GE
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April 16, 2007

Susan Svirsky
U.S. Environmental Protection Agency
c/o Weston Solutions, Inc.
10 Lyman Street
Pittsfield, MA 01201

Re: GE-Pittsfield/Housatonic River Site
Rest of River (GECD850)
Corrective Measures Study Proposal – Model Input Addendum

Dear Ms. Svirsky:

As you know, the General Electric Company (GE) submitted its Corrective Measures Study (CMS) Proposal for the Rest of River to the U.S. Environmental Protection Agency (EPA) on February 26, 2007. The CMS Proposal stated that GE would provide, in a subsequent deliverable, additional information on certain of its proposed inputs to EPA's PCB fate, transport, and bioaccumulation model to be used in the CMS. These inputs include the methodology for including an extreme hydrologic event in the model, certain PCB boundary conditions for the model, and the initial post-remediation PCB concentrations in the cap or backfill material to be placed under certain remedial scenarios. The enclosed Model Input Addendum provides additional information on those inputs. It also includes a proposal for water column and sediment sampling in the East Branch of the Housatonic River to provide data on the PCB inputs from the East Branch to the Rest of River.

Please let me know if you have any questions about the enclosed Addendum or would like to discuss any issues.

Very truly yours,

Andrew T. Silfer, P.E.
GE Project Coordinator

Enclosure

cc: Dean Tagliaferro, EPA
Timothy Conway, EPA
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Model Input Addendum

Housatonic Rest of River CMS Proposal

Prepared for:

General Electric Company

Pittsfield, MA

Prepared by:

Quantitative Environmental Analysis, LLC

Liverpool, NY

and

ARCADIS BBL

Syracuse, NY

April 16, 2007

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Job Number:

GENcms:130

April 16, 2007

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SECTION 1
INTRODUCTION

This document serves as an addendum to the Corrective Measures Study (CMS) Proposal that was submitted by the General Electric Company (GE) to the United States Environmental Protection Agency (EPA) on February 26, 2007 (BBL and QEA, 2007) for the Rest of River portion of the GE-Pittsfield/Housatonic River Site. This Model Input Addendum has been developed to describe a number of the input parameters and values that GE proposes to apply during mathematical model simulations of sediment remedial alternatives as part of the CMS.

The February 2007 CMS Proposal described a study of potential corrective measures (remedial actions) to address polychlorinated biphenyls (PCBs) within the Rest of River portion of the Housatonic River and its floodplain, which is located downstream of the confluence of the East and West Branches of the Housatonic River (the Confluence). The CMS Proposal was submitted to EPA for approval in accordance with the July 18, 2000 Resource Conservation and Recovery Act (RCRA) Permit issued to GE by EPA. The CMS Proposal identified the corrective measures that GE proposes to study, provided a justification for selecting those corrective measures, and presented GE's proposed methodology for evaluating those measures. On April 13, 2007, EPA conditionally approved the CMS Proposal, but directed GE to provide additional information in a "Supplement" to the Proposal.

Section 5.2.2 of the CMS Proposal described GE's proposed approach for using the model that was developed by EPA to simulate the fate, transport, and bioaccumulation of PCBs in the Housatonic River between the Confluence and Rising Pond Dam so as to evaluate the in-river sediment/riverbank remedial alternatives (which are described in Section 5.2.1 of the CMS Proposal). Specifically, the CMS Proposal discussed the approach GE will use in applying the PCB fate and transport (EFDC) and bioaccumulation (FCM) submodels to predict future sediment, surface water, and fish tissue PCB concentrations resulting from the sediment remedial alternatives to be studied in the CMS. This discussion included a description of:

- the temporal and spatial scales over which future simulations will be conducted;

- the development of model inputs necessary for future projections (i.e., boundary conditions and initial conditions);
- how the sediment remedial actions identified for evaluation will be represented in the model (production rates, post-remediation PCB concentrations, etc.);
- metrics that will be used as the basis for comparison of model predictions among alternatives; and
- certain proposed modifications to the EFDC model code.

While the CMS Proposal provided detail on the modeling approach and development of many of the inputs needed for the simulation of future conditions, it stated that certain model inputs would be specified in more detail in a subsequent deliverable, the Model Input Addendum. These inputs included the methodology for simulating an extreme hydrologic (i.e., very high flow) event in the model, certain PCB boundary conditions for the model, and the initial PCB concentrations in the cap or backfill material placed under certain remedial techniques. Thus, as a supplement to the CMS Proposal, this Model Input Addendum has been developed to provide additional detail on the following model inputs that were discussed in general in the CMS Proposal:

- flow and solids boundary conditions used in the simulation of an extreme hydrologic event (see Section 2);
- PCB boundary conditions for the East and West Branch and tributary and direct runoff flows (see Section 3); and
- post-remediation PCB concentrations for the cap/backfill materials after placement for simulation of remedial alternatives that include wet dredging with subsequent capping or backfilling or engineered capping without removal (see Section 4).

SECTION 2
EXTREME HYDROLOGIC EVENT

As discussed in the CMS Proposal, the future simulations with the model will be conducted using a 52-year time series of flow rates that provides a good statistical representation of the historical hydrograph. This time series is defined by two cycles of the 26-year hydrograph from EPA's 1979-2004 model validation period. To represent the potential impact of an extreme hydrologic event on future EFDC model projections of sediment and water column PCB levels, the hydrograph and associated total suspended solids (TSS) and PCB loads from an extreme event have been included in the 52-year CMS projection model inputs. The extreme event that was selected by EPA for the model projections is the second largest hydrological event on record at the USGS Coltsville, MA gage, which occurred in March of 1936.[1] EPA has developed data-based approaches to represent the flows and solids loads for the extreme event at each model boundary. GE has reviewed EPA's methodology and has developed methods to insert the extreme event into the 52-year model time series input files. This section provides a description of the flow rates and TSS concentrations that have been developed to represent this event for each model boundary. The PCB boundary conditions during this extreme event are included in Section 3.

2.1 HYDROGRAPH

EPA has synthesized an hourly hydrograph for the March 1936 extreme flow event that matches the USGS-reported peak flow for the Coltsville gage of 6,000 cfs. The synthesized hydrograph was produced by fitting a curve to the daily average values from the March 1936 extreme event, while honoring the instantaneous peak flow from that event. EPA used the drainage area proration factors provided in Appendix E1 of the RCRA Facility Investigation Report (RFI Report; BBL and QEA, 2003) to scale the hourly hydrograph values for the East and West Branches from the Coltsville values. Due to the absence of data, flow values for other

[1] The March 1936 (peak flow at Coltsville of 6,000 cfs) event was chosen over the largest event, which occurred in September 1938 (peak flow at Coltsville of 6,400 cfs), because the duration of the elevated flow was much longer

tributaries and direct drainage inputs to the model during the March 1936 flow event were estimated. These estimates considered the hourly flows calculated by the EPA watershed model (HSPF) during the 1990 Hurricane Bertha event, scaled-up by a factor of 1.6 (the ratio between the peak instantaneous flows at Coltsville of the 1936 and 1990 events – i.e., 6,000 cfs in 1936 and 3,850 cfs in 1990). The 1990 event was employed for this purpose as it was one of the largest events to occur during the model validation period.

The estimated extreme event values were inserted into the 52-year projection hydrograph in March/April of Year 26, and a smoothing function was applied at the insertion points to minimize discontinuity within the projection hydrograph. Specifically, the high flow event was inserted during Days 87 through 106 of Year 26; hourly flow values for the one-day periods surrounding the insertion start and end points were replaced with a 25-hour moving average of their constituent values. To further minimize discontinuities for the tributaries and direct drainage boundaries, the lead-in to the extreme event calculated from the 1990 event (about 3 days) replaced the Year 26 values only if those values were larger than the Year 26 values. The resulting hydrographs for Year 26 of the projection are presented in Figure 2-1 for the upstream inputs (East Branch and West Branch), three tributaries in Reach 5 (Sackett Brook, Roaring Brook, Yokun Brook), and one example direct drainage sub-basin in Reach 5. These plots illustrate the peak flows during the extreme event for each model inflow, as well as the transition between the original and synthesized flows at the beginning and end of the event. An example of the full 52-year hydrograph with the extreme event inserted is shown for the East Branch in Figure 2-2.

2.2 SOLIDS

TSS concentrations in the East and West Branches for the extreme event described above were developed by EPA based on the hourly hydrographs shown in Figure 2-1 and the flow-based relationships presented in Appendix B.2 of EPA's Final Model Documentation Report (FMDR; EPA, 2006b). Analysis of relationships between TSS and flow developed from HSPF

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for the 1936 event (i.e., the daily average flows surrounding the day of peak flow were much greater for the 1936 event).

model output for the tributaries and direct drainage inputs indicates that they are weak and thus do not support their use in developing TSS boundary conditions. Hence, TSS inputs for the 1990 Hurricane Bertha event were used as representative suspended solids values for the tributaries and direct drainage boundaries. No scaling was applied to the suspended solids loads as was performed for the flows, since there are no data available to support a proportional extrapolation of flow to suspended solids at these levels for the tributaries and direct drainage inputs. The suspended solids loads from the tributaries and direct drainage are small relative to the loads in the East and West Branches (e.g., FMDR Figure 4.2-1; EPA, 2006b) and therefore the model will not be overly sensitive to these surrogate estimates.

The extreme event TSS values were inserted into the 52-year projection time series in Year 26 at the same location as the extreme event hydrograph. The same smoothing function approach used to remove discontinuities in the hydrograph was applied at the insertion points for suspended solids. Figure 2-3 presents the TSS concentration time series for projection Year 26 developed for several model boundaries (i.e., East and West Branches, the three Reach 5 tributaries, and one example direct drainage sub-basin in Reach 5). An example of the full 52-year TSS boundary condition with the extreme event inserted is presented for the East Branch in Figure 2-4.

SECTION 3
PCB BOUNDARY CONDITIONS

In order to fully evaluate the different potential remedial scenarios proposed in the CMS Proposal, both internal PCB sources within the Rest of River (i.e., PCB fluxes from sediment diffusion, sediment erosion, and bank erosion) and external PCBs sources (i.e., those from the upstream, tributary, and direct runoff PCB boundary conditions) need to be understood. While the fate and transport processes simulated by the calibrated/validated EPA model compute future changes in the internal PCB sources, changes in the future external PCB sources are assigned in the model as boundary inputs. It is therefore important to develop reasonable approximations of future upstream, tributary, and direct runoff PCB boundary conditions for the model projections of remedial alternatives, while recognizing the inherent uncertainties in any such future estimates.

This section documents the approach that will be used to develop water column PCB concentrations that will be specified during the 52-year projection period for each model boundary (i.e., East Branch, West Branch, tributaries, and direct runoff from the local watershed).

3.1 EAST BRANCH

As discussed in the CMS Proposal, East Branch PCB loads were specified by EPA during model calibration/validation using a data-based approach described in Appendix B.2 of the FMDR (EPA, 2006b). This approach specified East Branch PCB boundary conditions during periods when data were not available based on loading equations developed from relationships between particulate-phase PCB concentrations and river flow rate (EPA, 2006b). While this approach was appropriate for specifying PCB loads during the model calibration and validation periods, it cannot be used directly during the simulation of future conditions in the Rest of River for two reasons: (1) it does not account for potential reductions in PCB loading that result from the various remedial measures conducted by GE and EPA within, and adjacent to, the upper two miles of the River; and (2) there are insufficient water column monitoring data at these boundaries to develop contemporary PCB loading relationships.

For these reasons, as stated in the CMS Proposal, the East Branch PCB boundary condition for model projections in the CMS will be developed based on an effective particulate-phase PCB concentration applied to the water column solids load. The corresponding dissolved-phase component will be calculated based on the effective particulate-phase PCB concentration and the three-phase partitioning equations used by EPA for the validation period boundary conditions (see FMDR Appendix B.2). Specifically, the water column PCB boundary condition time series for the East Branch will be developed by applying an estimated initial effective particulate-phase PCB concentration to the solids entering the Rest of River model (to represent current conditions at the start of the 52-year CMS projections). Initial concentrations will be assumed to decline linearly over a 10-year period to a future value that will be chosen to reflect reductions associated with additional planned remediation activities adjacent to the East Branch during the simulation period. The methods used to estimate these current and future effective particulate-phase PCB concentrations are summarized below.

3.1.1 Current Conditions

No direct measurements of water column particulate-phase PCB concentrations are available to characterize current conditions within the East Branch following implementation of the Upper ½ Mile and 1½ Mile Reach Removal Actions. Recent water column sampling provides evidence of post-remediation PCB inputs to the ½-Mile Reach. For example, PCBs were detected in approximately 20% of samples collected at Newell Street and Lyman Street during 2005 and 2006 as part of GE’s monthly water column monitoring program; detected concentrations in these samples range from 30 to 270 ng/L. However, since December 2005, the water column sampling data collected at the East Branch station used for the model boundary condition (i.e., Pomeroy Avenue) have all been non-detect at a method detection limit (MDL) of 22 ng/L. Moreover, review of the various potential sources of PCBs to the East Branch indicates that there would be substantial uncertainties in developing estimates of current particulate-phase PCB concentrations based upon an assessment of those sources.

Given these circumstances and the uncertainty in developing a representative estimate of the current effective particulate-phase PCB concentration, GE will collect additional data to support specification of the East Branch PCB model boundary condition. This data collection will include sampling of surface sediments in the East Branch and supplemental water column monitoring at Pomeroy Avenue:

1. Surface sediment samples will be collected from the Upper ½-Mile Reach of the East Branch to provide a measure of current post-remediation sediment PCB levels. The sediments in this reach reflect an integration of the solids that have entered this reach after the completion of the remediation (both from the GE Plant area and from other sources adjacent to this reach, as well as those transported in the river from the upper watershed) and the current sources of PCBs entering the river in this area. The PCB concentrations in those sediments should therefore be generally representative of contemporary water column particulate-phase PCB concentrations in this portion of the East Branch. Sampling of surface sediments from the ½-Mile Reach will be conducted under low flow conditions, likely in June 2007, and will be performed in accordance with the requirements for monitoring of restored sediments set forth in Section 11.5.4 of the *Removal Action Work Plan for Upper ½ Mile Reach of Housatonic River* (BBL 1999), which is Appendix F to the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site. Additional details on this sediment sampling program are summarized in Section A.1 of Appendix A.

