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Via Electronic Mail

September 27, 2021

Mr. Dean Tagliaferro
EPA Project Coordinator
U.S. Environmental Protection Agency
c/o HDR, Inc.
10 Lyman Street, Suite 2
Pittsfield, MA 01201

Re: GE-Pittsfield/Housatonic River Site
Rest of River (GECD850)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks

Dear Mr. Tagliaferro:

In accordance with Section 4.2.3.1 of General Electric Company's (GE's) *Final Revised Rest of River Statement of Work*, approved by the U.S. Environmental Protection Agency (EPA) on September 16, 2021, enclosed for EPA's review and approval is GE's *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks.*

Please let me know if you have any questions about the enclosed Work Plan.

Very truly yours,

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

Enclosure

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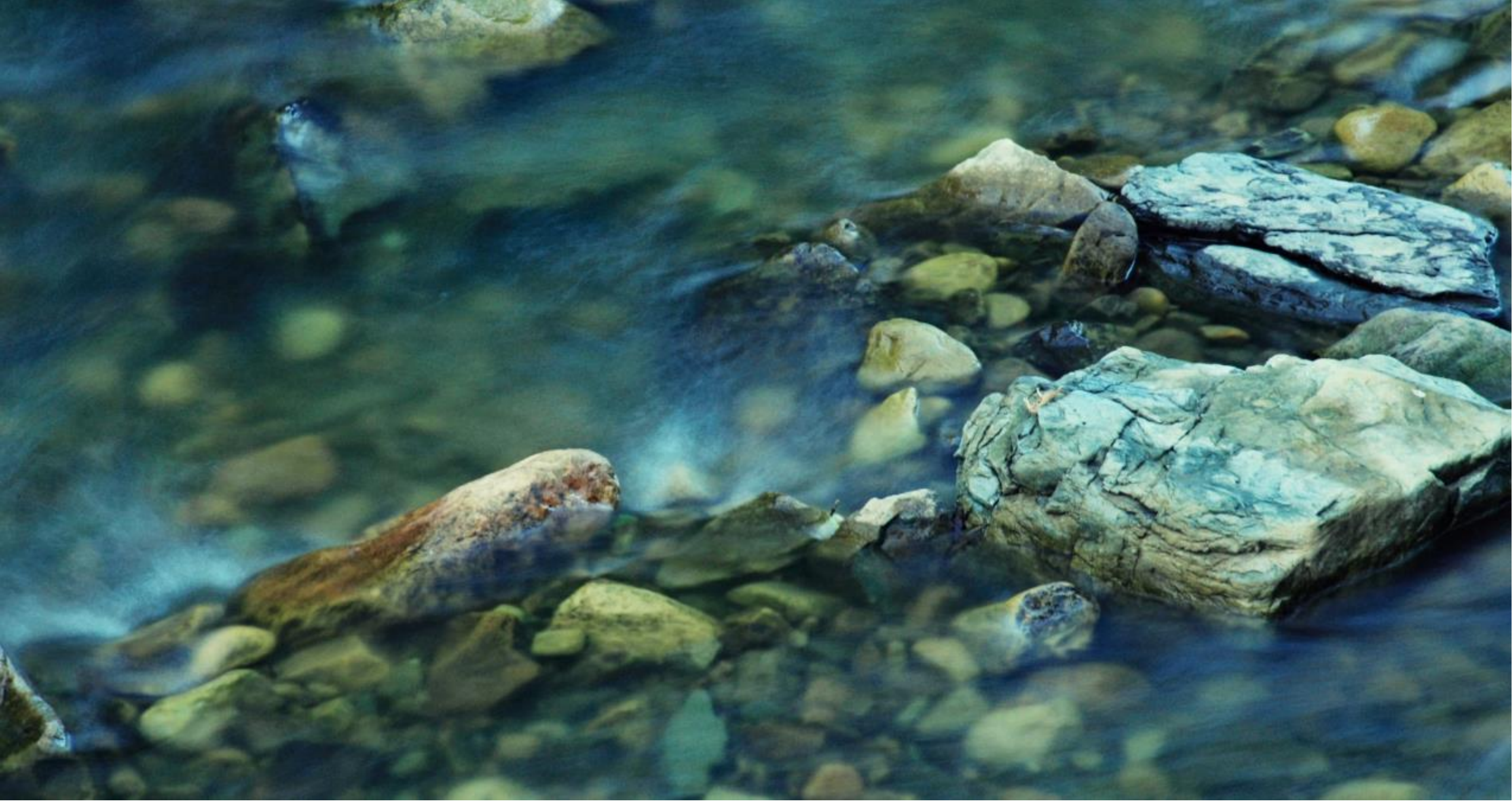

September 2021
Housatonic River – Rest of River

ANCHOR QEA
AECOM

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks

Prepared for General Electric Company
Pittsfield, Massachusetts

September 2021
Housatonic River – Rest of River

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks

Prepared for
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TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

ABBREVIATIONS

BANCS	Bank Assessment for Non-point source Consequences of Sediment
BEHI	Bank Erosion Hazard Index
CD	Consent Decree
cfs	cubic feet per second
cm	centimeter
CPT	cone penetration test
DGPS	differential global positioning system
DOC	dissolved organic carbon
DQO	Data Quality Objective
EPA	U.S. Environmental Protection Agency
FFP	full flow penetration
Final Accessibility Report	*Final Morphology and Accessibility Survey Report*
Final Revised SOW	*Final Revised Rest of River Statement of Work*
FSP/QAPP	*Field Sampling Plan/Quality Assurance Project Plan*
GE	General Electric Company
GPS	global positioning system
K_v	vertical hydraulic conductivity
LiDAR	Light Detection and Ranging
mg/kg	milligram per kilogram
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NBS	Near Bank Stress
PCB	polychlorinated biphenyl
PDI	pre-design investigation
PSA	Primary Study Area
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
Revised Final Permit	Revised Final Resource Conservation and Recovery Act Permit Modification
ROR	Rest of River
Sediment/Bank PDI Work Plan	*Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*
SI	EPA's Supplemental Investigation in 1998-2002
SIC	seepage-induced consolidation
SOP	standard operating procedure
SPME	solid-phase microextraction

TOC	total organic carbon
USGS	U.S. Geological Survey
VHG	vertical hydraulic gradient
WARSSS	*Watershed Assessment of River Stability and Sediment Supply*
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Background

Pursuant to Section II.H.3 of the Revised Final Resource Conservation and Recovery Act (RCRA) Permit Modification (Revised Final Permit), issued by the U.S. Environmental Protection Agency (EPA) to the General Electric Company (GE) on December 16, 2020, for the Rest of River (ROR) portion of the GE-Pittsfield/Housatonic River Site, GE is required to prepare pre-design investigation (PDI) work plans for the collection of pre-design data to be used to support the remedial activities in the ROR. As described in Section 4.2.3.1 of GE's September 2021 *Final Revised Rest of River Statement of Work* (Final Revised SOW; Anchor QEA et al. 2021; approved by EPA on September 16, 2021), two PDI work plans have previously been prepared for Reach 5A covering floodplain PDI activities—one for floodplain residential properties and another for non-residential floodplain areas. This *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Sediment/Bank PDI Work Plan) is a third work plan for Reach 5A and describes PDI activities for sediment and riverbanks in that reach.

1.2 Description of Reach 5A

Under the Consent Decree (CD) for the GE-Pittsfield/Housatonic River Site (EPA and GE 2000), the ROR is defined as that portion of the Housatonic River and its backwaters and floodplain (excluding Actual/Potential Lawns as defined in the CD) located downstream of the confluence of the East and West Branches of the Housatonic River (the Confluence) in Pittsfield, Massachusetts. Within Reaches 5 and 6, which constitute the portion of the ROR between the Confluence and Woods Pond Dam, also known as the Primary Study Area (PSA), the CD defines the ROR site boundary as the floodplain area extending laterally to the 1 milligram per kilogram (mg/kg) polychlorinated biphenyl (PCB) isopleth, which corresponds approximately to the 10-year floodplain.

Reach 5A (shown on Figure 1-1) comprises approximately the first five miles of the ROR, extending from the Confluence to the Pittsfield Wastewater Treatment Plant (WWTP). The river channel in this reach is free flowing, contains numerous meanders, and has riverbanks that are subject to erosion in places. The width of the river in this reach ranges from approximately 40 to 120 feet, and bankfull water depth[1] ranges from approximately 2 to 10 feet (BBL and QEA 2003). The sediment bed in Reach 5A consists predominantly of coarse to fine sands with approximately 10 to 15% silt and clay (EPA 2005). Sediment deposit reconnaissance and probing activities conducted by GE in 1994 identified three general types of sediment deposits in Reach 5A: (1) channel deposits (deposits that typically occur in parts of the riverbed that are permanently inundated during low-to-moderate flow conditions); (2) aggrading bars (small islands or mounds that are typically composed of coarse-

[1] The bankfull water depth is defined as the depth during conditions where the water surface elevation at a particular channel location is at the same level as the top of the riverbank, but is confined to the river channel and has not spilled out into the floodplain.

grained material and usually occur along the convex sides of channel curves); and (3) terrace deposits (deposits that occur in parts of the riverbed that are usually inundated during high-flow conditions, but are exposed during low to moderate flows). More than half (60%) of the sediment deposits identified in Reach 5A were characterized as terrace deposits, 30% were channel deposits, and 10% were aggrading bars. The overall probed thickness of sediment deposits within Reach 5A ranged from approximately 1.5 feet to 13 feet, with an average thickness of approximately 5.6 feet (BBL and QEA 2003).

The ROR contains numerous backwater areas, defined as quiescent areas adjacent and hydraulically connected to the main channel of the river. As described in GE's July 16, 2020 *Final Morphology and Accessibility Survey Report* (Final Accessibility Report; AECOM and Anchor QEA 2020), there are six areas defined as backwaters in Reach 5A based on field surveys conducted in 2018 and 2019, as shown on Figure 1-1.

1.3 Summary of Applicable Requirements

Section II.B.2.a of the Revised Final Permit sets forth the Performance Standards for remediation of riverbanks and sediment (including the river main channel and backwater areas) in Reach 5A.

For riverbanks, Section II.B.2.a.(1)(b) requires GE to remove contaminated soils from eroding riverbanks. A bank is to be considered "contaminated" if it contains a total PCB concentration equal to or greater than 5 mg/kg and erodible if the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) rating is classified in the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model as "Moderate-High" or greater at the same transect location as the PCB samples. Further, Section II.B.2.a.(2)(b) states, "The location of contaminated eroding riverbanks shall be determined using a BANCS model calibrated for the Housatonic River and the collection of additional riverbank soil PCB data. A bank shall be considered contaminated if it contains ≥ 5 mg/kg total PCBs measured in the surficial 0 to 12 inches as the average of three 12-inch cores taken at the toe, midpoint, and top of the bank at a maximum spacing of every 25 feet of linear bank." In addition, Section II.B.2.a.(2)(c) of the Revised Final Permit provides that for Reach 5A banks that do not require remediation based on the criteria described above, GE will evaluate the PCB data, erosion potential, adjacent floodplain removal (if any), constructability issues, and likelihood of future downstream transport at such concentrations should such banks erode, and based on these factors, consider supplemental riverbank removal and propose any further action consistent with its evaluation.

For sediments in the river channel, Section II.B.2.a.(1)(a) requires that riverbed sediment be removed throughout Reach 5A and that an engineered cap be placed over the entire riverbed. There are no specific sampling requirements in the Revised Final Permit to meet this Performance Standard; however, requirements related to characterization of sediment excavated from the ROR for the purposes of disposal are provided in Attachment E to the Revised Final Permit. That attachment states that only data collected pursuant to the Revised Final Permit can be used for disposal characterization for Reach 5A sediments. Specifically, the sampling needs to consist of collecting three vertical cores on transects (i.e., a core located to the left, center, and right of the channel at each transect) with transects spaced 250 linear feet apart along the river channel. Vertical sediment cores need to be segmented in six-inch increments and need to be of sufficient depth to characterize sediment PCB concentrations throughout the full vertical interval to be removed prior to cap construction.

Section II.B.2.d of the Revised Final Permit sets forth the Performance Standards for backwaters. For backwaters located outside of Core Area 1 habitat,[2] surface (0- to 12-inch depth) and subsurface sediment need to be removed, including any surface sediment in areas with total PCB concentrations greater than or equal to 50 mg/kg, and replaced with a contiguous engineered cap (or backfill) to achieve a spatially weighted average total PCB concentration of 1 mg/kg. For backwaters within Core 1 habitat, surface sediment (0- to 12-inch depth) greater than or equal to 50 mg/kg need to be removed and replaced with an engineered cap; and in areas where surface sediment total PCB concentrations are between 1 and 50 mg/kg, an amendment (e.g., activated carbon or other comparable amendment[s]) needs to be placed to reduce bioavailability. Section II.B.2.d.(2)(a) states that, for backwater areas, GE "shall propose in a Pre-Design Work Plan…additional sampling for PCBs in sediment, and a method for averaging surface and subsurface PCB concentrations using a 50-foot grid, including proposed averaging areas and depth intervals."

1.4 Definition of Riverbanks

As described in Section 1.3, the Revised Final Permit specifies different Performance Standards and sampling requirements for riverbanks and sediments in Reach 5A. As such, a critical element of the PDI will be to define the extent of riverbanks (i.e., toe and top-of-bank) in this reach so that the bank areas can be differentiated from the adjoining river channel areas. The Massachusetts Wetlands Protection Act regulations (310 CMR 10.54(2)(c)) define the toe and top-of-bank as follows:

- Toe: "The lower boundary of a Bank is the mean annual low flow level."
- Top-of-bank: "The upper boundary of a Bank is the first observable break in the slope or the mean annual flood level, whichever is lower."

GE will generally adopt these definitions for the purposes of this PDI (and ultimately for the remedial design), with the modification that the elevation of the top-of-bank will be no higher than the

[2] As defined in the Revised Final Permit, Core Area 1 habitat consists of areas identified by Massachusetts Division of Fisheries and Wildlife as areas with "the highest quality habitat for species that are most likely to be adversely impacted by PCB remediation activities," most of which species are plants because they are not mobile (Attachment B to Revised Final Permit).

elevation of the adjacent 1 mg/kg PCB isopleth. Some of the survey activities proposed in this Sediment/Bank PDI Work Plan will be used to support the definition of riverbanks.

1.5 Work Plan Organization

The remainder of this Sediment/Bank PDI Work Plan is organized into the following three sections:

- Section 2 provides a summary of existing riverbank soil and sediment PCB data for Reach 5A.
- Section 3 contains a summary of Data Quality Objectives (DQOs) for the riverbank and sediment PDI and a description of proposed PDI activities, including field surveys and sampling and analysis.
- Section 4 provides a schedule for performance of the PDI activities described herein and a description of how the data collection activities and analytical results will be reported.

2 Summary of Prior Reach 5A Sediment and Riverbank Soil Investigations and Field Surveys

2.1 Sediment PCBs

Numerous investigations were conducted dating back to the 1970s to evaluate the presence and extent of PCBs in the Housatonic River sediments. Between 1979 and 1998, 2,172 sediment samples were collected within the Massachusetts and Connecticut portions of the river by GE, as well as the Connecticut Agriculture Experiment Station and U.S. Geological Survey (USGS), with 282 of those samples collected within Reach 5A (BBL and QEA 2003; Table 4-2). EPA conducted the most current and comprehensive sampling of sediments in the ROR as part of its Supplemental Investigation (SI) between 1998 and 2002. That study included both systematic and discrete sediment sampling programs along the entire ROR to further delineate the nature and extent of PCBs in sediment and to facilitate EPA's human health and ecological risk assessments and modeling study. Specifically, the systematic sampling consisted of the collection of samples at regular intervals, and the discrete sampling consisted of "random, judgmental, or focused samples collected at distinct locations" to support specific sampling objectives (Weston 2000). That sampling program resulted in the collection of approximately 1,200 samples from nearly 360 locations within Reach 5A. Surface sediment (0- to 6-inch) PCB concentrations in this data set within Reach 5A ranged from non-detect to 290 mg/kg and have median and average concentrations of 11 and 20 mg/kg, respectively. These previous investigations show that average PCB concentrations in this reach generally increase with depth down to four feet, and then decrease considerably for depths below four feet, although the number of samples is reduced at these deeper depths (BBL and QEA 2003; Table 4-8).

In addition, EPA and GE conducted a joint sampling program to evaluate sediment PCB partitioning characteristics in 2001. This program included PCB analysis of porewater extracted from surface sediment (0- to 6-inch) core samples. For this program, approximately 45 sediment samples were collected in Reach 5 and Woods Pond, with 16 of those samples collected in Reach 5A.

2.2 Riverbank Soil PCBs

Several studies were conducted dating back to the late 1980s to characterize the PCB concentrations in floodplain and riverbank soils adjacent to the Housatonic River. Sampling conducted by GE prior to 1998 focused primarily on floodplain soils and did not include any extensive characterization of riverbank soils. EPA conducted the most current and comprehensive sampling of riverbank soils in the ROR during its SI between 1998 and 2002, which included the collection of 150 riverbank samples within Reach 5A (BBL and QEA 2003; Table 5-6). Most of these samples were collected from the top one foot of soil. Total PCB concentrations in the top foot of riverbank soils ranged from non-detect to 117 mg/kg, with median and average concentrations of 11 and 15 mg/kg, respectively (BBL and QEA 2003).

2.3 Data on Other Parameters

In addition to the PCB data described above, a considerable amount of sediment and riverbank soil data on other parameters has been collected in Reach 5A, much of which was collected as part of EPA's SI in 1998-2002. This data set includes, for sediments, approximately 1,000 sample results for total organic carbon (TOC), 600 for percent solids, and 260 for grain size distribution (in 0- to 6-inch samples), and, for riverbank soils, approximately 30 sample results for TOC, 140 for percent solids, and 40 for grain size distribution.

2.4 Field Surveys

Field surveys conducted previously in the river in Reach 5A (most recently by EPA as part of its SI) included flow and stage height monitoring, velocity measurements, measurement of river channel geometry, bank erosion surveys (using toe pins), river channel resurveys to evaluate changes in channel morphology, and a meandering and bank erosion study.

3 Pre-Design Investigation Activities

3.1 Data Quality Objectives

The overall objective of the PDI activities proposed in this Sediment/Bank PDI Work Plan is to provide the data necessary to meet the requirements of the Revised Final Permit and support remedial design for riverbank soils and channel/backwater sediments in Reach 5A. Specific DQOs for this PDI are as follows:

DQO 1. Provide updated survey and basemap information to support definition of riverbanks and support the overall remedial design process.

DQO 2. Update topographic and bathymetric information to support the remedial design in general and for use in development of a hydraulic model that will be used as a design support tool (e.g., in evaluations of cap armor layer design, flood storage capacity, and riverbank stabilization).

DQO 3. Provide data to determine the erodibility of riverbanks using the BEHI and NBS classifications, so as to apply the criteria for identifying which banks are erodible (per the Revised Final Permit) and thus where PCB contaminated soil may need to be removed.[3]

DQO 4. Identify and delineate structures and utilities to support the remedial design, in order to protect those features and worker safety.

DQO 5. Provide data on the PCB concentrations in the top one foot of riverbank soils, so as to define the extent of such soils containing PCB concentrations greater than 5 mg/kg.[4]

DQO 6. Characterize PCB concentrations in sediment and bank soils to be removed to support assessment of on-site versus off-site disposal requirements.

DQO 7. Characterize sediment PCB concentrations in backwater areas to assess the extent of removal and capping or backfill required to achieve an average post-remediation concentration of 1 mg/kg.

DQO 8. Collect data to support design of engineered caps that will be placed over channel and backwater sediments for both chemical isolation and erosion protection.

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[3] As noted in Section 1.3, the Revised Final Permit states that a bank will be considered erodible if its BEHI and NBS rating is classified in the BANCS model as "Moderate-High" or greater at the same transect location as the PCB samples. As discussed further in Section 3.2.4, since these indices give ratings of Moderate or High (not Moderate-High), GE proposes to implement this requirement by using a Moderate rating for the BEHI classification and a High rating for the NBS classification.

[4] The PCB data collected to meet this DQO, as well as the data collected on erodibility to meet DQO 3, will also be used in the evaluation of potential supplemental removal for riverbanks that do not meet the specific criteria for removal, as provided in Section II.B.2.a.(2)(c) of the Revised Final Permit.

DQO 9. Evaluate the geotechnical properties of sediment to be removed and capped and of the riverbanks that will be subject to soil excavation and reconstruction.

3.2 Field Surveys

Six field surveys are planned as part of the PDI activities to address DQOs 1 through 4. These will consist of topographic and bathymetric surveys, a survey to support assessment of bank erodibility, a survey of shoreline structures and utilities, sediment probing, and measurement of water surface elevations and current velocities. All survey coordinates will be gathered and recorded using the following horizontal and vertical datums, respectively: Massachusetts State Plane, Mainland Zone, North American Datum of 1983 (NAD83), U.S. feet; and North American Vertical Datum of 1988 (NAVD88), U.S. feet.

3.2.1 Topographic Surveys

Detailed topographic surveys of the riverbanks and floodplain will be conducted in support of DQOs 1, 2, 3, and 4. Initially, an aerial Light Detection and Ranging (LiDAR) survey[5] will be completed for the PSA (extending from the Confluence to Woods Pond Dam), including the river channel, the approximate 100-year floodplain, and nearby infrastructure (e.g., roads). This survey will be conducted for the entire PSA, rather than being limited to Reach 5A, because topographic (as well as bathymetric) data are needed to develop the hydraulic model that will be used as a design tool for Reach 5A; that model is planned to extend from the Confluence to Woods Pond Dam, given that the latter serves as a hydraulic control point for much of the PSA. The LiDAR survey will be completed using a RieglVQ-80-GlI Sensor system mounted in a small airplane (or possibly an Unmanned Aerial System) and will ideally be conducted during low-flow, leaf-off conditions.[6] Vertical and horizontal site control points will be established prior to completion of the LiDAR survey. The horizontal and vertical accuracies of this survey are anticipated to be 0.01 foot and 0.1 foot, respectively.

A focused survey of the riverbanks will also be conducted, as needed, using a mobile LiDAR system mounted to a shallow draft boat or held manually by staff wearing waders in areas of shallower water. This additional survey will allow for more precise mapping of riverbanks that may not be captured by the aerial LiDAR survey (e.g., in areas where banks are nearly vertical or undercut by the river). It will provide detailed information related to bank morphology and vegetation and include infrastructure observed from within the river. An example of a streambank LiDAR survey performed

[5] LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure distance to the land surface (https://oceanservice.noaa.gov/facts/lidar.html). These surveys generate relatively precise, three-dimensional information about land surface characteristics. An aerial vehicle is the most commonly used platform for acquiring LiDAR data over large areas. There are two types of LiDAR surveys: topographic and bathymetric. A topographic LiDAR survey typically uses a near-infrared laser to map the land surface, and a bathymetric LiDAR survey uses water-penetrating green light to measure riverbed elevations.

[6] The reason for conducting this survey during low-flow conditions is to support definition of the toe of the riverbank.

on the South River in Virginia is shown on Figure 3-1. Vertical and horizontal site control points will be established at several bank locations prior to completion of the LiDAR survey. As with the aerial survey described above, horizontal and vertical accuracies are anticipated to be 0.01 foot and 0.1 foot, respectively.

A standard operating procedure (SOP) for the LiDAR surveys will be provided to EPA for review following selection of a qualified survey contractor.

3.2.2 Bathymetric Survey

A bathymetric survey will be conducted throughout the PSA main channel in support of DQOs 1 and 2. As noted above, this survey, like the topographic survey, will be conducted for the entire PSA (not just Reach 5A) because bathymetric data for the PSA are needed to develop the hydraulic model that will be used as a design tool. It is anticipated that this survey will be conducted using conventional survey methods from a shallow draft vessel or on foot by staff wearing waders. (As noted below, the option of using LiDAR to supplement the in-stream bathymetric survey is also being considered.) Specifically, bathymetric survey cross-sections will be completed every 100 feet along the centerline of the river, as shown on Figures 3-2a through 3-2i.[7] Survey resolution is expected to be consistent with that typically achieved with a real-time kinematic global positioning system (GPS) (approximately 1 to 2 centimeters [cm] horizontal and 2 to 4 cm vertical).

The feasibility of supplementing the conventional bathymetric transect survey using topobathymetric LiDAR technology will also be evaluated. Topobathymetric LiDAR uses a visible green laser to penetrate the water to a depth 1.5 times the clarity as measured in the field using a Secchi disk. Given the relatively shallow water depths and expected water clarity under low-flow conditions in Reach 5A, it is anticipated that this may be a viable method for measuring most of the in-stream bathymetry; however, additional input is needed from a contractor qualified to conduct the survey to determine if this technology will provide a data set that meets the DQOs.

3.2.3 Sediment Probing

Sediment probing will be conducted in the river channel to characterize sediment thickness and general sediment texture in support of sediment sampling activities and remedial design. Sediment probing will be conducted on transects spaced 250 feet apart along the centerline of the river within Reach 5A (the same spacing for sediment PCB sampling transects described in Section 3.3.2.1) at three locations per transect (left, center, and right portions of the river channel). The objective of the

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[7] Note that the river stations and bathymetric transects shown on these figures were established to provide a locational reference to support this Sediment/Bank PDI Work Plan and the remedial design for Reach 5A and thus are shown only for Reach 5A. The stationing begins with Station 0+00 at the Confluence and extends to the downstream end of Reach 5A at Station 242+00 (in feet). However, the bathymetric transects continue at 100-intervals throughout the rest of Reach 5, and the corresponding stationing will be extended in future PDI work plans.

probing is to map the presence/absence of sediment deposits in the river channel and determine the likelihood of obtaining the desired sediment sample collection depth at the target sampling locations described in Section 3.3.2.1. Sediment probing will be conducted in advance of sediment sample collection. The 250-foot spacing for probing transects results in 98 transects and 294 discrete probing locations. Those locations are shown on Figures 3-2a through 3-2i.

Sediment probing will be performed following the methodology outlined in GE's current *Field Sampling Plan/Quality Assurance Project Plan* (FSP/QAPP; Arcadis 2013) unless a Rest of River FSP/QAPP has been submitted and approved by that time. In summary, sediment probing will be conducted from a shallow draft vessel (where possible) or by wading in shallow water areas. Probing will be performed utilizing a small-diameter (less than 0.5 inch) steel rod advanced manually through the sediment to refusal. Additional rod lengths will be available to accommodate deep water and/or thick sediment deposits. A standard survey rod (approximately 2-inch diameter) will be used to measure water depth and identify the sediment-water interface. During all probing activities, the horizontal coordinates of the probing location, water depth, sediment thickness, relative sediment consistency, date, time, and any pertinent visual observations will be recorded. Horizontal position data will be collected with a differential global positioning system (DGPS) capable of sub-foot accuracy.

