1.41
5/18/10	NMC1-1.5-TSS	MD	TSS	23.2	19.4	17.8	17.8
6/18/10	SMR4-MFT-C-.5-TSS	MD	TSS	83.6	86.2	-3.06	3.06
6/18/10	SMR4-BHT-W-4-TSS	MD	TSS	43.5	45.8	-5.15	5.15
6/18/10	SMR4-MET-W-2-TSS	MD	TSS	75.6	74.6	1.33	1.33
6/18/10	SMR4-BLT-C-.5-TSS	MD	TSS	105	105	0.00	0.00
6/23/10	CS4-LT-TSS	MD	TSS	19.9	20.2	-1.50	1.50
7/15/10	SMR5-ALT-E-.5-TSS	MD	TSS	201	201	0.00	0.00
7/15/10	SMR5-BHT-C-4-TSS	MD	TSS	19.4	19.6	-1.03	1.03
7/15/10	SMR5-BLT-E-.5-TSS	MD	TSS	211	214	-1.41	1.41
7/15/10	SMR5-BLT-C-.5-TSS	MD	TSS	280	286	-2.12	2.12
8/11/10	CS2-BLT-007-TSS	MD	TSS	92.1	93.4	-1.40	1.40
8/12/10	CS3-BLT-007-TSS	MD	TSS	140	146	-4.20	4.20
8/12/10	CS3-BLT-008-TSS	MD	TSS	38.1	39.4	-3.35	3.35
8/26/10	CS4-2-TSS	MD	TSS	44	42.2	4.18	4.18
8/26/10	CS4-10-TSS	MD	TSS	48.1	49.1	-2.06	2.06
9/09/10	SMR6-ALT-C-.5-TSS	MD	TSS	146	149	-2.03	2.03
9/09/10	SMR6-BHT-E-4-TSS	MD	TSS	29.1	30.4	-4.37	4.37

Table A2. Laboratory Matrix Duplicates - Total Suspended Solids (TSS)							
Date	**Sample ID**	**Type**	**Analyte**	**Replicate 1**	**Replicate 2**	**%RPD**	**ABS[%RPD]**
9/09/10	SMR6-BLT-E-.5-TSS	MD	TSS	110	114	-3.57	3.57
9/09/10	SMR6-BLT-W-.5-TSS	MD	TSS	98.3	94	4.47	4.47
10/09/10	CS5-2-TSS	MD	TSS	94	93.1	0.96	0.96
10/09/10	CS5-11-TSS	MD	TSS	48.3	49.7	-2.86	2.86
					Mean	**-0.84**	**2.75**
					Median	**-1.94**	**2.06**
					Min	**-5.15**	**0.00**
					Max	**17.8**	**17.8**

Table A3. Laboratory Matrix Duplicates - Total Mercury							
Date	Sample ID	Type	Analyte	Replicate 1	Replicate 2	%RPD	ABS[%RPD]
6/26/09	SMR-LT-C-THG	MD	THG	106	113	-6.39	6.4
6/26/09	SMR-AHT-W-H-THG	MD	THG	6.77	6.85	-1.17	1.2
7/08/09	OR-LT-C-THG	MD	THG	13.7	13.3	2.96	3.0
7/08/09	OR-BLT-W-THG	MD	THG	15.8	16.7	-5.54	5.5
7/08/09	OR-DAM-THG	MD	THG	2.84	2.82	0.71	0.7
7/23/09	SMR2-ALT-E-THG	MD	THG	220	213	3.23	3.2
7/23/09	SMR2-MFT-E-M-THG	MD	THG	27.1	25.7	5.30	5.3
7/23/09	SMR2-MFT-W-M-THG	MD	THG	65.8	73.8	-11.5	11.5
7/23/09	SMR2-AHT-E-M-THG	MD	THG	9.07	9.83	-8.04	8.0
7/23/09	SMR2-MET-C-L-THG	MD	THG	10.2	10	1.98	2.0
7/23/09	SMR2-TC5-THG	MD	THG	72.5	74.7	-2.99	3.0
4/01/10	WPT593-THG	MD	THG	3.77	3.63	3.78	3.8
4/01/10	DIS1	MD	THG	58.8	51.1	14.0	14.0
5/17/10	SMR3-MFT-C-L-THG	MD	THG	97.6	84.8	14.0	14.0
5/17/10	SMR3-BHT-W-L-THG	MD	THG	39.6	40.8	-2.99	3.0
5/17/10	SMR3-MET-E-M-THG	MD	THG	5.83	5.65	3.14	3.1
5/17/10	SMR3-BLT-E-L-THG	MD	THG	60.8	61.3	-0.82	0.8
5/18/10	NMC1-1.5-THG	MD	THG	10.2	10.5	-2.90	2.9
6/18/10	SMR4-ALT-W-.5-THG	MD	THG	15.4	16.7	-8.10	8.1
6/18/10	SMR4-MFT-C-.5-THG	MD	THG	77.4	78	-0.77	0.8
6/18/10	SMR4-BHT-W-4D-THG	MD	THG	27.3	29.2	-6.73	6.7
6/18/10	SMR4-AHT-W-4-THG	MD	THG	9.83	9.81	0.20	0.2
6/18/10	SMR4-MET-W-2-THG	MD	THG	54.1	53.1	1.87	1.9
6/23/10	CS4-LT-THG	MD	THG	24.2	24.8	-2.45	2.4
7/15/10	SMR5-MFT-E-.5-THG	MD	THG	34.8	42.7	-20.4	20.4
7/15/10	SMR5-BHT-C-2-THG	MD	THG	16.2	17.3	-6.57	6.6
7/15/10	SMR5-AHT-C-2-THG	MD	THG	7.34	7.07	3.75	3.7
7/15/10	SMR5-BLT-W-.5-THG	MD	THG	67.4	73	-7.98	8.0
8/11/10	CS2-MET-010-THG	MD	THG	20.1	22	-9.03	9.0

Table A3. Laboratory Matrix Duplicates - Total Mercury							
Date	**Sample ID**	**Type**	**Analyte**	**Replicate 1**	**Replicate 2**	**%RPD**	**ABS[%RPD]**
8/11/10	CS2-BLT-007-THG	MD	THG	226	258	-13.2	13.2
8/12/10	CS3-BLT-007-THG	MD	THG	194	191	1.56	1.6
8/12/10	CS3-BLT-008-THG	MD	THG	35.6	31	13.8	13.8
8/26/10	CS4-4-THG	MD	THG	13.1	13.5	-3.01	3.0
8/26/10	CS4-10-THG	MD	THG	53.7	42.7	22.8	22.8
9/09/10	SMR6-ALT-W-.5-THG	MD	THG	56.4	53.6	5.09	5.1
9/09/10	SMR6-MFT-W-.5-THG	MD	THG	18.5	18.9	-2.14	2.1
9/09/10	SMR6-AHT-E-.5-THG	MD	THG	5.48	5.43	0.92	0.9
9/09/10	SMR6-MET-C-2-THG	MD	THG	25.3	25.5	-0.79	0.8
9/09/10	SMR6-BLT-W-.5-THG	MD	THG	66.7	61.6	7.95	8.0
10/09/10	CS5-2-THG	MD	THG	63.5	73	-13.9	13.9
10/09/10	CS5-11-THG	MD	THG	65.5	40.6	46.9	46.9
					Mean	**0.41**	**7.11**
					Median	**-0.79**	**3.78**
					Min	**-20.4**	**0.20**
					Max	**46.9**	**46.9**