2. Supplemental water column sampling will be conducted at Pomeroy Avenue, which is the location used to represent the East Branch boundary condition in the EPA model. The sampling effort will begin in April and continue through June 2007, and may be extended depending on flow conditions. This supplemental sampling will be conducted using a lower PCB MDL of approximately 11 ng/L to provide a measure of current water column PCB concentrations. Samples will be collected routinely (i.e., twice weekly) using the same protocols as the GE monthly Water Column Monitoring Program, as well as during three high flow events (if possible) in which multiple samples will be collected

over the rising and falling limbs of the hydrograph. Details on this proposed water column sampling are provided in Section A.2 of Appendix A.

The data from the sediment and water column sampling will be analyzed to develop a representative particulate-phase PCB concentration that will be used as the starting value for the East Branch PCB boundary condition. Specifically, the PCB, TSS, and particulate organic carbon (POC) measurements from the water column sampling will be used to calculate particulate phase PCB concentrations under both low flow and high flow conditions using the 3-phase partitioning parameters documented in Appendix B.2 of the FMDR (EPA, 2006b). These calculated particulate-phase PCB concentrations will be compared with the East Branch surface sediment sampling data to assess the consistency between the two data sets.[2]

3.1.2 Future Conditions

As stated above, the initial (i.e., current condition) water column concentrations described in Section 3.1.1 will be assumed to decline linearly over a 10-year period to a future condition that reflects reductions associated with planned remediation activities adjacent to the East Branch during the simulation period. Since the majority of the model projection period (42 of the 52 years simulated) will utilize East Branch boundary conditions that reflect this "future" condition, the assumed future water column particulate-phase PCB concentration is important for the model projections. However, future conditions are difficult to estimate for two reasons. First, there is no validated model available to forecast future conditions in the East Branch. (EPA's "Upstream Model" of the East Branch was discontinued because it was deemed unnecessary; EPA 2006a). Second, there are a number of remediation projects currently in progress, or planned for the near future, to address remaining sources of PCBs to the East Branch; completion of these projects is not anticipated for several years. Therefore, any estimate of a future water column particulate-phase PCB concentration contains significant uncertainty.

[2] The surface sediment data set collected from the Upper ½-Mile Reach will be supplemented with any restored sediment sampling data from the 1½-Mile Reach if such data are collected by EPA.

Although this future value is inherently uncertain, it is clear that PCBs will be present at some low concentrations within the water column of the East Branch in the future. For example, it is expected that low levels of PCBs will continue to enter the East Branch from a number of adjacent or upstream areas. These include areas that have been, or will be, remediated to standards deemed protective of human health and the environment under the CD or the state Administrative Consent Order (ACO), but that will nonetheless contain residual amounts of PCBs (as recognized by the Performance Standards specified in the CD or under the ACO). Such areas include the Upper ½ Mile Reach banks, portions of the GE Plant Area, Unkamet Brook, the Former Oxbow Areas, the 1½ Mile floodplain properties, and certain off-site "fill" areas. In addition, there will continue to be some PCB inputs to the East Branch due to atmospheric/background sources of PCBs from the upstream watershed (see Section 3.3 below for a summary of background PCB levels), as well as from sediments within the East Branch itself, including the portions upstream of Newell Street.

At the same time, while there will continue to be PCBs that enter the East Branch and sorb to particulate matter, the future particulate-phase PCB concentration will likely be less than the current value due to the various remedial actions that are either planned or are currently underway. The major remaining projects that will likely lead to such a reduction include the remediation of the Unkamet Brook sediments, remediation of the soils in the Unkamet Brook Area and East Street Area 2-South, the capping of the Silver Lake sediments, the soil remediation at the off-site Dalton Avenue and Commercial Street Sites, and application of Best Management Practices for stormwater discharges from the GE Plant. Once the current particulate-phase PCB concentration has been established based on the new data to be collected, a qualitative assessment of the potential reduction in PCB loads that might be achieved through completion of those remaining remedial actions, in the context of the other sources that will remain, will be made. Since quantifying the extent to which the above-listed activities will reduce PCB loads to the East Branch is highly uncertain, future reductions will be bounded by sediment PCB data from the East Branch upstream of the ½-Mile Reach, as this area of the river is largely upstream of the major historical GE Plant source areas and thus can be considered to represent an equilibrium with regional background sources.

Sediment data collected from the East Branch upstream of the ½-Mile Reach suggest that a lower bound measure of future particulate-phase concentrations in the East Branch is between 0.3 to 0.6 mg/kg. A total of 275 surface sediment (0-6”) samples were collected upstream of the ½ Mile Reach (i.e., between Newell Street and Hubbard Avenue) by GE in 1995-96 and EPA in 1998-99; detected PCB concentrations of these samples ranged from less than 0.01 to 3 mg/kg. PCBs were only detected in 22 of these samples; however, a majority of the non-detects had detection limits of 0.5 to 1 mg/kg. The detected concentrations, coupled with the relatively high detection limit for the non-detect samples, indicate that the PCB concentration in this reach is greater than zero. In these circumstances, given the uncertainty in the actual concentration, a range of average concentrations has been determined using different methods for handling the non-detects. Using a concentration of ½ the MDL for non-detect samples yields an average concentration of 0.3 mg/kg for these data, while using the full MDL yields an average concentration of 0.6 mg/kg. In addition, the average concentration for only those samples with detected PCBs is approximately 0.4 mg/kg. Based on these data, GE will assume that future effective particulate-phase concentration in the East Branch will be no lower than 0.3 to 0.6 mg/kg.

In summary, GE proposes to specify the future effective particulate-phase PCB concentration for the East Branch boundary condition by reducing the current concentration (estimated as described in Section 3.1.1) based upon a qualitative assessment of potential future impacts of remediation projects affecting the East Branch, but no lower than 0.3 to 0.6 mg/kg.

3.1.3 Future Deliverable

Results of the proposed sampling summarized above and described in more detail in Appendix A will be documented in a letter report provided to EPA for approval. This letter report will also present the proposed current and future East Branch PCB boundary condition values to be used in the CMS model projections. This letter report will be provided to EPA within 30 days of receipt of all water column and sediment results from the analytical laboratory.

3.2 WEST BRANCH

The West Branch PCB boundary condition was specified in the EPA model based on loading equations developed from river flows and PCB concentrations (EPA, 2006b). This boundary condition provides a representation of PCB concentrations for current conditions in the West Branch, but it is not representative of the conditions that will exist following the planned removal of sediments adjacent to Dorothy Amos Park (see Section 2.3.7 of the CMS Proposal).

Because the sediments adjacent to Dorothy Amos Park represent the major identified source of PCBs to the West Branch, the approach used to specify the PCB boundary condition for future projections in the CMS will be based on the existing model boundary condition developed by EPA, scaled down by a reduction factor that reflects the decrease in sediment PCB concentrations that are projected to result from the planned remediation of the sediments adjacent to Dorothy Amos Park. The reduction factor calculation was based on PCB data from the top one foot of West Branch sediments collected during three different surveys: GE (2005); EPA (1999); and MDEP (2005).[3] For each sampling location, the length-weighted average 0-1 ft. PCB concentration was computed, and the Thiessen polygon spatial interpolation method was utilized to calculate an area-weighted average PCB concentration for the reach between the Dorothy Amos Park area and the Confluence (Figure 3-1). Based on this approach, the current 0-1 ft. area-weighted average sediment PCB concentration was estimated to be approximately 0.6 mg/kg. Using this same approach in conjunction with the spatial extent of sediment remediation described in GE's *Addendum to Second Supplemental Sampling Summary Report and Remedial Action Proposal for the West Branch of the Housatonic River* (dated October 27, 2006) and approved by the MDEP (as depicted on Figure 3-1) yielded a post-remediation average of approximately 0.4 mg/kg. Based on this analysis, the reduction factor was calculated to be 0.3. This reduction factor was then directly applied to the West Branch PCB boundary condition to reflect the remediation by scaling down the water column concentrations entering the model.

[3] Calculations for the top six-inches produced similar results, but the top one-foot was used for the analysis because it provided a larger data set (i.e., several cores segmented into 0-12" sections could not be used for the 0-6" analysis).

For specifying the 52-year time series of PCB boundary conditions in the West Branch, it was further assumed that the sediments will naturally attenuate (to some degree) following remediation of the major PCB source. There are no data from the West Branch to estimate such an attenuation rate. EPA conducted temporal trend analyses for water, sediment, and fish PCB concentration data collected since the early 1980s from the Rest of River, as described in Appendix A.1 of the FMDR (EPA, 2006b). These analyses suggested attenuation half lives of approximately 9 years for water column PCBs and 20 years for fish tissue PCBs, but found no statistically significant trend for sediment PCB data. However, the historical Rest of River water column-based half life of 9 years is not directly applicable to the West Branch future boundary condition because the nature of the PCB sources to the Rest of River and West Branch differs. The PCB sources to the Rest of River water column in the 1980s included not only internal sediment sources but also sources originating from the East Branch, such as inputs from the GE Plant area, while in the West Branch the in-river sediments from areas downstream of the planned remediation will represent the dominant source of PCBs in the future. Nonetheless, because some future natural attenuation of the West Branch sediments is expected, and because PCB levels in fish represent an integration of sediment exposures, a 20-year half life was chosen, based on the Rest of River fish trend analyses, to represent the rate of potential future natural attenuation for the West Branch PCB boundary condition.

Water column PCB concentrations developed for the West Branch boundary based on the methods described above are plotted over the 52-year projection period in Figure 3-2. In developing this boundary condition, the 26-year validation PCB time series was first modified to include estimates of PCBs during the extreme event that were developed by EPA using the flow-based relationship presented in Appendix B.2 of the FMDR. Two cycles of this modified time series were then decreased by the 0.3 reduction factor and exponential decay terms described above. The resulting boundary condition exhibits variability with river flow, and averages approximately 10 ng/L at the beginning of the projection period (i.e., immediately after the West Branch sediment remediation), and decreases to an annual average of approximately 2 ng/L by the end of the 52-year projection, due to the 0.3 reduction factor and the 20-year half life.

3.3 TRIBUTARIES

Due to the absence of known sources of PCBs within the watersheds of the tributaries that enter the river downstream of the Confluence (EPA, 2004a), and because the majority of the drainage area associated with these tributaries is located outside of the 1 mg/kg isopleth, the PCB boundary conditions for tributaries in the model projections were developed to reflect inputs of PCBs from atmospheric sources. The PCB concentration used to represent atmospheric loadings was derived from a combination of literature review and a back-calculation of water column concentrations using EPA fish tissue PCB data from a reference site located within the Housatonic River drainage basin.

A review of several literature studies that report monitoring results for PCB concentrations in remote, un-impacted waters for which atmospheric inputs represent the only known source of PCBs, as well as measurements of PCBs in precipitation, was conducted and is summarized in Table 3-1.

Table 3-1. Summary of literature reported PCB concentrations in remote, un-impacted waters and precipitation.

Location	Collection Date(s)	Surface Water[1]		Precipitation		Citation
		Mean Total PCB Concentration (ng/L)	Sample Size	Mean Total PCB Concentration (ng/L)	Sample Size	
Chester, NJ (light suburban)	1998 - 2001	-	-	0.52 (S.E. = 0.10)[2]	12	VanRy et al. 2002
Pinelands, NJ (background forest)		-	-	0.38 (S.E. = 0.076)[2]	27	
Tuckerton, NJ (coastal, light residential)		-	-	0.35 (S.E. = 0.11)[2]	13	
Savannah River	2004 - 2005	0.0832 (0.0214 - 0.145)	2	0.29	12	Glaser et al. 2006
Oconee River		0.170 (0.101-0.239)	2	-	-	
Ocmulgee River		0.376 (0.249 - 0.504)	2	-	-	
Etowah River	2003	0.29	NA	-	-	EPA 2004
Oostanaula River		0.28	NA	-	-	
South Tobacco Creek (agricultural watershed)	1994 - 1995	1.839 (0.020 - 6.35)	NA	2.872 (0.088 - 9.703)[3]	NA	Rawn et al. 1998
Siskiwit Lake (remote)	1983 - 1984	2.3	11	13[3]	12	Swackhamer et al. 1988
				17[4]	1	
Lake Michigan	1980	1.2	11	-	-	Pearson et al. 1996*
Lake Michigan	1991	0.47 (S.E. = 0.06, 0.43 - 0.62)	9	-	-	
Lake Michigan	1991	0.64 (S.E. = 0.43, 0.34 - 1.7)	11	-	-	
Southern Lake Michigan	1994 - 1995	0.179 (S.E. = 0.017, 0.070 - 0.350)	23	-	-	Offenberg and Baker 2000*
L375, Ontario (remote)	1990 - 1991	1.1	NA	-	-	Paterson et al. 1998
Green, Ontario (remote)		1.25	NA	-	-	
Orange, Ontario (remote)		0.75	NA	-	-	
Linge, Ontario (remote)		1.1	NA	-	-	
Musclow, Ontario (remote)		0.8	NA	-	-	
Sydney, Ontario (remote)		0.7	NA	-	-	