3.2.4 Bank Erodibility Assessment Field Survey

A BEHI/NBS evaluation, following the methodology outlined in *Watershed Assessment of River Stability and Sediment Supply* (WARSSS; Rosgen 2006), will be performed on all riverbanks within Reach 5A in support of DQO 3. Banks will be divided into segments and inventoried based on the changes of physical bank characteristics and the applied shear stress. Details are provided in the following subsections.

3.2.4.1 Bank Erosion Hazard Index

The BEHI is a method that evaluates a stream bank's susceptibility to erosion from erosional processes. This method integrates multiple variables that relate to combined erosional processes leading to annual erosion rates. Erosion risk is then established for a variety of BEHI variables and is eventually used to establish corresponding streambank erosion rates.

The individual BEHI variables for the erosion prediction model are as follows:

- Study bank height/bankfull height (study bank-height ratio);
- Root depth/bank height (root depth ratio);
- Weighted root density;
- Bank angle;

- Surface protection;
- Bank material; and
- Stratification of bank material.

For a given study bank, each variable is evaluated and recorded on a worksheet using the EPA-adopted WARSSS methodology (WARSSS Worksheet 3-11, included in Appendix A). The first five variables are converted to a BEHI score using previously developed relationships (shown on Figure 3-3). The BEHI score for each variable has values between 0 and 10. The scores for the first five variables are totaled and then potentially adjusted according to the type of bank materials (i.e., sand, gravel, and cobble) and stratification of the bank materials to obtain an overall BEHI risk score (Total Score) that could potentially vary from 5 to 50. The BEHI Total Score is converted to a qualitative rating descriptive of the bank erosion risk. Table 3-1 provides the BEHI score and rating.

Table 3-1
BEHI Score/Rating Conversion

BEHI Total Score	BEHI Rating
5 – 9.5	Very Low
10 – 19.5	Low
20 – 29.5	Moderate
30 – 39.5	High
40 – 45	Very High
46 – 50	Extreme

For the purposes of this assessment, the trigger for erodibility under the BEHI index will be considered to be a BEHI Total Score of 20 or greater—i.e., Moderate or greater.

To perform the BEHI analysis, the initial field activity will be to calibrate visual estimates to detailed bank measurements. Detailed measurements will be performed on a variety of bank conditions and recorded on BEHI worksheets to determine the BEHI rating of the bank. Once a number of bank conditions are observed and measured, field personnel will be able to "calibrate" their eyes to the various BEHI ratings. Field personnel will then continue downstream visually evaluating both banks until either a significant change in the river morphology or a different bank condition is noted. The beginning and ending points of changes in a bank's BEHI rating will be located using DGPS. Additional significant bank features or the condition of the bank will be noted on field maps and located with DGPS. Representative photographs of banks will be taken to document BEHI conditions and factors contributing to NBS.

3.2.4.2 Near Bank Stress

NBS is the evaluation of potential disproportionate energy distribution in the near-bank region (1/3 of channel cross-section) associated with the bank being evaluated. Increases in NBS can accelerate stream bank erosion. Rosgen (2006) developed seven methods for evaluating NBS in the field for a variety of inventory levels. These methods are as follows:

1. Channel pattern, transverse bar, or split channel/central bar creating NBS/high velocity gradient;
2. Ratio of radius of curvature to bankfull width;
3. Ratio of pool slope to average water surface;
4. Ratio of pool slope to riffle slope;
5. Ratio of near-bank maximum depth to bankfull mean depth;
6. Ratio of NBS to bankfull shear stress; and
7. Velocity profiles/isovels/velocity gradient.

The two primary methods for evaluating NBS in Reach 5A will be Method 2 (measuring the ratio of radius of curvature to bankfull width) and Method 5 (measuring the ratio of near-bank maximum depth to bankfull mean depth). These methods are often selected as the primary methods for determining NBS as they are the most reliable to obtain from mapping and field measurements and can be performed consistently on a large river system.

The measurement of the ratio of radius of curvature to bankfull width will be accomplished using aerial photography and available mapping of Reach 5A. This method evaluates the NBS only on outer meander bends; thus, results from this method apply only to portions of the total bank length of Reach 5A. To determine the ratio of near-bank maximum depth to bankfull mean depth, channel cross-sections obtained from the topography/bathymetry surveys described in Sections 3.2.1 and 3.2.2 will be evaluated in the fluvial geomorphology program RIVER*Morph*® (RIVER*Morph* 2021). The resultant values from the two methods will be converted into an adjective rating (i.e., Low, Moderate, or High) and mapped on lines representing the banks of Reach 5A. The higher NBS value of the two methods will be used where an overlap occurs.

The ratios determined from the mapping or field activities will be converted to a NBS rating ranging from Very Low to Extreme using the values in Table 3-2. For purposes of this assessment, the trigger for erodibility under the NBS index will be considered to be an NBS rating of High or greater. This is based on an interpretation of the Revised Final Permit language stating that a bank will be "considered erodible if the [BEHI] and [NBS] rating is classified in the BANCS model as Moderate-High or greater"; under this interpretation, the "Moderate or greater" rating applies to the BEHI score, while the "High or greater" rating applies to the NBS score. Where Method 2 is used, if the value is 2.0 or lower, the NBS will be considered to be High. When Method 5 is used, if the value is 1.81 or greater, the NBS will be considered to be High.

Table 3-2
Converting Ratio Values to a Near Bank Stress Rating

NBS Ratings	Method Number						
	1	2	3	4	5	6	7
Very Low	N/A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N/A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N/A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See (1) Above	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High		1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme		< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Note:
Source: Rosgen 2006; Worksheet 5-9

Utilizing the collected BEHI/NBS data and the GPS data, mapping will be produced that will indicate all riverbank segments that meet the "erodible" criteria—namely, both a BEHI rating of Moderate or greater and an NBS rating of High or greater.

3.2.5 Shoreline Structures and Utility Surveys

The presence of aboveground and underground utilities could pose risks during sample collection and/or remedial construction work to both the integrity of the utility and the safety of the workers. Therefore, a survey of shoreline structures and utilities will be conducted in support of DQO 4.

In preparation for PDI subsurface sediment work, a utility clearance will be conducted to identify the locations of utilities within the planned work area. Massachusetts law requires that a utility clearance be performed prior to initiation of any subsurface work. Massachusetts Dig Safe Inc. (i.e., 811) will be contacted as part the PDI activities to coordinate utility identification and mark-outs within Reach 5A. The Dig Safe (i.e., 811) utility mark-outs include a 30-day expiration date, beyond which the mark-outs are not valid unless markings are preserved. Identified utilities and their locations within the planned work area will be documented and surveyed as appropriate, and the locations of identified natural gas, electric, telephone, cable television/internet, water, and sewer lines will be depicted on maps. This documentation of utility locations and types will be retained to support future remedial design and construction work.

The presence and locations of observed in-river or shoreline structures and utilities will also be documented during field reconnaissance activities conducted concurrently with the topographic/bathymetric surveys.

During the PDI, active outreach will also be conducted with local city building departments and county and state transportation agencies regarding the presence of utilities and structures that could impact the PDI, remedy implementation, worker safety, and/or utility integrity.

3.2.6 Water Surface Elevation and Current Velocity Survey

To support the development of the hydraulic model, water surface elevations and river current velocities will be measured at various locations throughout the PSA. Specifically, three rounds of measurements will be collected under different flow conditions—low, moderate, and high flow.[8] Measurements will be made at six locations throughout the PSA, including three locations in Reach 5A (Holmes Road bridge, adjacent to Joseph Drive, and near the Pittsfield WWTP), one location in Reach 5B (New Lenox Road bridge), and two locations in Reach 5C (south of Roaring Brook, and Woods Pond Headwaters near Woodland Road), all as shown on Figure 3-4.[9] Locations were selected in relatively straight sections of the river, or at fixed locations such as bridges, that are reasonably easy to access. Measurements will be taken at all six locations during low and moderate flow conditions, but due to safety considerations, measurements during high-flow conditions will be taken only at bridge locations. Current velocities will be measured across a transect at each location using a Marsh McBirney Flow Mate Model 2000 (or equivalent) flow meter. Short-term velocity measurements will be made using either the Two-Point or Three-Point Method (depending on water depth), as described in USGS (2010). The velocity measurements will be made in accordance with the SOP provided in Appendix B. In addition, the water surface elevation of the river will be surveyed at each transect location, and the corresponding flow at the USGS gage at Coltsville at the time of the survey will be recorded.

3.3 Sampling and Analysis

3.3.1 Riverbank Soil PCB Characterization

Riverbank soil samples will be collected for PCB analysis to characterize the extent of riverbank soils having PCB concentrations greater than 5 mg/kg in the top one foot of soil (DQO 5) and to support assessment of on-site versus off-site disposal requirements for riverbank soils be removed (DQO 6). As described in Section 1.3, the Revised Final Permit requires that surficial (0- to 12-inch) riverbank soil samples be collected at the toe, midpoint, and top-of-bank along transects spaced no more than 25 feet apart. Data from the riverbank LiDAR survey described in Section 3.2.1 will be needed to

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[8] For the purposes of this survey, low, moderate, and high flows are defined as 50 to 100 cubic feet per second (cfs), 100 to 300 cfs, and > 300 cfs, respectively, as measured at the USGS gage in the East Branch of the Housatonic River at Coltsville, Massachusetts (Gage #01197000).

[9] For the same reasons discussed with respect to the topographic and bathymetric surveys, water surface elevation and flow measurements will be made throughout the PSA (not just in Reach 5A) to provide data for the hydraulic model to be used in design, which will need to extend to Woods Pond Dam given that dam's role as a hydraulic control point for much of the PSA.

specify target locations for discrete sampling locations along each transect. Figures 3-2a through 3-2i show the proposed riverbank transect locations in Reach 5A. The 25-foot spacing results in a total of 1,987 transects (considering both riverbanks) and 5,961 discrete riverbank soil sampling locations. Following completion of the LiDAR survey, GE will submit figures and tables showing proposed target sampling locations at the toe, midpoint, and top-of-bank to EPA for review and approval.

The SOP for soil sample collection is provided in Appendix C, which is largely the same as the SOP provided in Appendix 1 to the *Revised Pre-Design Investigation Work Plan for Reach 5A Floodplain Residential Properties* (Anchor QEA 2020). In accordance with that SOP, a surficial (0- to 12-inch) riverbank soil PCB sample will be obtained at each location using either a hand auger or macrocore sampler (or equivalent). The sample will be obtained by advancing the selected sampling device at an angle approximately perpendicular to the slope of the riverbank at each sampling location. The sampling crew will locate proposed riverbank soil sampling locations using a DGPS. It may be necessary to make small adjustments to some of the target sampling locations based on conditions encountered in the field. In the event that any more significant adjustments to target sampling locations are necessary, they will be discussed with and approved by the EPA field representative. Coordinates of the actual sampling locations will be recorded using DGPS. As described in Section 1.3, the Revised Final Permit states that the evaluation of the 5 mg/kg PCB criterion for riverbank soils in Reach 5A is to be based on the average of the three 12-inch cores taken at the toe, midpoint, and top of the bank at each transect location. Given this requirement, the three cores collected at these points on the bank at each transect will be composited into one sample and submitted for PCB analysis (total of 1,987 PCB analyses). All composite soil samples collected will be analyzed for PCBs as Aroclors using EPA Method 8082. These results will provide data both to characterize the extent of riverbank soils greater than 5 mg/kg and to apply the requirement to evaluate potential supplemental removal for banks that do not meet the specific removal criteria.

3.3.2 Sediment PCB Characterization

This section describes sediment samples to be collected in the main channel and six backwaters within Reach 5A. These samples will be used to: (1) support assessment of on-site versus off-site disposal requirements for sediments that will be removed from these areas (DQO 6); (2) assess the extent of removal and capping or backfill required to achieve an average post-remediation concentration of 1 mg/kg in the backwaters (DQO 7); and (3) support design of the engineered cap to be placed in these areas (DQO 8). This section also describes PCB characterization sampling to be conducted in certain other hydrographic features within Reach 5A that do not have specific sampling requirements under the Revised Final Permit, but where EPA has directed GE to conduct sampling.

3.3.2.1 Main Channel Sediments

As described in Section 1.3, Attachment E to the Revised Final Permit requires GE to collect three vertical sediment cores on transects (i.e., a core located to the left, center, and right of the channel at each transect) with transects spaced 250 linear feet apart along the river channel. This corresponds to 98 transects and 294 discrete sediment core locations; target sediment core locations are shown on Figures 3-2a through 3-2i. Sediment cores will be collected to a total depth of three feet (or less depending on sediment thickness) and will be processed in six-inch intervals (six samples per core) for a total of 1,764 samples. If there are any locations where sediment probing indicates that total sediment thickness is less than six inches, a single grab sample will be collected at that location.

Sediment sample collection and processing will be performed following the methodology outlined in GE's current (2013) FSP/QAPP (unless a Rest of River FSP/QAPP has been submitted and approved by that time). The sampling crew will locate proposed sediment sampling locations using a DGPS. It may be necessary to make small adjustments to some of the target sampling locations based on conditions encountered in the field. In the event that any more significant adjustments to target sampling locations are necessary, they will be discussed with and approved by the EPA field representative. Coordinates of the actual sampling locations will be recorded using DGPS. All sediment samples collected will be analyzed for PCBs as Aroclors using EPA Method 8082 and TOC by the Lloyd Kahn Method.

3.3.2.2 Backwater Sediments

As described in Section 1.3, the Revised Final Permit requires collection of backwater sediment PCB samples on a 50-foot grid. For the six backwater areas located in Reach 5A, this corresponds to 127 core locations, as shown on Figures 3-5a through 3-5e. For surface sediments, the Performance Standards for backwaters apply to the top one foot. Thus, for the core locations that are in backwaters (or portions of backwaters) located within Core Area 1 priority habitat (51 of 127 locations), sediment cores will be collected in a single interval to a depth of one foot for PCB analysis (51 samples). At the remaining 76 locations located outside Core Area 1 priority habitat, sediment cores will be collected to a total depth of five feet, and each core will be segmented into a 0- to 1-foot interval and six-inch intervals between one and five feet (684 samples). Samples within the top three feet of each such core will be analyzed initially for PCBs (380 samples), and samples collected from lower depths will be held for potential future analysis if the depth of PCB contamination in a core is found to be greater than three feet.

Backwater sediment sample collection and processing will be performed following the methodology outlined in GE's current FSP/QAPP (unless a Rest of River FSP/QAPP has been submitted and approved by that time). The sampling crew will locate proposed sediment sampling locations using a DGPS. It may be necessary to make small adjustments to some of the target sampling locations based on conditions encountered in the field. In the event that any more significant adjustments to target sampling locations are necessary, they will be discussed with and approved by the EPA field representative. Coordinates of the actual sampling locations will be recorded using DGPS. All backwater sediment samples collected will be analyzed for PCBs as Aroclors using EPA Method 8082 and TOC by the Lloyd Kahn Method.

As described in Section 1.3, the Revised Modified Permit requires that this Sediment/Bank PDI Work Plan also provide proposed averaging areas and depth intervals for evaluation of achievement of the backwater Performance Standards for surface and subsurface sediments (i.e., removal and capping to achieve a spatially weighted average total PCB concentration of 1 mg/kg). GE proposes that averaging areas for backwaters in Reach 5A be at the scale of an individual backwater (with one exception) given the considerable distance between them and their relatively small sizes.[10] The one exception is that BW5A-3 and BW5A-4 (shown on Figure 3-5c) will be combined into a single averaging area given that they are directly adjacent to one another and are individually smaller than the other four areas. With respect to depth intervals, surface sediments (0- to 1-foot depth) will be evaluated as a single depth interval in each averaging area (or relevant portion of such averaging area). Subsurface sediments deeper than one foot will also be evaluated as a single depth interval from 1 to X feet in each averaging area, where X is the depth to which the majority of PCB sample results in a given averaging area exceed 1 mg/kg, up to a maximum depth of five feet, subject to approval by EPA.

3.3.2.3 Other Waterbodies in Reach 5A Containing Sediment

As described on page 11 of GE's Final Accessibility Report (dated July 16, 2020, and approved by EPA on August 10, 2020), the final classification of four waterbodies in Reach 5A was deferred to further discussions, following sampling, in accordance with conditions in EPA's June 16, 2020 conditional approval letter for a prior version of that report. Those waterbodies are: (1) the outlet from Morewood Lake to the Housatonic River; (2) two streams flowing from east to west into the Housatonic River on and just south of the Massachusetts Audubon parcel (i.e., portions of Sackett Brook and Sykes Brook); and (3) West Pond located on the Massachusetts Audubon parcel—shown on Figures 3-6a though 3-6c. respectively. Based on subsequent discussions with EPA, GE is including a proposal for sediment PCB sampling in these areas in this Sediment/Bank PDI Work Plan. In addition, based on discussions with EPA, this work plan includes a proposal for sediment sampling in one of four other areas identified in the Final Accessibility Report as an "Intermittently Flowing Side

[10] Backwater sizes are as follows: 1.8 acres for BW5A-1; 0.3 acre for BW5A-2; 0.2 acre for BW5A-3; 0.07 acre for BW5A-4; 1.6 acres for BW5A-5; and 0.4 acre for BW5A-6.

Channel/River Sediment"—namely, an intermittently flowing side channel located immediately south and east of the Confluence, as shown on Figure 3-6d.[11] Specifically, GE proposes the following:

- *Outlet from Morewood Lake:* The portion of this outlet located within the floodplain of the Housatonic River contains sediment that may potentially have been impacted by the Housatonic River during periods of higher flow. Therefore, GE will collect samples of accumulated sediment in this outlet at five locations (spaced approximately 100 feet apart) in six-inch intervals to a maximum depth of two feet (or less if less than two feet of sediment is present in this channel). Proposed sample locations are shown on Figure 3-6a.
- *Two Streams Flowing from East to West, Located South of Audubon (portions of Sackett Brook and Sykes Brook):* GE proposes to sample accumulated sediments in the portions of these streams from the point where they intersect the Housatonic River to the point where they first intersect the wetland (i.e., emergent marsh and wet meadow and/or shrub swamp) portions of the floodplain. Beyond that point, these streams will be characterized as boatable floodplain. Samples will be collected at a total of 12 locations in these two streams spaced approximately 100 feet apart in six-inch intervals to a maximum depth of two feet (or less if less than two feet of sediment is present in any portion of these streams). Proposed sample locations are shown on Figure 3-6b.
- *West Pond:* Based on the field surveys conducted in 2018 and 2019, GE does not believe that West Pond meets the definition of a backwater provided in Section 1.2. Nonetheless, GE proposes to collect sediment samples from this pond using the backwater sampling approach described above—i.e., cores will be collected on 50-foot grid and segmented in six-inch intervals to a maximum depth of three feet. Proposed sample locations are shown on Figure 3-6c.
- *Intermittently Flowing Side Channel Located East of Confluence:* As described in the Final Accessibility Report, this feature is a small, intermittent side channel that is approximately 1,500 feet long and runs along the eastern side of the Housatonic River. Surface water from the Housatonic River is conveyed through this channel during higher flows, but the channel is typically dry for most of the year. GE proposes to collect samples of accumulated sediment in this channel at a total of 10 locations (spaced approximately 100 feet apart) in six-inch intervals to a maximum depth of two feet (or less if less than two feet of sediment is present in this channel). Proposed sample locations are shown on Figure 3-6d.

All sediment samples collected from these areas will be analyzed for PCBs as Aroclors using EPA Method 8082. A portion of each sample will be archived for potential future analysis of TOC (Lloyd Kahn Method) as needed.

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[11] Sampling of the remaining three areas identified as "Intermittently Flowing Side Channel/River Sediment" in the Final Accessibility Report will be addressed, as necessary, in GE's forthcoming second Revised PDI Work Plan for Reach 5A Non-Residential Floodplain Exposure Areas.

3.3.3 Porewater PCB Sampling

Porewater PCB data (along with measured groundwater seepage rates discussed in Section 3.3.4) will be used to estimate dissolved-phase PCB mass flux from sediments under current conditions, which will inform the design of the engineered cap isolation layer in the Reach 5A main channel and backwaters (DQO 8). To support this objective, additional sediment samples will be collected at 20 of the sediment sampling locations in the main channel and backwaters described above; those locations are shown on Figure 3-7. Specifically, these additional samples will be submitted for analysis of paired sediment and porewater PCBs to characterize PCB concentrations in sediment porewater and to verify/update site-specific partitioning relationships that were developed previously for the ROR using sediment and porewater data collected by GE in 2001 (BBL and QEA 2003).[12]

For this evaluation, concentrations of freely dissolved PCBs in sediment porewater will be measured *ex situ* using solid-phase microextraction (SPME) passive samplers.[13] Because the depth of capping is unknown, bulk sediments from the 1- to 3-foot depth interval at each of the 20 locations will be homogenized to obtain the volume of sediment required for both bulk sediment and porewater analysis.[14] A portion of the homogenized bulk sediment sample will then be sent to Anchor QEA's Environmental Geochemical Laboratory in Portland, Oregon, for the *ex situ* passive sampler analysis. Specifically, SPME fibers will be deployed in each of the bulk sediment samples, allowed to equilibrate for a minimum of 30 days, and then be retrieved and submitted to the analytical laboratory for congener-specific PCB analysis (using EPA Method 1668). The SOP for *ex situ* porewater passive sampling using SPME samplers (including details on preparation of the SPME fiber, sample deployment and retrieval, etc.) is provided in Appendix D.

The remaining portion of the homogenized bulk sediment samples that are not used for *ex situ* porewater analysis will be sent to the analytical laboratory for analysis of PCBs by both congener Method 1668 and Aroclor Method 8082, as well as for analysis of total and dissolved organic carbon (TOC and DOC).[15] Contaminant transport modeling to support cap design will be performed on a homolog-specific basis, to explicitly account for differences in the transport properties of each homolog. The paired Aroclor and congener PCB results in this data set will provide the data necessary to develop a relationship that can be used to convert the larger sediment Aroclor PCB data

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[12] Twenty locations are approximately the same number of sample locations that were analyzed for porewater PCBs in Reach 5A during the 2001 study and were deemed sufficient for characterization of porewater PCB concentrations over this reach at that time.

[13] Research over the last several decades has demonstrated that passive sampling using SPME samplers in controlled *ex situ* laboratory environment provides reliable characterization of freely dissolved porewater PCB concentrations suitable for management of contaminated sediments (Jonker et al. 2018).

[14] Sampling this 1- to 3-foot depth interval at 20 locations across Reach 5A is anticipated to capture the range of PCB concentrations experienced in this reach and will be sufficient for updating site-specific partitioning relationships.

[15] Note that bulk sediment samples will require centrifugation by the analytical laboratory for porewater DOC analysis.

set (described in Section 3.3.2) to homolog concentrations that can be used in the cap design model evaluations.

3.3.4 Groundwater Seepage

Characterization of groundwater seepage rates is required to support the design of the engineered cap isolation layer in the Reach 5A main channel and backwaters (DQO 8). Seepage rates will be calculated based on the observed hydraulic gradient and vertical hydraulic conductivity observed in this reach of the river using Darcy's Law. This approach is recognized by USGS as a common method for quantifying groundwater seepage in a freshwater river setting (USGS 2008). This characterization will include continuous recording of hydraulic head and river water surface elevations to calculate vertical hydraulic gradient (VHG) and vertical hydraulic conductivity (K_v) tests; details are provided in the subsections that follow.

3.3.4.1 Continuous Recording of Hydraulic Head

Hydraulic head will be measured beneath the river at 10 locations within the Reach 5A channel and backwaters to calculate VHG. Selected monitoring locations are shown on Figure 3-7. At each location, a piezometer will be installed into the sediment to a depth of six feet. The procedure for installation of these piezometers is included in the SOP provided in Appendix E. After installation, the riser of each new piezometer will be cut off just above the sediment surface, and the piezometer will be equipped with a sealed pressure transducer. Attached to the riser will be a screen extending approximately one foot above the mudline. This screen will be equipped with a sealed pressure transducer as well. The screen will be in connection with the river to facilitate measurement of the head of the river (i.e., water surface elevation). Each transducer will have an internal data logger that continuously monitors and records pressure, which is expressed as an equivalent water level above the transducer sensor, at approximate five-minute intervals. A water-tight cap will be placed on each piezometer after transducer deployment to isolate the transducers from the river. This will allow the pressure transducers to record the head within the formation adjacent to the well screen. Pressure transducers will be programmed as outlined in the SOP in Appendix E and serviced at regular intervals to gather data and ensure proper function. Installed piezometers will collect data monthly through the deployment period, depending on river conditions with the goal of collecting between four and 12 months of data to allow for potential seasonal changes in seepage rate to be assessed.

3.3.4.2 Vertical Hydraulic Conductivity Tests

K_v will be measured empirically using sediment cores collected at the locations where piezometers are installed. To measure sediment K_v in the field, sediment cores will be collected continuously in rigid-wall, plastic core liners from the existing sediment surface to the targeted bottom elevation. The bottom elevation will be determined in the field but, at a minimum, K_v testing will be completed from the sediment surface to the bottom of the piezometer. During K_v testing, a small quantity of porewater will be allowed to freely drain from the core by gravity through a perforated bottom cap. The rate of porewater flow will be recorded and later used to calculate the K_v of each tested core sample.

More information on sediment core collection for this test and calculation of vertical hydraulic conductivity is included in the SOP provided in Appendix E.

3.3.5 Geotechnical Characterization

Geotechnical characterization data will be collected to support the remedial design and provide information about the strength (bearing capacity) and compressibility of the sediments to be removed and capped, and the stability of the riverbank that will be subject to soil excavation and reconstruction (DQO 9). The geotechnical investigation will be conducted using a phased, adaptive approach, in which data gathered during initial phases will be used to inform or adjust the scope of the subsequent phases of the investigation. Specifically, the geotechnical investigation will be conducted using the following phased approach:

- Phase 1: Analysis of geotechnical parameters to be conducted during the PDI on samples collected in conjunction with the sediment and riverbank soil PCB characterization sampling described in Sections 3.3.1 and 3.3.2;
- Phase 2: Cone penetration testing (CPT) and full flow penetration (FFP) testing to be performed during the PDI to provide data on the subsurface soil stratigraphy and strength over the general areas where capping and removal will occur;
- Phase 3: Geotechnical borings (including standard penetration testing) to be advanced during the PDI, as necessary, at locations to provide additional data on the stratigraphy, consistency, and geotechnical properties in specific areas of the river identified based on the Phase 2 CPT investigation; and
- Phase 4: Additional location-specific geotechnical investigations that may be implemented, if needed, following completion of the PDI and submission of the Conceptual Remedial Design/Remedial Action (RD/RA) Work Plan, based on conditions encountered as part of the PDI and to address data gaps identified during development of the Conceptual RD/RA Work Plan.