Table A4. Laboratory Matrix Duplicates - Methylmercury							
Date	Sample ID	Type	Analyte	Replicate 1	Replicate 2	%RPD	ABS[%RPD]
6/26/09	SMR-LT-C-THG	MD	MHG	2.41	2.72	-12.09	12.1
6/26/09	SMR-AHT-W-H-THG	MD	MHG	0.277	0.258	7.10	7.1
7/08/09	OR-LT-C-THG	MD	MHG	0.394	0.399	-1.26	1.3
7/08/09	OR-BLT-W-THG	MD	MHG	0.389	0.399	-2.54	2.5
7/23/09	SMR2-ALT-E-THG	MD	MHG	5.71	6.01	-5.12	5.1
7/23/09	SMR2-MFT-E-M-THG	MD	MHG	0.713	0.717	-0.56	0.6
7/23/09	SMR2-MFT-W-M-THG	MD	MHG	1.92	1.83	4.80	4.8
7/23/09	SMR2-AHT-E-M-THG	MD	MHG	0.191	0.182	4.83	4.8
7/23/09	SMR2-MET-C-L-THG	MD	MHG	0.191	0.18	5.93	5.9
7/23/09	SMR2-TC5-THG	MD	MHG	12.1	11.5	5.08	5.1
4/01/10	WPT593-THG	MD	MHG	0.101	0.106	-4.83	4.8
4/01/10	DIS2	MD	MHG	1.1	1.28	-15.1	15.1
5/17/10	SMR3-MFT-C-L-THG	MD	MHG	2.42	2.39	1.25	1.2
5/17/10	SMR3-BHT-W-L-THG	MD	MHG	0.672	0.675	-0.45	0.4
5/17/10	SMR3-MET-E-M-THG	MD	MHG	0.126	0.127	-0.79	0.8
5/17/10	SMR3-BLT-E-L-THG	MD	MHG	1.05	1.1	-4.65	4.7
5/18/10	NMC1-1.5-THG	MD	MHG	0.174	0.176	-1.14	1.1
6/18/10	SMR4-ALT-W-.5-THG	MD	MHG	0.286	0.339	-17.0	17.0
6/18/10	SMR4-MFT-C-.5-THG	MD	MHG	1.65	1.64	0.61	0.6
6/18/10	SMR4-BHT-W-4D-THG	MD	MHG	0.481	0.506	-5.07	5.1
6/18/10	SMR4-AHT-W-4-THG	MD	MHG	0.198	0.182	8.42	8.4
6/18/10	SMR4-MET-W-2-THG	MD	MHG	1.1	1.04	5.61	5.6
6/23/10	CS4-LT-THG	MD	MHG	5.88	5.87	0.17	0.2
7/15/10	SMR5-MFT-E-.5-THG	MD	MHG	0.7	0.631	10.37	10.4
7/15/10	SMR5-BHT-C-2-THG	MD	MHG	0.363	0.32	12.59	12.6
7/15/10	SMR5-AHT-C-2-THG	MD	MHG	0.111	0.129	-15.00	15.0
7/15/10	SMR5-BLT-W-.5-THG	MD	MHG	1.53	1.61	-5.10	5.1
8/11/10	CS2-MET-009-THG	MD	MHG	1.98	1.96	1.02	1.0
8/11/10	CS2-MET-010-THG	MD	MHG	2.25	2.24	0.45	0.4

Table A4. Laboratory Matrix Duplicates - Methylmercury							
Date	**Sample ID**	**Type**	**Analyte**	**Replicate 1**	**Replicate 2**	**%RPD**	**ABS[%RPD]**
8/11/10	CS2-BLT-007-THG	MD	MHG	5.21	5.36	-2.84	2.8
8/11/10	CS2-BLT-DK059-THG	MD	MHG	4.25	4.16	2.14	2.1
8/11/10	CS2-BLT-DK059-DHG	MD	MHG	4.82	4.69	2.73	2.7
8/12/10	CS3-BLT-007-THG	MD	MHG	5.49	4.79	13.6	13.6
8/12/10	CS3-BLT-008-THG	MD	MHG	3.2	3.34	-4.28	4.3
8/26/10	CS4-4-THG	MD	MHG	0.294	0.298	-1.35	1.4
8/26/10	CS4-10-THG	MD	MHG	3.6	3.74	-3.81	3.8
9/09/10	SMR6-ALT-W-.5-THG	MD	MHG	1.32	1.2	9.52	9.5
9/09/10	SMR6-BHT-E-4-THG	MD	MHG	0.848	0.855	-0.82	0.8
9/09/10	SMR6-MET-E-2-THG	MD	MHG	0.256	0.245	4.39	4.4
9/09/10	SMR6-BLT-W-.5-THG	MD	MHG	1.41	1.32	6.59	6.6
10/09/10	CS5-2-THG	MD	MHG	1.22	1.11	9.44	9.4
10/09/10	CS5-11-THG	MD	MHG	2.85	2.74	3.94	3.9
					Mean	**0.40**	**5.34**
					Median	**0.31**	**4.73**
					Min	**-17.0**	**0.17**
					Max	**13.6**	**17.0**

Table A5. Field Duplicates							
Date	Sample ID	Type	Analyte	Replicate 1	Replicate 2	%RPD	ABS[%RPD]
6/26/09	SMR-DUP-DHG	FD	THG	3.49	3.65	-4.48	4.5
6/26/09	SMR-DUP-THG	FD	MHG	1.96	5.33	-92.5	92.5
6/26/09	SMR-DUP-DHG	FD	MHG	0.16	0.146	9.15	9.2
6/26/09	SMR-DUP-THG	FD	THG	86.5	195	-77.1	77.1
6/26/09	SMR-DUP-TSS	FD	TSS	134	135	-0.74	0.7
7/23/09	SMR2-DUP-THG	FD	MHG	1.04	3.51	-109	109
7/23/09	SMR2-DUP-DHG	FD	MHG	0.0846	0.077	9.41	9.4
7/23/09	SMR2-DUP-THG	FD	THG	40.8	93.6	-78.57	78.6
7/23/09	SMR2-DUP-DHG	FD	THG	1.82	1.75	3.92	3.9
7/23/09	SMR2-DUP-TSS	FD	TSS	116	140	-18.75	18.8
5/17/10	SMR3-DUP-THG	FD	THG	39.6	32.3	20.31	20.3
5/17/10	SMR3-DUP-DHG	FD	THG	1.14	1.18	-3.45	3.4
5/17/10	SMR3-DUP-THG	FD	MHG	0.672	0.554	19.25	19.2
5/17/10	SMR3-DUP-MHG	FD	MHG	0.0549	0.0505	8.35	8.3
5/17/10	SMR3-DUP-TSS	FD	TSS	44	39.2	11.54	11.5
6/18/10	SMR4-DUP-THG	FD	THG	27.3	28.8	-5.35	5.3
6/18/10	SMR4-DUP-DHG	FD	THG	1.15	1.09	5.36	5.4
6/18/10	SMR4-DUP-THG	FD	MHG	0.481	0.522	-8.18	8.2
6/18/10	SMR4-DUP-DHG	FD	MHG	0.0366	0.0209	54.61	54.6
6/18/10	SMR4-DUP-TSS	FD	TSS	36.9	43.5	-16.42	16.4
7/15/10	SMR5-DUP-THG	FD	THG	17.3	17.9	-3.41	3.4
7/15/10	SMR5-DUP-DHG	FD	THG	1.46	1.39	4.91	4.9
7/15/10	SMR5-DUP-THG	FD	MHG	0.654	0.628	4.06	4.1
7/15/10	SMR5-DUP-DHG	FD	MHG	0.0363	0.0348	4.22	4.2
7/15/10	SMR5-DUP-TSS	FD	TSS	39.3	42.1	-6.88	6.9
9/09/10	SMR6-DUP-THG	FD	THG	17.7	16.2	8.85	8.8
9/09/10	SMR6-DUP-DHG	FD	THG	0.777	0.882	-12.66	12.7
9/09/10	SMR6-DUP-THG	FD	MHG	0.306	0.288	6.06	6.1
9/09/10	SMR6-DUP-DHG	FD	MHG	0.0359	0.0188	62.52	62.5

Table A5. Field Duplicates							
Date	**Sample ID**	**Type**	**Analyte**	**Replicate 1**	**Replicate 2**	**%RPD**	**ABS[%RPD]**
9/09/10	SMR6-DUP-TSS	FD	TSS	19.9	19.9	0.00	0.0
8/26/10	CS4-DUP-THG	FD	MHG	0.125	0.136	-8.43	8.4
8/26/10	CS4-DUP-DHG	FD	MHG	0.0554	0.0281	65.4	65.4
8/26/10	CS4-DUP-THG	FD	THG	6.85	6.76	1.32	1.3
8/26/10	CS4-DUP-DHG	FD	THG	1.4	1.24	12.1	12.1
8/26/10	CS4-DUP-TSS	FD	TSS	10.4	9.88	5.13	5.1
					Mean	**-3.7**	**21.8**
					Median	**3.92**	**8.4**
					Min	**-109**	**0.00**
					Max	**65.4**	**109**

APPENDIX 10-2

Data Files

Table B1. Small tidal channel results for eastern Mendall Marsh.

WPT	Coordinates	Sample IDs	Datetime (EDT)	TSS mg/L	THg ng/L	FTHg ng/L	MHg ng/L	%MeHg	FMHg ng/L
473	N44 35 09.7 W68 51 32.1	TC-1	6/26/09 16:43	2.11	22.6	18.8	8.48	37.52	7.06
474	N44 35 15.2 W68 51 38.2	TC-2	6/26/09 17:00	11.9	19.9	11.5	3.66	18.39	3.28
599	N44.59172 W68.85910	599	4/01/10 14:31		16.6		1.14	6.87	
600	N44.59039 W68.85848	600	4/01/10 14:38		9.82		1.23	12.53	
601	N44.58976 W68.85829	601	4/01/10 14:46		18.2		0.779	4.28	
602	N44.58897 W68.85734	602	4/01/10 14:55		15.7		0.744	4.74	
603	N44.58999 W68.86189	603	4/01/10 15:12		16.7		2.37	14.19	
604	N44.58788 W68.86062	604	4/01/10 15:20		12.3		1.89	15.37	
605	N44.58589 W68.85931	605	4/01/10 15:26		29.3		1.82	6.21	

Table B2. Small tidal channel sampling results for western Mendall Marsh.