Location	Collection Date(s)	Surface Water[1]		Precipitation		Citation
		Mean Total PCB Concentration (ng/L)	Sample Size	Mean Total PCB Concentration (ng/L)	Sample Size	
Trout, Ontario (remote)		0.9	NA	-	-	
Nipigon, Ontario (remote)		0.9	NA	-	-	
Chesapeake Bay	1993	0.92 (S.E. = 0.47)[5]	31	-	-	Nelson et al. 1998
Aquia Creek	2005 - 2006	0.16 (0.05 - 0.26)	2	-	-	ICPRB 2007
Chopawamsic Creek		0.31 (0.06 - 0.64)	3	-	-	
Coan Mill Stream		0.27 (0.19 - 0.34)	2	-	-	
Monroe Creek		0.37 (0.35 - 0.39)	2	-	-	
Nomini Creek		0.16 (0.13 - 0.19)	2	-	-	
Occoquan River		0.18	1	-	-	
Pohick Creek		0.12 (0.08 - 0.16)	2	-	-	
Potamac Creek		0.12 (0.08 - 0.16)	2	-	-	
Powel Creek		0.24 (0.17 - 0.32)	2	-	-	
Quantico Creek		0.16 (0.04 - 0.37)	3	-	-	
Upper Machodoc Creek		0.045 (0.04 - 0.05)	2	-	-	
Williams Creek		0.19 (0.18 - 0.20)	2	-	-	
Boshkung, Ontario (isolated)	1986 - 1987	0.93 (0.82 - 1.05)	2	-	-	Macdonald and Metcalf 1991
Wood, Ontario (isolated)		1.85 (0.86 - 3.99)	2	-	-	
St. Nora, Ontario (isolated)		1.6 (1.51-1.69)	2	-	-	
Opeongo, Ontario (isolated)		1.23 (0.99 - 1.52)	2	-	-	
L110, Ontario (remote)	1993 - 1994	0.33 (S.E. = 0.06)[5]	12	-	-	Jeremiason et al. 1999
L227, Ontario (remote)		0.29 (S.E. = 0.06)[5]	13	-	-	
Lake Tahoe	1995	0.3754	2	4.95 (4.8 - 5.1)[4]	2	Datta et al. 1998
Marlette Lake		0.684	1	-	-	
Lake Superior	1986	0.547 (S.D. = 0.366)[6]	NA	-	-	Baker and Eisenreich 1990
Lake Erie	1993	0.79 (0.2 - 1.6)	5	-	-	Anderson et al. 1999
Lake Huron		0.13 (0.088 - 0.16)	4	-	-	
Lake Michigan		0.21 (0.17 - 0.27)	5	-	-	
Lake Ontario		0.22 (0.19 - 0.25)	5	-	-	
Lake Superior		0.083 (0.07 -0.10)	3	-	-	
Lake Superior	1988	0.33 (S.E. = 0.04)	NA	-	-	Jeremiason et al. 1994*
Lake Superior	1990	0.32 (S.E. = 0.03)	NA	-	-	
Lake Superior	1992	0.18 (S.E. = 0.02)	NA	-	-	

Notes:
[1] Values in parentheses represent ranges, unless otherwise noted -- S.E. = standard error; S.D = standard deviation.
[2] Volume Weighted Mean.
[3]Rain.
[4]Snow.
[5]Only dissolved phase PCBs reported.
[6]Sum of 35 congeners.
**1/2 life calculations presented.*
NA = Sample size not available.

The data summarized in Table 3-1 suggest that the year of sampling, type of waterbody, and proximity to an urban area account for the large variability observed among the studies (e.g., reported water column PCB concentrations range from 0.02 to 6.4 ng/L). A number of studies reported PCB concentrations in lakes; however, the Great Lakes are too large to be considered for tributary boundary conditions while the smaller lakes exhibit relatively high concentrations, likely due to a longer residence time than flowing stream systems. Thus, those most relevant to the Housatonic River tributaries are likely the more recent studies of streams and precipitation, which suggest current PCB concentrations from atmospheric inputs are commonly in the range of 0.3 to 0.5 ng/L (Figure 3-3).

In addition, water column PCB concentrations have been estimated for Threemile Pond (a reference site to the Housatonic River study area) using average whole body fish tissue PCB concentrations (based on EPA data) and Great Lakes-based guidance values and formulae for bioaccumulation factors (BAFs; EPA, 1997). Threemile Pond fish PCB concentrations fall within the range of 0.03 to 0.07 mg/kg, concentrations that are consistent with values collected in a large number of lakes in the U.S and are therefore considered representative of atmospheric PCB inputs (Table 3-2; EPA 2004b). Based on site-specific lipid averages for pumpkinseed, yellow perch, brown bullhead, and largemouth bass, log BAF values calculated for these species in Threemile Pond ranged from 5.5 to 5.9 log-L/kg, which translate to water column PCB concentrations in the range of 0.1 to 0.2 ng/L (Table 3-2).

Table 3-2. Estimated Threemile Pond BAFs and water column PCB concentrations.

Species[1]	N[2]	Mean PCB Concentration (mg/kg)[2]	Mean PCB Concentration (mg/kg lipid)[2]	Mean Lipid (percent)[2]	Trophic Level	BAF[3]	Water Concentration (ng/L)[4]
BB	6	0.03	1.27	2.48	Bottom	5.6	0.1
LB	14	0.07	3.53	2.06	TL4	5.9	0.1
PS	12	0.06	2.17	2.98	TL3	5.7	0.1
YP	17	0.07	4.43	1.70	TL3	5.5	0.2

Notes:
[1]Fish PCB and lipid values are for whole body adults.
[2]Data source: EPA (QEA and BBL, 2003).
[3]BAF was calculated using the Great Lakes composite baseline BAF formulae, which are a function of lipid content (EPA 1997).
[4]Water PCB concentration was back-calculated by BAF = [tissue PCB]/[water PCB].

Based on the data and calculations described above, the starting concentration for tributary boundary conditions for CMS model projections was assigned to be 0.3 ng/L. This value represents the approximate midpoint between the relevant literature reported values of approximately 0.3 to 0.5 ng/L and the estimated water column concentrations in Threemile Pond of 0.1 to 0.2 ng/L.

A supplementary assumption was made that, over the 52-year projection period, tributary PCB concentrations would decline in response to long-term reductions in atmospheric PCB loadings. This assumption can be supported by several literature studies. Six Integrated Atmospheric Deposition Network sites within the Great Lakes region sampled from 1990 to

2003 estimated total PCBs in the atmosphere to have half lives ranging from 4 to 26 years and averaging 14 years (Sun et al., 2007). Additionally, Sun et al. (2007) reported PCB data collected from 1996 to 2003 for urban Chicago resulting in a half life of 8.0 years. Similar decreasing trends in surface water PCB concentrations of the Great Lakes (which respond strongly to atmospheric inputs) have yielded half lives in the range of 4 to 9 years (Pearson et al., 1996; Offenberg and Baker, 2000; Jermaison et al., 1994). Based on these literature studies, the assumption that PCB concentrations decline at a half life of 10 years was used for specifying tributary PCBs in the model boundary conditions. The resulting 52-year PCB concentration time series to be used for all modeled tributaries, which is based on a starting value of 0.3 ng/L and an exponential decay at a 10-year half life, is shown in Figure 3-4.

3.4 DIRECT DRAINAGE

Direct runoff entering the River from the watershed contains solids that originate, in part, from localized wash-off of floodplain soils adjacent to the river. The solid loadings associated with this process are calculated by HSPF and used as an input to EFDC. These floodplain soils contain PCBs and thus likely contribute some amount of PCBs to the river. Such PCB loadings were considered negligible when compared to the internal PCB fluxes associated with sediments in Reach 5 and were hence excluded from the model calibration (EPA, 2004a). However, under future conditions, where the extent of remediation would be much greater, these loads may be more significant. Thus, the PCB loads associated with direct runoff will be represented in the PCB boundary conditions for the CMS model projections. Direct drainage PCB loads will be estimated by specifying an effective PCB concentration for the solids that enter the river via direct runoff calculated by HSPF.

Thus, an effective particulate-phase PCB concentration and time-variable solids loads were used to calculate the PCB loadings for the direct drainage boundary conditions. In HSPF, the Housatonic River watershed was divided into tributary and direct drainage sub-basins with relatively similar hydrologic/hydraulic properties; time-variable solids loads are predicted by HSPF for each direct drainage sub-basin. The effective particulate-phase PCB concentration associated with the solids entering the river from each direct drainage sub-basin was calculated as the area-weighted soil PCB concentration within each sub-basin. This area-weighted average was calculated based on: (a) the 0-6" Thiessen polygon data coverage described in Appendix D of the CMS Proposal within the 1 ppm isopleth in Reaches 5 and 6 and the 100-year floodplain in Reaches 7 and 8; and (b) an assumed PCB concentration of zero for the portions of the sub-basins outside the 1 ppm isopleth/100-year floodplain.

The individual direct drainage sub-basins located in Reaches 5 through 8 (labeled with EPA's HSPF Basin IDs) and the area-weighted average soil PCB concentrations calculated using the method described above are shown in Figure 3-5. These calculations indicate that the area-weighted average soil PCB concentrations ranged from 0.4 to 3.3 ppm in Reaches 5 and 6, with much lower values (PCBs typically below 0.2 ppm) for the sub-basins in Reaches 7 and 8.

The 52-year time series of water column PCB concentrations calculated for the direct drainage sub-basins based on HSPF-predicted TSS loads and the effective particulate phase PCB concentrations shown in Figure 3-5 are plotted in Figure 3-6. These calculated concentrations will be used as the boundary condition for the direct drainage areas in the EFDC model. The results in Figure 3-6 indicate that concentrations vary greatly due to flow and solids variations (e.g., flows and concentrations for these sub-basins go to zero during dry weather), with annual average PCB concentrations for the direct drainage boundaries in Reaches 5 and 6 being between approximately 1 and 10 ng/L, with much lower annual averages of < 0.1 ng/L for the direct drainage sub-basins in Reaches 7 and 8.

SECTION 4
POST-REMEDIATION SEDIMENT PCB CONCENTRATIONS

As discussed in the CMS Proposal, the proposed active remedial alternatives for in-river sediments will include some amount of sediment removal and/or capping. Sediment removal/capping generally will be simulated in the model by changing the bed PCB concentrations in the appropriate model grid cells from the current predicted value to a lower (non-zero) value. Therefore, simulation of these scenarios requires making estimates of the post-remediation sediment PCB concentrations to be used in the model. Such assumptions will be made separately, depending on the specified remedial technology for a given scenario.

The CMS Proposal stated that simulation of areas of the river subject to mechanical dredging in the dry (with subsequent addition of cap or backfill material) or placement of a thin-layer cap will use a post-remediation sediment PCB concentration of 0.021 mg/kg, which is the PCB concentration used for backfill in remediation evaluations for areas outside the River and represents one-half of the average detection limit from sampling of backfill sources. For areas of the river subject to hydraulic or mechanical dredging in the wet (followed by placement of a cap or backfill material) or engineered capping alone (without any prior removal), the CMS Proposal stated that the post-remediation concentration for the placed cap/backfill material will be based upon the product of estimated values for: (1) a post-dredging and/or pre-capping sediment PCB concentration; and (2) a reduction efficiency for cap/backfill placement. This approach is being used to reflect the likelihood of mixing during wet dredging and subsequent cap/backfill placement, or during cap placement by itself, between the disturbed native sediment and the cap/backfill material. The approach used to estimate the post-dredging residual concentrations and the selected reduction efficiency for the model simulations is described below.

4.1 REDUCTION EFFICIENCY

A review of the literature and information gathered from other contaminated sediment sites provided a large dataset for post-removal sediment concentrations (e.g., Scenic Hudson, 2000; GE, 2000). A typical sediment PCB reduction efficiency value suggested by those data is approximately 95 percent, although the results varied greatly, from an increase in sediment concentration post-removal to a reduction of 99 percent. The large variation in reduction efficiencies can be attributed to a number of factors such as large amounts of debris present, inappropriate dredge type, misunderstanding of the extent of contamination, and site conditions.

Despite the many examples of post-removal sediment PCB concentrations, information on PCB concentrations in cap/backfill material placed following sediment removal, or cap material placed without prior sediment removal, is scarce. However, some post-placement cap/backfill PCB concentration data are available from the Grasse River site in New York.

In 2001, a Capping Pilot Study was conducted in the Grasse River, during which native sediment was capped with 12 or 24 inches of various materials. Ninety-five percent of the core samples taken through the pilot cap material were below detection limits (<0.1 mg/kg; McShea, 2002; Alcoa, 2002). A comparison of the PCB data from surface sediment (i.e., top 3-inch) samples collected in the study area with pre-capping surface concentrations indicated that the post-remediation percent reduction of PCB concentrations was approximately 92 to 97 percent (Alcoa, 2003, as cited in Alcoa, 2006). In 2005, three additional pilot capping studies were conducted on the Grasse River. These included: (1) placement of a thin-layer cap (3 to 6 inches) over contaminated sediments in a shallow area; (2) removal of one foot of sediment from a shallow area, followed by replacement with one foot of cap material; and (3) removal and capping of sediments from a section of the main channel (Alcoa, 2006). The test of shallow dredging followed by capping resulted in a reduction efficiency of approximately 99 percent (Alcoa, 2006). Despite some difficulties in one portion of the main channel, an approximate PCB reduction efficiency in that area was estimated at 95 percent (Alcoa, 2006). Alcoa (2006) suggested that placement of the cap in a single lift may have contributed to the lower reduction efficiency observed in the main channel area.

Based on the data described above, a reduction efficiency of 99 percent will be used in the CMS model projections for simulation of sediment remedial alternatives involving removal in the wet with subsequent cap or backfill placement, or involving capping alone in the wet.

4.2 PRE-CAPPING/BACKFILL CONCENTRATION

As described in the CMS Proposal, residual concentrations, which are defined as the concentration of sediments left behind following wet dredging and before any capping or backfill placement, are generally consistent with the vertically averaged concentration of the sediments removed (e.g., Patmont, 2006; Patmont and Palermo, 2007). Thus, PCB residual concentrations for areas subject to removal in the wet will be calculated as the vertical average of the sediments removed for each such proposed remedial scenario. For areas of the river subject to engineered capping alone (with no prior removal), the pre-capping PCB concentration will be set equal to the surficial 6-inch average sediment PCB concentration.

4.3 POST-REMEDIATION CONCENTRATION

Based on the approach described above, initial post-remediation sediment PCB concentrations specified in the model for mechanical/hydraulic dredging in the wet or engineered capping alone will be calculated based on the pre-capping concentration (calculated using the approach described in Section 4.2) times 0.01 (i.e., the 99% reduction factor discussed in Section 4.1). As an example, if a sediment alternative proposes 2.5-ft. of removal in the shallow portions of Woods Pond, and this area has a 2.5-ft. vertical average sediment concentration of approximately 29 mg/kg at the end of the 26-year model validation, an initial post-remediation sediment PCB concentration of approximately 0.3 mg/kg would be specified in the model for simulation of that alternative.