Additional details related to the geotechnical data collection and analysis to be completed as part of this phased approach are provided in the following subsections.

3.3.5.1 Phase 1: Initial Geotechnical Testing

The Phase 1 geotechnical investigation will include collection of data to identify soil/sediment material types and general index properties (e.g., moisture content, grain size, Atterberg limits, density, and specific gravity), measure the estimated undrained shear strength of the soil using vane shear testing, and characterize the consolidation properties of soft sediments. The Phase 1 geotechnical sampling will be performed in conjunction with the PCB characterization sampling described in Sections 3.3.1 and 3.3.2 and is described below.

3.3.5.1.1 Soil/Sediment Properties

A subset of the riverbank soil and sediment samples collected for PCB characterization (described in Sections 3.3.1 and 3.3.2) will be analyzed for geotechnical parameters. Specifically, approximately 10% of sediment, backwater, and composite riverbank soil samples will be selected and submitted for analysis for the following geotechnical parameters:

- Moisture content (ASTM D2216/D2974A);
- Particle size analysis (ASTM D6913/D7928); and
- Atterberg limits for fine-grained materials (ASTM D4318).

The sampling locations will be selected in the field to provide data for each unique geologic material type and from various sampling depths. The sampling locations will also be selected to include collection of at least 20 surface sediment samples spatially distributed across Reach 5A to provide data to support specification of roughness coefficients in the hydraulic model.

In addition, a smaller subset of the geotechnical samples described above (approximately 10% to 20% of the initial subset of samples collected for index property testing described above) will be submitted for bulk density analysis (ASTM D7263), and up to five samples from each unique geologic material type within Reach 5A will be submitted for specific gravity analysis (ASTM D854). Table 3-3 provides a summary of the target number of samples for testing of each geotechnical parameter along with the analytical methods.

Table 3-3
Summary of Phase 1 Geotechnical Testing

Parameter	Analytical Method	Approximate Number of Samples
Moisture Content	ASTM D2216/D2974A	450
Particle Size	ASTM D6913/D7928	450
Atterberg Limits	ASTM D4318	TBD[1]
Bulk Density	ASTM D7263	90
Specific Gravity	ASTM D854	30

Note:

1. TBD (to be determined): The number of samples to be analyzed for Atterberg limits will depend on the amount of fine-grained sediments/soils encountered.

3.3.5.1.2 Vane Shear Testing

Vane shear testing will be conducted within the backwater portions of Reach 5A to measure the undrained shear strength of the relatively soft sediments in those areas. Vane shear testing is an *in situ* method that is used to measure the undrained shear strength of saturated fine-grained sediments (clays and silts). The vane shear testing will focus on the backwater areas, where more fine-grained sediments are expected. Vane shear testing may also be conducted at locations within the main river channel if fine-grained sediments are encountered. The vane shear testing will be performed on *in situ* fine-grained sediments using a hand-held vane shear test apparatus. The vane shear testing will be collocated with the PCB characterization sampling for the backwater areas (Section 3.3.2.2).

The vane shear testing in the backwater areas will be conducted at approximately 68 locations with target testing depths of one foot, two feet, and three feet below the mudline. Testing of additional depth samples (e.g., four and five feet below the mudline) may be conducted depending on the thickness of fine-grained material encountered during the PCB characterization sampling effort. Approximate locations for vane shear testing in backwater areas are shown on Figures 3-8a through 3-8e. Note that the actual testing locations may be adjusted in the field based on observations of the material types encountered during the PCB characterization sampling. Vane shear testing will be conducted in general accordance with ASTM D2573/D2573M and the SOP provided in Appendix F.

3.3.5.1.3 Seepage-Induced Consolidation Testing

Seepage-induced consolidation (SIC) testing (Znidarcic et al. 1992) will be performed to evaluate consolidation characteristics of soft sediments (i.e., silt or clay). The SIC test uses the stresses imposed by constant head differential, which produces a downward seepage force to induce low-effective stress settlement in a reconstituted sample of soil/sediment. The test also includes a step-loading procedure that follows the SIC increment to generate the remainder of the load-settlement data. The data generated during this test are used in an extended power function equation that is used to compute settlement as a function of effective stress.

Core samples will be collected from up to 10 locations within the river channel (if soft sediments are encountered) and from each of the six backwater areas. The core samples will consist of a 2- to 4-foot-thick core section of fine-grained soil/sediment (i.e., primarily silt or clay). The core sampling locations will be determined in the field based on observations of the material types encountered during the PCB characterization sampling and based on the vane shear testing described above. Selected sub-samples for SIC testing will be collected from the cores with the intent of representing the range of material types encountered. The SIC testing (and associated core sampling) will be conducted in accordance with the SOP provided in Appendix G. The SIC testing will require site-specific water, which will be used to prepare slurried samples.

3.3.5.2 Phase 2: Cone Penetration and Full Flow Penetration Testing

Phase 2 of the geotechnical investigation program will include CPT and, where appropriate, FFP testing to obtain stratigraphic profiles with depth and *in situ* strength measurements to assess the shear strength of the underlying materials where caps will be constructed in Reach 5A. Shear strengths will be measured using the CPT and (in soft to very soft sediments/soils where the CPT is unable to accurately register penetration values) FFP tests; and this testing may also be coupled with field vane shear testing to supplement the hand-held vane shear testing of shallow sediment planned for Phase 1.

CPT/FFP soundings will be performed in general accordance with ASTM D5778 at 21 locations within the main river channel throughout Reach 5A and at two to three locations per backwater, for a total of 14 backwater locations. Target locations for CPT/FFP soundings in the main channel are shown on Figure 3-9, and those in backwaters are shown on Figures 3-8a through 3-8e.[16] Note that the actual CPT/FFP locations may be adjusted based on observations of the material types, field conditions, and accessibility considerations encountered during the Phase 1 geotechnical investigation activities.

Pore pressure dissipation tests will be conducted at selected CPT locations to estimate the horizontal coefficient of consolidation of the substrate materials. As noted above, FFP (or ball penetration) tests will be performed in soft to very soft sediments/soils, if present, where the CPT is unable to accurately register penetration values. The FFP tests will be performed using the CPT thrust system with a spherical tip of 100 cm^2 projected area. In such cases, after the full flow penetrometer reaches refusal, further testing will be continued using the cone penetrometer to obtain a complete strength profile extending from the mudline to top of hard bottom.

Field shear vane testing will be performed at CPT/FFP locations with fine-grained sediment to supplement the shear strength data obtained from the CPT/FFP soundings and to correlate the field shear vane testing and CPT/FFP undrained shear strength measurements.

The CPT/FFP testing and field vane shear testing will be performed in accordance with ASTM D5778 and ASTM D2573, respectively, and the SOP provided in Appendix H.

3.3.5.3 Phase 3: Geotechnical Borings

Phase 3 of the geotechnical investigation program will include implementation of geotechnical borings and sampling/testing to further assess the geotechnical parameters for the underlying soft sediments/soils where capping or removal will be performed in the Reach 5A river channel or backwater areas. Geotechnical borings are not currently planned for the riverbank areas; the need to perform riverbank geotechnical characterization will be determined after the extent of riverbank remediation is determined (as discussed in Section 3.3.5.4).

[16] Many of the CPT/FFP locations are co-located with porewater and groundwater seepage locations shown on Figure 3-7.

Geotechnical drilling will be performed in general accordance with ASTM methods for collecting soil samples for visual classification and geotechnical laboratory testing (as needed). The geotechnical borings will be advanced using a hollow-stem auger drill rig to collect subsurface samples. As part of the drilling, standard penetration testing (ASTM D1586) will be performed to collect information on the engineering properties of the underlying materials. Additionally, field vane shear testing will be performed to provide *in situ* estimates of soil shear strength (in cohesive soils only).

It is currently anticipated that 10 to 20 test borings will be completed in areas where the Phase 2 CPT testing indicates the presence of soft underlying sediments/soils within Reach 5A. The geotechnical borings will likely require use of a track-mounted or amphibious rig depending on access and field conditions at the time of sampling. The geotechnical borings will be advanced through the sediment until refusal is encountered or as directed by the field geologist based on material conditions encountered, to a maximum depth of approximately 50 feet below the top of sediment.

The sediment and soil samples retrieved from the borings will be logged in the field using the Unified Soil Classification system. Samples for laboratory testing will be selected as follows:

1. Representative samples of each material type encountered during drilling will be selected for laboratory index testing for classification purposes.
2. Shear strength tests will be conducted on undisturbed samples of cohesive materials that are deemed representative for assessing slope stability considerations.
3. Field vane shear testing will be performed at selected boring locations at varying depths below the mudline or ground surface to estimate the *in situ* undrained shear strength of cohesive sediment/soil.

Representative samples will be collected from the test borings for physical testing in accordance with applicable ASTM standards. Physical testing will include, but not be limited to, the following geotechnical tests:

- Particle size analysis (ASTM D6913);
- Atterberg limits for fine-grained soils (ASTM D4318);
- Moisture content (ASTM D2216/D2974A); and
- Organic content (ASTM D2974).

At least one set of index tests per soil type encountered will be performed for each boring.

Undisturbed samples will be collected using Shelby tubes for advanced laboratory testing of strength and compressibility characteristics. The number and locations of Shelby tube sampling will be determined in the field based on observations of the material types during the drilling operations to target silt or clay layers. The Shelby tube samples will be analyzed for unconsolidated, undrained triaxial shear strength (ASTM D2850), consolidated undrained triaxial shear strength (ASTM D4767), one-dimensional consolidation (ASTM D2435), and permeability (ASTM D2434) or hydraulic conductivity (ASTM D5084) based on grain size and cohesion.

Additional information related to the advancement of geotechnical borings, the collection of samples from them, and decommissioning of the boreholes is presented in the SOP provided in Appendix I.

3.3.5.4 Phase 4: Supplemental Geotechnical Investigations

Phase 4 of the geotechnical investigation program, which is not part of the PDI, would involve additional location-specific investigations, if warranted, following submission of the Conceptual RD/RA Work Plan based on conditions encountered as part of the PDI and to address data gaps identified during development of the Conceptual RD/RA Work Plan. In addition, geotechnical investigations are anticipated for riverbank areas; however, determination of the scope of those investigations will be deferred until after the extent of riverbank remediation is known based on the PCB characterization sampling and bank erodibility assessment. These additional geotechnical investigations, if warranted, will be proposed as supplemental engineering data collection activities in the Conceptual RD/RA Work Plan.

3.4 Summary of Pre-Design Investigation Activities

Table 3-4 provides a brief summary of the various field surveys and sampling and analysis activities described in Sections 3.2 and 3.3.

Table 3-4
Summary of Pre-Design Investigation Activities

Program	Survey / Sampling	Description
Field Surveys	Topographic Survey	LiDAR survey of entire PSA, including the river channel, riverbanks, approximate 100-year floodplain, and nearby infrastructure.
	Bathymetric Survey	Conventional survey of PSA main channel with cross-sections every 100 feet. Includes evaluation of feasibility of supplementing conventional bathymetric transect survey using topobathymetric LiDAR.
	Sediment Probing	Probing on transects spaced 250 feet apart with three probe locations per transect.
	Bank Erodibility Assessment	Visual observations and field measurements of BEHI/NBS variables.
	Shoreline Structures and Utility Surveys	Utility clearance via Massachusetts Dig Safe, and field reconnaissance of in-river or shoreline structures and utilities.
	Water Surface Elevation and Current Velocity	Measurement of current velocity and water surface elevation at 6 locations throughout the PSA (three in Reach 5A; one in Reach 5B, and two in Reach 5C).

Program	Survey / Sampling	Description
Sampling and Analysis	Riverbank Soil PCBs	Collection of surficial (0- to 12-inch) riverbank soil samples at toe, midpoint, and top-of-bank along transects spaced 25 feet apart. Compositing the three samples collected at each transect location for PCB analysis.
	Sediment PCBs in Main Channel	Collection of three sediment cores on transects (i.e., a core located to the left, center, and right of the channel at each transect) with transects spaced 250 linear feet apart. Cores to be collected to a total depth of three feet and processed in six-inch intervals, with analysis for PCBs and TOC.
	Sediment PCBs in Backwaters	Collection of sediment cores on a 50-foot grid. Within Core Area 1 habitat, a single interval to be collected to a depth of 1 foot for PCB and TOC analyses. Outside of Core Area 1 habitat, cores to be collected to a total depth of 5 feet and segmented into a 0- to 1-foot interval and six-inch intervals between 1 and 5 feet, with analysis of the samples collected from the top 3 feet for PCBs and TOC and samples from 3 to 5 feet to be archived for potential future analysis.
	Sediment PCBs in Other Waterbodies	Collection of sediment cores in five waterbodies (outlet from Morewood Lake, portions of Sackett Brook and Sykes Brook, West Pond, and an intermittently flowing side channel located east of the Confluence); to be collected in six-inch intervals to a maximum depth of 2 or 3 feet, as indicated in text, with analysis for PCBs (and potentially TOC).
	Porewater PCBs	Collection of bulk sediment samples at 20 locations for *ex situ* analysis of freely dissolved PCBs in sediment porewater using SPME passive samplers.
	Groundwater Seepage	Measurement of hydraulic head using piezometers installed at 10 locations in Reach 5A, and measurement of vertical hydraulic conductivity using sediment cores collected at the same locations as piezometers.
	Geotechnical	Collection of geotechnical characterization data, including various soil/sediment properties (moisture, particle size distribution, Atterberg, bulk density, and specific gravity), vane shear testing, SIC testing, CPT/FFP testing, and geotechnical borings for visual classification and geotechnical laboratory testing.

4 Schedule and Reporting

As described in Section 3.2, results from the LiDAR (topographic and bathymetric) surveys will be used to develop more specific target riverbank soil sampling locations, and the sediment probing survey will be used to inform the sediment sampling. Therefore, GE proposes to initiate those surveys within 45 days after EPA approval of this Sediment/Bank PDI Work Plan, subject to weather constraints and the timing of EPA approval. As noted in Section 3.2, the LiDAR survey is best performed during low-flow, leaf-off conditions, so approval for that portion of this Sediment/Bank PDI Work Plan would be needed by early 2022 to conduct that survey in early spring of that year. Following completion of those surveys, GE will provide specific target coordinates for riverbank soil sampling locations for EPA review and approval within 30 days of receipt of the processed LiDAR information from the survey contractor. Subsequently, GE will initiate riverbank soil and sediment PCB sampling and the remaining survey activities described herein within 45 days after EPA approval of the riverbank soil sampling locations.

Following completion of the sampling described herein and receipt of the results, GE will evaluate the need for analysis of any held backwater sediment samples and/or for additional pre-design sampling or analysis. If GE determines that analysis of held samples is warranted, GE will provide EPA with the results of the sampling completed, consult with EPA regarding the analysis of any held samples, and, upon agreement, proceed with the analysis of the held samples. Following any such analyses of held samples, GE will evaluate the need for additional pre-design sampling and/or other data collection to complete the PDI and will advise EPA of the results of that evaluation. Specifically, if GE determines that additional pre-design sampling and/or data collection is warranted, GE will submit an addendum to this Sediment/Bank PDI Work Plan presenting the data received to date and proposing the additional data collection. That addendum, if warranted, will be submitted within 60 days after receipt and completion of validation of all analytical results associated with the sampling proposed herein (including the analysis of any held samples).[17] Upon EPA approval, GE will conduct the additional data collection. If GE determines that no additional pre-design data collection is warranted, GE will notify EPA and proceed to the development of a PDI Summary Report for Reach 5A Sediment and Banks, described in the next paragraph.

Following the completion of all required PDIs in Reach 5A, a PDI Summary Report for Reach 5A Sediment and Banks will be prepared that summarizes the data collected pursuant to this

[17] This procedure is slightly different from the procedure described in the Final Revised SOW, which would involve submission of a PDI Summary Report after the initial round of data collection, with an evaluation of the need for additional data collection and a proposal for such additional data collection included in that report, to be followed (if necessary) by one or more supplemental PDI summary reports. Upon further consideration, GE proposes, for the sediments and banks in Reach 5A, to submit a work plan addendum to propose any necessary additional data collection and then to include all the PDI data in a PDI Summary Report, as described below.

Sediment/Bank PDI Work Plan and any addendum or addenda thereto. That report will include the following:

- A summary of the sediment and riverbank investigations performed and investigation results in Reach 5A;
- A summary of validated analytical data and discussion of any quality assurance/quality control issues with the data;
- Data validation reports and laboratory data reports;
- Supporting documentation of the PDI activities (e.g., sampling logs, photographs);
- An evaluation of the sufficiency of the available data, in terms of spatial coverage, to delineate the Reach 5A riverbank areas that meet the criteria for removal of contaminated eroding riverbanks in the Revised Final Permit and to apply the requirement that, for other riverbanks, GE will evaluate the PCB data, erosion potential, and other factors and, based thereon. consider supplemental riverbank removal;
- An evaluation of the sufficiency of the data to support RD/RA activities for the Reach 5A riverbanks, main channel sediments, and backwater sediments;
- A preliminary identification of any supplemental engineering or other data that may be needed to complete the remedial design and that will be proposed in the Conceptual RD/RA Work Plan; and
- A description of the next steps to evaluate Reach 5A sediments and riverbanks, including submission of a Conceptual RD/RA Work Plan for Reach 5A, in accordance with the Final Revised SOW.

In the meantime, a summary table of the analytical results received in each month collected under this Sediment/Bank PDI Work Plan and any addendum(a) thereto will be included in GE's monthly progress reports under the CD.

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Figures

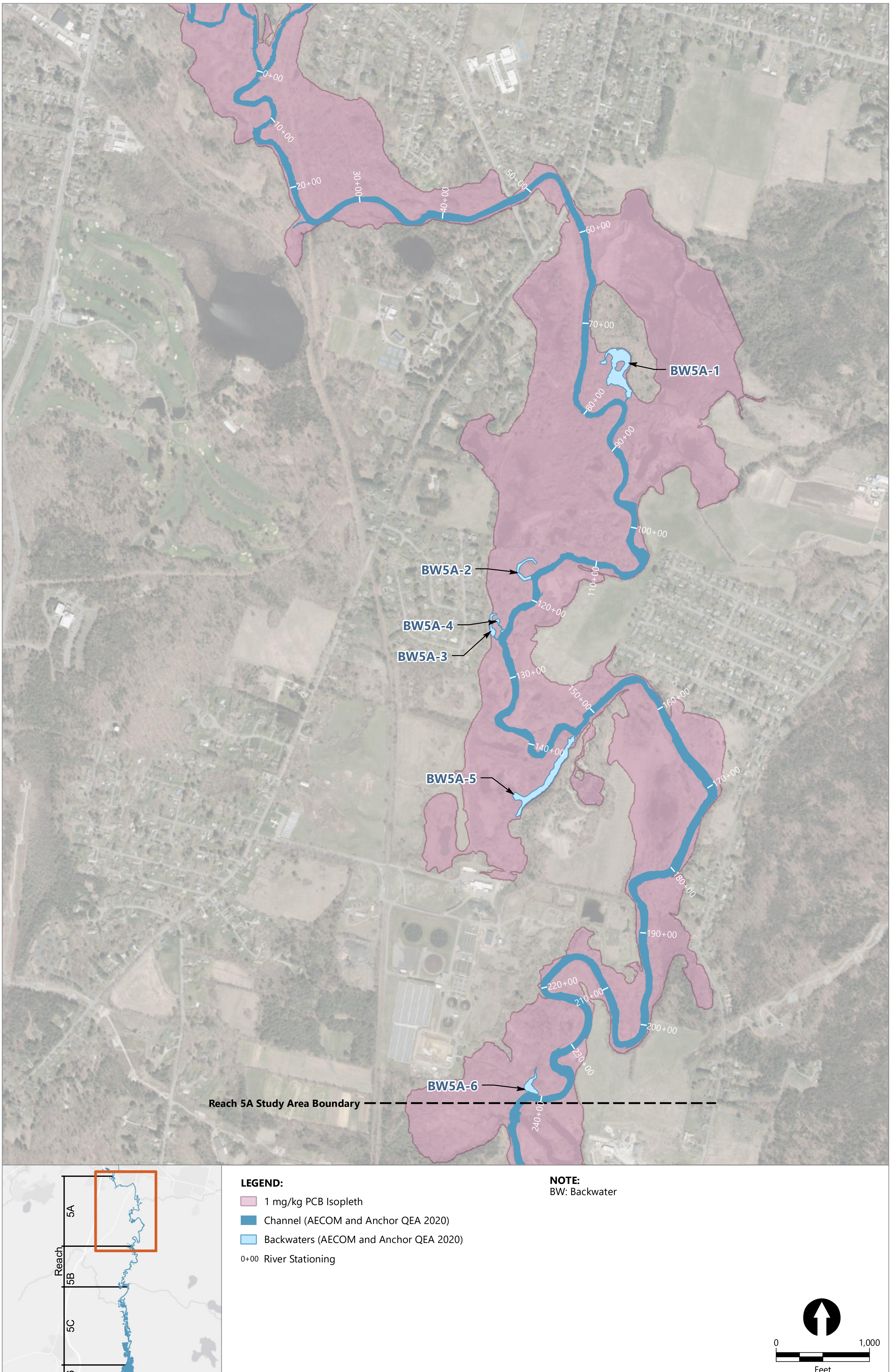

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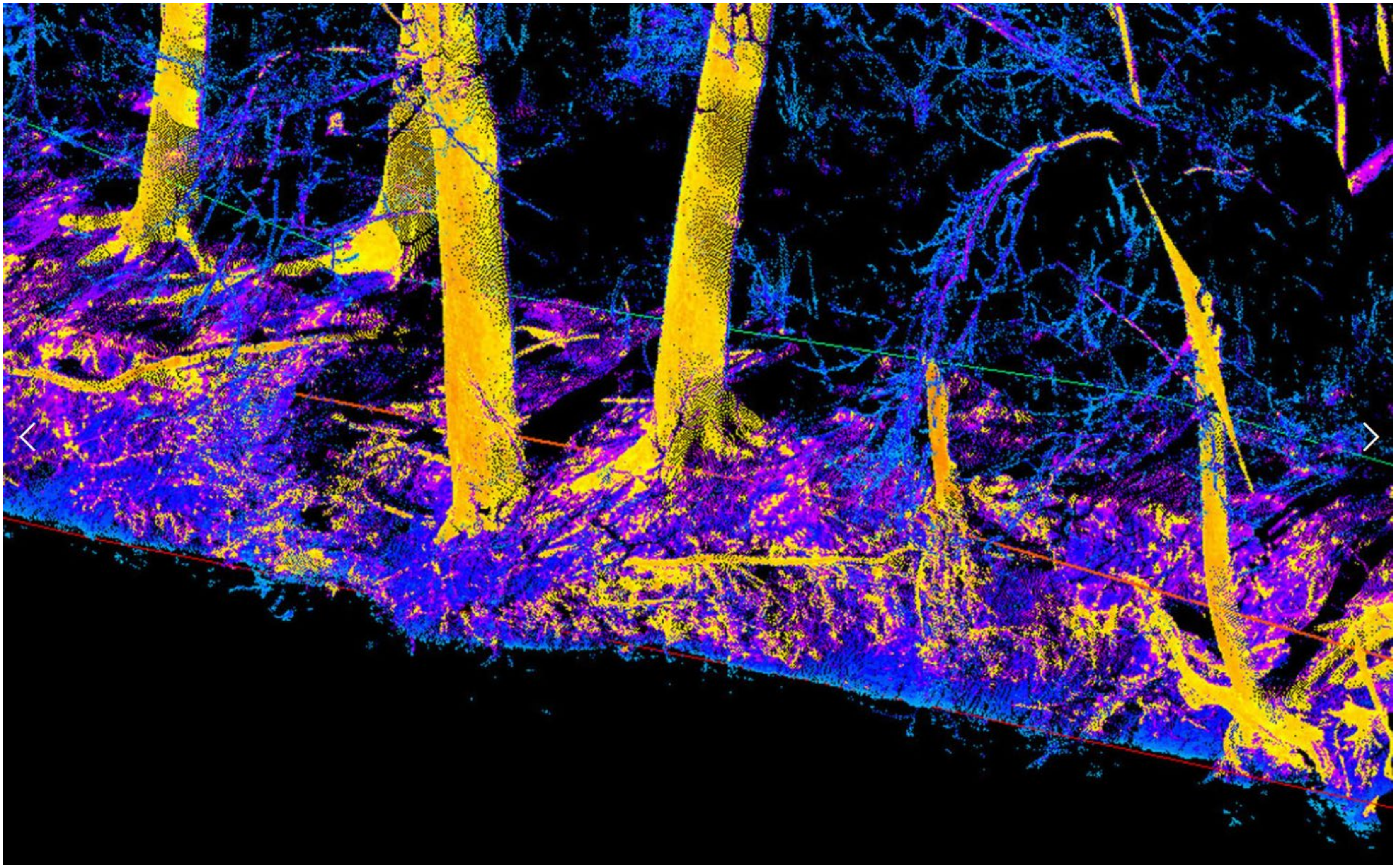
Figure 1-1
Reach 5A Site Map
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



South River Riverbank LiDAR Survey (Spicer Group; https://www.spicergroup.com/mobile-mapping-1/south-river-riverbank-lidar-survey)

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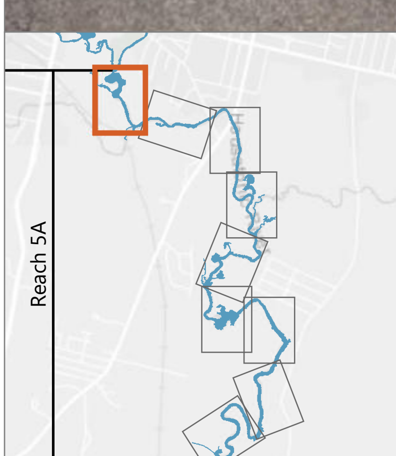
Figure 3-1
Example of Streambank LiDAR Survey Results (South River, Virginia)

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth

Channel (AECOM and Anchor QEA 2020)

0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*

Sediment Sampling and Probing Locations (250-foot Transects)

Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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Figure 3-2a
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations

LEGEND:

1 mg/kg PCB Isopleth

Channel (AECOM and Anchor QEA 2020)

0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*

Sediment Sampling and Probing Locations (250-foot Transects)

Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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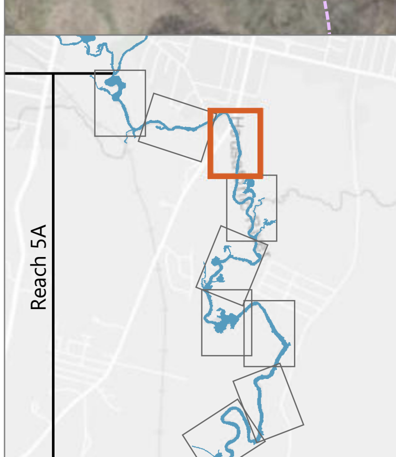
Figure 3-2b

Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks

Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth

Channel (AECOM and Anchor QEA 2020)

0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*

Sediment Sampling and Probing Locations (250-foot Transects)

Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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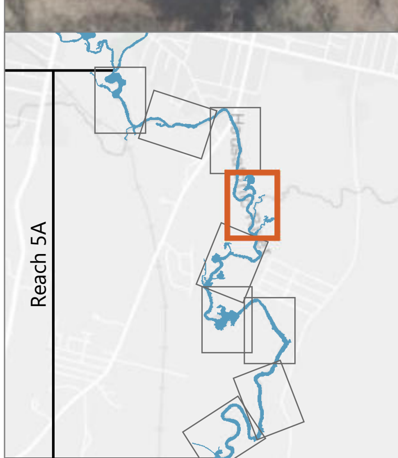
Figure 3-2c
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth

Channel (AECOM and Anchor QEA 2020)

Backwaters (AECOM and Anchor QEA 2020)

0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*

Sediment Sampling and Probing Locations (250-foot Transects)

Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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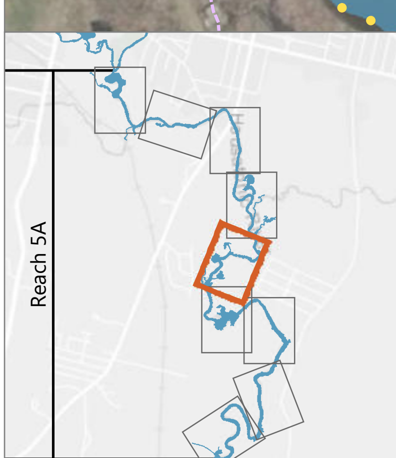
Figure 3-2d
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing

Proposed Survey and Sampling Locations

- Proposed Bathymetric Transects (100-foot Spacing)*
- Sediment Sampling and Probing Locations (250-foot Transects)
- Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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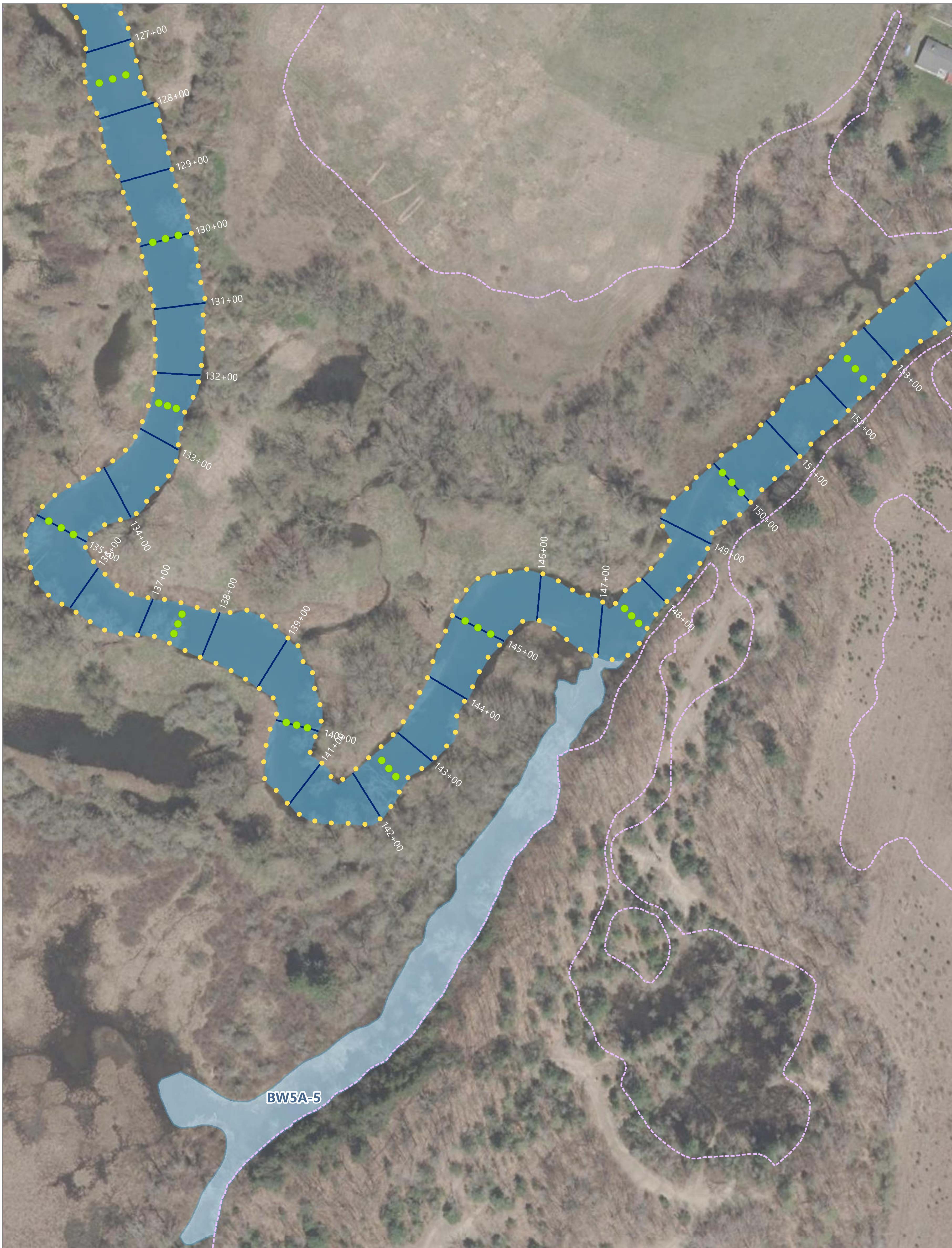
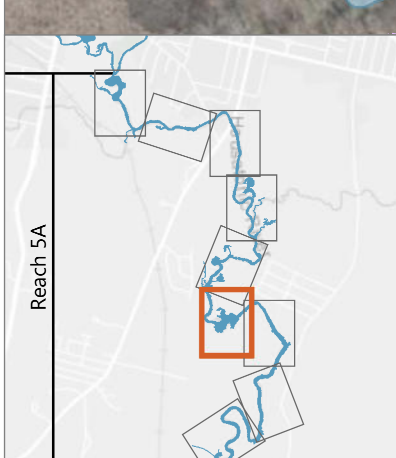
Figure 3-2e
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River





LEGEND:

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- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing

Proposed Survey and Sampling Locations

- Proposed Bathymetric Transects (100-foot Spacing)*
- Sediment Sampling and Probing Locations (250-foot Transects)
- Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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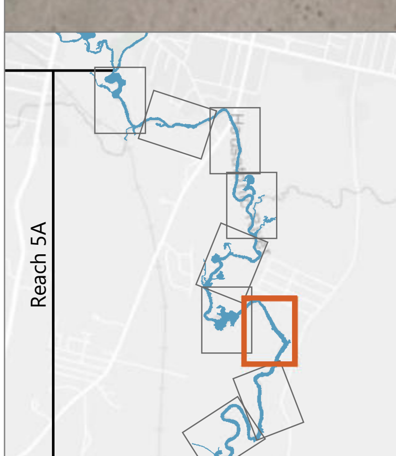
Figure 3-2f
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth
Channel (AECOM and Anchor QEA 2020)
0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*
Sediment Sampling and Probing Locations (250-foot Transects)
Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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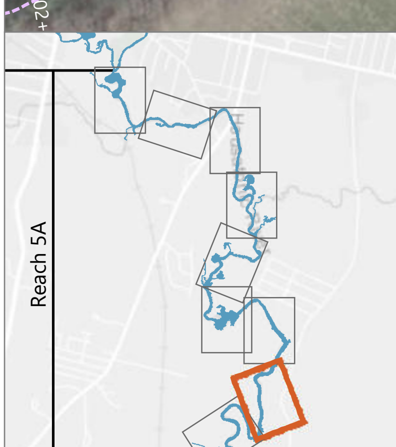
Figure 3-2g
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- 0+00 River Stationing

Proposed Survey and Sampling Locations

- Proposed Bathymetric Transects (100-foot Spacing)*
- Sediment Sampling and Probing Locations (250-foot Transects)
- Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

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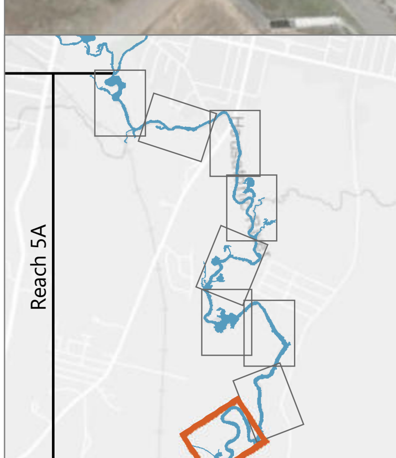
Figure 3-2h
Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth

Channel (AECOM and Anchor QEA 2020)

Backwaters (AECOM and Anchor QEA 2020)

0+00 River Stationing

Proposed Survey and Sampling Locations

Proposed Bathymetric Transects (100-foot Spacing)*

Sediment Sampling and Probing Locations (250-foot Transects)

Riverbank Soil Transect Locations (25-foot Spacing)

NOTE:
* Bathymetric transects will continue at 100-foot intervals for all of Reach 5 (only shown for Reach 5A on this figure).

0 160
Feet

Publish Date: 2021/09/24, 11:24 AM | User: eiverson
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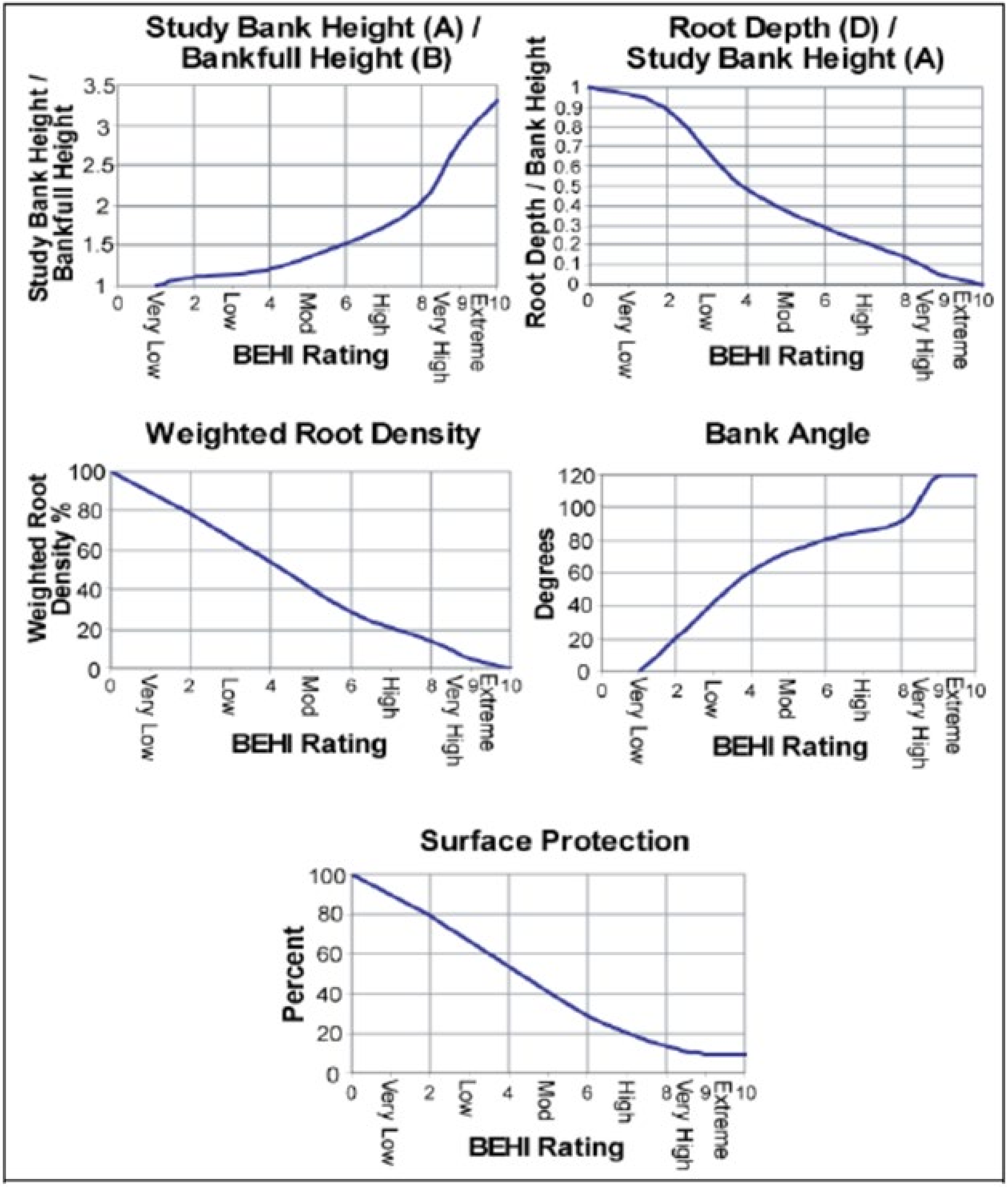
Figure 3-2i

Proposed Survey (Bathymetry Transects and Probing), Riverbank Soil, and Sediment Sampling Locations

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



Filepath: P:\GE\Housatonic_Rest-of-River\Remedial_Design\Documents\PDI Work Plans\Reach 5A Sediment-Banks\Figures\Source_Files\Figure_3-3_BEHI.pptx

ANCHOR QEA

Figure 3-3
Streambank Erodibility Criteria Showing Conversion of Measured Ratios and Bank Variables to a BEHI Rating

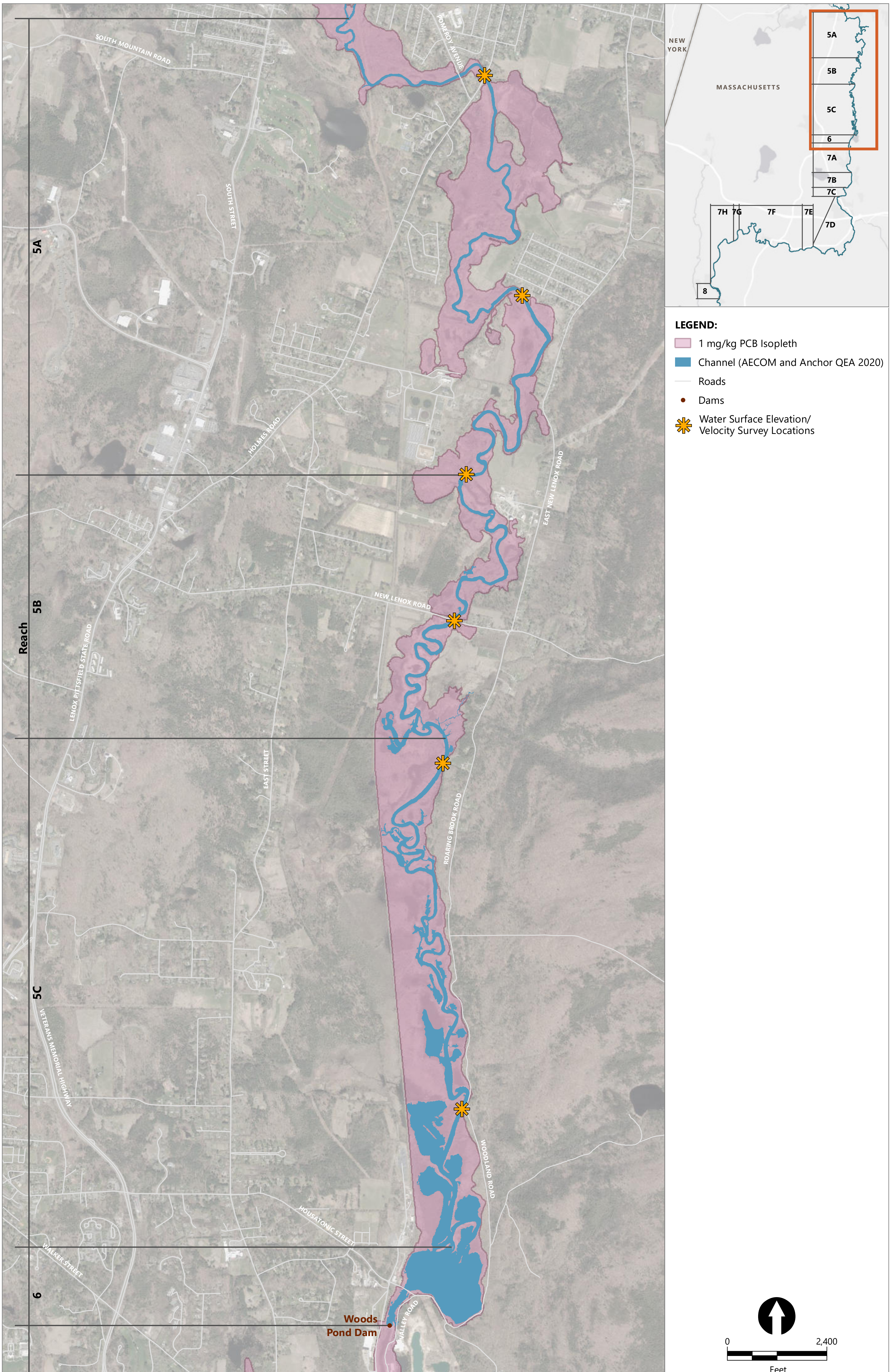


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Figure 3-4
Water Surface Elevation and Velocity Survey Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River

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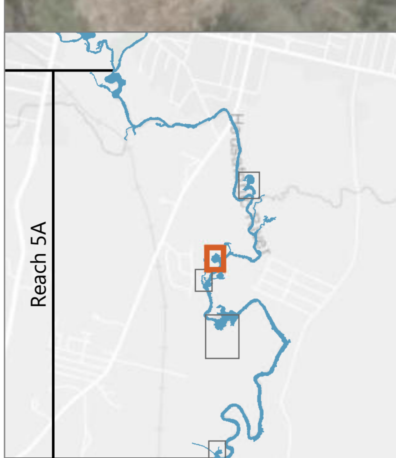
Figure 3-5a
Backwater Sediment Sampling Locations (BW5A-1)

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Core Area 1 Habitat
- Backwater Sampling Grid (50-feet)

Proposed Backwater Sediment Sampling Locations

- Outside Core Area 1 Habitat

0 40
Feet

Publish Date: 2021/09/27, 9:35 AM | User: eiverson
Filepath: \\orcas\GIS\Jobs\GE_0469\HousatonicRiver\Maps\Sampling\Sediment\AQ_R5A_PDI_Fig3_5_BackwaterSampling.mxd

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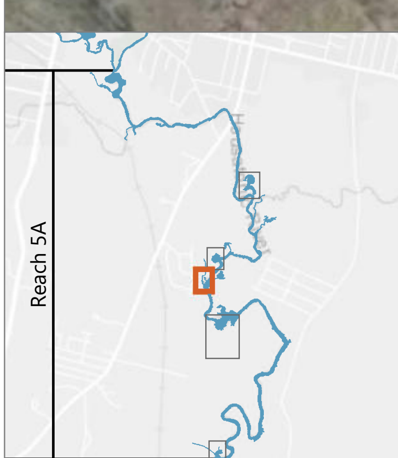
Figure 3-5b
Backwater Sediment Sampling Locations (BW5A-2)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

1 mg/kg PCB Isopleth
Channel (AECOM and Anchor QEA 2020)
Backwaters (AECOM and Anchor QEA 2020)
0+00 River Stationing
Backwater Sampling Grid (50-feet)

Proposed Backwater Sediment Sampling Locations

Outside Core Area 1 Habitat

0 40
Feet

Publish Date: 2021/09/27, 9:35 AM | User: eiverson
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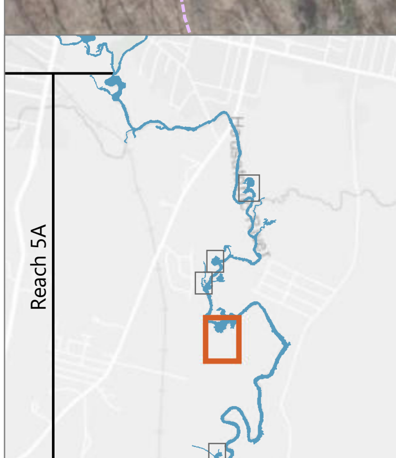
Figure 3-5c
Backwater Sediment Sampling Locations (BW5A-3 and BW5A-4)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Backwater Sampling Grid (50-feet)

Proposed Backwater Sediment Sampling Locations

- Outside Core Area 1 Habitat

0 90
Feet

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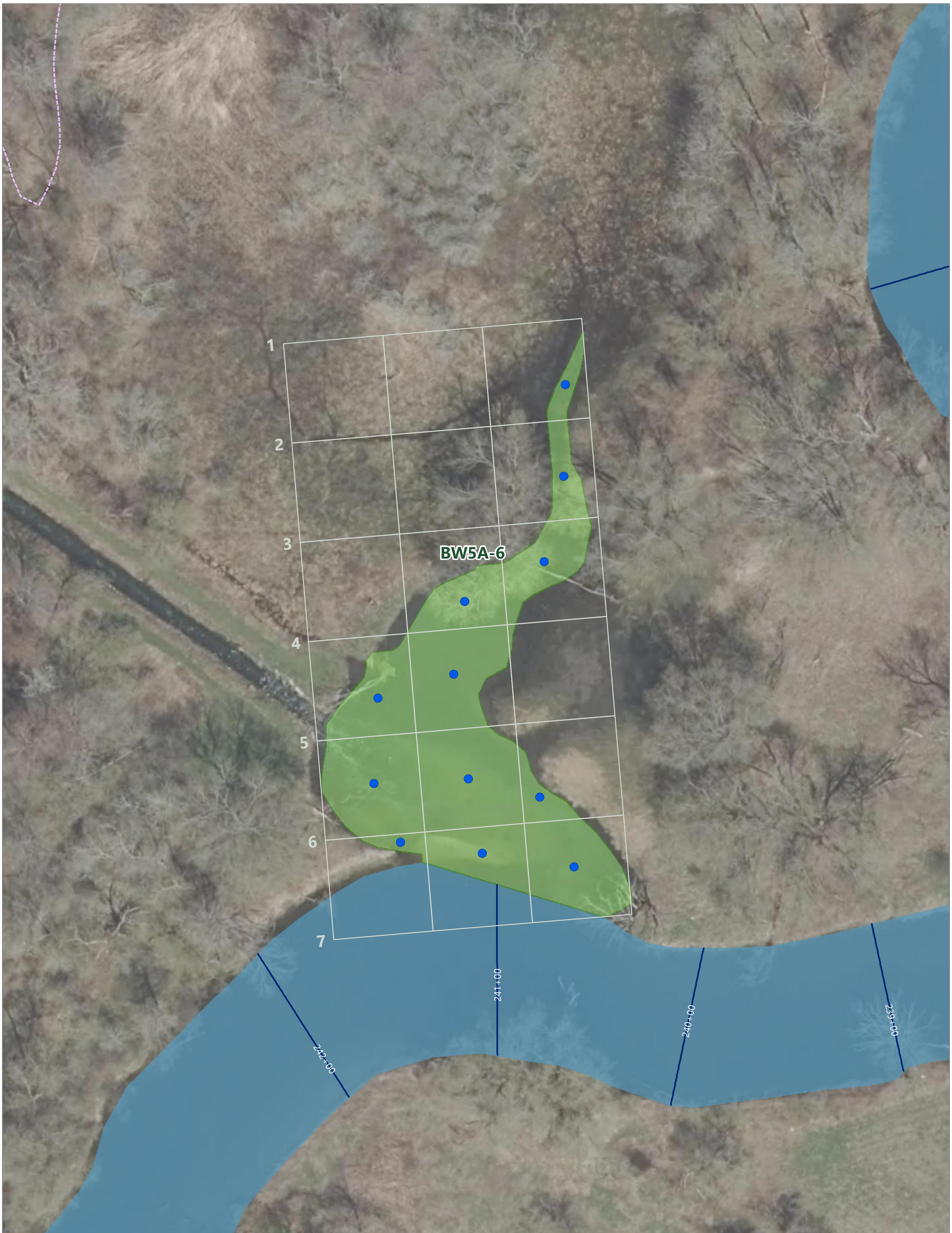
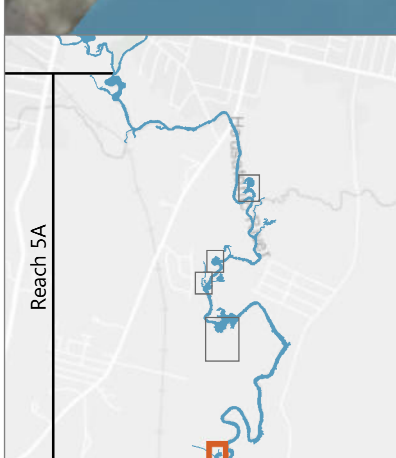
Figure 3-5d
Backwater Sediment Sampling Locations (BW5A-5)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River





LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Backwater Sampling Grid (50-feet)

Proposed Backwater Sediment Sampling Locations

- Outside Core Area 1 Habitat

0 40
Feet

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Figure 3-5e
Backwater Sediment Sampling Locations (BW5A-6)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River

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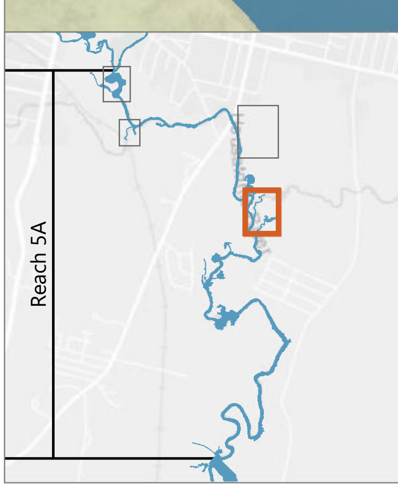
ANCHOR QEA