Station ID	Distance (m)	Tide Stage	Datetime (EDT)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
669		MET	8/11/10 15:30	10.5	8.38	5.08	3.3	2.19	2.04	0.15
T-190	191	MET	8/11/10 15:50	9.47	13.5	6.35	7.15	2.37	1.79	0.58
T-250	250	MET	8/11/10 16:10	19.3	18.2	5.96	12.2	1.98	1.72	0.26
T-320	320	MET	8/11/10 16:25	26.2	20.1	7.06	13.0	2.25	1.62	0.63
T-369	369	MET	8/11/10 16:40	11	12	8.23	3.77	2.04	1.84	0.20
T-357	357	MET	8/11/10 17:03	11.7	10.7	6.11	4.59	1.95	1.87	0.08
T-408	408	MET	8/11/10 17:13	3	9.62	7.32	2.3	3.57	3.3	0.27
T-455	456	MET	8/11/10 17:25	2.12	12.8	7.77	5.03	4.55	4.29	0.26
T-55	55	BLT	8/11/10 17:45	92.1	226	5.7	220	5.21	1.59	3.62
669		BLT	8/11/10 18:00	21.1	25	9.11	15.9	3.8	3.75	0.05
T-190	191	BLT	8/11/10 18:25	7.36	10.7	6.07	4.63	1.6	1.54	0.06
T-250	250	BLT	8/11/10 18:45	7.41	9.77	5.78	3.99	1.72	1.56	0.16
T-320	320	BLT	8/11/10 19:05	17.4	13.9	10.1	3.8	2.14	1.02	1.12
64		BLT	8/11/10 19:30	3.43	12.7	9.39	3.31	2.71	2.42	0.29
T-408	408	BLT	8/11/10 19:40	4.86	8.15	6.82	1.33	4.25	4.82	
T-408	408	BLT	8/11/10 20:00	2.32	11.9	9.18	2.72	4.93	4.77	0.16
T-455	456	BLT	8/11/10 19:50	1.34	11.1	8.77	2.33	6.01	5.26	0.75
T-55	55	BLT	8/12/10 6:35	140	194	7.12	187	5.49	2.07	3.42

Table B2. Small tidal channel sampling results for western Mendall Marsh.

Station ID	Distance (m)	Tide Stage	Datetime (EDT)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
669		BLT	8/12/10 7:00	4.17	9.21	6.79	2.42	3.96	3.62	0.34
T-190	191	BLT	8/12/10 7:08	8.08	13.5	7.26	6.24	2.37	2.3	0.07
T-250	250	BLT	8/12/10 7:15	9.55	13.4	7.29	6.11	2.76	2.3	0.46
T-320	320	BLT	8/12/10 7:25	14.9	17.2	7.52	9.68	2.78	2.2	0.58
64		BLT	8/12/10 7:45	3.92	13.5	9.82	3.68	3.69	3.13	0.56
T-408	408	BLT	8/12/10 7:55	1.77	14.5	8.75	5.75	5.46	4.54	0.92
T-357	357	BLT	8/12/10 8:15	25.3	11.2	5.92	5.28	2.33	2.08	0.25
T-408	408	BLT	8/12/10 8:25	2.38	9.73	7.29	2.44	3.83	3.73	0.10
T-455	456	BLT	8/12/10 8:40	1.76	11.2	6.4	4.8	2.94	2.49	0.45
T-0	0	BLT	8/12/10 9:40	38.1	35.6	9.74	25.9	3.2	2.54	0.66

Table B3. Tidal cycle sampling results for South Marsh River at Peninsula Location, June 26, 2009.

Sample ID	Date/time	Water Depth m	Xsect Area m^2	Sample Depth m	Cell Q m^3/s	Temp C	Salinity ppth	Spec Cond µS/cm	TSS mg/L	THg ng/L	FTHg ng/L	PHg ng/L	MHg ng/L	FMHg ng/L	PMHg
BLT-E-M	6/26/09 7:08	1.22	93.5	0.6	14.1	17.95	0.84	1632	161	140	3.84	136	3.27	0.304	2.97
BLT-C-M	6/26/09 7:20	1.07	78.3	0.5	16.2	18.07	0.36	739	427	262	4.05	258	7.61	0.306	7.30
BLT-W-M	6/26/09 7:30	1.22	93.5	0.6	11.0	18.02	0.37	757	1143	735	4.24	731	26.7	0.22	26.5
ALT-E	6/26/09 8:56	0.60	35.8	0.3	-0.02	17.84	0.22	444	74.2	50.4	3.76	46.6	1.38	0.222	1.16
ALT-C	6/26/09 8:45	0.60	35.8	0.3	-0.86	17.93	0.15	316	132	106	4.23	102	2.41	0.256	2.15
ALT-W	6/26/09 8:36	0.80	52.8	0.4	-0.23	17.82	0.26	559	344	389	3.5	386	9.02	0.191	8.83
MFT-E-L	6/26/09 11:40	2.00	182.3	1.5	-27.4	18.62	0.93	1828	411	469	3.66	465	13.3	0.185	13.1
MFT-E-M	6/26/09 11:30	2.00	182.3	0.5	-32.7	18.55	1.03	2010	152	137	3.37	134	3.73	0.143	3.59
MFT-W-L	6/26/09 11:52	2.80	287.3	1.5	-45.8	18.78	1.09	2123	135	195	3.65	191	5.33	0.146	5.18
MFT-W-M	6/26/09 11:48	2.80	287.3	0.5	-53.3	19.01	0.76	1521	106	71	3.55	67.5	1.69	0.195	1.50
AHT-E-H	6/26/09 14:22	4.60	562.1	0.5	24.8	19.27	1.64	3135	13.1	11.1	3.48	7.6	0.298	0.146	0.152
AHT-E-M	6/26/09 14:28	4.60	562.1	2.0	11.1	17.77	3.29	6023	9.41	11.2	3.42	7.8	0.234	0.149	0.085

Table B3. Tidal cycle sampling results for South Marsh River at Peninsula Location, June 26, 2009.															
Sample ID	**Date/time**	**Water Depth m**	**Xsect Area m^2**	**Sample Depth m**	**Cell Q m^3/s**	**Temp C**	**Salinity ppth**	**Spec Cond µS/cm**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg**
AHT-E-L	6/26/09 14:32	4.60	562.1	4.7	2.05	14.43	11.38	19061	95	93.6	2.57	91.0	2.4	0.090	2.31
AHT-W-H	6/26/09 14:50	4.60	562.1	0.5	44.8	19.2	1.86	3522	8.18	8.32	3.67	4.7	0.24	0.151	0.089
AHT-W-M	6/26/09 14:55	4.60	562.1	2.0	39.7	17.89	3.22	5875	7.86	8.86	4.03	4.8	0.243	0.167	0.076
AHT-W-L	6/26/09 15:00	4.60	562.1	4.5	29.5	12.95	15.45	25290	29	21.4	2.14	19.3	0.438	0.068	0.371
MET-E-H	6/26/09 16:58	3.30	358.8	0.5	29.3	19.24	1.4	2832	6.62	7.38	3.83	3.6	0.226	0.181	0.045
MET-E-M	6/26/09 17:02	3.30	358.8	2.0	26.8	18.96	1.46	4258	7.1	7.49	3.25	4.2	0.244	0.157	0.087
MET-E-L	6/26/09 17:08	3.30	358.8	3.0	5.98	12.46	12.46	30299	16	5.81	1.83	4.0	0.143	0.0731	0.070
MET-W-H	6/26/09 16:30	4.10	481.1	0.5	30.4	19.3	1.48	2696	5.89	6.77	3.26	3.5	0.277	0.186	0.091
MET-W-M	6/26/09 16:35	4.10	481.1	2.0	26.9	18.57	2.27	2768	5.27	6.38	3.44	2.9	0.218	0.161	0.057
MET-W-L	6/26/09 16:40	4.10	481.1	3.9	1.06	12.14	18.8	28900	9.25	6.57	1.83	4.7	0.145	0.0799	0.065

Table B4. Tidal cycle sampling results for South Marsh River at Peninsula Location, July 23, 2009.