In the model, regardless of the initial post-remediation sediment PCB concentration, the processes affecting surface sediment PCBs (i.e., deposition and erosion) will project surface sediment concentrations towards an equilibrium with the water column particulate PCB concentrations (which will be driven to a large extent by the boundary conditions) after the simulated remediation is complete. Thus, the values chosen for initial post-remediation sediment concentrations will have a relatively short-term impact on the future model predictions.

SECTION 5
REFERENCES

Alcoa, 2002. *Grasse River Capping Pilot Study*. Presented at Sediment Remediation Action Team Meeting, March 2002.

Alcoa, 2006. *Draft - Remedial Options Pilot Study Documentation Report, Grasse River Study Area*, *Massena, NY*. Submitted to EPA Region 2 in May 2006.

Anderson, D.J., T.B. Bloem, R.K. Blankenbaker, and T.A. Stanko, 1999. Concentrations of Polychlorinated Biphenyls in the Water Column of the Laruentian Great Lakes: Spring 1993. *Journal of Great Lakes Resources* 25(1):160-170.

Baker, J.E. and S.J. Eisenreich, 1990. Concentrations and Fluxes of Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls Across the Air-Water Interface of Lake Superior. *Environmental Science and Technology* 24(3):342 – 352.

BBL, 1999. *Removal Action Work Plan for Upper ½ Mile Reach of Housatonic River.* Appendix F to Consent Decree. Prepared for General Electric Company, Pittsfield, MA, dated August 1999, and EPA approval letter dated August 5, 1999.

BBL and QEA, 2003. *RCRA Facility Investigation Report – Rest of River* (RFI Report). Prepared for General Electric Company, Pittsfield, MA.

BBL and QEA, 2007. *Housatonic River – Rest of River Corrective Measures Study Proposal* (CMS Proposal). Prepared for General Electric Company, Pittsfield, MA.

Datta, S., L.L. McConnell, J.E. Baker, J. Lenoir, and J.N. Seiber, 1998. Evidence for Atmospheric Transport and Deposition of Polychlorinated Biphenyls to the Lake Tahoe Basin, California-Nevada. *Environmental Science and Technology* 32(10):1378-1385.

EPA, 1997. *Final Revisions to the Polychlorinated Biphenyl Criteria for Human Health and Wildlife for the Water Quality Guidance for the Great Lakes System; Final Rule* 62(48):11724-11731, March 12, 1997.

EPA, 2004a. *Model Calibration: Modeling Study of PCB Contamination in the Housatonic River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the US Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region, December 2004.

EPA, 2004b. *National Study of Chemical Residues in Lake Fish Tissue Years 1-4*. U.S. Environmental Protection Agency, Office of Water, Washington D.C.

EPA, 2004c. *Coosa River PCB Water Sampling Investigation Report. Project No. 03-1068, 04-0048*. EPA Region 4, March 2004 (data revised, April 2004).

EPA, 2006a. *Responsiveness Summary to the Peer Review of Model Validation: Modeling Study of PCB Contamination in the Housatonic River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. November 2006.

EPA, 2006b. *Final Model Documentation Report: Modeling Study of PCB Contamination in the Housatonic River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. November 2006.

GE, 2000. *Environmental Dredging: An Evaluation of its Effectiveness in Controlling Risks*. General Electric Company Corporate Environmental Programs. Prepared with assistance from: Blasland, Bouck and Lee, Inc., and Applied Environmental Management, Inc. August 2000.

Glaser, D., M. Meyers, J. Connolly, R. McAlister, 2006. *Are Water Quality Standards Achievable and Necessary for Reaching Risk-Based Goals? A PCB Example*. Presented at SETAC, Montreal. November 2006.

Interstate Commission on the Potomac River Basin, 2007. *Calculation of Polychlorinated Biphenyl (PCB) External Loads for the Potomac PCB Model Draft*. Prepared by C. Haywood and C. Buchanan for the Tidal Potomac PCB TMDL Steering Committee. January 2007.

Jeremiason, J.D., K.C. Hornbuckle, and S.J. Eisenreich, 1994. PCBs in Lake Superior, 1978-1992: Decrease in Water Concentrations Reflect Loss by Volatilization. *Environmental Science and Technology* 28(5): 903-914.

Jeremiason, J.D., S.J. Eisenreich, M.J. Paterson, K.G. Beaty, R. Hecky, and J.J. Elser, 1999. Biogeochemical Cycling of PCBs in Lakes of Variable Trophic Status: A Paired-Lake Experiment. *Limnology and Oceanography* 44(3) Part 2:889-902.

Macdonald, C.R. and C.D. Metcalf, 1991. Concentration and Distribution of PCB Congeners in Isolated Ontario Lakes Contaminated by Atmospheric Deposition. *Canadian Journal of Fisheries and Aquatic Sciences* 48:371-381.

McShea, L., M. Logan, and J. Mihm, 2002. Sediment Capping Pilot Study Conducted on Grasse River. *Technology News and Trends* September 2002.

Nelson, E.D., L.L. McConnell, and J.E. Baker, 1998. Diffusive Exchange of Gaseous Polycyclic Aromatic Hydrocarbons and Polychlorinated Biphenyls Across the Air-Water Interface of the Chesapeake Bay. *Environmental Science and Technology* 32(7):912-919.

Offenberg, J.H. and J.E. Baker, 2000. PCBs and PAHs in Southern Lake Michigan in 1994 and 1995: Urban Atmospheric Influences and Long-Term Declines. *Journal of Great Lakes Resources* 26(2):196-208.

Paterson, M.J., D.C.G. Muir, B. Rosenberg, E.J. Fee, C. Anema, and W. Franzin, 1998. Does Lake Size Affect Concentrations of Atmospherically Derived Polychlorinated Biphenyls in Water, Sediment, Zooplankton, and Fish? *Canadian Journal of Fisheries and Aquatic Sciences* (55)3:544-553.

Patmont, C., 2006. *Contaminated Sediment Dredging Residuals: Recent Monitoring Data and Management Implications.* Presented to the National Research Council Committee On Sediment Dredging At Superfund Megasites. June 2006.

Patmont, C. and M. Palermo, 2007. *Case Studies of Environmental Dredging Residuals and Management Implications*. Presented at the Fourth International Conference on Remediation of Contaminated Sediments. Savannah, GA. January, 2007.

Pearson, R.F. K.C. Hornbuckle, S.J. Eisenreich, and D.L. Swackamer, 1996. PCBs in Lake Michigan Water Revisited. *Environmental Science and Technology* 30(5):1429-1436.

Rawn, D.F.K., T.H.J. Halldorson, B.D. Lawson, D.C.G.Muir, 1998. Polychlorinated Biphenyls in a Rural Watershed in the Southern Prairie Region of Canada. *Environmental Pollution* 102(1):77-90.

Scenic Hudson, 2000. *Results of Contaminated Sediment Cleanups Relevant to the Hudson River*. An Update to Scenic Hudson's Report *Advances in Dredging Contaminated Sediment*. Prepared for Scenic Hudson by Joshua Cleland. October 2000.

Sun, P., I. Basu, P. Blanchard, K.A. Brice, and R.A. Hites, 2007. Temporal and Spatial Trends of Atmospheric Polychlorinated Biphenyl Concentrations Near the Great Lakes. *Environmental Science and Technology* 41(4):1131-1136.

Swackhamer, D.L., B.D. McVeety, and R.A. Hites, 1988. Deposition and Evaporation of Polychlorobiphenyl Congeners To and From Siskiwit Lake, Isle Royale, Lake Superior. *Environmental Science and Technology* 22(6):664-672.

Van Ry, D.A., C.L. Gigliotti, T.R. Glenn IV, E.D. Nelson, L.A. Totten, and S.J. Eisenreich, 2002. Wet Deposition of Polychlorinated Biphenyls in Urban and Background Areas of the Mid-Atlantic States. *Environmental Science and Technology* 36(15):3201-3209.

FIGURES

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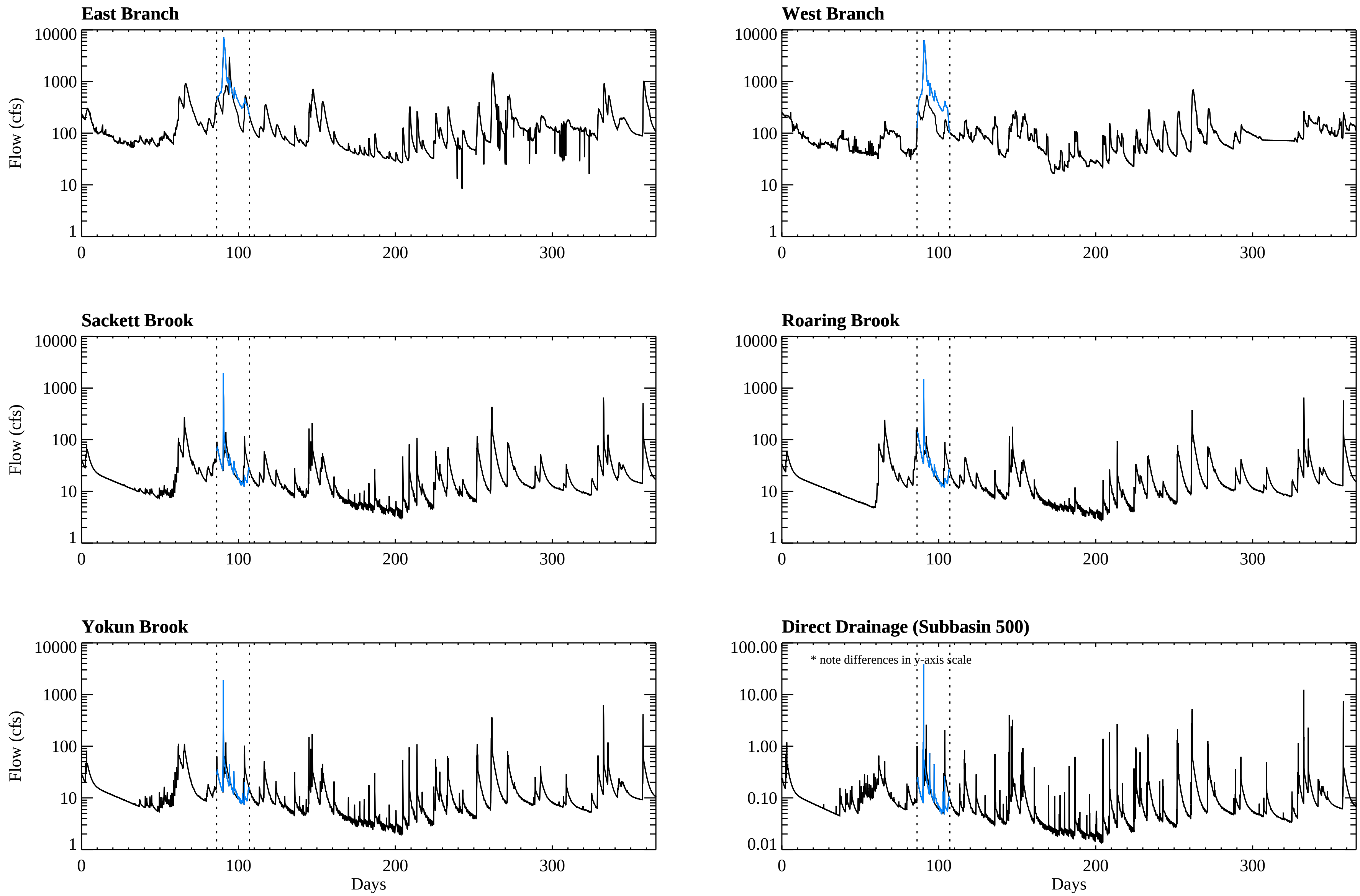
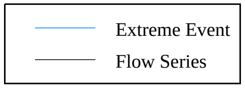


Figure 2-1. Flow boundary conditions for extreme event in projection Year 26 (Reach 5/6)

Note: Vertical dashed lines represent extent of extreme event substitutions in projection Year 26.