Figure 3-6a
Sediment Sampling Locations in Other Reach 5A Waterbodies (Outlet from Morewood Lake)

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- 0+00 River Stationing
- Proposed Sediment Sampling Locations

Super Habitats (AECOM and Anchor QEA 2020)

- Emergent marsh and wet meadow
- Transitional floodplain forest
- Hardwood forest, agricultural field
- Shrub swamp
- Channel (AECOM and Anchor QEA 2020)
- Lake/Pond

0 90
Feet

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Figure 3-6b

Sediment Sampling Locations in Other Reach 5A Waterbodies (Portions of Sackett Brook and Sykes Brook)

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River

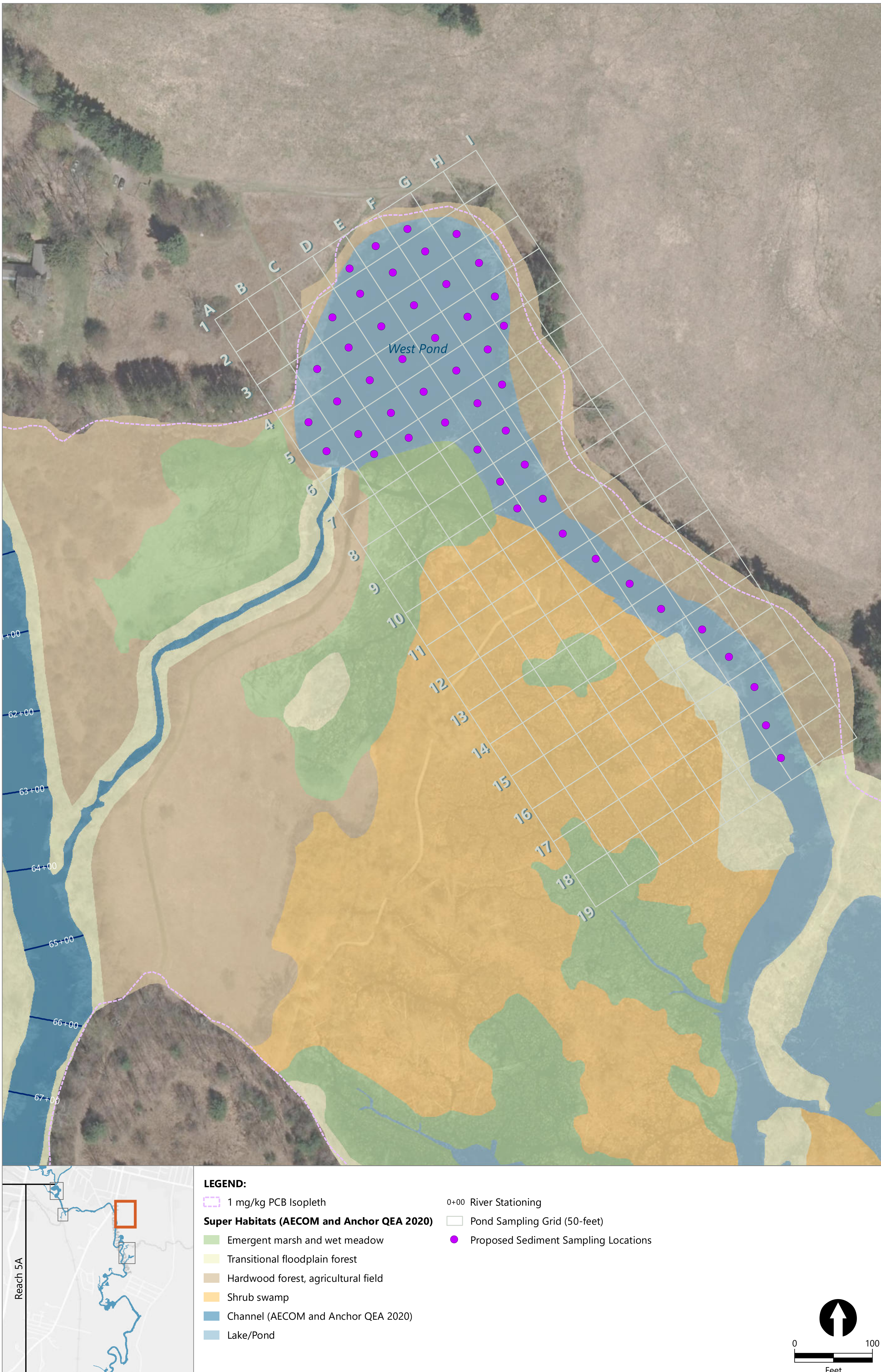

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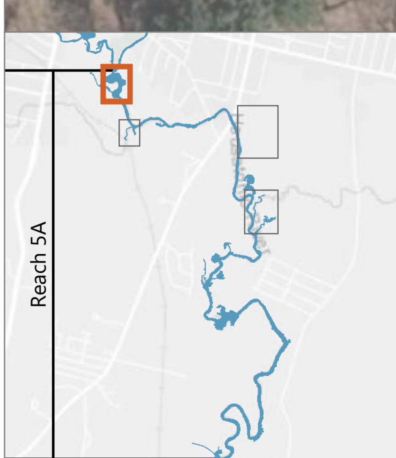
Figure 3-6c
Sediment Sampling Locations in Other Reach 5A Waterbodies (West Pond)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- 0+00 River Stationing
- Proposed Sediment Sampling Locations

Super Habitats (AECOM and Anchor QEA 2020)

- Emergent marsh and wet meadow
- Transitional floodplain forest
- Hardwood forest, agricultural field
- Channel (AECOM and Anchor QEA 2020)

0 75
Feet

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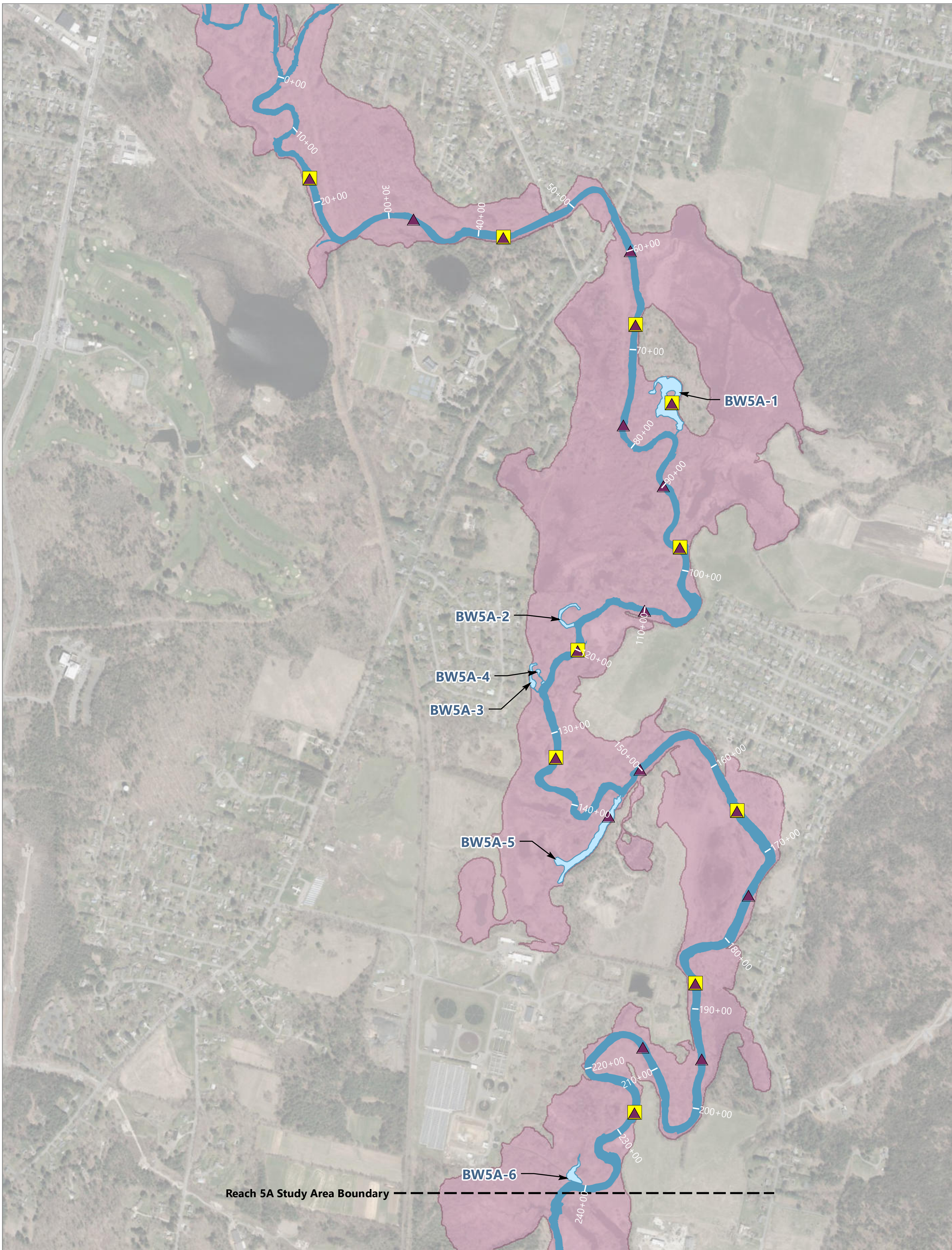
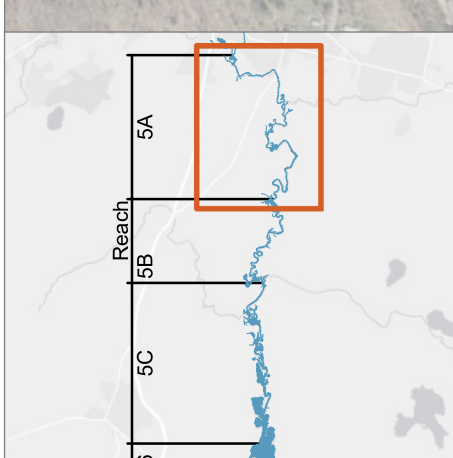
Figure 3-6d
Sediment Sampling Locations in Other Reach 5A Waterbodies (Intermittant Side Channel)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River





LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Proposed Porewater Sampling Locations
- Proposed Groundwater Seepage Sampling Locations

0 1,000
Feet

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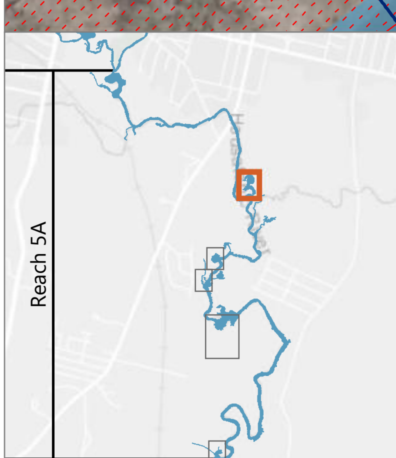
Filepath: \\orcas\GIS\Jobs\GE_0469\HousatonicRiver\Maps\Sampling\Sediment\AQ_R5A_PDI_Fig3_7_PorewaterGWSeepage.mxd

ANCHOR QEA

Figure 3-7
Proposed Porewater and Groundwater Seepage Sampling Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Core Area 1 Habitat
- Backwater Sampling Grid (50-feet)

Proposed Backwater Geotech Testing Locations

- Proposed Vane Shear Testing Locations[1]
- Proposed CPT/FFP Locations[2]

NOTES:

1. The vane shear testing locations are approximate and may be adjusted in the field to target fine-grained sediment/soils.
2. The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
3. CPT: Cone Penetration Testing
4. FFP: Full Flow Penetration testing

0 50
Feet

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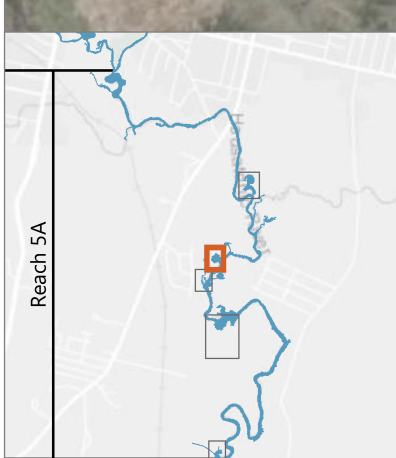
Figure 3-8a

Vane Shear and CPT/FFP Locations in Backwater Areas (BW5A-1)



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Core Area 1 Habitat
- Backwater Sampling Grid (50-feet)

Proposed Backwater Geotech Testing Locations

- Proposed Vane Shear Testing Locations[1]
- Proposed CPT/FFP Locations[2]

NOTES:

1. The vane shear testing locations are approximate and may be adjusted in the field to target fine-grained sediment/soils.
2. The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
3. CPT: Cone Penetration Testing
4. FFP: Full Flow Penetration testing

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Feet

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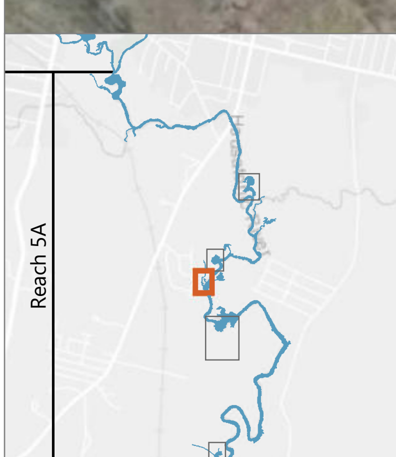
Figure 3-8b
Vane Shear and CPT/FFP Locations in Backwater Areas (BW5A-2)



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Backwater Sampling Grid (50-feet)

Proposed Backwater Geotech Testing Locations

- Proposed Vane Shear Testing Locations[1]
- Proposed CPT/FFP Locations[2]

NOTES:

1. The vane shear testing locations are approximate and may be adjusted in the field to target fine-grained sediment/soils.
2. The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
3. CPT: Cone Penetration Testing
4. FFP: Full Flow Penetration testing

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Feet

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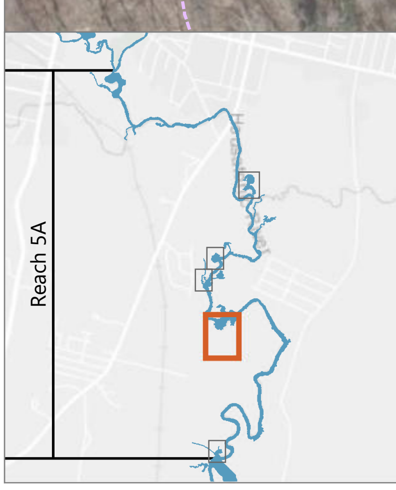
Figure 3-8c

Vane Shear and CPT/FFP Locations in Backwater Areas (BW5A-3 and BW5A-4)



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Backwater Sampling Grid (50-feet)

Proposed Backwater Geotech Testing Locations

- Proposed Vane Shear Testing Locations[1]
- Proposed CPT/FFP Locations[2]

NOTES:

1. The vane shear testing locations are approximate and may be adjusted in the field to target fine-grained sediment/soils.
2. The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
3. CPT: Cone Penetration Testing
4. FFP: Full Flow Penetration testing

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Feet

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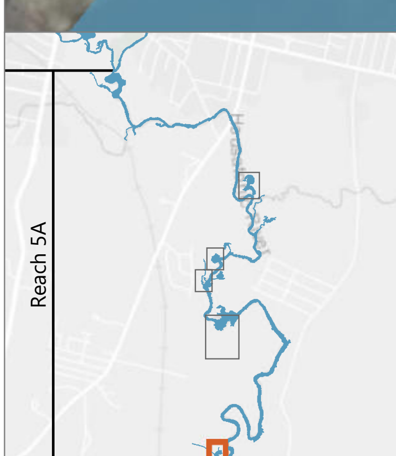
Figure 3-8d
Vane Shear and CPT/FFP Locations in Backwater Areas (BW5A-5)
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River



LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Backwater Sampling Grid (50-feet)

Proposed Backwater Geotech Testing Locations

- Proposed Vane Shear Testing Locations[1]
- Proposed CPT/FFP Locations[2]

NOTES:

1. The vane shear testing locations are approximate and may be adjusted in the field to target fine-grained sediment/soils.
2. The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
3. CPT: Cone Penetration Testing
4. FFP: Full Flow Penetration testing

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Feet

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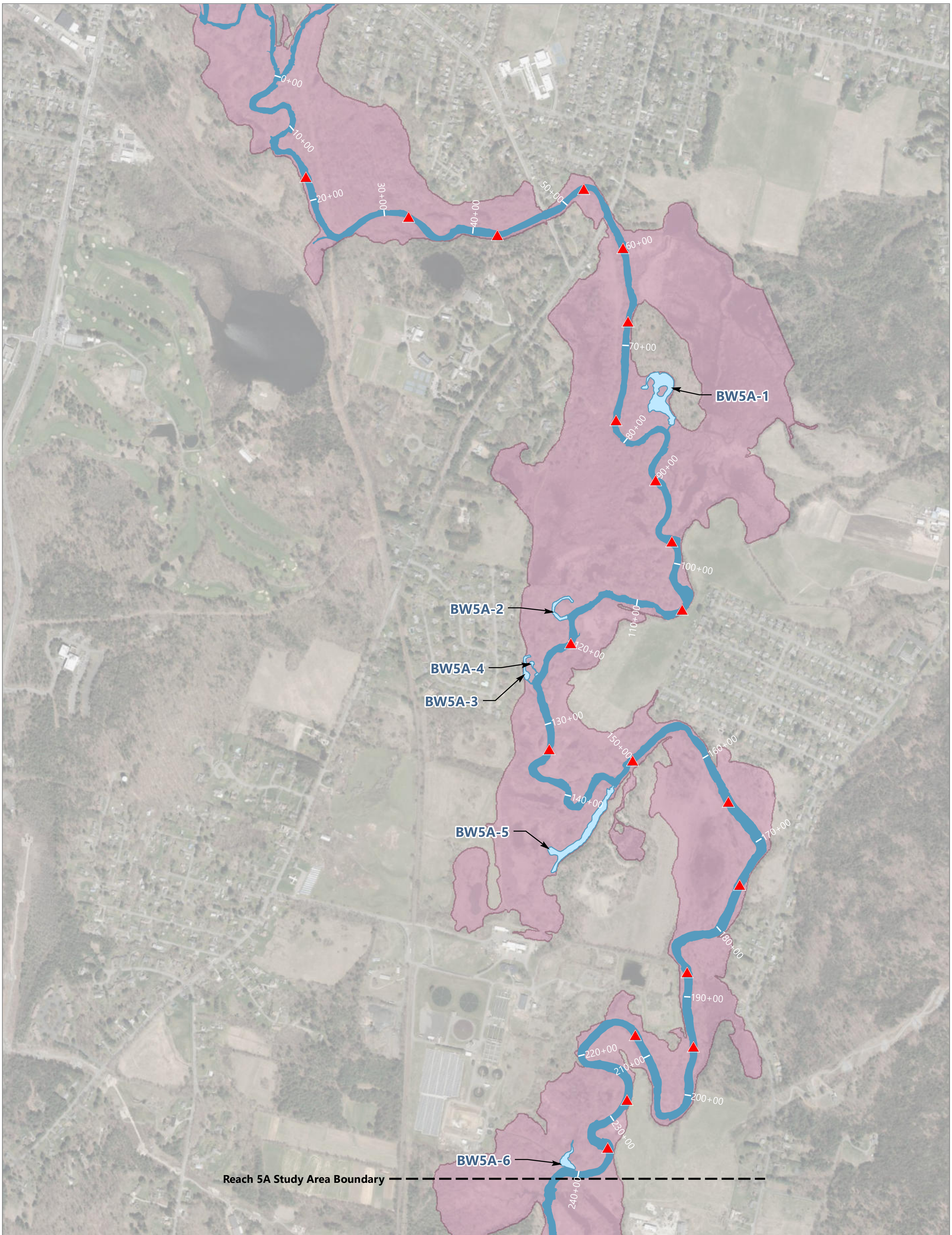
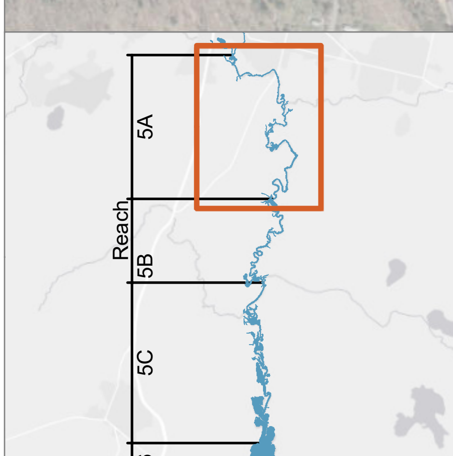
Figure 3-8e

Vane Shear and CPT/FFP Locations in Backwater Areas (BW5A-6)

Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River





LEGEND:

- 1 mg/kg PCB Isopleth
- Channel (AECOM and Anchor QEA 2020)
- Backwaters (AECOM and Anchor QEA 2020)
- 0+00 River Stationing
- Proposed CPT/FFP Locations[1]

NOTES:

1 The CPT/FFP locations are approximate and may be adjusted in the field based on access, field conditions, or the results of Phase 1 geotechnical data.
2. CPT: Cone Penetration Testing
3. FFP: Full Flow Penetration testing

0 1,000
Feet

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Figure 3-9
Main Channel CPT/FFP Locations
Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks
Housatonic River – Rest of River

Appendix A
BEHI Worksheet

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.

Stream:		Location:
Station:		Observers:
Date:	Stream Type:	Valley Type:

BEHI Score (Fig. 3-7)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	**(A)**	**Bankfull Height** (ft) =	**(B)**	(**A**) / (**B**) =	**(C)**	

Root Depth / Study Bank Height (E)

Root Depth (ft) =	**(D)**	**Study Bank Height** (ft) =	**(A)**	(**D**) / (**A**) =	**(E)**	

Weighted Root Density (G)

Root Density as **%** =	**(F)**	(**F**) x (**E**) =	**(G)**	

Bank Angle (H)

Bank Angle as *Degrees* =	**(H)**	

Surface Protection (I)

Surface Protection as **%** =	**(I)**	

Bank Material Adjustment:

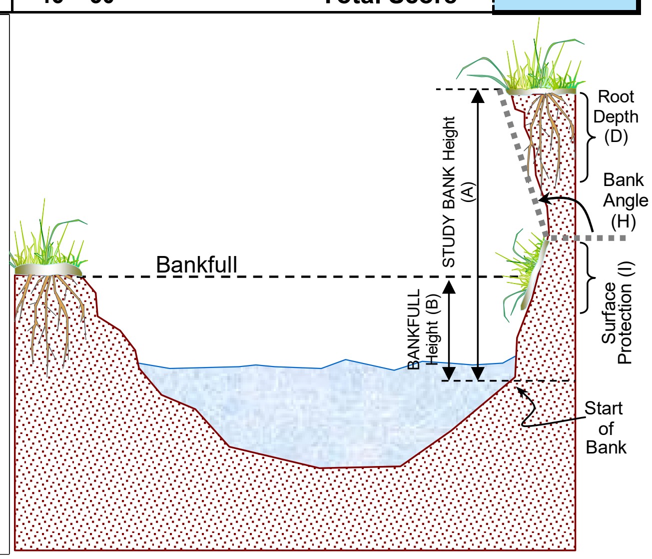
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and **Total Score**



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Appendix B
Standard Operating Procedure for Measurement of Water Velocity

Standard Operating Procedure

Measurement of Water Velocity

Scope and Application

This standard operating procedure (SOP) is applicable to measurement of water velocity using the Marsh McBirney Flo-Mate 2000. This SOP contains methods for data collection requirements and general safety considerations. The Flo-Mate 2000 uses an electromagnetic sensor to measure the velocity in a conductive liquid such as water. The velocity is measured in one direction using the Faraday law of electromagnetic induction, which states that a voltage is produced as a conductor moves through a magnetic field. The magnitude of this voltage is directly proportional to the velocity at which the conductor moves through the magnetic field. When the flow approaches the sensor from directly in front, then the direction of flow, the magnetic field, and the sensed voltage are mutually perpendicular to each other. Therefore, the voltage output will represent the velocity of the flow at the electrodes.

Health and Safety Considerations

Health and safety issues are addressed in the Rest of River Health and Safety Plan (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel. Regardless of whether measurements are performed from a bridge, from a vessel, or via wading, two personnel are mandatory to assist with record keeping and act as watch person in the event an emergency were to occur.

Personnel Qualifications

Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Anchor QEA and AECOM 2021). Field personnel will also work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

The following equipment and materials will be available as needed to carry out the procedures contained in this SOP. Additional equipment may be required depending on field conditions.

- Appropriate personal protective equipment and clothing as defined in the HASP
- Marsh McBirney Flo-Mate 2000
- Wading rod or extension rod
- Tape for securing flow meter cable to extension rod
- Field laptop or tablet and/or paper field forms and pencil/pen (as necessary)

Procedures

The following steps are to be followed when using the Flo-Mate 2000 to measure water velocity. Modifications to this procedure may be required on a case-by-case basis depending on the specific conditions in the portion of waterbody where velocity is being measured.

1. Positioning
    a. If wading, stand in a position that least affects the velocity of the water passing the current meter by facing the bank, with the water flowing against the side of the leg. Holding the wading rod at the tag line, stand from 1 to 3 inches downstream from the tag line and 18 inches or more from the wading rod.
    b. If taking measurements from a bridge, weigh the respective advantages of using the upstream or downstream side of the bridge per USGS (2010) (described below) for the specific location, and select one or the other.
        i. Advantages of using the upstream side of the bridge are as follows:
            (a) Hydraulic characteristics at the upstream side of bridge openings usually are more favorable. Flow is usually smoother and there is less turbulence than at the downstream side of the bridge.
            (b) Approaching drift can be seen and be more easily avoided.
            (c) The streambed at the upstream side of the bridge is not likely to scour as much as at the downstream side.
        ii. Advantages of using the downstream side of the bridge are as follows:
            (a) Vertical angles are more easily measured because the sounding line will move away from the bridge.
            (b) The flow lines of the stream may be straightened out by passing through a bridge opening with piers.
    c. If using a boat, secure the boat on location using an anchor and/or mooring lines as appropriate. Water velocity should be measured from either side of the vessel at a distance of at least 45 centimeters away from the hull to minimize impacts to water velocity by the vessel; do not measure from either the bow or stern of the vessel.
2. Measure water depth at the sampling location. Do not measure water depth while any nearby vessel is travelling in the vicinity of the measurement location. Record the water depth on the field sample collection log sheet.
3. Record the position of the measurement using GPS (latitude, longitude, and elevation).