Sample ID	Date/time (EDT)	Water Depth (meters)	Sample Depth (meters)	Cell Area m2	Cell Q m3/s	Temp C	Salinity (ppth)	SpecCond (µS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
MFT-W-M	7/23/09 9:30	2.5	0.5	41.9	-34.9	19.9	5.39	10,030	122	65.8	1.94	63.9	1.920	0.092	1.82
MFT-W-L	7/23/09 9:38	2.5	2	41.9	-33.1	19.79	6.25	10,999	240	129	1.79	127	4.520	0.107	4.41
MFT-C-M	7/23/09 10:01	3	0.5	53.6	-25.4	19.82	6.4	11,229	120	73.9	1.80	72.1	2.070	0.111	1.96
MFT-C-L	7/23/09 10:08	3	2.5	53.6	-23.1	19.69	6.83	11,910	212	159	1.65	157	4.100	0.075	4.02
MFT-E-M	7/23/09 10:29	3.29	0.5	60.7	-28.4	19.47	7.46	12,931	50.1	27.1	1.66	25.4	0.713	0.108	0.605
MFT-E-L	7/23/09 10:42	3.29	3	60.7	-24.5	18.89	8.85	15,146	140	93.6	1.75	91.9	3.510	0.077	3.43
BHT-E-H	7/23/09 11:17	4.3	0.5	56.4	-6.8	19.07	8.58	14,720	24.2	12.0	1.73	10.3	0.343	0.087	0.256
BHT-E-M	7/23/09 11:24	4.3	2	56.4	-8.5	18.7	9.53	16,186	31.3	23.6	1.72	21.9	0.548	0.080	0.468
BHT-E-L	7/23/09 11:30	4.3	4	56.4	-13.5	18.23	10.7	18,061	45.1	29.4	1.73	27.7	0.583	0.058	0.525
BHT-C-H	7/23/09 11:39	4.3	0.5	56.4	-4.9	18.88	9.07	15,485	17.1	11.1	1.74	9.36	0.233	0.071	0.162
BHT-C-M	7/23/09 11:44	4.3	2	56.4	-10.2	18.29	10.68	18,056	17.6	10.0	1.74	8.22	0.240	0.099	0.141

Table B4. Tidal cycle sampling results for South Marsh River at Peninsula Location, July 23, 2009.

Sample ID	Date/time (EDT)	Water Depth (meters)	Sample Depth (meters)	Cell Area m2	Cell Q m3/s	Temp C	Salinity (ppth)	SpecCond (µS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
BHT-C-L	7/23/09 11:49	4.3	4	56.4	-9.6	17.84	11.61	19,444	29.6	17.9	1.71	16.2	0.376	0.054	0.322
BHT-W-H	7/23/09 11:56	4.7	0.5	63.7	-5.0	19.17	8.98	15,489	13.6	8.93	1.76	7.17	0.218	0.075	0.143
BHT-W-M	7/23/09 12:00	4.7	2.25	63.7	-14.0	17.84	11.62	19,463	19	20.5	1.73	18.8	0.274	0.070	0.204
BHT-W-L	7/23/09 12:06	4.7	4.5	63.7	-15.9	16.85	14.25	23,480	214	96.9	1.55	95.4	2.050	0.078	1.97
AHT-W-H	7/23/09 13:07	4.6	0.5	61.8	26.0	19.27	7.79	13,430	12	9.1	1.68	7.40	0.181	0.070	0.111
AHT-W-M	7/23/09 13:13	4.6	2.3	61.8	16.1	17.71	11.22	18,858	14	24.9	1.56	23.3	0.196	0.066	0.130
AHT-W-L	7/23/09 13:18	4.5	4.2	60.0	-1.2	15.03	17.38	28,155	30	19.3	1.24	18.1	0.355	0.055	0.300
AHT-C-H	7/23/09 13:28	4.2	0.5	54.7	23.0	19.39	7.71	13,360	10	6.7	1.80	4.93	0.185	0.103	0.082
AHT-C-M	7/23/09 13:34	4.2	2	54.7	9.8	17.09	12.69	21,136	13	7.3	1.61	5.72	0.177	0.073	0.104
AHT-C-L	7/23/09 13:41	4.2	4	54.7	8.2	14.45	20.23	32,344	29	20.2	1.25	19.0	0.362	0.050	0.312
AHT-E-H	7/23/09 13:54	4.25	0.5	55.6	19.4	19.53	7.25	12,604	11	6.2	1.78	4.41	0.184	0.100	0.084

Table B4. Tidal cycle sampling results for South Marsh River at Peninsula Location, July 23, 2009.															
Sample ID	**Date/time (EDT)**	**Water Depth (meters)**	**Sample Depth (meters)**	**Cell Area m2**	**Cell Q m3/s**	**Temp C**	**Salinity (ppth)**	**SpecCond (µS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
AHT-E-M	7/23/09 13:59	4.25	2	55.6	-3.9	15.97	16.58	26,966	16	9.1	1.37	7.70	0.191	0.061	0.130
AHT-E-L	7/23/09 14:02	4.25	4	55.6	-10.0	14.19	20.8	33,170	20	13.8	1.12	12.7	0.254	0.041	0.213
MET-E-M	7/23/09 14:57	3.5	0.5	66.0	33.7	19.93	6.61	11,564	9	5.8	1.82	3.98	0.179	0.100	0.079
MET-E-L	7/23/09 15:05	3.5	3	66.0	4.4	14.4	20.53	32,831	20	12.7	1.21	11.5	0.210	0.046	0.164
MET-C-M	7/23/09 15:16	3.2	0.5	58.5	29.3	19.91	6.55	11,472	11	6.7	1.72	4.98	0.238	0.077	0.161
MET-C-L	7/23/09 15:23	3.2	2.5	58.5	3.7	14.23	19.75	31,531	18	10.2	1.14	9.06	0.191	0.047	0.144
MET-W-M	7/23/09 15:32	3.14	0.5	57.0	25.1	19.67	7.47	12,923	10	6.9	1.87	5.04	0.269	0.129	0.140
MET-W-L	7/23/09 15:38	3.14	2.5	57.0	8.6	15.05	18.79	30,088	20	15.9	1.29	14.6	0.281	0.057	0.224
BLT-W-L	7/23/09 17:38	1.1	0.5	26.8	7.5	19.91	3.45	6,295	650	505.0	2.26	503	14.9	0.224	14.7
BLT-C-L	7/23/09 17:50	0.84	0.5	18.6	9.9	19.71	2.85	5,266	643	418.0	2.24	416	17.3	0.202	17.1
BLT-E-L	7/23/09 17:59	0.88	0.5	19.8	7.5	19.81	3	5,524	269	174.0	2.29	172	7.11	0.228	6.88

Table B4. Tidal cycle sampling results for South Marsh River at Peninsula Location, July 23, 2009.															
Sample ID	**Date/time (EDT)**	**Water Depth (meters)**	**Sample Depth (meters)**	**Cell Area m2**	**Cell Q m3/s**	**Temp C**	**Salinity (ppth)**	**SpecCond (µS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
ALT-W-L	7/23/09 20:17	1.2	0.5	30.2	-11.2	19.41	3.26	5,958	113	172.0	2.22	170	6.02	0.218	5.80
ALT-C-L	7/23/09 20:25	1.2	0.5	30.2	-13.9	19.45	4.62	8,277	293	161.0	2.03	159	6.28	0.187	6.09
ALT-E-L	7/23/09 20:35	1.26	0.5	32.2	-13.5	19.37	4.88	8,704	262	220.0	2.84	217	5.71	0.160	5.55

Table B5. Tidal cycle sampling results for South Marsh River at Boat Launch Location, April 1, 2010.														
Sample ID	**Date/time (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Discharge m3/sec**	**Temp (C)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
MFT-C-M	4/01/10 10:35	0.5	2.8	155	6.42	0.08	159	85.6	95.6	2.84	92.76	1.64	0.11	1.53
MFT-C-L	4/01/10 10:35	2.5	2.8	155	6.38	0.08	169	80.6	70.6	2.82	67.78	1.25	0.17	1.08
MET-C-M	4/01/10 16:42	0.5	3	-	6.64	0.07	156	39.4	30.1	2.22	27.88	0.564	0.0933	0.471
MET-C-L	4/01/10 16:42	2.7	3	-	6.70	0.07	157	76.4	49.6	2.36	47.24	0.907	0.105	0.802

Table B6. Tidal cycle sampling results for South Marsh River at Boat Launch Location, May 17, 2010.

Sample ID	Date/time (EDT)	Sample Depth (m)	Water Depth (m)	Q (m3/sec)	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	MHg ng/L	PMHg ng/L
MFT-W-M	5/17/10 11:39	0.5	2.5	-196	12.62	8.08	13880	41.8	38.7	1.42	37.28	0.913	0.0637	0.8493
MFT-W-L	5/17/10 11:39	2	2.5	-196	12.63	8.09	13920	52.7	49	1.34	47.66	1.17	0.0565	1.1135
MFT-C-M	5/17/10 11:24	0.5	2.5	-173	12.33	8.12	13968	80	83	3	79.86	1.49	0.0809	1.4091
MFT-C-L	5/17/10 11:24	2	2.5	-173	12.2	8.58	14709	114	97.6	2.1	95.5	2.42	0.0769	2.3431
MFT-E-M	5/17/10 11:06	0.5	2.8	-131	12.4	7.86	13567	156	149	1.41	147.59	4.31	0.0643	4.2457
MFT-E-L	5/17/10 11:06	2	2.8	-131	12.43	7.81	13428	263	286	1.45	284.55	7.96	0.0543	7.9057
BHT-E-H	5/17/10 12:50	0.5	4.3	-135	11.83	12.01	20080	13.6	10	1.51	8.49	0.216	0.0525	0.1635
BHT-E-M	5/17/10 12:50	2	4.3	-135	10.58	14.46	23850	23	25.6	2.79	22.81	0.339	0.0561	0.2829
BHT-E-L	5/17/10 12:50	4	4.3	-135	10.01	14.77	24345	39.1	44.2	2.07	42.13	0.513	0.0678	0.4452
BHT-C-H	5/17/10 13:10	0.5	4.2	-93	13.46	9.81	16662	10.6	6.71	1.57	5.14	0.153	0.0597	0.0933
BHT-C-M	5/17/10 13:10	2	4.2	-93	10.34	15.13	24850	16.7	15.7	1.78	13.92	0.294	0.0594	0.2346