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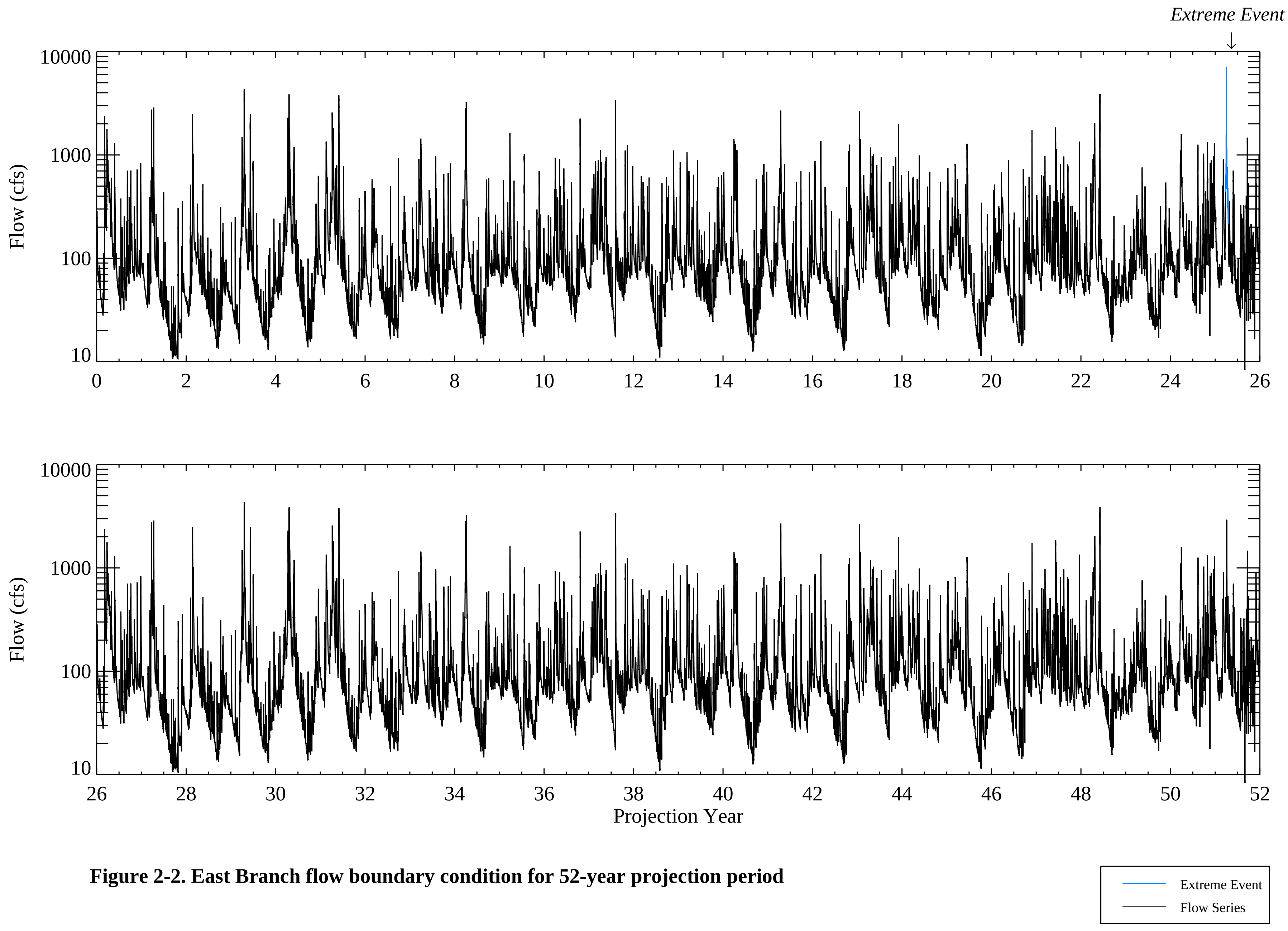

Figure 2-2. East Branch flow boundary condition for 52-year projection period

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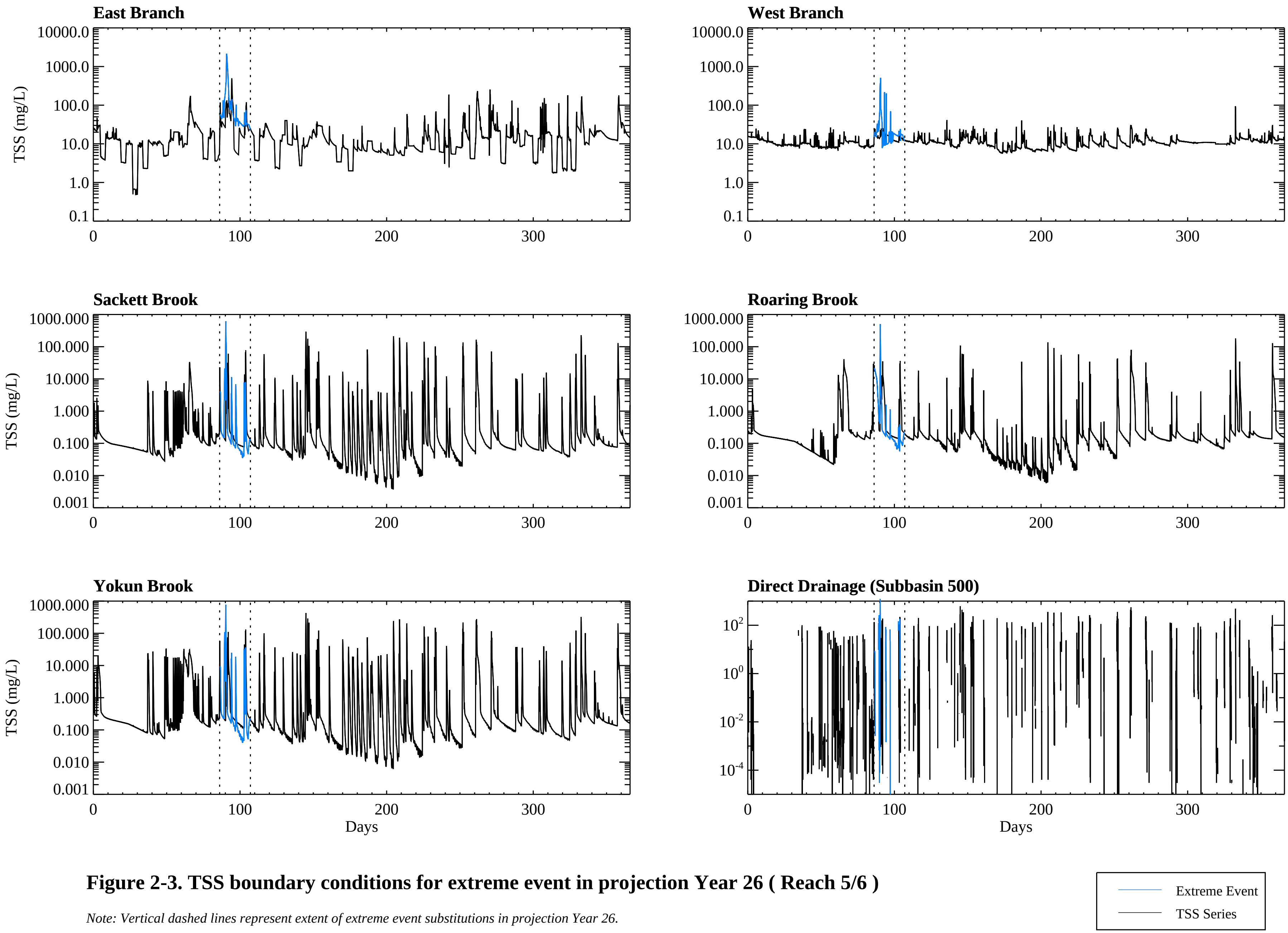

Figure 2-3. TSS boundary conditions for extreme event in projection Year 26 (Reach 5/6)

Note: Vertical dashed lines represent extent of extreme event substitutions in projection Year 26.

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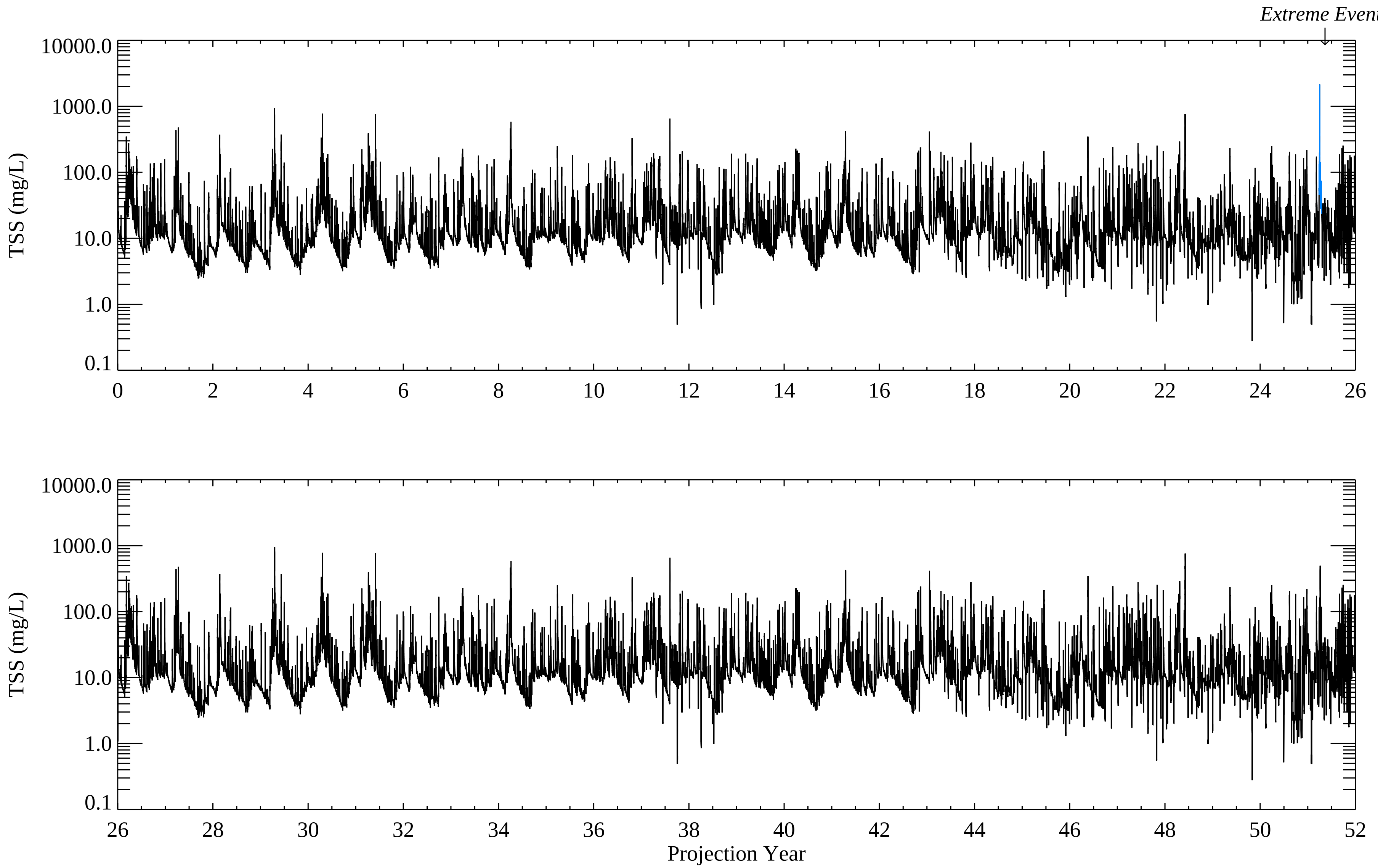

Figure 2-4. East Branch TSS boundary condition for 52-year projection period

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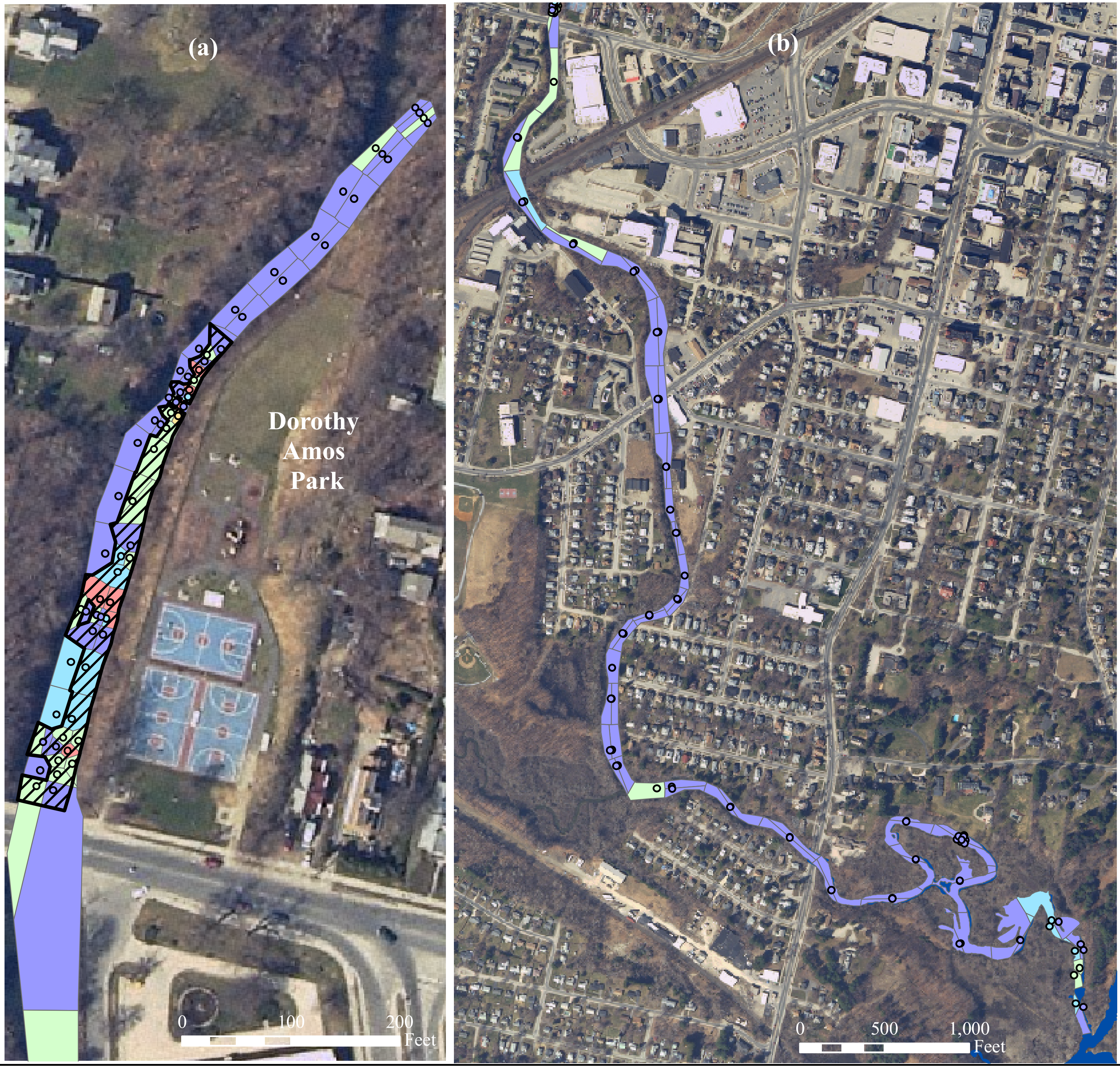

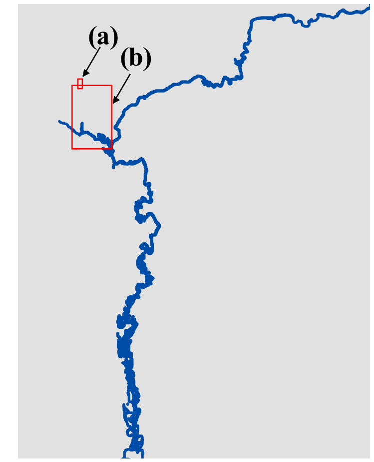

LEGEND

PCBs (mg/kg)

- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 5.0
- 5.0 - 10.0
- > 10.0
- Planned Remediation Areas

Notes:
1) Non-detects set to 1/2 MDL.
2) Theissen polygons calculated from length-weighted average sediment PCB concentrations in the top 1-foot of sediment.
3) Four locations with data missing from top 1-ft included in analysis: WSD00350L2, WSD00350M2, WSD00550L1 and WSD00550R1.