4. Calculate the depth that water velocity measurements will be made for each of the monitoring locations. Short-term velocity measurements will be made using either the Two-Point or Three-Point Method (USGS 2010) in water depths of 2.5 feet or greater.
    a. Two-point method: Measurements will be made at 0.2 and 0.8 of the total water depth as measured from the water surface.
    b. Three-point method: Measurements will be made at 0.2, 0.6, and 0.8 of the total water depth as measured from the water surface. This method is used when velocities in the vertical are abnormally distributed.
5. Record weather and environmental/water conditions in the project logbook or project-specific log sheet.
6. Measure up from the bottom of the rod and mark (with tape) the two or three depth intervals (depending on method used) where velocity measurements are required for that given location (e.g., 0.2, 0.6, and 0.8 of water depth).
7. Attach the electromagnetic transducer to the 0.8 depth mark using a gear clamp provided with the flow meter.
8. Secure the flow meter cable to the extension rods using tape.
9. Lower the extension rod assembly until the lower most extension rod is resting on the river bottom.
10. Turn the Marsh McBirney flow meter on by holding the ON/C button.
11. To change between feet per second and meters per second (m/s), press down the ON/C and OFF keys simultaneously to cycle between them. Note: The user also has the option to turn the Flo-Mate 2000’s audible beeper on and off with the units of measurement (if required, as this is the user’s personal preference).
12. Ensure the unit is set to measure real-time fixed-point average (FPA) and is set to a period between 5 to 20 seconds. Note: When set to FPA, the instrument will display the average water velocity result at the end of the frequency specified. This will assist in stabilizing the readings obtained. To change between FPA and time constant filtering (rC), press and hold the up and down arrow keys simultaneously. Once FPA appears on the screen, press the up arrow to increase the time or down arrow to decrease the time.
13. Slowly rotate the extension rods in approximately five-degree increments waiting for at least three consecutive readings before rotating further.
14. Continue rotating the rods until you are confident that the electromagnetic probe is parallel with the direction of the current (so that it is measuring the highest velocity). Maintain the probe in this position for at least 1 minute, and record the largest flow rate observed on the project log sheet.

15. Remove the extension rods from the water and move the electromagnetic transducer to the next depth mark.
16. Lower the extension rod assembly back into the water until the lower most extension rod is resting on the river bottom.
17. Repeat steps 13 and 14.
18. Remove the extension rods from the water and, if using the three-point method, move the electromagnetic transducer to final depth mark.
19. Lower the extension rod assembly back into the water until the lower most extension rod is resting on the river bottom.
20. Repeat steps 13 and 14.
21. Once velocities have been obtained from all depth intervals at a given location, move to the next monitoring location along the same transect. Repeat steps 1 through 17 until water velocities have been obtained from all monitoring points along the transect.
22. Turn off the flow meter. Record any pertinent observations in the project logbook or project specific log sheet.

Field Data Collection

At each monitoring location, the following information should be collected and recorded:

1. Date and time
2. Names of field personnel
3. Weather and water conditions at the time
4. Location identification/name
5. GPS position (northing, easting, and elevation)
6. Rod length
7. Water depth
8. Velocity measurement
9. Notes regarding conditions that might affect the measurements obtained or issue encountered, if any

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2021.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2017.

USGS (U.S. Geological Survey), 2010. *Discharge Measurements at Gaging Stations*. Chapter 8 of Book 3, Section A. Available at: https://pubs.usgs.gov/tm/tm3-a8/tm3a8.pdf.

Appendix C
Standard Operating Procedure for
Soil Sample Collection and Handling

ARCADIS Design & Consultancy for natural and built assets

STANDARD OPERATING PROCEDURE FOR SOIL SAMPLE COLLECTION AND HANDLING

GE-Pittsfield/Housatonic River Site - Rest of River

Rev: 2

Rev Date: September 2021

SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Reviewed by
1	July 2020	All	Revisions to address EPA's comments in June 9, 2020 conditional approval letter	Dave Knutsen
2	September 2021	1, 2, and 7	Minor revisions to reflect inclusion of this SOP (originally from PDI Work Plan for Reach 5A Floodplain Residential Properties) in PDI Work Plan for Reach 5A Sediment and Riverbanks	Adam Ayers

EXHIBIT

A-1 Subsurface Log Data Sheet

1 SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) describes the procedures that the General Electric Company (GE) will use for the collection of riverbank soil samples within the Rest of River at the GE-Pittsfield/ Housatonic River Site. This SOP will apply to the collection and handling of riverbank soil samples pursuant to GE's *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Work Plan; Anchor QEA and AECOM 2021).

2 OVERVIEW OF PRE-DESIGN SOIL SAMPLING

The scope of the soil sampling covered by this SOP will be as described in the Work Plan, as approved by the U.S. Environmental Protection Agency (EPA).

Soil samples may be collected through a variety of mechanisms, typically with a hand-driven Macrocore™ sampler, a scoop or spoon, a hand-driven split-spoon sampler, a stainless-steel bucket auger, or a direct-push technique.

Soil samples will be processed for analysis at the contract laboratory for polychlorinated biphenyls (PCBs) as Aroclors and, if so specified in the applicable work plan, for moisture content.

3 PERSONNEL QUALIFICATIONS

All field personnel who work in areas that may result in exposure to hazardous substances or health hazards must be trained in compliance with 29 Code of Federal Regulations (CFR) 1910.120 (i.e., 40-hour Occupational Safety and Health Administration [OSHA] Hazardous Waste Operations [HAZWOPER] training) and annual refresher courses, and participate in a medical monitoring program before engaging in any field collection activities. Additionally, field personnel will be under the direct supervision of qualified professionals who are experienced in performing the tasks required for sample collection.

Field personnel will be responsible for documenting soil collection events in the field database. Only qualified personnel (e.g., individuals who hold a degree in engineering, geology, or a related science and/or have at least two years of relevant experience) will provide descriptions of soil samples. The sampling contractor (if necessary) will be responsible for obtaining accurate and representative samples and keeping a separate general log of soils encountered.

4 EQUIPMENT LIST

The following equipment and materials will be available, as required, during soil sampling:

- Personal protective equipment (PPE), as required by the applicable Health and Safety Plan (HASP)
- The selected sampler
- Disposable scoops or spoons
- Appropriate sample containers and forms
- Insulated coolers with ice or "blue ice"

- Camera
- Global positioning system (GPS)
- Chain-of-custody form
- Analysis request form
- Laptop computer and printer/field notebook
- Decontamination supplies (paper towels, trash bag, rags, plastic sheeting for table) as required in the applicable SOP for soil sampling equipment cleaning
- Sample labels
- Teflon® sheeting or stainless-steel tray
- Brass push rod, if necessary
- Spatula or knife
- Hand spade
- Stainless steel scoop
- Stainless steel spoon
- 6-foot ruler.

5 CAUTIONS

Cautions include typical hazards associated with mobilization/demobilization to work area (e.g., slips, trips, falls), and working in the floodplain of a river (e.g., accidental immersion in river). Additional cautions are further described in the HASP for the Rest of River (Arcadis 2017).

6 HEALTH AND SAFETY CONSIDERATIONS

Health and safety issues are addressed in the Rest of River HASP (Arcadis 2017).

7 PROCEDURES

The soil sample collection methods described in this SOP include surficial soil sampling (applicable to collection of samples from the top one foot of soil) and subsurface soil sampling (applicable to the collection of samples from depths greater than one foot). Note that while this SOP contains methods for collection of subsurface soil samples, subsurface soil sampling is not required for riverbanks as described in the Work Plan.

7.1 Surficial Soil Sampling Procedures

Surficial soil samples will be collected using a hand-driven Macrocore™ sampler, a hand-driven split-spoon sampler, a stainless-steel bucket auger, or a spade and scoop, as determined by the field team. Samples collected from the 0-1 foot depth interval will be collected independently from samples collected at depths below one foot, thus eliminating the problem of how to section a longer sample core with less than 100% recovery to obtain a sample of the 0-1 foot depth interval.

The following procedures will be used to collect surficial soil samples:

1. Don PPE (as required by the HASP).
2. Using a GPS system, locate the pre-programmed target coordinates for the sample location. The target coordinates will be in northing and easting format, using the North American Datum of 1983 (NAD 83).
3. If the sample location is a grassed area or an area with overlying material, such as gravel, leaves, roots, sod (grass and dense root matter below the grass), blacktop, concrete, etc., remove any overlying material that contains no soil or only a negligible amount of soil. Then collect the underlying soil, starting the soil sampling interval (e.g., top 12 inches) at the remaining soil interface, including any material with an appreciable soil component. Following sample collection, replace the removed sod or other overlying material.
4. If a Macrocore™ sampler is used, advance the sampler (with a new acetate liner) using a slide hammer into the soil with a straight, vertical entry, so as to secure a reasonably representative sample. Drive the sampler to one foot and pull the liner out (while keeping the outer casing in place) for the collection of the 0-1 foot sample prior to collecting deeper soil (as discussed in Section 7.2).
5. Secure a representative sample from the appropriate depth. If a Macrocore™ sampler is used, cut open the liner and remove the sample. Remove any impermeable and vegetative materials (e.g., blacktop, concrete, or other deleterious materials such as the root matter itself, grass, leaves, stones, wood, or artificial debris) from the sample, leaving any soil-related components in the sample. Homogenize the collected soil material thoroughly. Once homogenized, place the sample into a suitable sample jar.
6. Label all sample containers with the following:
    - Site name
    - Project number
    - Location number
    - Depth of sample
    - Date
    - Time of sample collection
    - Initials of sampling personnel.
7. Handle, pack, and ship the samples using the chain-of-custody procedures in accordance with the applicable SOP for sample handling, packing, and shipping.
8. Record all appropriate information in the field database and on the proper forms.

7.2 Subsurface Soil Sampling Procedures

This section describes the general procedures for the collection of subsurface soil samples using a hand-driven Macrocore™ sampler or a direct-push method.

The hand-driven Macrocore™ sampler used to collect surficial soil samples may also be used to collect subsurface samples, as described below.

Direct-push drilling methods also may be used to collect subsurface soil cores. An example of this technique is the AMS Power Probe™ dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. The hammer simultaneously advances an outer steel casing which contains a disposable plastic liner used to collect soil samples.

The following procedures will be used to collect subsurface soil samples:

1. Don PPE (as required by the HASP).
2. Using a GPS system, locate the pre-programmed target coordinates for the sample location if not occupying the same sample location/bore hole as the surficial soil sample. The target coordinates will be in northing and easting format, using the North American Datum of 1983 (NAD 83).
3. If a Macrocore™ sampler is used, following collection of the sample from the top foot (as described in Section 7.1, step 4), put in a new liner, drive the sampler to the target deeper depth, and retrieve for the deeper increment sample. If a direct-push method is used, advance the soil boring, using the selected direct-push equipment, to the target total depth and retrieve the deeper sample. In either case, a maximum of three attempts will be made to advance the sampler to the target depth at the desired sampling location. If the sampler cannot be advanced to the target depth at the desired location due to subsurface refusal, make up to three attempts to advance the boring to the total target depth at nearby locations. Similarly, if soil sample recovery is less than 50% for the target analytical sampling interval specified in the applicable work plan, make up to three attempts to collect additional soil from the same sampling interval. However, this additional sampling need not be conducted at areas where GE and EPA field representatives agree that the nature of the subsurface materials is not likely to allow proper sample recovery (e.g., coarse gravel, loose fine sands, concrete rubble, fill).
4. Collect soil samples from the depth intervals specified in the applicable work plan. Remove any deleterious materials (e.g., root matter, stones, wood, artificial debris) identified during the collection process. Homogenize the collected samples thoroughly. Once homogenized, place the soil samples into suitable sample jars.
5. Record each sampling interval based on any spaces or gaps and the recovery of the core. For example, if a soil sampler is advanced from 1 to 3 feet below ground surface (bgs) but the soil recovery is only 1.5 feet, the log will indicate that the description only applies to 1 to 2.5 feet bgs (i.e., assume that the lower portion of the soil sample was not recovered), unless reasons to infer otherwise are evident in the sample or adjacent samples.
6. Label all sample containers with the following:
    - Site
    - Project number
    - Boring number

- Sample interval
- Date
- Time of sample collection
- Initials of sampling personnel.

7. Handle, pack, and ship the samples in accordance with the procedures set forth in the applicable SOP for sample handling, packing, and shipping.
8. Record all appropriate information in the field database and on the proper forms.

7.3 Soil Descriptions

As samples are collected, qualified personnel will describe each soil sample. Additional information regarding procedures to identify soil types is provided in ASTM Standard D2488-17e1, entitled Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM 2017). Soil descriptions will be entered in the field database, field notebook, or on the Subsurface Log (Exhibit A-1) for the following parameters:

- Soil type
- Color
- Percent recovery
- Moisture content
- Texture
- Grain size and shape
- Consistency
- Blow counts, if collected
- Miscellaneous observations.

A common soil sample description format should be used in the field notes, such as: color; primary constituent (underlined or capitalized); secondary constituent(s) designated by "and" (if approximately 50% of the sample – should only be used if a second primary constituent is identified), "some" (if approximately 30% to 50% of the sample), "little" (if approximately 10% to 30% of the sample), and/or "trace" (if less than 10% of the sample); description of consistency; moisture content; miscellaneous observations; and initial interpretations (capitalized in parentheses).

Example 1: Brown fine SAND, some Silt, little medium-coarse Sand, trace concrete and brick debris, loose, wet, trace black staining (FILL).

Example 2: Olive-gray SILT and CLAY, trace fine Gravel, angular dense, moist (GLACIAL TILL).

In addition, the boring logs must identify the specific depth of the fill/native soil interface (if present) and include a detailed description of any debris observed in the fill or soil. Observations of staining, sheens, or other potential indicators of impacted soil should also be described in detail, including the starting and ending depths of such observations.

8 FIELD SURVEY PROCEDURES

A field survey control program will be conducted using standard instrument survey techniques to document the sampling location and elevation. Generally, to accomplish this, a local control baseline will be set up. If specified in the work plan, this local baseline control can then be tied into the appropriate vertical and horizontal datum such as the National Geodetic Vertical Datum of 1929 (NGVD29) and the State Plane Coordinate System. At a minimum, the elevation of floodplain soil samples will be determined using NGVD29.

9 EQUIPMENT CLEANING/DECONTAMINATION

Cleaning and decontamination of non-dedicated sampling equipment will follow the procedures described in the applicable SOP for soil sampling equipment cleaning. The sampling equipment is to be cleaned before the start of sampling activities, between samples, and following the completion of sampling activities. In addition, tools used in the handling and opening of sampling equipment, such as wrenches for opening split-spoon samplers or knives for cutting direct-push sample liners, are to be cleaned with a non-phosphate soap and water before the start of sampling activities, between boreholes, and following the completion of sampling activities, at a minimum.

10 WASTE MANAGEMENT

Rinse water, PPE, or other residuals generated during the sampling will be placed in appropriate containers and will be disposed of by GE consistent with its ongoing disposal practices.

11 DATA RECORDING AND MANAGEMENT

Data from soil collection will be recorded in the field database using a laptop computer or field notebook. Upon completion of sampling at one location, all data from the location will be entered into the database. Blank field log sheets or a field book can also be used to record information manually in case difficulties with data entry using the computer are encountered. Manually recorded data will be transcribed into the field database at the end of each day. Additionally, a hard copy of the field log will be printed out. The hard copy will serve as a backup to the electronic copy, as well as the chain-of-custody form. This form will be signed by sample collection personnel. A copy of the signed field log form will be maintained by the field crew.

12 SHIPPING AND HANDLING

Shipping and handling of the soil samples will follow the procedures described in the applicable SOP for sample handling, packing, and shipping.

13 QUALITY ASSURANCE

Quality assurance/quality control (QA/QC) procedures will include the collection of field QA/QC samples. Field QA/QC samples to be collected are blind duplicate samples, equipment blank samples, and matrix spike samples. One set of field QA/QC samples will be collected at a frequency of one in 20 samples. Blind duplicate samples and matrix spike samples will be prepared by filling additional appropriately marked containers at pre-selected sampling stations (both samples will not be collected at the same station). The station where these samples are collected will be rotated randomly for each set of QA/QC samples collected. After collection, QA/QC samples will be handled in a manner consistent with all other environmental samples.

Disposable equipment will be used to minimize need for equipment blank samples. However, if non-dedicated equipment is used, equipment blank samples will be prepared as follows:

1. Put on new disposable gloves.
2. Slowly pour laboratory-supplied organic-free water into or over the collection vessels or cleaned equipment and fill labeled sample containers.
3. After collection, handle equipment blank samples in a manner consistent with all other environmental samples.

Field duplicates will be prepared by homogenizing soil collected at the same time and depth and then filling two sets of sample jars. The duplicate sample will be labeled so that the sample designations will not indicate the duplicate nature of the samples. Information concerning the source of sample duplicates should be documented in the field notebook and on the version of the chain-of-custody form retained by the sampling team. This information should NOT be provided in the copy of the chain-of-custody form submitted to the laboratory.

14 REFERENCES

Anchor QEA and AECOM. 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2021.

Arcadis. 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2017.

ASTM. 2017. *ASTM Standard D2488-17e1, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).* ASTM International, West Conshohocken, PA, 2017.

Appendix D
Standard Operating Procedure for Measurement of Hydrophobic Organic Contaminants in Sediment Porewater by *Ex Situ* Solid-Phase Microextraction

Standard Operating Procedure

Measurement of Hydrophobic Organic Contaminants in Sediment Porewater by Ex Situ Solid-Phase Microextraction

Scope and Application

This standard operating procedure (SOP) is applicable to the *ex situ* measurement of porewater concentrations of hydrophobic organic contaminants (HOCs) such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs)/dibenzofurans (PCDFs), and pesticides in sediment porewater using solid-phase microextraction (SPME). In this method, polydimethylsiloxane (PDMS)-coated glass fiber is inserted into the sediment for sufficient time to allow uptake and equilibration of target analytes in freely dissolved phase with the PDMS coating, as described by Mayer et al. (2000).

At equilibrium, the dissolved porewater concentrations (C_w) can be estimated from the measured concentration absorbed to the fiber (C_{PDMS}) and the PDMS-water partition coefficient (K_{PDMS-w}), as shown in Equation 1. Performance reference compounds (PRCs) are used to determine if equilibrium is achieved (Fernandez et al. 2009). Procedures outlined in this SOP will be followed, and any deviations must be noted.

Equation 1

$$C_w = \frac{C_{PDMS}}{K_{PDMS-w} \times f_e}$$

where:

C_W	=	concentration in sediment porewater (nanograms per liter [ng/L])
C_{PDMS}	=	concentration in PDMS polymer (ng/L)
K_{PDMS-W}	=	PDMS-water partitioning coefficient (-L/L)
f_e	=	fraction of equilibrium (-)

Health and Safety

All laboratory work will be performed in accordance with the Anchor QEA Environmental Geochemistry Laboratory (EGL) Chemical Hygiene Plan (CHP) by approved staff. Approval to work in the EGL requires orientation to laboratory safety procedures and potential hazards under the guidance of the Laboratory Manager, as specified in the CHP.

Equipment and Supplies

The following is a list of equipment and supplies that may be necessary to carry out the procedures contained in this SOP. Additional equipment may be required, depending on field conditions.

- Appropriate personal protective equipment (i.e., safety glasses, disposable gloves, and a laboratory coat). *Note: Safety glasses must be used to protect eyes when SPME fibers are handled.*
- Laboratory shaker table
- Analytical balance
- PDMS-coated SPME fiber[1]
- 2-liter (L) glass jars with polytetrafluoroethylene (PTFE)-lined caps
- Heavy-duty aluminum foil
- Ceramic fiber cutter
- Glass cylinder with Teflon cap (2 by 20 inches)
- Methanol (high-performance liquid chromatography [HPLC] grade[2]), 1 L[3]
- Acetone (HPLC grade), 1 L
- hexane (HPLC grade), 1 L
- Sodium azide (note: review Safety Data Sheets prior to handling sodium azide)
- Water (HPLC grade), 4 L
- 2-milliliter (mL) amber glass vials for PRC storage
- Micropipetter and tips (10 to 1,000 microliters [µL])
- Properly labeled solvent squirt bottles
- Stainless-steel SPME sampling devices
- Alconox®, Liquinox®, or equivalent industrial detergent
- Kimwipe®
- Pre-cleaned 60 mL amber glass volatile organic compound (VOC) vials with labels
- Ruler
- Heavy-duty aluminum foil
- Mylar barrier bags
- Water (HPLC grade)

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[1] Standard is Polymicro Technologies (Phoenix, Arizona) FSS10001070 (Glass rod OD: 1,000 µm, Fiber OD: 1,070 µm).

[2] HPLC grade denotes a high-purity reagent rated for use in high-performance liquid chromatography (HPLC).

[3] For typical deployment of 2 meters of SPME fiber.

- Kimwipe®
- Cooler and ice

Ex Situ Solid-Phase Microextraction Procedure

Sediment Sampling and Preparation

1. Sediment samples will be collected in the field and filled in 1 or 2 L glass jars with PTFE-lined caps. Sediment samples should be thoroughly homogenized. It is recommended to use sufficiently large sample jars to limit variation caused by small-scale heterogeneity. Field duplicate samples will be collected at a rate of 1 per 20 samples to assess field precision and SPME analysis precision. The reproducibility will be determined by calculating relative percent difference (RPD), as described below. Sediment jars will be shipped on ice in coolers to the EGL.
2. Upon arrival, the sediment jars will be stored in a refrigerator until further analysis. Holding time limit is 14 days for PAHs in soil and sediment samples stored at less than 4°C. The sediment jars should be stored in the dark to reduce the chance of photodegradation of target contaminants.
3. Prior to the deployment of SPME fibers, coarse particles that might potentially damage SPME fibers should be removed. This should be limited to coarse sieving (e.g., 500 micrometers [µm]) for removal of non-sorbing constituents like stones because potentially any manipulation may cause changes in the sediment composition, leading to a matrix that does not fully reflect the *in situ* conditions.
4. A quantity of the biocide sodium azide (NaN_3) should be added to sediments to produce a concentration of 100 milligrams per liter water to inhibit biological activity during the experiments.

SPME Fiber Selection

The SPME fiber is obtained from Polymicro Technologies, Inc., in Phoenix, Arizona (part number: 1068020127, FSS500570). It consists of a 500-µm-diameter, inert glass core coated with 35 µm of PDMS.

Equation 2

$$C_{det,SPME} = \frac{n_{det}/V_{PDMS}}{K_{PDMS-w} \times f_e}$$

where:

$C_{det,SPME}$ = method detection limit by SPME (ng/L)
n_{det} = mass detected by the analytical method (nanograms [ng])
V_{PDMS} = volume of PDMS in SPME fiber (L)
K_{PDMS-w} = PDMS-water partitioning coefficient (-)
f_e = fraction of equilibrium (-)

SPME Fiber Preparation

Fiber Cutting and Cleaning

- Determine the length of SPME fiber needed in each sample to achieve target detection limits using Equation 2 (see Detection Limit Calculation section).
- Handling of fibers requires clean nitrile gloves. All work surfaces should be covered with clean, heavy-duty aluminum foil. Fiber processing should be performed in a manner that minimizes background contamination.
- Cut the total length of fiber needed into 40-centimeter (cm) sections to fit into a glass cylinder:
  - Wash the ceramic fiber cutter with water, methanol, acetone, and n-hexane.
  - Cut the fiber by gently scratching a line on the fiber and then bending along the line.
- Wash the glass cylinder with water, methanol, acetone, and hexane to remove background contaminants.
- Transfer the cut fibers to the clean glass cylinder.
- Wash the fibers with high-performance liquid chromatography (HPLC) grade hexane, acetone, methanol, and water in the following order:
  - Fill the cylinder about one-third with hexane.
  - Agitate for 24 hours in hexane.
  - Discard hexane in a waste container.
  - Add a small volume of acetone to remove residual hexane and discard acetone in a waste container (repeat a few times).
  - Fill the cylinder about one-third with acetone.

  - Agitate for 24 hours in acetone.
  - Discard acetone and add small volume of water to remove residual acetone (repeat a few times).
  - Fill the cylinder one-third with water and agitate for 24 hours to remove acetone swelled in PDMS polymer.
  - Discard water.
- Take out a method blank SPME and wrap with foil and store in a heat-sealed Mylar bag.
- After deployment period of SPME, transfer the method blank SPME in a pre-weighed VOC amber glass sample vial. Fibers may be cut if needed to fit into the vial. The vial of the method blank SPME will be shipped to an analytical lab together with the PRC-spiked reproducibility standards.

Spiking Performance Reference Compounds

- Place clean SPME fibers in the glass cylinder.
- Prepare a mixture of methanol and water (approximately 300 mL) in a glass beaker and spike PRCs in the methanol/water mixture. The mixing ratio of methanol and water need to be adjusted for different target analytes (e.g., PAHs and PCBs) to optimize PRC spiking.
- Add the PRC spiked methanol/water mixture to the glass cylinder and mix well by gently shaking the glass cylinder. Rinse the beaker with a small volume methanol and add the rinsate to the glass cylinder. Seal the cylinder.
- Agitate to equilibrate for 14 days on a shaker table.
- After 14 days of agitation, transfer the PRC spiking solution to a different container and store container temporarily in the hood.
- Fill the glass cylinder with HPLC-grade water and leave on a shaker table overnight to remove swelled methanol from PDMS polymer.
- Remove the fibers from the glass cylinder and blot dry with Kimwipes.
- Cut to the desired length for deployment.
- Collect the PRC-loaded passive sampler reproducibility standards in 60 mL amber glass vials (n = 5) and send to an analytical laboratory immediately along (record masses). Fibers may be cut if needed to fit into the vial.

SPME Fiber Deployment

- Insert PRC-spiked fibers into sediment with a gloved hand. Leave approximately 5 millimeters of fiber above the sediment surface to facilitate retrieval.

- Seal the jars and place into a Mylar bag to reduce the chance of photodegradation of some target contaminants.
- Agitate the sediment jars on a shaker table at 60 rotations per minute for a minimum of 30 days.