Table B6. Tidal cycle sampling results for South Marsh River at Boat Launch Location, May 17, 2010.														
Sample ID	**Date/time (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q (m3/sec)**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**MHg ng/L**	**PMHg ng/L**
BHT-C-L	5/17/10 13:10	4	4.2	-93	9.87	15.25	25086	36.5	36.3	2.54	33.76	0.53	0.0575	0.4725
BHT-W-H	5/17/10 13:03	0.5	4.5	-99	12.99	10.71	18056	9.86	6.36	1.43	4.93	0.141	0.0743	0.0667
BHT-W-M	5/17/10 13:03	2	4.5	-99	9.85	15.42	25317	18.2	13.7	1.25	12.45	0.247	0.0492	0.1978
BHT-W-L	5/17/10 13:03	4	4.5	-99	9.38	16.78	27394	44	39.6	1.14	38.46	0.672	0.0549	0.6171
AHT-W-H	5/17/10 15:44	0.5	4.1	58	14.5	9.02	15387	8	7.83	2.14	5.69	0.102	0.0491	0.0529
AHT-W-M	5/17/10 15:44	2	4.1	58	9.46	17.89	29036	9.08	5.68	2.39	3.29	0.107	0.0619	0.0451
AHT-W-L	5/17/10 15:44	3.7	4.1	58	7.92	24.22	38430	13.6	8.34	2.18	6.16	0.13	0.0241	0.1059
AHT-C-H	5/17/10 15:26	0.5	4.2	5	14.13	9.06	15448	8.24	6	1.48	4.52	0.118	0.059	0.059
AHT-C-M	5/17/10 15:26	2	4.2	5	10.28	15.39	25271	8.28	5.48	1.27	4.21	0.109	0.0568	0.0522
AHT-C-L	5/17/10 15:26	3.7	4.2	5	7.83	24.34	38618	14.4	8.62	0.888	7.732	0.129	0.0127	0.1163
AHT-E-H	5/17/10 15:08	0.5	4.5	-4	14.24	9.7	16790	8.3	6.09	1.54	4.55	0.144	0.0637	0.0803

Table B6. Tidal cycle sampling results for South Marsh River at Boat Launch Location, May 17, 2010.

Sample ID	Date/time (EDT)	Sample Depth (m)	Water Depth (m)	Q (m3/sec)	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	MHg ng/L	PMHg ng/L
AHT-E-M	5/17/10 15:08	2	4.5	-4	10.77	13.4	22240	9.05	6.26	1.52	4.74	0.114	0.0446	0.0694
AHT-E-L	5/17/10 15:08	4	4.5	-4	8.05	20.15	32440	14.4	8.24	1.23	7.01	0.152	0.0371	0.1149
MET-E-M	5/17/10 17:02	0.5	3.5	121	12.83	10.46	17640	8.82	5.83	1.52	4.31	0.126	0.0496	0.0764
MET-E-L	5/17/10 17:02	3	3.5	121	7.84	24.45	38675	12.1	6.83	1.03	5.8	0.104	0.033	0.071
MET-C-M	5/17/10 17:18	0.5	2.8	136	13.59	8.34	14314	8.19	5.44	1.49	3.95	0.114	0.0623	0.0517
MET-C-L	5/17/10 17:18	2.5	2.8	136	8.22	23.55	37429	12.9	6.51	0.93	5.58	0.102	0.019	0.083
MET-W-M	5/17/10 17:33	0.5	0.8	164	15.09	8.32	14316	11.3	6.94	1.79	5.15	0.219	0.0832	0.1358
MET-W-L	5/17/10 17:33	2.5	2.8	164	7.96	24.41	38704	10.4	6.45	1.03	5.42	0.131	0.0466	0.0844
BLT-W-L	5/17/10 19:28	0.5	1.2	38	14.57	8.52	14707	77.3	76.2	1.89	74.31	1.18	0.0735	1.1065
BLT-C-L	5/17/10 19:16	0.5	1.2	48	14.31	8.96	15316	124	138	2.52	135.48	2.25	0.0879	2.1621
BLT-E-L	5/17/10 19:08	0.5	1.2	50	14.25	7.62	13204	68.7	60.8	1.85	58.95	1.05	0.0602	0.9898

Table B6. Tidal cycle sampling results for South Marsh River at Boat Launch Location, May 17, 2010.														
Sample ID	**Date/time (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q (m3/sec)**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**MHg ng/L**	**PMHg ng/L**
ALT-W-L	5/17/10 9:20	0.5	1	-15	13.12	5.74	10100	35.3	22.6	3.8	18.8	0.445	0.114	0.331
ALT-C-L	5/17/10 9:10	0.5	0.8	-13	12.94	6.56	11500	41.5	32.3	4.82	27.48	0.996	0.108	0.888
ALT-E-L	5/17/10 9:00	0.5	1	-11	13.02	6.42	11170	37.6	26.8	2.46	24.34	0.531	0.0696	0.4614

Table B7. Tidal cycle sampling results for South Marsh River at Boat Launch Location, June 18, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q m3/s	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
MFT-W-M	6/18/10 13:57	0.50	2.90	-194.9	17.81	10.23	17296	23.1	24.2	2	22.2	0.452	0.0682	0.3838
MFT-W-L	6/18/10 13:57	2.00	2.90	-194.9	17.97	10.17	17170	27.2	25.8	1.86	23.94	0.476	0.0938	0.3822
MFT-C-M	6/18/10 13:37	0.50	2.40	-169.7	17.9	6.87	16691	83.6	77	1.70	75.7	1.65	0.0615	1.5885
MFT-C-L	6/18/10 13:37	2.00	2.40	-169.7	17.65	10.12	17120	84.6	109	3.01	105.99	2.36	0.0763	2.2837
MFT-E-M	6/18/10 13:20	0.50	1.70	-158.3	17.08	10.69	18019	30.3	24.1	2.21	21.89	0.571	0.0773	0.4937
MFT-E-L	6/18/10 13:20	1.50	1.70	-158.3	16.86	10.82	18209	44.6	47.3	2.62	44.68	1	0.0861	0.9139
BHT-E-H	6/18/10 15:22	0.50	3.80	-154.7	17.52	12.87	21275	7.58	6.1	1.9	4.2	0.128	0.063	0.065
BHT-E-M	6/18/10 15:22	2.00	3.80	-154.7	14.68	16.5	26830	12.2	8.25	1.73	6.52	0.17	0.0697	0.1003
BHT-E-L	6/18/10 15:22	3.50	3.80	-154.7	13.86	16.57	27300	29.5	14.6	2	12.6	0.245	0.0606	0.1844
BHT-C-H	6/18/10 15:48	0.50	4.50	-114.7	16.06	14.84	24430	8.06	5.88	2.06	3.82	0.159	0.0532	0.1058
BHT-C-M	6/18/10 15:48	2.00	4.50	-114.7	13.94	17.38	28090	17.2	13.6	2.54	11.06	0.307	0.0573	0.2497

Table B7. Tidal cycle sampling results for South Marsh River at Boat Launch Location, June 18, 2010.															
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q m3/s**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
BHT-C-L	6/18/10 15:48	4.00	4.50	-114.7	13.13	19.9	38836	31.3	22.1	2.85	19.25	0.392	0.075	0.317
BHT-W-H	6/18/10 16:08	0.50	4.70	-55.2	16.9	14.14	23270	6.87	5.58	1.58	4	0.129	0.0433	0.0857
BHT-W-M	6/18/10 16:08	2.00	4.70	-55.2	13.52	17.56	28750	17	4.59	1.56	3.03	0.263	0.0479	0.2151
BHT-W-L	6/18/10 16:08	4.00	4.70	-55.2	12.77	18.77	30220	43.5	28.8	1.09	27.71	0.522	0.0209	0.5011
AHT-W-H	6/18/10 5:01	0.50	4.20	31.3	15.68	10.68	17976	5.23	5.00	2.12	2.88	0.128	0.0691	0.0589
AHT-W-M	6/18/10 5:01	2.00	4.20	31.3	13.57	17.93	28704	8.16	6.87	1.59	5.28	0.126	0.051	0.075
AHT-W-L	6/18/10 5:01	4.00	4.20	31.3	11.67	19.13	30820	13.5	9.83	1.1	8.73	0.198	0.0289	0.1691
AHT-C-H	6/18/10 5:23	0.50	4.10	49.9	15.77	10.05	17022	4.80	4.48	1.9	2.58	0.13	0.0576	0.0724
AHT-C-M	6/18/10 5:23	2.00	4.10	49.9	13.67	15.59	25480	7.36	5.17	1.48	3.69	0.0884	0.0425	0.0459
AHT-C-L	6/18/10 5:23	4.00	4.10	49.9	11.49	19.77	31759	13.4	9.43	1.08	8.35	0.184	0.0409	0.1431
AHT-E-H	6/18/10 5:41	0.50	3.80	37.8	15.69	10.35	17484	4.65	4.60	1.71	2.89	0.11	0.047	0.063