Figure 3-1. Average sediment PCB concentrations in West Branch.

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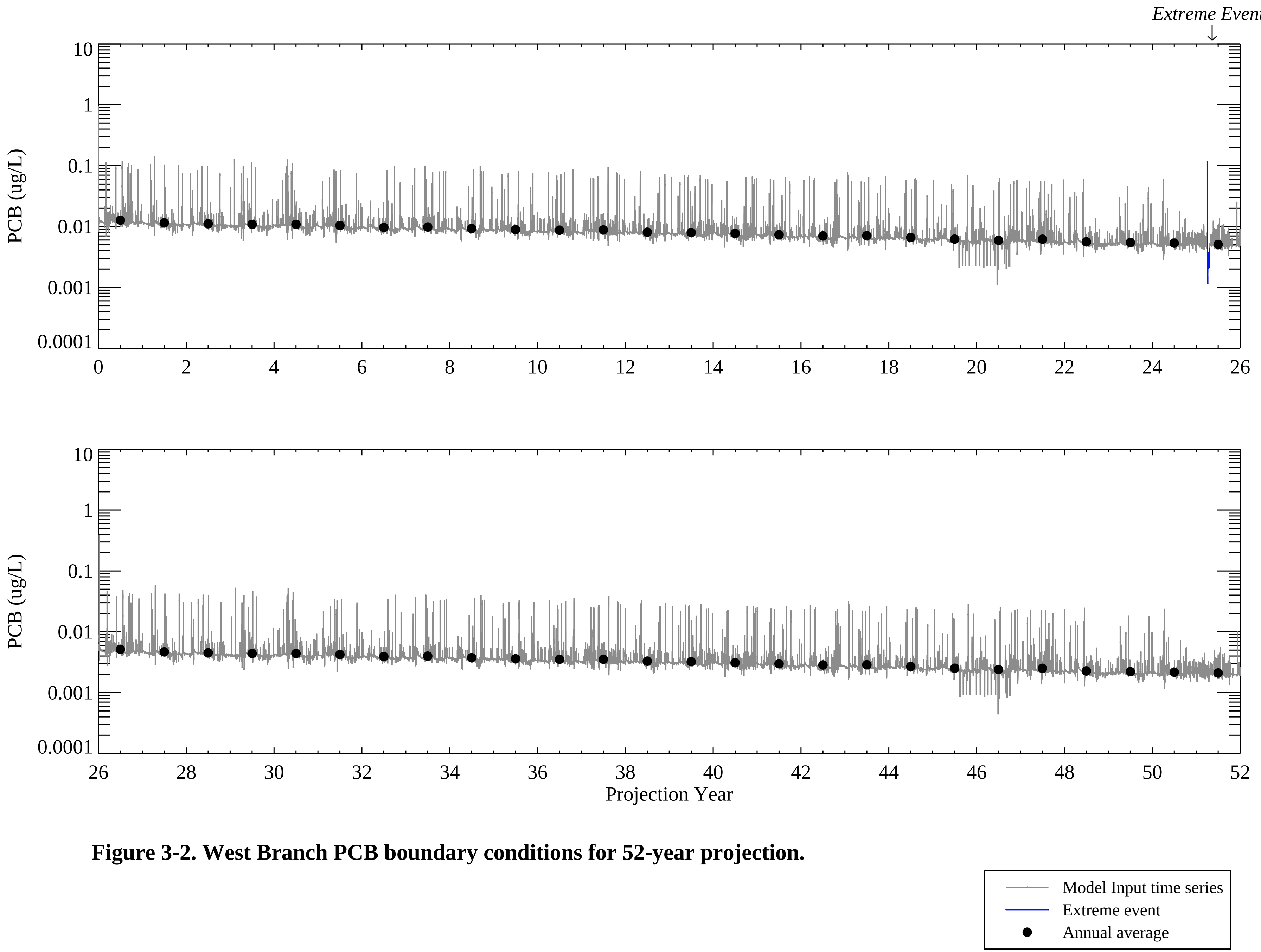

Figure 3-2. West Branch PCB boundary conditions for 52-year projection.

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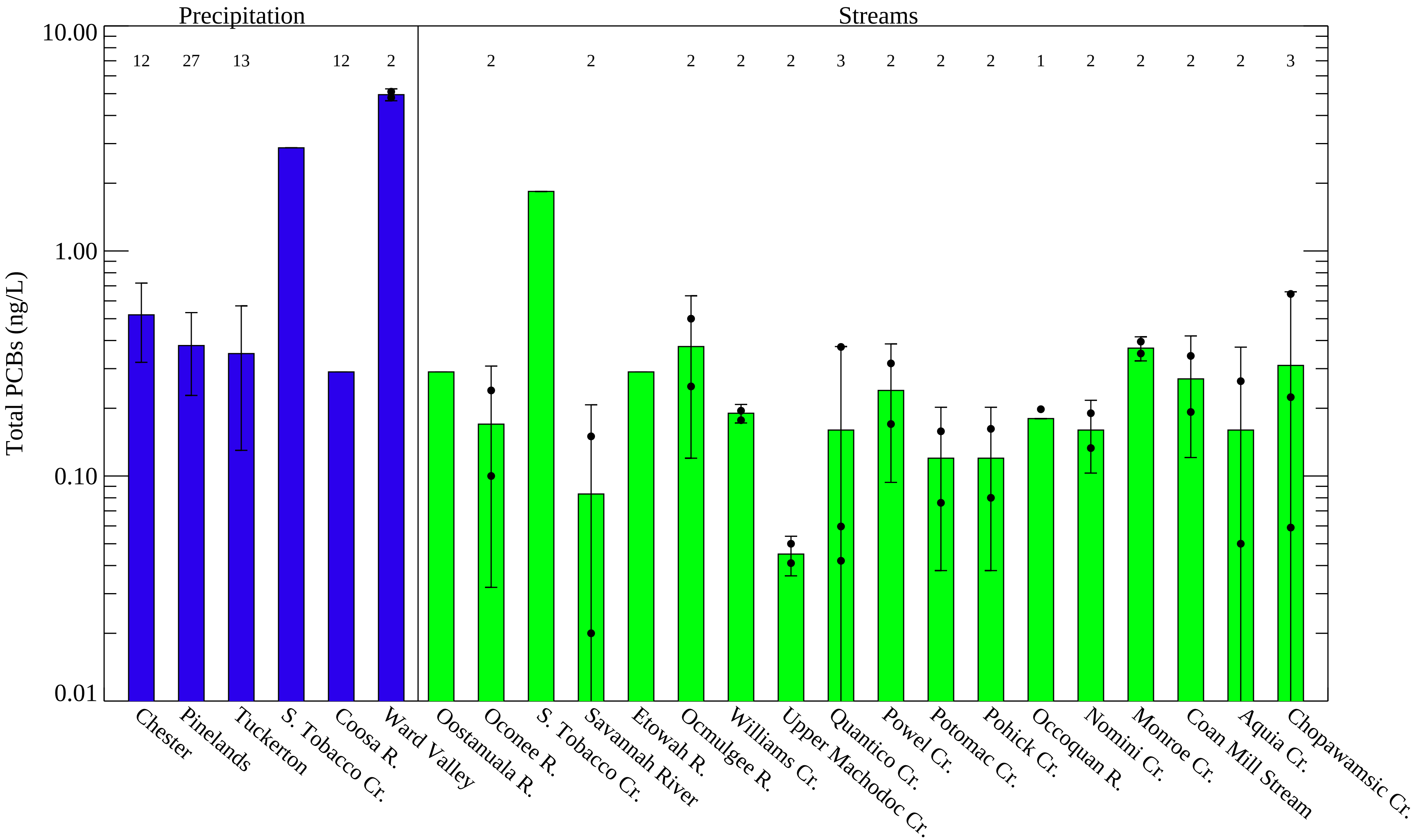

Figure 3-3. Literature reported values of background PCB concentrations in surface waters.

Bars represent arithmetic means; error bars are 2 standard errors of the mean; filled circles represent raw data points (when available).

Number of observations posted at top of plot.

Data collected from 1990 through 2006.

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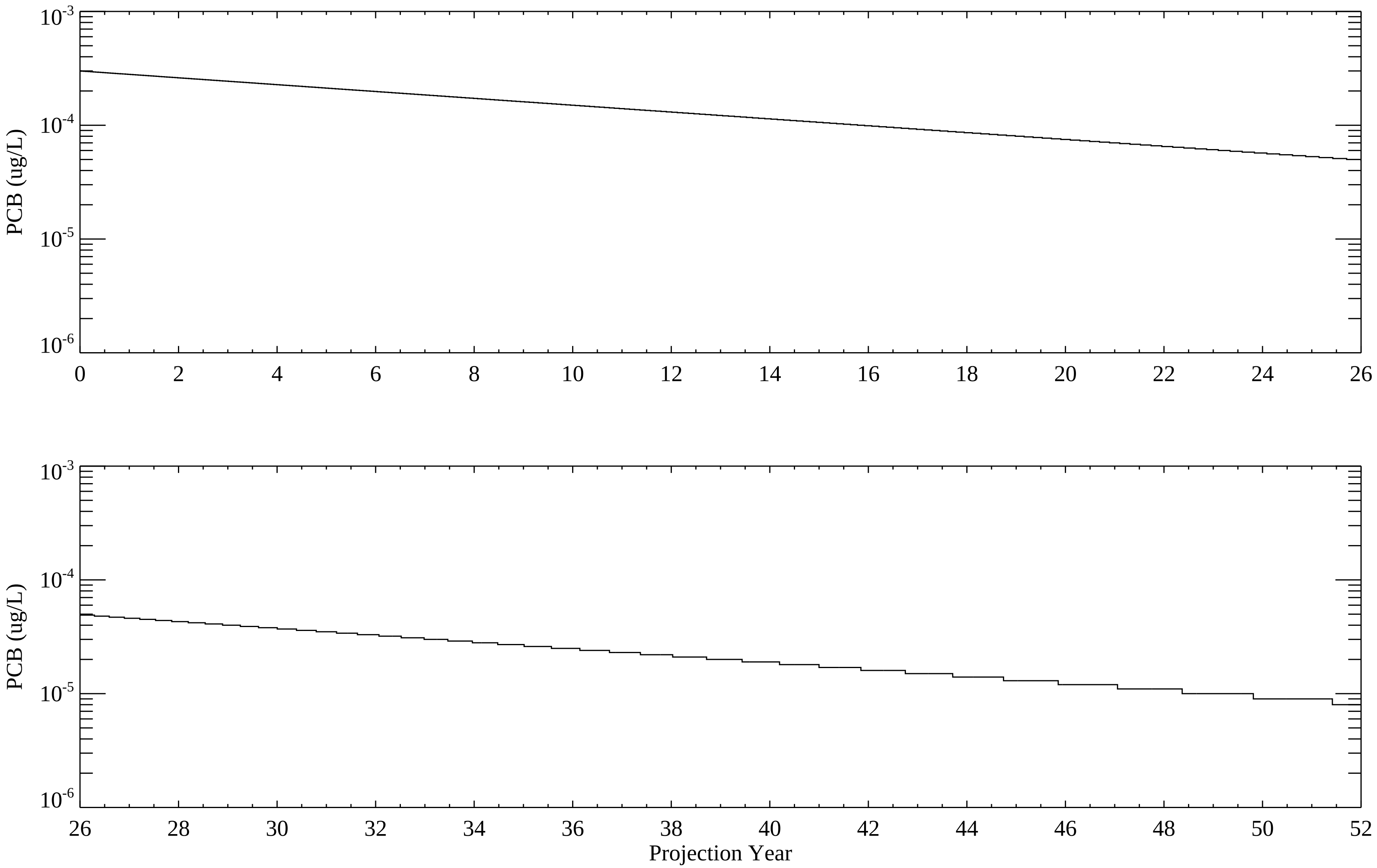