SPME Fiber Retrieval

- Withdraw the fibers from the sediment with pre-cleaned metal tweezers or with gloved hand.
- Wipe retrieved fibers with damp Kimwipe a few times to remove attached sediment particles.
- Using a new set of clean gloves, wipe the fibers again with dry Kimwipe, and transfer to a pre-labeled, pre-weighed amber glass sample vial. Fibers may be cut if needed to fit into the vial.
- Document any color changes on the surface of the fiber. In particular, surface coating of nonaqueous phase liquid (NAPL) onto the fibers can exaggerate freely dissolved concentrations. Breakage of fibers should be recorded. Any observances of color change and odor of the passive sampling material or solid support should be documented. Changes in color may be due to changes in the biogeochemistry of the sediment or the presence of NAPL, which can also be detected by odor.
- Measure the total mass of the glass vial containing the fibers using an analytical balance and convert to the length. Seal sample vials immediately and ship to the analytical laboratory on ice.

Data Analysis

Water concentrations (C_w) will be calculated as fiber concentrations (C_{PDMS}) divided by the PDMS-water partition coefficients ($K_{PDMS\text{-}W}$) as shown by Equation 1. Fiber concentrations are defined as the mass of contaminants absorbed by the fiber (nanograms [ng]) to the volume of PDMS (L). PDMS-water partition coefficients of target analytes are estimated from correlation with K_{ow} based on literature $K_{PDMS\text{-}W}$ and K_{ow} values of PAHs, PCBs, and organochloride pesticides (Equation 3).

Equation 3

$$logK_{PDMS-W} = 0.903 \times logK_{OW} - 0.159 \; (\mathrm{R}^2 = 0.94)$$

where:

K_{PDMS-W} = PDMS-water partitioning coefficient (L/L)

K_{OW} = octanol-water partitioning coefficient (liters per kilogram)

Log K_{ow} of PAHs will be taken from the U.S. Environmental Protection Agency document on sediment benchmarks for PAHs (USEPA 2003). Log coefficient (K) of PCBs are values of Hawker and Connell (1988) adjusted based on a regression with De Bruijn (1989). Log K of PCDD/PCDF are cited from Govers and Krop (1998).

If equilibrium is not achieved as indicated by the PRC dissipation rate, the porewater concentrations will be corrected with the fraction to equilibrium (f_e) with PRC results in conjunction with the external resistance model (Lampert et al. 2015).

Quality Assurance/Quality Control

Quality Assurance/Quality Control Samples

Quality assurance/quality control (QA/QC) samples will be collected during the *ex situ* SPME sampling to make sure contamination is not introduced during the entire sampling process, including SPME fiber preparation (pre-deployment), deployment, and retrieval. The general QA/QC samples are described below. The number of QA/QC samples per deployment may vary depending on the data quality objectives of the project. In addition, a variety of internal QA/QC checks should be followed in the analytical laboratory.

SPME Fiber Blank

An SPME fiber blank will be prepared to assess any residual, analytical background contaminants introduced during fiber cleaning and cutting. For the method blank, an SPME fiber will be cut and cleaned with other SPME fibers, wrapped with aluminum foil, and stored in an air-tight bag in a refrigerator at 4°C until other SPME fibers will be deployed.

Performance Reference Compound-Loaded Passive Sampler Reproducibility Standard

Low variability of PRC concentrations in the PRC-loaded passive sampler reproducibility standards is a key step in accurately characterizing the fraction of equilibrium of target analytes. PRC-spiked SPME samples should exhibit reproducible PRC concentrations (e.g., coefficient of variation [CV] less than 20% [Ghosh et al. 2014]). After spiking PRCs, five of the PRC-loaded passive sampler reproducibility standards will be immediately sent to the analytical laboratory to measure the initial PRC concentrations. The CV should be less than 20% (n = 5) at EGL and reported if otherwise.

Field Replicate Samples

Field replicate samples will be collected as close as possible to the same point in space and time in the field to assess the variability associated with field sampling. They will be collected as two separate sediment samples from the same source, stored in separate containers, and analyzed independently at the laboratory.

Method Replicate Samples

Method duplicate or replicate samples will be analyzed at a rate of 1 per 20 samples, or at least one duplicate per analytical batch to assess reproducibility of SPME analysis at the laboratory.

Temperature Blank

Ensure that samples maintain proper temperature during transition.

Detection Limit Calculation

The mass of PDMS polymer needed depends on the detection limit of the chosen analytical method (e.g., regular gas chromatography [GC]/electron capture detector or GC/mass spectrometry [MS] versus high-resolution GC/high-resolution MS), anticipated porewater concentrations, and the PDMS-water partition coefficients estimated ($K_{PDMS\text{-}w}$). The length of the fiber can be determined to achieve the desired method detection limit. By default, 200 cm SPME fiber is deployed in a 2 L sediment jar to achieve sufficient method detection limits for target analytes with a wide range of K_{ow}. With $K_{PDMS\text{-}w}$ and the laboratory reported detection limits for HOCs, the detection limits for water concentrations by SPME can be estimated by Equation 2.

Depletion Calculation

The deployment of SPME fibers in a sediment will inevitably start depleting porewater concentrations of HOCs, but desorption from the sediment will replenish the aqueous pool. For accurate measurement, the ratio of PDMS polymer mass and sediment organic carbon mass in a sediment jar must be controlled to ensure negligible depletion of porewater concentration due to the chemical uptake by SPME when equilibrium is reached. As a general rule, the depletion caused by SPME deployment should be less than 1% when equilibrium is reached. Assuming sediment organic carbon and PDMS polymer have similar partitioning characteristics, a ratio of 1:100 PDMS polymer mass to sediment organic carbon mass should reduce any depletion to an acceptable value of <1%. For more details, please refer to Ghosh et al. (2004).

Reproducibility of SPME Analysis

Method replicate samples will be analyzed at a rate of 1 per 20 samples, or at least one duplicate per analytical batch. The reproducibility will be determined for duplicate samples as shown in Equation 4.

Equation 4

$$\mathrm{RPD} = ((\mathrm{X}_1 - \mathrm{X}_2) \times 100)/((\mathrm{X}_1 + \mathrm{X}_2) \div 2)$$

where:

RPD	=	relative percent difference
X_1	=	larger result value
X_2	=	smaller result value

SPME Fouling

Upon retrieval, any color changes in the sampler should be documented. Such changes may be due to changes in sediment biogeochemistry or may indicate the potential that the fiber may have been in contact with NAPL or have bio-fouling on the surface of the fiber. The use of PRCs may aid in addressing potential artifacts of fouling. If NAPL appears to be present in a sediment sample or on a passive sampler, it should be recorded so that the resulting porewater concentrations will be recognized as potentially affected by artifacts.

References

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Appendix E
Standard Operating Procedure for Vertical Hydraulic Gradient and Hydraulic Conductivity Data Collection

ANCHOR QEA

Standard Operating Procedure

Vertical Hydraulic Gradient and Hydraulic Conductivity Data Collection

Scope and Application

This standard operating procedure (SOP) is applicable to the collection of vertical hydraulic gradient and vertical hydraulic conductivity data. Hydraulic gradient data will be collected via installation of one or more piezometers and surface water gauges. Each piezometer and surface water gauge will be equipped with a pressure transducer and a datalogger. The piezometer will be installed below the sediment surface (i.e., the mudline) with the final depth determined in the field based on field conditions. Vertical hydraulic conductivity data will be measured empirically using sediment cores.

Procedures outlined in this SOP are expected to be followed. Substantive deviations from the procedures detailed in this SOP will be recorded in the Daily Activity Log or field logbook, on a Field Deviation Form, and reported to the field lead or project manager.

Health and Safety Warnings

Health and safety issues for the work associated with this SOP, including physical, chemical, and biological hazards, are addressed in the *Housatonic River – Rest of River, Health and Safety Plan* (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel.

Personnel Qualifications

Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Sediment/Bank PDI Work Plan; Anchor QEA and AECOM 2021). Field personnel will work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

The following equipment may be necessary to carry out the procedures contained in this SOP. Additional equipment may be required depending on field conditions:

- Appropriate personal protective equipment and clothing, as defined in the HASP
- Field laptop or tablet and/or paper field forms, as necessary
- Decontamination equipment
- Spill kit and absorbent boom
- Standardized field log forms (field forms)

- Black ballpoint pen
- Sharpie permanent marker, or equivalent
- Engineer's ruler or tape, at least 5 feet long
- Core-tube caps
- Filter material (e.g., steel wool, glass wool, permeable geotextile, coffee-filter material, or the equivalent)
- One-eighth-inch Phillips-head screwdriver or equivalent for perforating core-tube caps
- Multiple measuring cups or containers with openings larger than 3 inches
- Plastic graduated cylinders with capacities ranging from approximately 10 milliliters (mL) to 50 mL
- Differential global positioning system (DGPS)
- Nominal 1- to 2-inch-diameter PVC pipe with water-tight couplings and 1-foot-long, 0.010-inch slotted screen sections. The piezometer diameter will be selected based on the size of drill casing and the diameter of the transducers selected for the project.
- Drive-point piezometers with 1-foot-long, 0.010-inch slotted screen sections (optional)
- Additional lengths of riser pipe with water-tight couplings (5-foot lengths)
- Pressure transducers with data loggers
- Small-diameter wire with wire rope clips
- Screw-tightening J-plug capable of creating a water-tight seal when tightly closed
- Camera

Vertical Hydraulic Conductivity Data Collection

Vertical hydraulic conductivity will be measured empirically using sediment cores collected from locations identified in the Sediment/Bank PDI Work Plan where a piezometer is to be installed. The following procedures will be followed to collect sediment and soil cores (cores) for empirical measurement of vertical hydraulic conductivity at each vertical hydraulic gradient monitoring location:

1. Cores will be collected in up to 5-foot-long increments, if practicable. For vertical hydraulic conductivity measurements, cores will be collected in Lexan tubes. Cores will be collected continuously from the sediment surface to the approximate screen depth of the piezometer to be installed at the same station.
2. If possible, cores for vertical hydraulic gradient measurements should be obtained during the drilling of the borehole for piezometer installation. If this is not practicable, cores for vertical hydraulic gradient measurements should be located as close as practicable to piezometers.

3. If a single, continuous core sample cannot be obtained from the mudline to the piezometer screen depth, multiple cores that collectively cover that depth interval will be collected and tested for vertical hydraulic conductivity.
4. After each core sample is collected and recovered, it will be quickly capped at the bottom with a cap containing filter material, e.g., steel wool, glass wool, permeable geotextile, coffee-filter material, or the equivalent. (The bottom cap will later be perforated during vertical hydraulic conductivity testing, and the filter material will help retain the sediment as the porewater drains.) After quickly securing the cap to the bottom of the core tube, the tube will be returned to a vertical position as quickly as possible. If water is observed in the tube above the top of the sediment, it will be retained in the tube, if practicable, throughout this process. A cap will also be placed on the top of the tube.
5. The outside of the core tube will be wiped with a dry, disposable towel so that no water drips from the outside of the core and the outside of the core is dry enough to clearly mark with an indelible pen.
6. The bottom cap will then be secured with duct tape wrapped around the connection between the cap and the tube (not around the bottom of the cap).
7. Each core will be transferred in a vertical position to the processing area and maintained in a vertical position.
8. Horizontal lines will be marked on the tube using the indelible pen to indicate the sediment level (labeled "S") and the initial water level (labeled "W"), as viewed through the transparent Lexan tube.
9. The tube will be photographed clearly showing the marked and labelled horizontal lines and an engineer's ruler or tape held or affixed to the outside of the tube.
10. The recovered sediment length and the total height of water above the bottom of the tube (or the distance of the water level down from the top of the tube) will be measured to the nearest 0.01 foot and recorded, along with the core sample designation, on the Vertical Hydraulic Conductivity Field Test Data Sheet form (Attachment 1). If the water level is not visible (i.e., the water level is within the sediment), that will be noted as "Water level not visible."
11. The total length of the core tube will be measured and recorded to the nearest 0.01 foot.
12. With the core secured in a vertical position, the vertical hydraulic conductivity will be measured empirically by collecting measured volumes of porewater that drain from the inside of the tube in a sequence of time increments, as described below. The core will be maintained in a vertical position throughout the measurement process.
13. After verifying that no water is draining along the outside of the tube, the bottom cap will be perforated using a 1/8-inch Phillips-head screwdriver, or equivalent, to create 10 holes in the bottom cap.

14. The top cap will then be removed from the tube, or punctured, to allow water to drain freely from the core sample under the force of gravity. The tube will be watched until water is visibly flowing or dripping out of the perforated bottom cap. If no water flow or drops are observed, additional perforations will be made.
15. After draining water is observed, an empty measuring cup or other suitable container will be placed beneath the bottom of the dripping core tube to collect the water that drains from the inside of the core. The clock time will immediately be noted and recorded to the nearest second (HH:MM:SS) on the Vertical Hydraulic Conductivity Field Test Data Sheet form (Attachment 1); "Start Test" will be written on the same row in the "Notes" column.
16. After approximately 2 minutes, the container will be replaced with an empty container to continue collecting the water that drips from the core and the clock time will immediately be noted and recorded to the nearest second (HH:MM:SS) on the next row of the data sheet. When replacing one container with the next, care will be taken to collect all of the water that drips from the core, to the extent practicable. The water collected in the newly removed container will be carefully transferred into a graduated cylinder, and the collected volume of water will be measured to the nearest 0.1 mL; this volume will be recorded on the same line of the data sheet as the clock time when that volume increment stopped being collected from the draining vertical core. The measured incremental volume of water will then be poured into a final, sealable container that will be used to verify the cumulative volume of water drained during the test.
17. Repeat Step 16 approximately every 2 minutes up to a total of 10 measurements, then every 5 minutes for 8 measurements, to complete approximately 1 hour of testing. If a total of 100 mL of water has been collected before finishing 1 hour of testing, the test can be discontinued at that point (go to the next step). However, if less than a total of 20 mL of water is collected in 1 hour, continue testing as long as practicable to collect a total of at least 20 mL. If the equipment is in a secure setting where it can be safely left unattended, additional water can be collected by slow drainage while performing other duties, or the core can be allowed to drain overnight if necessary for volume measurement the next morning. The actual total drainage volume and associated test duration will depend on the vertical hydraulic conductivity of the core.
18. The total cumulative volume of water will be measured to the nearest 1 mL and recorded near the bottom of the data sheet with the words "Final Total Volume."
19. After the test is completed, the data sheet will be photographed and retained in the project records; the core can then be processed for other purposes

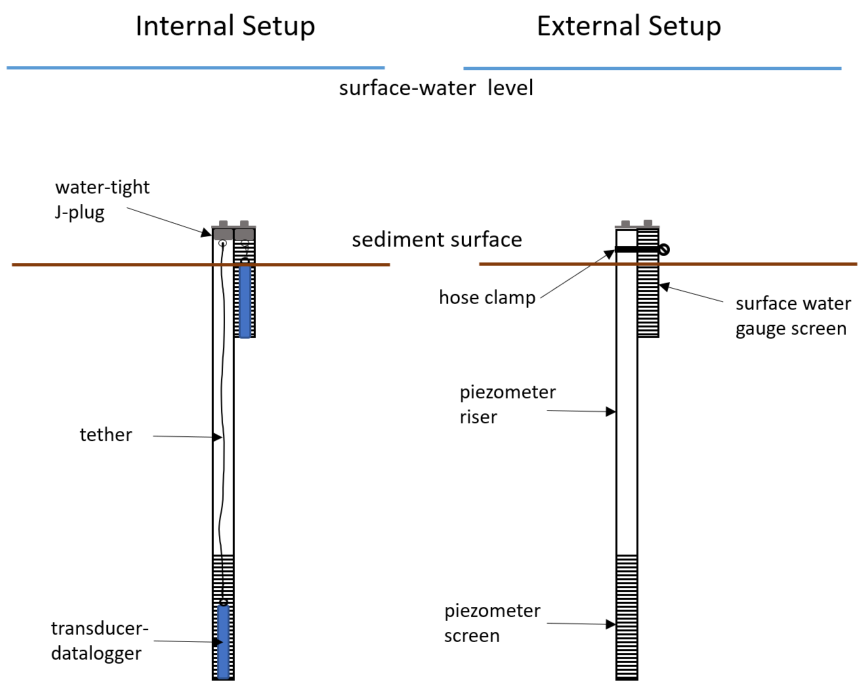
Vertical Hydraulic Gradient Device Installation

Vertical hydraulic gradient measurement devices will be installed in the sediment. These devices will include piezometers and surface water measurement gauges, each equipped with sealed pressure transducers (e.g., Solinst® Level logger, In-Situ miniTROLL, or similar). To install vertical hydraulic gradient measurement devices, the following procedures will be followed.

Vertical Hydraulic Gradient Piezometer and Surface Water Gauge Screen Installation Procedures

Figure 1 shows a schematic of the piezometer and surface water gauge screen installation.

Figure 1
Schematic of Piezometer and Surface Water Gauge Screen



Piezometer Installation

Each piezometer will be installed using either a drive-point method or by drilling using dual-tube Geoprobe; sonic, hollow-stem auger; or similar tooling. The installation method will depend on sediment physical conditions and vessel/drill rig accessibility.

If installed as a drive-point, the piezometer will be driven or pushed to a total depth of approximately 6 feet below the sediment surface, with a 1-foot-long screen positioned approximately 5 to 6 feet below the sediment surface.

If installed via drilling, the piezometer will be installed using the following procedures:

1. Safety checks will be made, including arranging all winch cables and checking for kinks or burrs, checking the sonic drill rig for fluid leaks, and checking that all "kill" switches are operational.
2. The stabilizers will be lowered, and the drill rig tower will be raised and secured with safety pins and bolts.
3. The sampling team will ensure that the spill kit is accessible and that sufficient absorbent boom is onboard the vessel to encircle and contain any sheens that may occur during drilling operations and movement of vessel spuds.
4. The piezometer boring will be advanced to the target depth of 6 feet below mudline. For efficiency, the borehole drilled for piezometer installation should also be used to collect the vertical hydraulic conductivity test samples described above, if possible. In any case, the piezometer will be installed as close as practicable to the location where vertical hydraulic conductivity test samples are collected.
5. A 1- to 2-inch nominal diameter piezometer will be installed at the base of the borehole, with a 1-foot long, 0.010-inch slot screen positioned approximately 5 to 6 feet below the sediment surface and an appropriate length of riser pipe with water-tight couplings.
6. Filter sand will be placed around the piezometer screen to a depth of approximately 0.5 to 1 foot above the top of the piezometer screen.
7. After the filter sand is placed, bentonite chips will be incrementally placed above the filter pack and sections of drill casing will be removed until the top of the bentonite is approximately 1.5 feet below the sediment surface.
8. The borehole will then be backfilled to mudline with filter pack material.
9. The piezometer riser pipe will be cut approximately 0.5 foot above the sediment surface and temporarily capped until transducer installation. If necessary, this step will be conducted by divers.

Surface Water Gauge Installation

A 1- to 2-inch nominal diameter surface water gauge (consisting of a 1.5-foot long, 0.01-inch slot screen) will be installed immediately next to each piezometer to a depth of approximately 1 foot below the sediment surface. This will be accomplished by the following steps and, if necessary, will be conducted by divers:

1. The surface water gauge screen will be pushed into the surface of the filter pack material or sediment adjacent to the piezometer. If necessary, filter pack material or sediment will be temporarily removed by hand to facilitate this installation, then backfilled around the surface water gauge to match the surrounding mudline.

2. The surface water gauge will be secured to the top of the piezometer riser with a hose clamp tightened to the extent practicable.
3. The surface water gauge will be temporarily capped until transducer installation.

Measuring and Marking

1. A weighted tape or engineers' ruler will be used to measure the depth to the bottom of each piezometer and surface water gauge screen below the sediment surface, and the depth to the nearest 0.1 foot will be recorded.
2. A marking of survey tape or flagging will be tied to the top of the remaining riser pipe to differentiate between the shallow and deep piezometers. The flags will be marked with the station number and an "S" for the surface water gauge screen or a "P" for the piezometer using a wax pen or other indelible marker.
3. A weight with a short, submerged buoy will be located within 3 feet of the piezometer to be used as visual locator for servicing the VHG device. Additionally, a second anchor will be located within 3 feet and a downline secured. The downline will be weighted as necessary, run along the bottom toward shore, and ideally be connected to a location on the bank to allow the diver to follow for future servicing; alternatively, a lead-rope may be used.

Transducer Installation, Data Collection, and Downloading

The following procedures will be conducted to equip the piezometer and surface water gauge with transducers and to collect and download hydraulic data. If necessary, these steps will be conducted by divers. Otherwise, these steps can be conducted by field staff wearing waders.

1. Sealed pressure transducer and datalogger devices will be deployed. Each will be pre-programmed (following manufacturer's guidelines) to collect data every 5 minutes at appropriate calendar dates and clock times and synchronized so that both transducers at each station record water pressure readings simultaneously. Data collection will begin before installing the devices, and the start time of data collection will be noted. The transducers will have sufficient internal memory and battery power to record and store data for several months, if necessary. Each pressure transducer will have a pressure rating of between 25 and 50 pounds per square inch (psi).
2. After the transducers have been programmed and are collecting data, each transducer will be connected to the base of an appropriate water-tight J-plug using a length of wire (i.e., a tether). After the wire is securely fastened to the transducer and the base of the water-tight J-plug, the wire between them will be approximately 3 feet longer than the total depth of the piezometer and surface water gauge, so each transducer will rest on the bottom of the piezometer or surface water gauge when deployed and before the water-tight J-plug is placed and tightened.

3. Each transducer will be lowered to the bottom of the piezometer or surface water gauge and allowed to rest and collect data for at least 60 minutes without the water-tight J-plug in place. The data collected during this period, with the piezometer and surface water gauge open and directly connected to surface water, represent "zero gradient" calibration data. These data reflect only the difference in elevation between the two transducers, with no influence of vertical hydraulic gradient.
4. Following at least 60 minutes of zero-gradient data collection as discussed in the previous step, any loose tether wire will be placed into the top of the piezometer and surface water gauge without pulling the wire upward, so that the transducers remain at the bottom of each. The water-tight J-plugs will be placed at the top of the piezometer and surface water gauge, and the J-plugs will be hand-tightened to the extent practicable to produce a secure, water-tight seal. The date and clock time that the caps are tightened will be recorded in the field notes.
5. After the J-plugs are tightly secured, the equipment setup is complete. The transducers now record pressure data that include the influence of vertical hydraulic gradient.

To retrieve the transducers for data download, the following procedures will be followed:

1. Access the piezometer/surface water gauge location.
2. Visually inspect the piezometer and surface water gauge and report any damage or disturbance to either device or to the water-tight J-plugs.
3. Loosen the water-tight J-plug and slightly dislodge the cap from the top of the piezometer or surface water gauge—<u>avoid pulling the tether wire</u> connected to the transducer. This step creates a direct hydraulic connection to surface water with the transducers still in place (resting at the bottom of piezometer). Record the date and time the caps are loosened and slightly dislodged. Leave the transducers in place to continue recording "zero-gradient" data for at least 60 minutes.
4. Following the minimum 60-minute zero-gradient data collection period, gently pull each tether wire upward to retrieve the pressure transducer and take the connected J-plug/tether/transducer assemblies to the data-downloading location.
5. Connect each pressure transducer to a computer or tablet, and download the data following the transducer manufacturer's procedure; then check the data to ensure that the transducer is functioning properly, and store the data for later processing.
6. After data downloading, reinstall the pressure transducers by lowering each transducer into the corresponding piezometer or surface water gauge so that the transducers rest at the bottom of both devices without the water-tight J-plugs in place. Continue recording "zero-gradient" data for at least 60 minutes.

7. Place any excess tether wire back into the piezometer and surface water gauge, replace the J-plugs, and tighten both securely to create a water-tight seal on each.

Piezometer Abandonment

The piezometers and surface water gauge will be abandoned at the end of the required data collection period. The following steps will be followed for abandonment:

1. Piezometers will be abandoned during the final servicing event. After the transducers have been removed and brought to the surface, abandonment will proceed.
2. A tremie pipe will be inserted into the piezometers to allow bentonite to be placed inside the piezometer. The bentonite will seal the screened zone and prevent contaminants from migrating into the piezometer casing and upward into the surface water.
    a. Time-release bentonite pellets will be used to ensure that bentonite is placed within the screened zone and reduces the risk of bridging. Sufficient bentonite will be placed to fill the screened zone.
    b. Time-release bentonite pellets will be placed following the manufacturer's specifications. Bentonite will be allowed to hydrate prior to the following steps being attempted.
3. Following placement of the bentonite, attempts will be made to remove the piezometers manually or with the assistance of a lifting device such as a crane mounted on the dive boat.
4. If piezometers are able to be removed, the borehole will be allowed to collapse, and the piezometer screen and casing will be disposed of as IDW.
5. If a piezometer cannot be removed, the PVC piezometer casing will be cut off below the mudline, the water-tight J-plug reinstalled, and sediment placed to cover.
6. If a PVC piezometer casing breaks during removal, attempts will be made to remove it. If the remaining pieces of the piezometer cannot be removed, the bentonite previously placed will prevent contaminants from migrating into the piezometer casing and upward into the surface water. The remaining piezometer will be abandoned as outlined in step 5.

Data Use

Vertical Hydraulic Conductivity

Using the data collected during each vertical hydraulic conductivity (K_v) test, the K_v of the tested sediment interval will be calculated as follows using a form of Darcy's Law, as shown in Equation 1.

Equation 1

$$K_v = \frac{Q}{A \cdot i_v}$$

where:

K_v	=	vertical hydraulic conductivity of test sample
Q	=	average flow rate during period of approximately constant flow
A	=	circular area of the bottom of the cylindrical core sample
i_v	=	vertical hydraulic gradient through the test sample

The vertical hydraulic gradient during the test will be calculated using Equation 2.

Equation 2

$$i_v = \frac{dH}{dL}$$

where:

dH	=	head change between the top and the bottom of the saturated sediment sample
dL	=	vertical length of the saturated sediment sample

dH is equal to the height of the water level within the liner, measured from the bottom of the sediment sample. If the water level is within the sediment sample (i.e., not visible above the sample), dH and dL are equal; therefore, the vertical hydraulic gradient (i_v) equals 1.

Vertical Hydraulic Gradient

The hydraulic head recorded by the transducers will be used to calculate a continuous record of i_v for each piezometer and surface water gauge location, as shown in Equation 3.

Equation 3

$$i_v = \frac{dH - dH_c}{dZ}$$

where:

i_v	=	vertical hydraulic gradient (calculated every five minutes)
dH	=	head difference measured with piezometer tightly sealed and surface water gauge screen (pressure recorded in piezometer minus pressure recorded in surface water gauge screen, expressed as equivalent feet of water)
dH_c	=	calibrated zero-gradient head difference
dZ	=	vertical separation between piezometer and surface water gauge screen screens

dH_c is the head difference measured between the piezometer and surface water gauge with the water-tight J-plugs loosened so that both are directly hydraulically connected to surface water.