Table B7. Tidal cycle sampling results for South Marsh River at Boat Launch Location, June 18, 2010.														
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q m3/s**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
AHT-E-M	6/18/10 5:41	2.00	3.80	37.8	13.41	16.04	26165	6.39	4.61	1.42	3.19	0.1	0.0281	0.0719
AHT-E-L	6/18/10 5:41	3.50	3.80	37.8	11.46	19.8	31790	9.62	6.47	1.01	5.46	0.124	0.047	0.077
MET-E-M	6/18/10 7:15	0.50	2.60	165.6	15.58	10.28	17340	5.68	4.31	1.81	2.5	0.123	0.0671	0.0559
MET-E-L	6/18/10 7:15	2.00	2.60	165.6	12.26	19.12	31320	7.75	6.7	1.27	5.43	0.149	0.0372	0.1118
MET-C-M	6/18/10 7:36	0.50	2.30	202.6	16	11.19	18340	5.76	5.48	1.8	3.68	0.119	0.073	0.046
MET-C-L	6/18/10 7:36	2.00	2.30	202.6	13.24	19.21	30726	9.09	9.72	1.46	8.26	0.167	0.0526	0.1144
MET-W-M	6/18/10 7:56	0.50	2.20	258.6	16	11.26	15244	24	20	2	18	0.401	0.0905	0.3105
MET-W-L	6/18/10 7:56	2.00	2.20	258.6	13.04	16.32	27340	75.6	54.1	2.03	52.07	1.1	0.0848	1.0152
BLT-W-L	6/18/10 10:07	0.5	0.70	23	17.7	8.43	14390	53	47.4	3.56	43.84	0.932	0.138	0.794
BLT-C-L	6/18/10 9:57	0.5	0.60	27.1	17.22	7.68	13267	105	85.7	3.74	81.96	1.92	0.105	1.815
BLT-E-L	6/18/10 9:46	0.5	0.80	33.9	16.96	8.09	13912	148	84	3.64	80.36	1.72	0.105	1.615

Table B7. Tidal cycle sampling results for South Marsh River at Boat Launch Location, June 18, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q m3/s	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
ALT-W-L	6/18/10 11:42	0.5	0.80	-15.5	18.51	8.5	4570	22.5	15.4	2.54	12.86	0.286	0.0943	0.1917
ALT-C-L	6/18/10 11:34	0.5	0.75	-12.7	18.03	7.95	13695	19.6	11.9	2.58	9.32	0.281	0.115	0.166
ALT-E-L	6/18/10 11:21	0.5	0.75	-9.86	18.64	7.26	12590	20.6	12.6	2.73	9.87	0.335	0.105	0.23

Table B8. Tidal cycle sampling results for South Marsh River at Boat Launch Location, July 15, 2010.														
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q (m3/s)**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
MFT-W-M	07/15/2010 12:17	0.50	3.57	-39.412	22.52	14.2	23453	37.1	6.71	2.06	4.65	0.524	0.042	0.482
MFT-W-L	07/15/2010 12:17	2.00	3.57	-39.412	20.26	14.72	24206	35.9	5.95	1.87	4.08	0.448	0.08	0.368
MFT-C-M	07/15/2010 12:01	0.50	3.25	-39.412	21.52	11.53	19382	25.6	13	4.52	8.58	0.471	0.0633	0.4077
MFT-C-L	07/15/2010 12:01	2.00	3.25	-39.412	21.2	13.48	22356	44.9	22.5	5.32	17.18	0.63	0.0649	0.5651
MFT-E-M	07/15/2010 11:43	0.50	2.20	-38.41	22.31	11.25	18950	63	34.8	2.16	32.64	0.7	0.0944	0.6056
MFT-E-L	07/15/2010 11:43	2.00	2.20	-38.41	21.98	10.7	18015	144	89.2	1.96	87.24	1.66	0.0566	1.6034
BHT-E-H	07/15/2010 13:47	0.50	4.65	-14.74	19.47	17.44	28273	14.7	10.4	1.63	8.77	0.148	0.033	0.115
BHT-E-M	07/15/2010 13:47	2.00	4.65	-14.74	18.42	18.89	30351	14.5	10.4	1.44	8.96	0.188	0.0443	0.1437
BHT-E-L	07/15/2010 13:47	4.00	4.65	-14.74	16.54	21.68	34450	30.2	26.3	1.25	25.05	0.456	0.0551	0.4009
BHT-C-H	07/15/2010 13:27	0.50	4.72	-14.30	19.66	17.21	27895	18	11	1.48	9.52	0.278	0.0452	0.2328

Table B8. Tidal cycle sampling results for South Marsh River at Boat Launch Location, July 15, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q (m3/s)	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
BHT-C-M	07/15/2010 13:27	2.00	4.72	-14.30	18.26	19.17	30798	21.8	16.2	1.34	14.86	0.363	0.0541	0.3089
BHT-C-L	07/15/2010 13:27	4.00	4.72	-14.30	17.03	20.79	33151	19.4	17.6	1.26	16.34	0.308	0.0315	0.2765
BHT-W-H	07/15/2010 13:03	0.50	4.46	-19.58	19.12	16.96	27545	24.6	19.1	1.6	17.5	0.325	0.0563	0.2687
BHT-W-M	07/15/2010 13:03	2.00	4.46	-19.58	18.87	17.62	28415	26	19.6	1.55	18.05	0.237	0.0404	0.1966
BHT-W-L	07/15/2010 13:03	4.00	4.46	-19.58	18.35	18.47	29789	39.3	17.3	1.46	15.84	0.654	0.0363	0.6177
AHT-W-H	07/15/2010 16:33	0.50	3.80	12.21	22.42	13.16	21888	9.08	6.51	1.86	4.65	0.122	0.0766	0.0454
AHT-W-M	07/15/2010 16:33	2.00	3.80	12.21	18.29	19.04	30585	10.2	6.55	1.38	5.17	0.101	0.0512	0.0498
AHT-W-L	07/15/2010 16:33	3.00	3.80	12.21	15.91	22.91	36190	10	7.34	1.11	6.23	0.116	0.0396	0.0764
AHT-C-H	07/15/2010 16:08	0.50	4.30	5.841	21.9	13.85	22901	9.36	6.39	1.81	4.58	0.133	0.0786	0.0544
AHT-C-M	07/15/2010 16:08	2.00	4.30	5.841	16.75	21.42	34034	11.5	7.34	1.21	6.13	0.111	0.058	0.053
AHT-C-L	07/15/2010 16:08	4.00	4.30	5.841	15.35	23.87	37592	12.1	8.47	1.09	7.38	0.14	0.0398	0.1002

Table B8. Tidal cycle sampling results for South Marsh River at Boat Launch Location, July 15, 2010.														
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q (m3/s)**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
AHT-E-H	07/15/2010 15:40	0.50	3.50	12.87	21.59	14.9	24461	11.2	6.54	1.75	4.79	0.13	0.0579	0.0721
AHT-E-M	07/15/2010 15:40	2.00	3.50	12.87	16.25	22.25	35243	12.6	8.1	1.43	6.67	0.151	0.0451	0.1059
AHT-E-L	07/15/2010 15:40	3.00	3.50	12.87	15.5	23.54	37082	14	9.54	1.49	8.05	0.14	0.0573	0.0827
MET-E-M	07/15/2010 17:57	0.50	2.30	65.01	21	14.85	24396	15	14.7	1.86	12.84	0.221	0.0679	0.1531
MET-E-L	07/15/2010 17:57	2.00	2.30	65.01	16.09	22.79	36014	19.3	16.8	1.21	15.59	0.376	0.052	0.324
MET-C-M	07/15/2010 18:16	0.50	2.20	57.75	22.24	12.6	20999	16.5	10.8	1.95	8.85	0.259	0.0536	0.2054
MET-C-L	07/15/2010 18:16	2.00	2.20	57.75	16.91	21.49	34150	11.8	3.9	1.33	2.57	0.191	0.0579	0.1331
MET-W-M	07/15/2010 18:33	0.50	2.10	49.17	22.39	12.4	20680	24.9	16.8	2.08	14.72	0.349	0.0694	0.2796
MET-W-L	07/15/2010 18:33	1.50	2.10	49.17	20.02	16.25	26485	27.4	28.7	1.49	27.21	0.417	0.0465	0.3705
BLT-W-L	07/15/2010 20:25	0.5	0.71	8.844	23.74	7.49	13072	90.6	67.4	3.35	64.05	1.53	0.141	1.389
BLT-C-L	07/15/2010 20:14	0.5	0.74	10.494	24.27	6.52	11444	280	232	3.57	228.43	7.47	0.141	7.329