Figure 3-4. Tributary PCB boundary condition for 52-year projection period

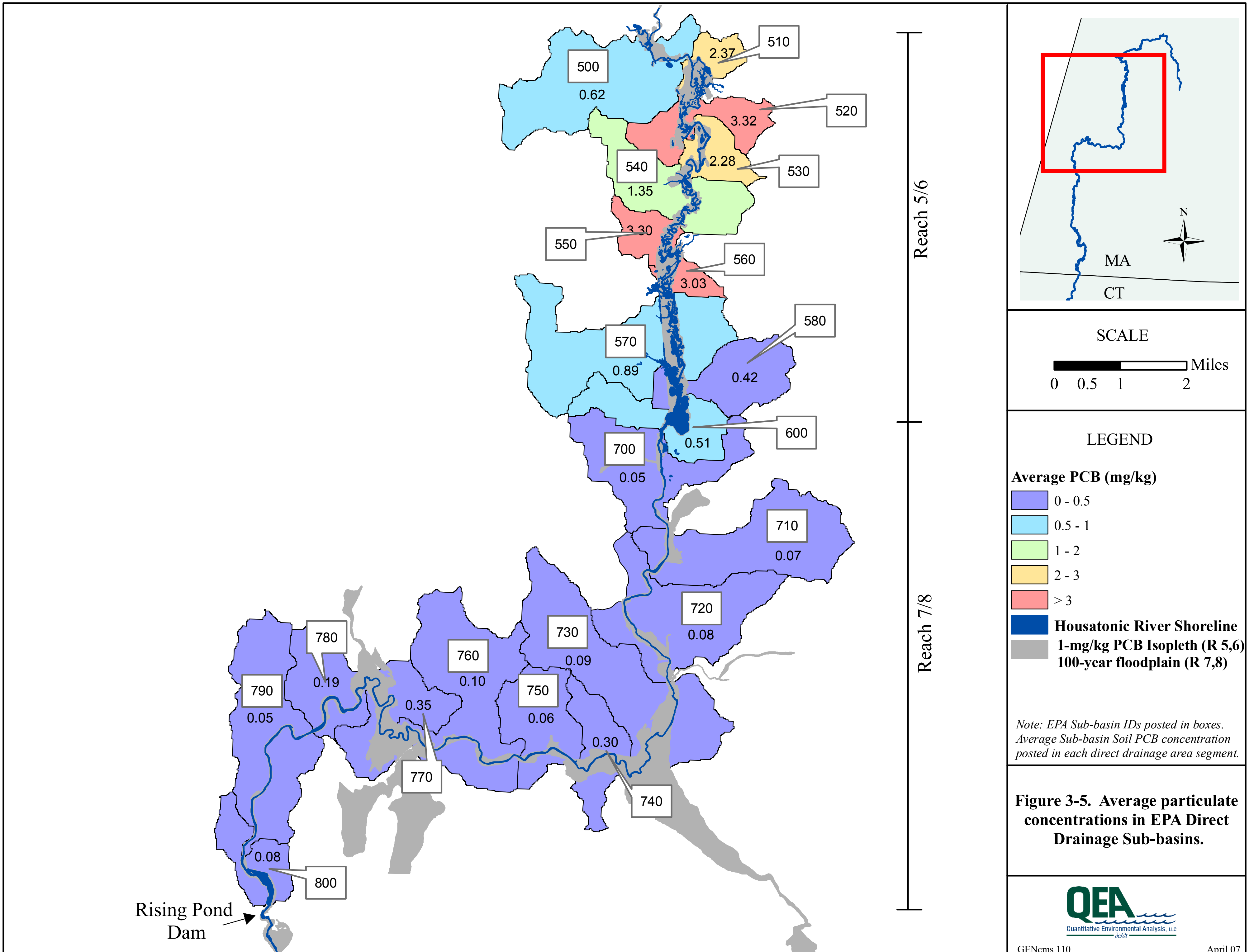

Figure 3-5. Average particulate concentrations in EPA Direct Drainage Sub-basins.

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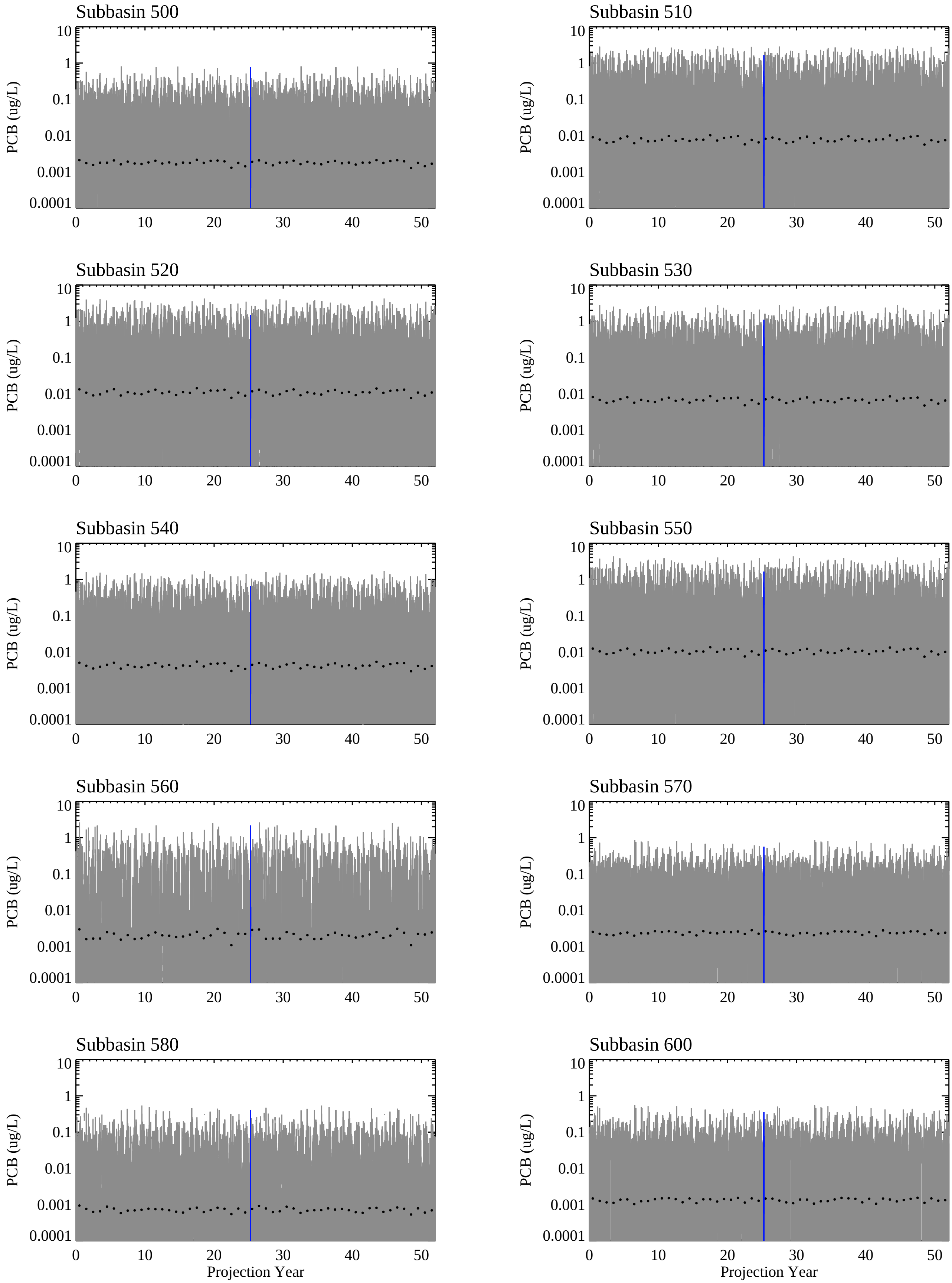

Figure 3-6a. Reach 5,6 direct drainage PCB boundary conditions for 52-year projection.

Model Input time series
Extreme event
• Annual average

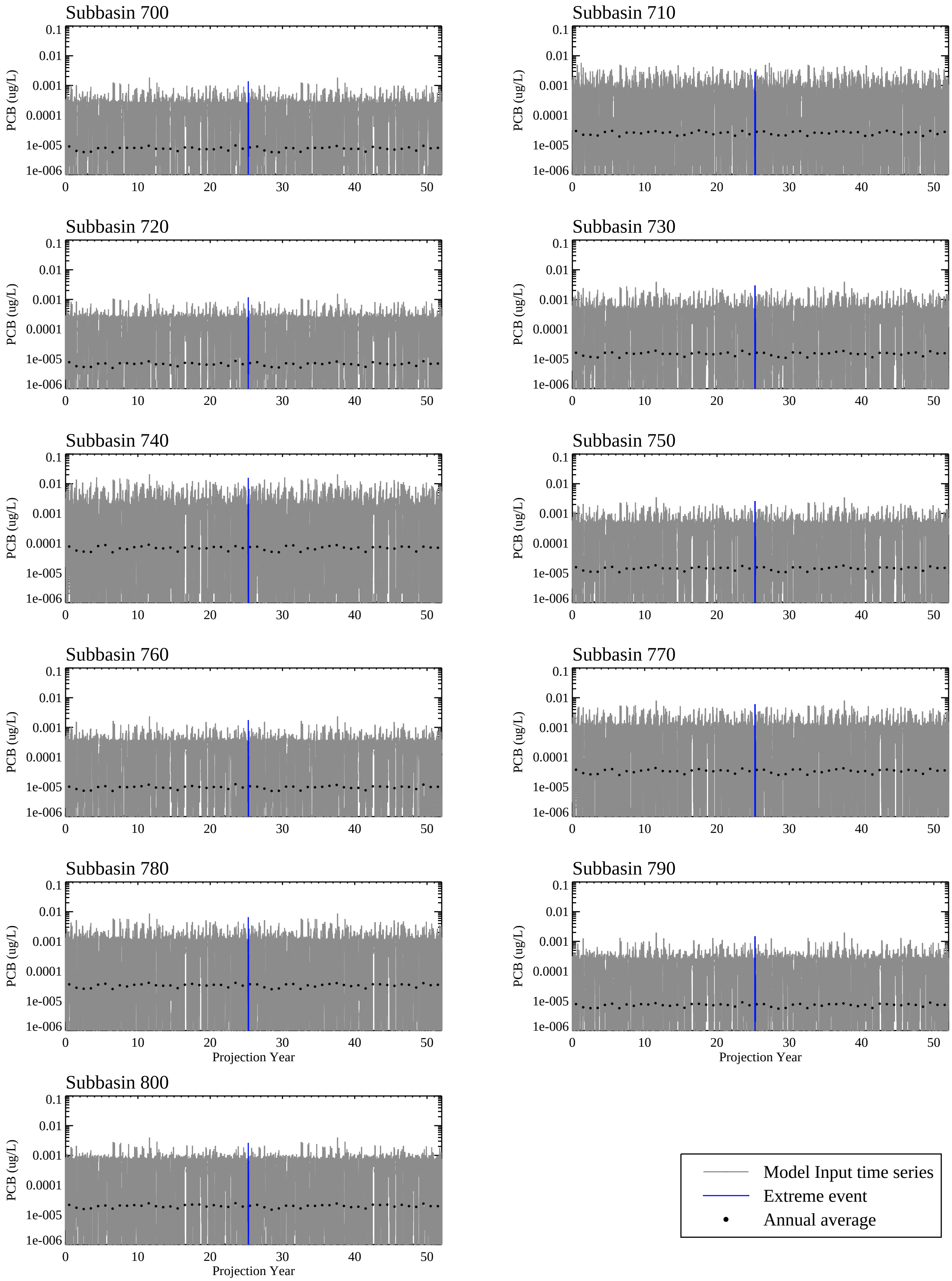

Figure 3-6b. Reach 7, 8 direct drainage PCB boundary conditions for 52-year projection period.

APPENDIX A
SUPPLEMENTAL SAMPLING PLAN

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APPENDIX A
SUPPLEMENTAL SAMPLING PLAN

A.1 SURFACE SEDIMENT SAMPLING PLAN

The approach for developing the East Branch boundary condition for the CMS model simulations will include the specification of current water column particulate-phase PCB concentrations at Pomeroy Avenue. To assess these concentrations, GE will collect post-remediation surface sediment samples from the Upper ½-Mile Reach of the East Branch. The sediments in this reach reflect an integration of the solids that have entered this reach after the completion of the remediation (both from the GE Plant area and from other sources adjacent to this reach, as well as those transported in the river from the upper watershed) and the current sources of PCBs entering the river in this area. The PCB concentrations in those sediments should therefore be generally representative of contemporary water column particulate-phase PCB concentrations in this portion of the East Branch.

Sediment sampling in the ½ Mile Reach will likely be conducted in early June 2007 during low flow conditions, and at a time that does not coincide with any water column monitoring event at Pomeroy Avenue (see Section A.2) so as not to affect the results of the water column sampling. Sampling will be performed in accordance with the restored sediments monitoring requirements set forth in Section 11.5.4 of the *Removal Action Work Plan for Upper ½ Mile Reach of Housatonic River* (½ Mile Work Plan; BBL 1999), as summarized below:

1. Sediment samples will be collected from 39 locations in this reach of the river, as identified in Section 11.5.2 and shown on Figure 11-2 of the ½ Mile Work Plan (a copy of which is provided as Attachment 1 to this Appendix). Samples will be collected using Lexan® core tubes or a grab sampling device.

2. Sediment samples will be collected in such a way as to sample (to the extent practical) the full sediment inventory that has deposited on top of the armor stone at a given location. The sampled sediment thickness may thus differ from location to location.

3. All samples collected will be submitted to Northeast Analytical, Inc. (NEA) for analysis of total PCBs in accordance with GE's current *Field Sampling Plan/Quality Assurance Project Plan* (FSP/QAPP; ARCADIS BBL 2007).

A.2 SUPPLEMENTAL WATER COLUMN SAMPLING PLAN

In addition to the sediment sampling described above, intensive water column sampling will be conducted at Pomeroy Avenue to obtain additional data for use in developing the East Branch boundary condition for the CMS model simulations. Although detection of PCBs in the water column in the Upper ½-Mile Reach provides evidence of PCB inputs in the East Branch,[1] the available post-remediation PCB water column sampling data at Pomeroy Avenue have been non-detect since December 2005 at a method detection limit (MDL) of 22 ng/L; hence the current PCB concentration is uncertain. Therefore, supplemental water column monitoring will be performed during late spring/early summer 2007, using a lower detection limit, to further support the specification of the East Branch PCB boundary condition for the model projections. Due to the correlation between PCB concentrations and river flow, this water column sampling program will include both routine and storm event-based components. In addition, the supplemental water column sampling will include flow monitoring that will be conducted periodically to support the development of a revised post-remediation stage-discharge rating curve at Pomeroy Avenue.

A.2.1 Routine Sampling

GE currently conducts routine monthly sampling of the water column in the Housatonic River at 10 locations, and analyzes the samples for total PCBs, total suspended solids (TSS), particulate organic carbon (POC), and chlorophyll-a. Pomeroy Avenue Bridge, which is the location used to represent the East Branch boundary condition in the EPA model, is included as

[1] For example, PCBs were detected in approximately 20% of samples collected at Newell Street and Lyman Street during 2005 and 2006 as part of GE's monthly water column monitoring program; detected concentrations in these samples range from 30 to 270 ng/L.

one of GE's routine sampling locations. To achieve the objectives of the proposed supplemental sampling program, the routine sampling at Pomeroy Avenue will be modified in two ways:

1. The PCB method currently being utilized for analysis of Pomeroy Avenue samples will be modified to achieve a lower detection limit of approximately 11 ng/L.

2. The frequency of routine sampling at Pomeroy Avenue will be increased from monthly to twice weekly. This higher frequency routine sampling will begin in April and continue through June 2007. The sampling period may be extended depending on flow conditions.

The protocols used during GE's current monthly water column sample collection method, which is described in detail in Appendix E of GE's FSP/QAPP, will remain unchanged for the routine component of the supplemental sampling effort:

1. The width of the river channel will be measured, and the 1/4, 1/2, and 3/4 distances across the river will be determined.
2. Samples will be collected by wading into the river providing flow conditions permit safe access to the river; if current velocities are too great for wading, sampling will be performed from the Pomeroy Avenue Bridge.
3. Field data measurements (temperature, pH, turbidity, conductivity, and dissolved oxygen) will be taken from the midpoint of the channel (mid-depth) using a water quality probe prior to collection of the water sample.
4. A composite grab sample will be formed from an aliquot collected at each of the three points across the channel (i.e., the 1/4, 1/2, and 3/4 distances determined in (1), above) obtained from the mid-point of the water column.
5. Sample aliquots will be transferred to appropriate sample containers and will be submitted for PCBs, TSS, and POC analyses. Analysis of chlorophyll-a will not be performed on the routine samples as it currently is in the monthly water column monitoring program.

The analytical method used for TSS (EPA160.2) and POC (SM 19th Edition 5310B Modified) will be unchanged from the current quantitation methods for these analyses. Total PCBs are currently quantified by NEA using an EPA Aroclor-based analytical method (EPA SW-846 Method 8082) having a nominal detection limit of 22 ng/L (per Aroclor). For samples collected at Pomeroy Avenue as part of this supplemental monitoring program, the total PCB MDL will be reduced to approximately 11 ng/L by changing the current initial extract volume from 4 mL to 2 mL.

A.2.2 Storm Event Sampling

Sampling of three storm events (if possible) over the late spring/early summer 2007 period is proposed to augment the routine sampling described above. Storm event sampling will be initialized based on the monitoring of weather and river forecast center web sites;[2] the mobilization trigger for high flow sampling will be a predicted flow rate at the USGS Coltsville gage (#01197000) in excess of 200 cfs.[3] Sampling during each event will attempt to capture both the rising and falling limbs of the hydrograph for an approximate 24- to 48-hour period (actual sampling duration may be longer or shorter depending upon river conditions). Samples will be collected every two hours during the rising limb and peak of the hydrograph, and every two to four hours during the falling limb; the actual sampling frequency during the rising limb and peak of the hydrograph may be increased based on real-time monitoring of river flow conditions at the USGS Coltsville gage and at the Pomeroy Avenue staff gage (i.e., samples may be collected every hour if flow appears to be increasing rapidly).

Below is a brief summary of the sample collection protocols that will be used for the storm event sampling, which are generally consistent with the EPA standard operating procedure (SOP) for surface water sample collection during the Supplemental Modeling Study that was conducted in March 2003 (EPA 2003). One modification to the EPA SOP is that depth-

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[2] NOAA Advanced Hydrologic Prediction Service web site: http://newweb.erh.noaa.gov/ahps2/hydrograph.php?wfo=aly&gage=ctvm3&view=1,1,1,1,1,1

[3] While the mobilization criteria for storm event sampling is predicted flows at Coltsville greater than 200 cfs, the objective of the sampling is to capture events that are greater than 300 cfs at Coltsville; ideally, storm event sampling would capture an event closer to 1,000 cfs.

integrated samples will be collected using the USDH-76 sampler described below, rather than the mid-depth grab sampling protocol described in the original SOP:

1. One depth-integrated water column sample will be collected above the thalweg of the river channel using a USDH-76 sampler. The sampler (containing a 1-L collection bottle) will be lowered from the bridge at a constant rate (using a winch and cable system) from the water surface to a depth of 6" above the sediment bed, and then back to the surface.
   a. To determine the point in the water column that is 6 inches above the sediment bed, the depth-integrated sampler will be lowered without the sample bottle until it rests on the river bottom; the cable will then be marked 6 inches below the end of the winch system. The sampler will then be retrieved and a collection bottle inserted.
   b. Sample collection will proceed by first lowering the depth-integrated sampler to a depth 6 inches above the bottom of river (using the depth mark on the cable as a guide), and then slowly back to the water surface at a constant rate; an appropriate retrieval rate will result in the collection bottle being approximately ¾ full. If the sample collection bottle is full upon retrieval then the sample does not accurately represent the entire water column and should therefore be discarded. If the sample collection bottle is less than ¾ full, the sample is unacceptable as this may indicate that the raising or lowering rate was too fast or that the intake port is obstructed.
2. After each retrieval, the sample collection bottle will be closed and shaken; contents will then be split equally into sample bottles for PCB, TSS, and POC analyses. The sampler will be deployed and retrieved as many times as necessary to fill the required sample containers.

Samples collected during high flow event monitoring will be submitted for analysis of PCB, TSS, and POC utilizing the analytical methods for routine monitoring described in Section A.2.1, above.

A.2.3 Flow Monitoring

Periodic monitoring of river flow conditions will be conducted to support the development of a revised post-remediation stage-discharge rating curve at Pomeroy Avenue. Flow monitoring will be conducted during several routine sampling events and at various times during storm sampling events, with the objective of capturing a range of flow rates that will facilitate the development of a revised rating curve. The flow data collected under this program will be used to assess the applicability of the current Pomeroy Avenue stage-discharge rating curve to post-remediation conditions.[4] If necessary, and if the range of flows measured under this limited program is sufficient, a revised stage-discharge rating curve will be developed for the Pomeroy Avenue station.

Flow monitoring will be conducted using a method that is generally consistent with the EPA Supplemental Modeling Study SOP (EPA 2003). An abbreviated version of this SOP is provided below:

1. Velocity measurements will be made using a portable electronic current meter, and will be recorded in accordance with USGS protocols (Buchanan et al., 1969, 99-0198) at pre-established 2-ft. intervals across the river channel according to the following protocol:
    a. First, the elevation of the water surface will be determined using readings from the EPA pressure transducer located at Pomeroy Avenue[5] or by measuring from an established benchmark on the bridge down to the surface of the water.
    b. Based on the water surface elevation (and cross-sectional elevation data of the riverbed[6]) the water depth at each of the 2-ft. intervals across the river will be calculated.

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[4] The current stage-discharge rating curve is presented in Figure 3 of Attachment B-1 to the Model Calibration Report (EPA 2004).

[5] EPA is currently in the process of installing a pressure transducer at the Pomeroy Avenue Bridge.

[6] If needed, GE proposes to resurvey the river cross section at Pomeroy Avenue to facilitate the flow monitoring at this location.

c. Velocity measurements will be taken at different depths in the water column depending on the total water depth at a given position.

- *Water depth equal 2.5 ft or less*: velocity will be measured at 6/10 of the water depth from the surface.
- *Water depth greater than 2.5 ft*: velocity will be measured at 2/10 of the water depth and 8/10 water depth from the surface.

2. Velocity measurements, staff gage readings, and riverbed cross-sectional elevation data will be used to calculate flow rates at the time of sampling.

REFERENCES

ARCADIS BBL, 2007. *Field Sampling Plan/Quality Assurance Project Plan*. Prepared for General Electric Company, Pittsfield, MA. Revised March 2007.

BBL, 1999. *Removal Action Work Plan for Upper ½ Mile Reach of Housatonic River*. Appendix F to Consent Decree. Prepared for General Electric Company, Pittsfield, MA, dated August 1999, and EPA approval letter dated August 5, 1999.

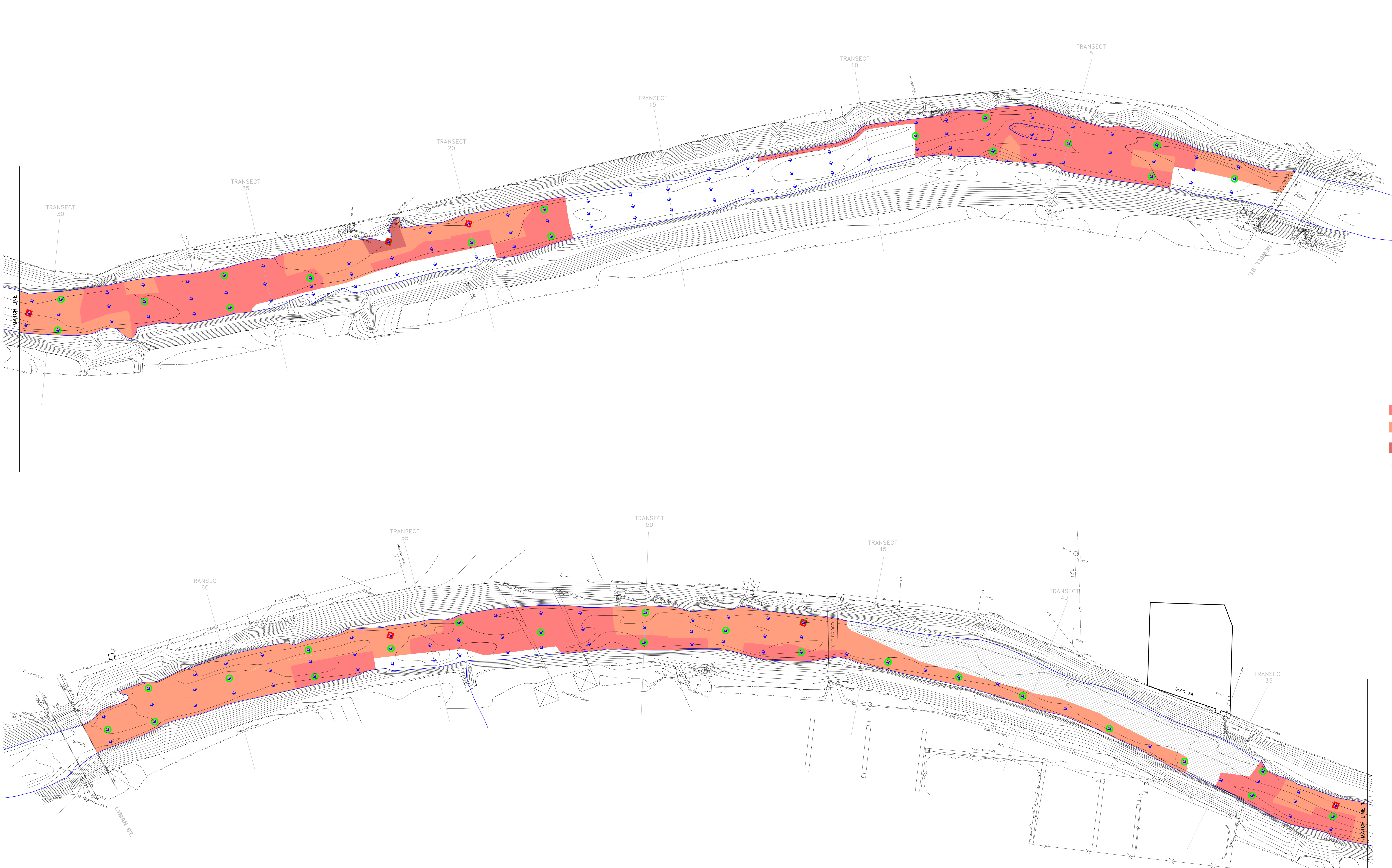
Buchanan, T.J. and Somers, W.P., 1969. Discharge Measurement at Gauging Stations. Techniques of Water-Resource Investigations, Book 3, Chapter A8, U.S. Geological Survey Washington, DC (99-0198).

EPA, 2002. *Rest of River Site Investigation Data Report.* Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. August 2002.

EPA, 2003. *Standard Operating Procedure SS-7, Supplemental Modeling Study*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. 2003.

EPA, 2004. *Model Calibration: Modeling Study of PCB Contamination in the Housatonic River*. Prepared by Weston Solutions, Inc., West Chester, PA, for the U.S. Army Corps of Engineers, New England District, and the U.S. Environmental Protection Agency, New England Region. December 2004.

ATTACHMENT 1



LEGEND:

- 1.5 FEET SEDIMENT REMOVAL DEPTH
- 2.0 FEET SEDIMENT REMOVAL DEPTH
- 2.5 FEET SEDIMENT REMOVAL DEPTH
- BUILDING 68 REMOVAL AREA
- EPA SEDIMENT SAMPLE LOCATION (AUGUST – OCTOBER 1998)
- RESTORED SEDIMENT MONITORING LOCATION
- SEDIMENT CAP ISOLATION LAYER MONITORING LOCATION

NOTE:

1. FIGURE DEPICTS GENERAL LOCATIONS OF MAJOR COMPONENTS OF THE RESTORATION PLAN. SEE FIGURES 4–1 THROUGH 4–4 FOR COMPLETE DOCUMENTATION OF REMOVAL AREAS.
2. SEDIMENT CAP ISOLATION LAYER MONITORING LOCATIONS ARE SUBJECT TO CHANGE BASED ON PCB CONCENTRATIONS IN POST EXCAVATION SAMPLES.

GRAPHIC SCALE

GENERAL ELECTRIC COMPANY
PITTSFIELD, MASSACHUSETTS
REMOVAL ACTION WORK PLAN –
UPPER 1/2–MILE REACH OF HOUSATONIC RIVER

SEDIMENT CAP ISOLATION LAYER AND RESTORED SEDIMENT MONITORING LOCATIONS

BBL BLASLAND, BOUCK & LEE, INC.
engineers & scientists

FIGURE
11-2

X 20197X01.DWG
L: ON=* OFF=*REF,ARROW, REST–CAP, REST–CAP–SHD,
REST–OTHER,REST–OTHER–SHD*
P: 49TOD.PCP
6/11/99 SYR–54–NES AK GMS MAD
20197030/HABITAT/20197B06.DWG