Table B8. Tidal cycle sampling results for South Marsh River at Boat Launch Location, July 15, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q (m3/s)	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
BLT-E-L	07/15/2010 20:01	0.5	0.67	14.883	24.07	7.61	13072	211	111	3.22	107.78	4.03	0.155	3.875
ALT-W-L	07/15/2010 9:45	0.5	0.85	-5.907	22.66	6.39	11251	62.8	43.7	3.27	40.43	1.06	0.189	0.871
ALT-C-L	07/15/2010 9:37	0.5	0.80	-4.026	22.4	6.47	11345	114	180	10.3	169.7	4.4	0.319	4.081
ALT-E-L	07/15/2010 9:25	0.5	0.70	-2.0394	22.35	4.98	8925	201	222	3.81	218.19	3.79	0.2	3.59

Table B9. Tidal cycle sampling results for South Marsh River at Boat Launch Location, September 9, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q m3/	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
MFT-W-M	09/09/2010 10:07	0.5	4.0	-308	18.94	15.39	25172	24.2	18.5	2.31	16.19	0.309	0.107	0.202
MFT-W-L	09/09/2010 10:07	2.0	4.0	-308	18.91	15.74	25800	24.2	28.3	1.20	27.1	0.391	0.0188	0.3722
MFT-C-M	09/09/2010 9:50	0.5	4.0	-284.3	19.24	14.18	23340	26.6	17	1.12	15.48	0.273	0.0259	0.2471
MFT-C-L	09/09/2010 9:50	2.0	4.0	-284.3	19.17	14.48	23870	24.8	20.6	1.18	19.42	0.3	0.0188	0.2812
MFT-E-M	09/09/2010 9:40	0.5	3.0	-251.2	19.19	14.21	23430	27.1	21.6	1.16	20.44	0.452	0.0232	0.4288
MFT-E-L	09/09/2010 9:40	2.0	3.0	-251.2	19.14	14.48	23883	40.3	30.2	2.57	27.63	0.707	0.0377	0.6693
BHT-E-H	09/09/2010 11:00	0.5	4.3	-206.3	18.43	18.51	29805	12	9.35	1.07	8.28	0.137	0.0188	0.1182
BHT-E-M	09/09/2010 11:00	2.0	4.3	-206.3	18.35	18.56	29880	14.2	10.1	1.07	9.03	0.154	0.0416	0.1124
BHT-E-L	09/09/2010 11:00	4.0	4.3	-206.3	17.61	20.64	32600	29.1	49.1	1.65	47.45	0.848	0.0598	0.7882
BHT-C-H	09/09/2010 11:15	0.5	4.6	-177.5	18	19.7	31515	20	11.9	1.59	10.31	0.232	0.0341	0.1979
BHT-C-M	09/09/2010 11:15	2.0	4.6	-177.5	17.93	19.89	31780	18.4	12.4	1.04	11.36	0.224	0.0188	0.2052

Table B9. Tidal cycle sampling results for South Marsh River at Boat Launch Location, September 9, 2010.

Sample ID	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Q m3/	Temp (celsius)	Salinity (ppth)	SpecCond (uS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
BHT-C-L	09/09/2010 11:15	4.5	4.6	-177.5	17.06	22.7	35620	19.6	13.9	1.71	12.19	0.262	0.0275	0.2345
BHT-W-H	09/09/2010 11:35	0.5	4.6	-153.4	18.28	19.58	31340	14.5	8.8	1.03	7.77	0.134	0.0339	0.1001
BHT-W-M	09/09/2010 11:35	2.0	4.6	-153.4	17.69	20.79	33110	11.5	7.85	0.939	6.911	0.136	0.0188	0.1172
BHT-W-L	09/09/2010 11:35	4.5	4.6	-153.4	17.09	22.67	35830	19.9	17.7	0.777	16.9	0.306	0.0359	0.2701
AHT-W-H	09/09/2010 13:50	0.5	4.5	52.9	19.8	13.57	22460	7.6	5.13	1.36	3.8	0.102	0.0757	0.0263
AHT-W-M	09/09/2010 13:50	2.0	4.5	52.9	18.05	19.46	31170	7.96	5.72	0.992	4.7	0.114	0.051	0.063
AHT-W-L	09/09/2010 13:50	4.0	4.5	52.9	16.92	23.41	36900	8.76	5.97	0.931	5.0	0.107	0.056	0.051
AHT-C-H	09/09/2010 13:30	0.5	4.7	118.8	19.4	14.73	24175	7.62	5.26	1.19	4.1	0.109	0.0529	0.0561
AHT-C-M	09/09/2010 13:30	2.0	4.7	118.8	18.36	18.41	29660	9.18	5.66	1.11	4.6	0.112	0.0491	0.0629
AHT-C-L	09/09/2010 13:30	4.5	4.7	118.8	16.91	23.4	36875	9.07	6.74	0.866	5.9	0.116	0.0389	0.0771
AHT-E-H	09/09/2010 13:05	0.5	4.0	185.2	18.59	17.79	28735	8.06	5.48	0.99	4.5	0.11	0.0459	0.0641

Table B9. Tidal cycle sampling results for South Marsh River at Boat Launch Location, September 9, 2010.														
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q m3/**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
AHT-E-M	09/09/2010 13:05	2.0	4.0	185.2	18.31	18.71	30100	8.43	5.83	1.22	4.6	0.116	0.0489	0.0671
AHT-E-L	09/09/2010 13:05	3.5	4.0	185.2	16.89	23.43	36920	10.2	6.1	0.88	5.2	0.112	0.0459	0.0661
MET-E-M	09/09/2010 15:50	0.50	2.00	255.9	19.65	13.25	21990	14.3	13	1.34	11.7	0.286	0.0673	0.2187
MET-E-L	09/09/2010 15:50	1.50	2.00	255.9	18.37	18.37	29290	15.6	12.8	1.05	11.8	0.256	0.0612	0.1948
MET-C-M	09/09/2010 16:10	0.50	1.80	184.1	20.22	11.04	18580	16.6	12.6	2.01	10.6	0.296	0.0945	0.2015
MET-C-L	09/09/2010 16:10	1.50	1.80	184.1	19.12	15.45	25100	33.9	25.3	1.75	23.6	0.497	0.0642	0.4328
MET-W-M	09/09/2010 16:25	0.50	1.60	171.8	20.42	11.34	19065	23.1	17.4	1.78	15.6	0.407	0.0995	0.3075
MET-W-L	09/09/2010 16:25	1.40	1.60	171.8	20.35	11.28	18950	34	21.9	1.97	19.9	0.547	0.0817	0.4653
BLT-W-L	09/09/2010 17:50	0.5	0.50	35.4	20.21	8.53	14640	98.3	66.7	1.95	64.8	1.41	0.133	1.277
BLT-C-L	09/09/2010 17:40	0.5	0.75	40	20.16	8.43	14475	152	113	1.91	111.1	2.61	0.115	2.495
BLT-E-L	09/09/2010 17:30	0.5	0.50	54.8	20.54	8.95	15290	110	81	1.84	79.2	1.51	0.149	1.361

Table B9. Tidal cycle sampling results for South Marsh River at Boat Launch Location, September 9, 2010.															
Sample ID	**Datetime (EDT)**	**Sample Depth (m)**	**Water Depth (m)**	**Q m3/**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
ALT-W-L	09/09/2010 7:37	0.5	0.90	-38.2	19.32	9.65	16402	71.3	56.4	4.82	51.58	1.32	0.133	1.187
ALT-C-L	09/09/2010 7:27	0.5	1.00	-29.75	19.32	9.6	16328	146	131	1.65	129.35	2.83	0.0529	2.7771
ALT-E-L	09/09/2010 7:15	0.5	0.65	-23.5	19.13	9.61	16335	98.6	98.1	2.12	95.98	2.01	0.0716	1.9384

Table B10. Tidal cycle sampling results for Cindy's Slough CS Location, August 26, 2010.														
Sample IDs	**Datetime (EDT)**	**Water Depth (inches)**	**Stage (m)**	**Q m3/s**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
CS4-1	8/26/10 9:57	2.38	0.060	0.001	18.4	11.2	18809	14.1	17.5	5.81	11.69	2.24	1.71	0.53
CS4-2	8/26/10 10:29	17.25	0.438	0.051	19.04	13.98	23063	44	27.5	2.47	25.03	0.596	0.267	0.329
CS4-3	8/26/10 11:03	37.25	0.946	0.148	19.06	14.3	23549	25.8	16.7	3.98	12.72	0.318	0.133	0.185
CS4-4	8/26/10 11:30	52.00	1.321	0.191	19.06	14.4	23693	18.9	13.1	1.57	11.53	0.294	0.0915	0.20
CS4-5	8/26/10 12:07	64.50	1.638	0.071	18.88	14.72	24173	14.9	9.89	1.38	8.51	0.194	0.108	0.086
CS4-6	8/26/10 13:10	65.00	1.651	-0.061	19.29	14.6	24005	9.88	6.76	1.24	5.52	0.136	0.0281	0.1079
CS4-7	8/26/10 14:07	52.00	1.321	-0.140	19.73	14.4	23701	8.95	5.79	1.62	4.17	0.16	0.09	0.07
CS4-8	8/26/10 15:00	37.25	0.946	-0.062	20.35	14.24	23465	8.62	6.57	2.08	4.49	0.231	0.119	0.112
CS4-9	8/26/10 15:48	16.25	0.413	-0.029	20.63	12.22	20402	12.6	15.8	6.24	9.56	1.87	1.35	0.52
CS4-10	8/26/10 16:13	2.75	0.070	-0.003	20.2	11.43	19179	48	53.7	8.37	45.33	3.6	3.09	0.51

Table B11. Tidal cycle sampling results for Cindy's Slough CS Location, October 9, 2010.														
Sample IDs	**Datetime (EDT)**	**Water Depth (inches)**	**Stage (m)**	**Q m3/s**	**Temp (celsius)**	**Salinity (ppth)**	**SpecCond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**MHg ng/L**	**FMHg ng/L**	**PMHg ng/L**
CS5-1	10/09/10 9:25	2.00	0.05	0.00520	10.46	7.14	12432	3.34	9.7	6.17	3.53	2.03	1.65	0.38
CS5-2	10/09/10 9:55	17.00	0.43	-0.06000	10.71	5.1	9092	94	63.5	2.79	60.71	1.22	0.199	1.021
CS5-3	10/09/10 10:18	41.00	1.04	-0.20320	11.48	4.63	8289	51.9	40.3	2.76	37.54	0.637	0.152	0.485
CS5-4	10/09/10 10:32	54.00	1.37	-0.32200	11.89	4.43	7956	43.9	29	2.13	26.87	0.491	0.112	0.38
CS5-5	10/09/10 11:00	79.00	2.01	-0.88200	12.8	4.42	7940	30.8	24	1.82	22.18	0.345	0.0672	0.2778
CS5-6	10/09/10 11:50	96.00	2.44	-0.99000	13.35	5.03	8952	17.7	14.1	1.71	12.39	0.226	0.0474	0.1786
CS5-7	10/09/10 12:56	90.00	2.29	1.28390	13.38	5.21	9260	10.4	7.93	1.81	6.12	0.133	0.0609	0.0721
CS5-8	10/09/10 13:53	79.00	2.01	1.60000	13.39	4.78	8530	9.01	8.11	2.48	5.63	0.606	0.417	0.189
CS5-9	10/09/10 14:47	54.00	1.37	0.52000	13	5.03	8946	7.88	9.11	3.5	5.61	1.23	1.03	0.2
CS5-10	10/09/10 15:10	41.00	1.04	0.22000	12.82	5.29	9390	8.13	9.95	4.31	5.64	1.65	1.38	0.27
CS5-11	10/09/10 15:45	17.00	0.43	0.07470	12.6	5.66	10001	48.3	65.5	5.19	60.31	2.85	1.7	1.15
CS5-12	10/09/10 16:30	7.00	0.18	0.04100	12.04	5.87	10347	29.8	26.8	6.38	20.42	2.37	1.86	0.51

Table B12. Tidal cycle and longitudinal sampling results for Cindy's Slough, June 23, 2010.															
Sample IDs	**Datetime (EDT)**	**Water Depth (m)**	**Avg Velocity (m/s)**	**Temp (celsius)**	**Salinity (ppth)**	**Spec Cond (uS/cm)**	**TSS mg/L**	**THg ng/L**	**FTHg ng/L**	**PTHg ng/L**	**%FTHg**	**MHg ng/L**	**%MeHg**	**FMHg ng/L**	**PMHg ng/L**
CS1-AHT	6/23/10 9:50	1.45	0.029	18.51	10.88	18321	13.3	8.89	1.97	6.92	22.2	0.188	2.1	0.0966	0.0914
CS2-MET	6/23/10 11:13	1.14	0.073	18.31	9.49	16142	16.5	11.7	3.27	8.43	27.9	0.573	4.9	0.365	0.208
CS3-BLT	6/23/10 12:10	0.42	0.152	17.31	7.71	13313	16.9	21.6	9.34	12.26	43.2	5.59	25.9	4.64	0.95
CS4-LT	6/23/10 15:20	0.09	0.206	17.27	7.21	12521	19.9	24.2	9.5	14.7	39.3	5.88	24.3	4.88	1.00
CS5-LT2	6/23/10 18:30	0.09	0.181	17.1	7.38	12788	8.91	16	9.51	6.49	59.4	5.51	34.4	4.93	0.58
CS6-AHT	6/23/10 18:50	0.43	0.01	18.93	11	18500	29.4	22	2.66	19.34	12.1	0.698	3.2	0.372	0.326
CS7-MFT	6/23/10 19:30	1.13	nm	18.82	11.18	18783	19.5	15.7	2.15	13.55	13.7	0.416	2.6	0.158	0.258
CS8-BHT	6/23/10 19:52	1.47	nm	18.79	11.11	18675	15.9	15.1	2.06	13.04	13.6	0.325	2.2	0.107	0.218
CS9-BHT2	6/23/10 20:15	1.80	nm				14								
DK669-MET	6/23/10 11:45			17.8	5.84	10297	4.98	26.8	16.7	10.1	62.3	10.4	38.8	8.8	1.6
DK669-LT	6/23/10 18:00			18.23	7.78	13434	1.71	43.7	31.9	11.8	73.0	27.5	62.9	24.4	3.1

Table B14. Tidal cycle sampling results for Orland River, July 8, 2009

Sample IDs	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Est Area (m2)	Avg Velocity (m/s)	Q (m3/s)	Temp (celsius)	Salinity (ppth)	SpecCond (µS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
LT-C	7/8/09 6:50	0.5	1.2	227	-0.417	-32.2	15.28	12.9	21460	16.9	13.7	1.78	11.92	0.394	0.078	0.316
LT-W	7/8/09 7:05	0.5	0.8	227	0.000	0.0	14.67	13.44	22340	10.2	6.65	1.94	4.71	0.278	0.126	0.152
MFT-W-L	7/8/09 9:30	0.2	0.5	862	-0.400	-69.2	15.88	6.67	11660	11.7	6.87	1.96	4.91	0.3	0.108	0.192
MFT-CW-H	7/8/09 9:44	1	2.1	862	-0.476	-278.7	15.06	11.6	19420	3.96	3.88	1.94	1.94	0.148	0.123	0.025
MFT-C-H	7/8/09 10:00	0.5	2.8	862	-0.179	-379.8	15.2	11.23	19092	6.11	4.04	2.02	2.02	0.203	0.133	0.07
MFT-C-L	7/8/09 10:05	1.5	2.8	862	-0.536	-295.0	14.56	13.66	22650	7.46	5.94	1.76	4.18	0.217	0.0924	0.1246
MET-C-H	7/8/09 15:40	0.5	3	750	0.167	412.5	15.3	9.4	16080	4.58	4.05	1.92	2.13	0.165	0.107	0.058
MET-C-L	7/8/09 15:50	1.5	3	750	0.500	318.8	12.21	10.81	18130	4.31	7.88	1.28	6.6	0.185	0.0654	0.1196
MET-CW-H	7/8/09 16:06	0.5	2.1	750	0.238	421.7	16.9	5.4	9589	9.38	6.89	1.98	4.91	0.279	0.142	0.137
MET-W-L	7/8/09 16:25	0.5	1	750	0.000	0.0	16.71	5.67	10003	7.56	6.55	2.11	4.44	0.259	0.143	0.116
BLT-W	7/8/09 17:30	0.5	1.2	300	0.417	88.0	15.71	8.31	14195	18.2	15.8	1.72	14.08	0.389	0.093	0.296

Table B14. Tidal cycle sampling results for Orland River, July 8, 2009

Sample IDs	Datetime (EDT)	Sample Depth (m)	Water Depth (m)	Est Area (m2)	Avg Velocity (m/s)	Q (m3/s)	Temp (celsius)	Salinity (ppth)	SpecCond (µS/cm)	TSS mg/L	THg ng/L	FTHg ng/L	PTHg ng/L	MHg ng/L	FMHg ng/L	PMHg ng/L
BLT-C	7/8/09 17:42	0.5	1.6	300	0.313	119.5	14.95	9.24	15795	14.1	12.3	1.72	10.58	0.316	0.0966	0.2194
TC-1	7/8/09 18:40									1710	1420	9.7	1410.3	20.9	0.389	20.511
TC-2	7/8/09 18:52									818	826	10.2	815.8	18.3	0.905	17.395
DAM	7/8/09 19:50						18.16	0.02	53	2.3	2.84	2.27	0.57	0.23	0.179	0.051