Quality Assurance/Quality Control

Entries in the field forms or field books will be double-checked by the field team staff to verify that the information is correct. Programming of transducers will be checked by one other field staff member to ensure the transducers are properly programmed. It is the responsibility of the field team leader to periodically check to ensure that the procedures followed are in conformance with those stated in this SOP.

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric. September 2021.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2017.

List of Attachments

Attachment 1 Vertical Hydraulic Conductivity Field Test Data Sheet

Attachment 1
Vertical Hydraulic Conductivity Field Test Data Sheet

Vertical Hydraulic Conductivity Field Test
Data Sheet

Core ID = ______________________________

Sample Depth Interval (feet) = ______________________________

Sediment Sample Length (feet) = ______________________________ (to nearest inch or 0.1 foot)

Total Core Tube Length = ______________________________ (to nearest 0.1 inch or 0.01 foot)

Core Diameter = ______________________________ (to nearest 0.1 inch or 0.01 foot)

Water-Level Reference Point = ______________________________ ("Top of Tube" or "Bottom of Tube")

Date	Cumulative Time (HH:MM:SS)	Water Level (feet)*	Pore Water Collected (mL)**		Notes
			Incremental	Cumulative	

Notes:

* Height of water above bottom or below top of core tube, measured to nearest 0.01 ft at specified time.
  Indicate measurement reference point at top of form.

** Volume of porewater to be measured to the nearest 0.1 mL.

Appendix F
Standard Operating Procedure for Vane Shear Testing

Standard Operating Procedure

Vane Shear Testing

Scope and Application

This standard operating procedure (SOP) is applicable to for conducting vane shear tests in sediments. Vane shear testing will be conducted to measure the *in situ* undrained shear strength of the sediments (ASTM D2573-01). This method is appropriate for clay and silt and other fine-grained materials. This method is not appropriate for sand, gravel, or other highly permeable materials that may partially drain during the tests. The vane shear tests will be conducted with a RocTest Model M-3 Field Inspection Vane Tester or equivalent.

This SOP describes the equipment, field procedures, materials, and documentation procedures needed for the vane shear tests. Substantive deviations from the procedures detailed in this SOP will be recorded on a Daily Log or Field Deviation Form and will be reported to the field lead or project manager.

Health and Safety Considerations

Health and safety issues are addressed in the *Housatonic River – Rest of River, Health and Safety Plan* (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel.

Personnel Qualifications

The vane shear testing shall be performed by personnel trained to operate the testing apparatus. Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Anchor QEA and AECOM 2021). Also, field personnel will work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

The following is a list of equipment needed to carry out the procedures described in this SOP. Additional equipment may be required depending on field conditions.

- Vane shear apparatus (RocTest Model M-3 Field Inspection Vane Tester, or equivalent), with torque reading head, extension rods, blade vanes of varying size, and slip coupling
- Hand tools and supplies (e.g., rubber mallet, hammer, pipe wrenches, clamps, weighted measuring tape)
- Blank vane shear test logs
- Field logbook and digital camera to document field activities

- Personal protective equipment and clothing, as defined in the HASP
- Decontamination materials

Procedures

Vane shear tests will be conducted from a vessel or by wading in the water. The following methods will be used to conduct the vane shear tests:

1. Use a minimum of a two-person crew to operate the vane shear test apparatus and vessel (where necessary to access to the testing location).
2. Assemble the Model M-3 Field Inspection Vane Tester or equivalent. The vane shear apparatus consists of a torque recording head, boring rods, slip coupling, and a vane. The vane will be selected based on the type of sediment expected (large vane for soft sediment ranging to small vane for stiff sediment; a "dummy" vane is used to testing the internal resistance in the boring rods). Select the largest vane that can be advanced based on field conditions.
3. Measure the depth from a reference point (e.g., the water surface) to the top of sediment using a weighted tape.
4. Insert or push the vane shear test apparatus into the sediment to the depth to be tested. Do not rotate the apparatus during insertion. Blows, vibration, and rotation used to advance the vane may affect the measurements. Avoid pounding or vibrating in the vane. Use a direct push.
5. Verify that the recording head is set to zero.
6. Rotate the vane shear apparatus clockwise, holding only the handle of the apparatus. Rotate the apparatus as slowly as feasible, while maintaining a constant rate of rotation.
7. Note any resistance during the initial rotation until the slip coupling engages. This value is the resistance of rods. Alternately, measure the rod resistance using the dummy vane.
8. Continue rotating the vane shear torque head until the sediment in the formation fails. Failure is indicted when the rods and vane turn at the same rate as the head or resistance decreases. Continue to hold the head steady and allow the torque in the tool to be dissipated at the vane end of the apparatus.
9. Record the maximum torque by observing the position of the hash mark on the torque gauge. This is the peak resistance of the rods and the vane. The peak resistance should be corrected by multiplying the peak resistance by the appropriate correction factor for the vane size used, as provided by the vane manufacturer. The difference between the corrected peak resistance and the dummy vane resistance is the peak shear strength of the sediment.
10. Determine the remolded strength by quickly rotating the vane and rods (five to ten times) using the wrenches provided, if needed, until the resistance in the vane is constant. Begin the

remolded strength test within 1 minute but not more than 5 minutes from the completion of the quick rotations.

11. Re-zero the scale hash marks on the measuring head.
12. Slowly rotate the vane assembly until failure is noted. Read and record the maximum torque on the gauge. This measurement is the remolded shear strength, subject to the corrections discussed above for peak shear strength.
13. Advance the vane to the next test depth interval.
14. Repeat the test steps to test the next depth interval until all intervals have been tested.
15. Stiffer zones may be encountered with depth. If the larger vane cannot be advanced to the proposed depth, withdraw the test apparatus, and replace the vane with a smaller vane. Reinsert the apparatus and advance the new vane to the proposed test depth. Conduct the vane shear test as described above.
16. Decontaminate the vane shear test apparatus to remove visible sediment.
17. Move to the next test location.

Quality Assurance/Quality Control

Entries in the field forms or field books will be reviewed by the field team staff to verify that the recorded information is accurate. It is the responsibility of the field team leader to periodically check to verify that the procedures are in conformance with those stated in this SOP.

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2021.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2017.

ASTM (ASTM International), 2007. ASTM D2573-01(2007). Standard Test Method for Field Vane Shear Test in Cohesive Soil.

List of Attachments

Attachment 1 Vane Shear Field Log

Attachment 1
Vane Shear Field Log

Field Vane Shear Log

Project: ____________________

Location: ____________________

Technician: ____________________

Date: ____________________

ROCTEST M-3 Vane Tester	
Vane Diameter	Vane constant
25.4mm (1")	0.488
32mm (1.25")	0.244
65mm (2.56")	0.029

Test Location ID	Coordinates		Test Time	Water Depth in feet	Test Depth below Mudline in feet	Vane Diameter in mm	Vane Scale Reading in kPa	Peak Undrained Shear Strength		Residual Undrained Shear Strength		Sample Description
	Easting	Northing						kPa	lbs/ft^2	kPa	lbs/ft^2	

Note:

1 kPa = 20.89 psf

Appendix G
Standard Operating Procedure for Seepage-Induced Consolidation Testing

Standard Operating Procedure

Seepage-Induced Consolidation Testing

Scope and Application

This standard operating procedure (SOP) is applicable to the collection of sediment samples for Seepage-Induced Consolidation Testing (SICT). The SICT is well suited for measuring the compressibility of very soft, highly compressible sediments, soils, or slurries and allows for measurements in the low effective stress range. SICTs are carried out using specialized testing equipment following procedures in accordance with the SICT Equipment Description and User's Manual (Znidarcic et al. 1992).

This SOP describes the equipment, field procedures, materials, and documentation procedures needed for the SICT. Substantive deviations from the procedures detailed in this SOP will be recorded in a Daily Log or Field Deviation Form and will be reported to the field lead or project manager.

Health and Safety Considerations

Health and safety issues are addressed in the *Housatonic River – Rest of River, Health and Safety Plan* (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel.

Personnel Qualifications

Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Anchor QEA and AECOM 2021). Also, field personnel will work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

Samples submitted for SICT will be collected from sediment cores. As such, the equipment required for collecting samples for SICTs will follow the procedures outlined in GE's current *Field Sampling Plan/Quality Assurance Project Plan* (FSP/QAPP; Arcadis 2013), unless a Rest of River FSP/QAPP has been submitted and approved by that time. Specific equipment required for collection of samples for SICT includes the following:

- Personal protective equipment and clothing as defined in the HASP
- Nitrile or appropriate gloves
- Stainless-steel bowls
- Stainless steel and/or Teflon-lined spatulas and spoons

- Labels and appropriate forms/documentation for sample shipment
- Insulated cooler(s) and waterproof sealing tape
- 16-ounce glass or high-density polyethylene (HDPE) sampling jars
- 5-gallon sealable container (bucket or carboy) with waterproof sealing lids

Seepage Induced Consolidation Testing Sample Collection and Processing Procedures

SICT samples will be collected as bulk (large volume) sediment samples according to the following procedures:

1. Following collection of sediment and recording the description of the sample, take representative amounts of sediment along the length of the sampling interval and place into a large stainless-steel bowl. Recover a large quantity of sediment, enough to fill three 16-ounce jars per SICT sample.
2. In a stainless-steel bowl, homogenize the sediment into a uniform, consistent mixture.
3. Label three 16-ounce glass or HDPE jars with identical sample identification numbers and fill each jar with the homogenized sediment.
4. Collect river water in one labeled and sealable 5-gallon container (i.e., carboy) for each SICT sample and seal the container.
5. Complete all necessary sample shipment documentation.
6. Properly package all samples for shipment to the SICT laboratory.

Quality Assurance/Quality Control

Entries in the field forms or field books will be reviewed by the field team staff to verify that the recorded information is accurate. It is the responsibility of the field team leader to periodically check to verify that the procedures are in conformance with those stated in this SOP.

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2021.

Arcadis, 2013. *Field Sampling Plan/Quality Assurance Project Plan*. Revision 5. Prepared for General Electric Company. Revised July 2013.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2017.

Znidarcic, D., A.N. Abu-Hejleh, T. Fairbanks, and A. Robertson, 1992. Seepage-Induced Consolidation Test; Equipment Description and Users Manual. Prepared for Florida Institute of Phosphate Research, University of Colorado, Boulder. 52 pp.

Appendix H
Standard Operating Procedure for Cone Penetration Testing and Full Flow Penetration Testing

ANCHOR QEA

Standard Operating Procedure

Cone Penetration Testing and Full Flow Penetration Testing

Scope and Application

This standard operating procedure (SOP) is applicable to the performance of cone penetration testing (CPT) and full flow penetration (FFP) testing. The probes used in CPT and FFP testing are interchangeable on the probe equipment and data collection setup. Within this SOP, reference to CPT is also applicable to the use of FFP probe. The equipment used, data collection, and data reduction for CPT and FFP tests will be in accordance with the current ASTM International (ASTM) D5778 standard. The equipment, data collection, and data reduction for field vane shear testing, if conducted, will be in accordance with the current ASTM D2573 standard.

This SOP describes the equipment, field procedures, materials, and documentation procedures needed for the CPT/FFP testing. Substantive deviations from the procedures detailed in this SOP will be recorded in a Daily Log or Field Deviation Form and will be reported to the field lead or project manager.

Health and Safety Considerations

Health and safety issues are addressed in the *Housatonic River – Rest of River, Health and Safety Plan* (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel.

Personnel Qualifications

Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Sediment/Bank PDI Work Plan; Anchor QEA and AECOM 2021). Also, field personnel will work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

The following equipment may be necessary to carry out the procedures described in this SOP. Additional equipment may be required depending on field conditions.

- Sampling vessel equipped with necessary differential global positioning system (DGPS) navigation and communication equipment (where water depth is sufficient for a vessel)
- CPT rig with FFP probe and vane shear apparatus (provided by CPT subcontractor)—an all-terrain or amphibious rig may be needed for access in some locations
- Field logbook
- Personal protective equipment and clothing, as defined in the HASP

- Standardized field log forms (field forms) for documentation
- Lead line
- Tape measure

Cone Penetration Testing and Full Flow Penetration Testing Procedure

Testing will be performed by a licensed drilling contractor using a CPT rig at locations described in the Sediment/Bank PDI Work Plan. Testing will be performed using the following procedures:

1. Prior to mobilization, the accessibility of all testing locations will be reviewed to determine whether special measures or equipment are needed to access the testing locations.
2. Utilities will be cleared before testing is commenced. This will be accomplished by notifying Massachusetts Dig Safe Inc. (i.e., 811) and a private utility locator, if needed.
3. The CPT rig will be maneuvered to the proposed sample location.
4. The location will be recorded on the appropriate forms by the field lead, and depth to sediment will be measured with a survey tape attached to the head assembly and lead line.
5. In soft to very soft sediments/soils where the CPT is unable to accurately register penetration values, FFP (or ball penetration) tests will be performed using the CPT thrust system with a spherical tip of 100 cm^2 projected area. In such cases, after the full flow penetrometer reaches refusal, further testing will be continued using the CPT to obtain a complete strength profile extending from the mudline to top of hard bottom.
6. CPT and, where conducted, FFP tests will be performed to the designated depths and in general accordance with current version of ASTM D5778.
7. The depth of tests will be measured and recorded electronically by the CPT data recorder.
8. In areas where fine-grained sediments are identified via CPT or FFP tests, the field geologist or engineer may direct the CPT/FFP subcontractor to conduct *in situ* vane shear testing. The vane shear testing will be conducted following ASTM Method D2573 – *Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils*.

Quality Assurance/Quality Control

Entries in the field forms or field books will be reviewed by the field team staff to verify that the recorded information is accurate. Programming of transducers will be checked by one other field staff to ensure properly programmed. It is the responsibility of the field team leader to periodically check to ensure that the procedures are in conformance with those stated in this SOP.

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts. September 2021.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2017.

ASTM (ASTM International), D2573/D2573M-18. Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils.

ASTM, D5778-20. Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.

Appendix I
Standard Operating Procedure for Geotechnical Drilling and Standard Penetration Testing

Standard Operating Procedure

Geotechnical Drilling and Standard Penetration Testing

Scope and Application

This standard operating procedure (SOP) describes the equipment, field procedures, materials, and documentation procedures applicable to the advancement of soil borings via geotechnical drilling and collection and processing of subsurface soil boring data.

The geotechnical data will be collected from soil borings that will be advanced using hollow-stem auger drilling methods with a split-spoon sampling device in general accordance with the current ASTM D1586 standard (*Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*) or using sonic drilling methods in general accordance with the current ASTM D6914 – *Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices*.

This SOP describes the equipment, field procedures, materials, and documentation procedures needed to install soil borings and collect and process subsurface soil boring data. Substantive deviations from the procedures detailed in this SOP will be recorded in a Daily Log or Field Deviation Form and will be reported to the field lead or project manager.

Health and Safety Considerations

Health and safety issues are addressed in the *Housatonic River – Rest of River, Health and Safety Plan* (HASP; Arcadis 2017). The HASP will be followed during all activities conducted by field personnel.

Personnel Qualifications

Field personnel executing these procedures will have read, be familiar with, and comply with the requirements of this SOP and the *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks* (Sediment/Bank PDI Work Plan; Anchor QEA and AECOM 2021). Also, field personnel will work under the direct supervision of qualified professionals who are experienced in performing the tasks described herein.

Equipment and Supplies

The following equipment will be necessary to carry out the procedures described in this SOP. Additional equipment may be required depending on field conditions.

- Sampling vessel equipped with necessary differential global positioning system (DGPS) navigation and communication equipment (where water depth is sufficient for a vessel)
- Drill rig (provided by drilling subcontractor)—an all-terrain or amphibious rig may be needed for access in some locations.

- Sufficient number of split-barrel samplers so that at least one sampler is always clean and available for sampling. Three split-barrel samplers are generally the minimum necessary (provided by drilling subcontractor).
- Shelby tubes (provided by drilling subcontractor)
- Split-barrel liners (as appropriate; provided by drilling subcontractor)
- Sonic drill, probe rods, and core liner (supplied by subcontractor)
- Hand tools—wrenches, hammer
- Standardized field log forms (field forms)
- Plastic zip-top bags
- Field logbook
- Personal protective equipment (PPE) and clothing as defined in the HASP
- Indelible black ink pens and markers
- White board and pens
- Digital camera
- Clear, waterproof tape
- Engineer’s tape measure
- Appropriate sample containers
- Pocket penetrometer
- Torvane
- Stainless steel and/or Teflon-lined spatulas and pans, trays, bowls, trowels, or spoons
- Labels and appropriate forms/documentation for sample shipment
- Sample chain-of-custody forms
- Cleaning supplies
- Insulated cooler(s) and waterproof sealing tape
- Bags of ice or “blue ice” packs
- Nitrile or appropriate gloves
- Paper towels
- Backfill materials (e.g., Portland cement, potable water, and bentonite powder or chips; provided by drilling subcontractor)

Geotechnical Drilling and Sample Data Collection Procedures

The following procedures will be followed to advance soil borings, collect sediment and soil samples from them, decommission the borings, and restore the surface.

A. Preparation

1. Prior to mobilization, review the accessibility of all testing locations to determine whether special measures or equipment are needed to access the testing locations.
2. Clear utilities before sampling commences by notifying Massachusetts Dig Safe Inc. (i.e., 811) and a private utility locator, if needed.
3. Don the appropriate PPE, as indicated in the HASP.
4. Locate sampling location(s) in accordance with project documents, and document pertinent information in the appropriate field logbook.
5. If boring location is upland, clear away vegetation and debris from the ground surface at the boring location.
6. Prepare an area near the sampling location or on the sampling vessel to perform sample collection activities. Sample collection should be performed at a safe distance from all heavy equipment, or as determined by heavy equipment operator(s) and/or the field lead.

B. Soil Boring Advancement

Geotechnical soil borings will be completed by a licensed drilling subcontractor. The geotechnical borings will be advanced using hollow-stem auger drilling methods with a split-spoon sampling device in general accordance with the current ASTM D1586 standard – *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils* or using sonic drilling methods in general accordance with the current ASTM D6914 – *Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices*. The drilling method will be selected upon review of available geotechnical data from prior investigation efforts, based on access limitations or restrictions and the availability of equipment.

The geotechnical borings will be advanced following the general steps outlined below. The drilling operations will be performed by a licensed drilling contractor. Some variation from these methods may occur based on the specific equipment selected to complete the borings.

1. The drilling equipment will be maneuvered to the proposed sample location, and the location coordinates will be recorded.
2. Safety checks will be made at the beginning of the day (e.g., arranging all winch cables and checking for kinks or burrs, checking the drill rig for fluid leaks, and checking that all "kill" switches are operational).

3. The stabilizers will be lowered, and the drill rig tower will be raised and secured with safety pins and bolts.
4. The soil boring will be advanced to the designated sample depth, adding hollow stem auger sections, drill string, or sonic core barrel flights as necessary depending on the drilling method used.
5. For split-spoon sampling, the number of blows required to drive the sampler through each 15-centimeter (6-inch) increment will be recorded on the appropriate forms and field log.
6. After sample collection, the split-spoon sampling device or sonic core tube will be carefully transferred to the field geologist or engineer for characterization.
7. Where fine-grained soils are encountered in the soil borings, the field geologist or engineer may direct the drilling subcontractor to conduct an *in situ* vane shear test by attaching the downhole vane shear testing apparatus to the drilling equipment. The vane shear testing will be conducted following ASTM Method D2573 – *Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils*.
8. The field geologist or engineer will direct the drilling subcontractor where and to what depth interval to collect relatively undisturbed Shelby tube samples for laboratory testing of strength and compressibility characteristics. The Shelby tube sampling locations will be determined in the field based on observations of the material types during the drilling operations to target fine-grained (i.e., silt or clay) layers. The Shelby tubes will be pushed into undisturbed soil with a slow, steady force in general accordance with the current ASTM D1587 – *Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes*. ***It is extremely important that the Shelby tube samples are not disturbed in any way (e.g., dropped, rolled, subjected to extreme temperatures, etc.).***
   a. The pressure used by the driller subcontractor to push the Shelby tube will be noted in the field logbook.
   b. After sample collection, the Shelby tube be carefully transferred to the field geologist or engineer.
   c. Immediately upon retrieval of the Shelby tube, the bottom of the tube will be capped. The cap will be secured with duct or electrical tape.
   d. The Shelby tube sample will be evaluated at the top of the tube; the length of recovered soil will be recorded by carefully feeding a tape measure down the top of the Shelby tube; and the top of the tube will be secured with a core cap and wrapped in duct tape.
   e. The Shelby tube will be stored upright to preserve core soil integrity and kept at 4°C, plus or minus 2°C, until shipment.

f. Shelby tubes will be shipped upright with ample padding and protection to the contracted laboratory for processing and testing.

g. Acceptance criteria for soil intervals and Shelby tube samples are as follows:

   i. The surface is intact.

   ii. The tube appears intact without obstruction or blocking.

   iii. Recovery is greater than 50% of drive length.

h. Sealed tubes will be wiped clean with a clean paper towel.

i. The boring number and depth will be noted on the outside of the tube, with the top indicated using a directional arrow.

9. The field geologist or engineer will record field conditions and drive notes on the Boring Logs (see Attachments 1 and 2). The logs will include the following information:

   a. The sample station identification

   b. Drilling method

   c. Horizontal coordinates of the actual coring location as determined by DGPS

   d. Date and time of collection of each soil core sample

   e. Names of field personnel collecting and handling the samples

   f. Observations made during sample collection, including weather conditions, complications, and other details associated with the sampling effort

   g. Length of drive penetration and estimated recovery measurements

   h. Qualitative notation of apparent resistance of soil column to coring (i.e., how the core drove)

C. Sample Collection

All sampling information, including geotechnical soil characterization, sample depth, sample volume, and requisite geotechnical analyses, will be recorded in the field logbook and on any associated forms. Sample lithology will be described in accordance with the physical soil description along the entire length of the sample in accordance with the current ASTM D2488 – *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)* and ASTM D2487 – *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*. Sample characteristics will be recorded including soil type, moisture content, density/consistency of soil, and color.

Field personnel will record field conditions and drive notes on the Boring Logs (Attachment 1). References to soil description will be in accordance with the Physical Description of Soil Key (Attachment 2).

The following general steps are to be followed when collecting subsurface soil samples:

1. Open the split-spoon sampler or core tube liner, being careful not to disturb the sample. (Note that Shelby tubes will not be opened for sampling or visual characterization.)
2. Place the sample on a stable table alongside an engineer's tape measure, extended to the appropriate depth sampled and take photographs of the sample.
3. Label sample containers with appropriate information. Record the sample identification number, depth from which the sample was taken, sample recovery and the analyses to be performed on the samples in the field logbook and on the appropriate forms.
4. Record a description of the sample on the Boring Log (Attachment 1).
5. If fine-grained materials are encountered within a sampling depth interval, consider the need for a field vane shear strength test and/or a pocket penetrometer test as follows:
    a. For fine-grained material, the field geologist/engineer may conduct a field vane shear strength test on a relatively undisturbed portion of the soil sample using a Torvane to gather soil shear strength data. The field vane shear strength test will be performed in accordance with ASTM Method D2573 – *Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils*. The shear strength readings from the Torvane will be recorded on the Boring Log.
    b. For fine-grained materials, the field geologist or engineer may also or alternatively conduct a pocket penetrometer test on a relatively undisturbed portion of the soil sample. The pocket penetrometer test will be performed according to manufacturer instructions to provide a general understanding of soil consistency, shear strength and approximate unconfined compression strength. The pocket penetrometer test results will be recorded on the Boring Log.
6. Collect representative samples of soil from the sampling device at appropriate intervals and place the samples in labeled sample containers for laboratory testing in accordance with the Sediment/Bank PDI Work Plan.
7. Clean samplers and other small sampling equipment between each sample/subsample.
8. Complete the field logbook entry and other forms, being sure to record all relevant information before leaving the sampling location.
9. If soil cuttings are disposed of in investigation-derived waste (IDW) drums, record the number of drums used and ensure that drums are labeled accordingly and placed in a safe area.
10. Complete chain-of-custody forms, properly package all samples for shipment to laboratories, and complete all necessary sample shipment documentation.

D. Borehole Decommissioning

Upon completion, boreholes will be backfilled with bentonite or cement grout. The actual methods of decommissioning boreholes may vary depending on site conditions and jurisdictional requirements for decommissioning. The drilling contractor will be responsible for determining the appropriate borehole decommissioning methods.

Where bentonite is used, the boreholes will be backfilled with bentonite pellets or chips and hydrated until the pellets or chips come within 6 inches of the surface. The chips will be installed by gravity feed down the center of the borehole. The depth of the pellets or chips will be tracked using a weighted tape to ensure there is no bridging. The chips will be hydrated, as necessary, at 2-foot intervals using sufficient quantities of clean water to allow for adequate saturation and expansion of the bentonite.

Where a cement grout is used, the boreholes will be plugged using grouting methods. A sufficient volume of grout will be premixed on site, according to procedure stipulated by the manufacturer, to compensate for unexpected losses to the formation. This process will be checked against the calculated volume of the borehole to be decommissioned to ensure that bridging does not occur during emplacement. The use of alternate grout materials, including grout containing Portland cement, may be necessary to control zones of high grout loss. The mixing (and placing) of grout will be performed with recorded weights and volumes of materials, according to procedures stipulated by the manufacturer. Lumpy grout will not be used in an effort to prevent bridging within the tremie and the well. Bentonite based grout will be mixed to the manufacturer's specifications and then pumped into place using minimum pump pressure. All additives to grouts will be evaluated for their effects on the subsurface. Depending upon the borehole depth, plugging may be accomplished using a pressure grouting technique or by gravity feed through a tremie pipe. With either method, grout is introduced in one continuous operation until grout flows out at the ground surface without evidence of drill cuttings or fluid. The tremie pipe will be kept full of grout from start to finish with the discharge end of the pipe completely submerged as it is slowly and continuously lifted. Approximately 5 to 10 feet of tremie pipe will remain submerged during group emplacement. If possible, steel tape soundings will be made to ensure the level of the tremie material is in agreement with the calculated volume and that the desired placement of plugging materials is achieved. A staged grouting procedure may be considered if there is significant grout loss into the formation because of the weight exerted by the full column of grout as it sets. If used for borehole or well drilling, temporary casing or hollow-stem augers will be removed in increments (immediately following each lift of grout installation) well in advance of the time when the grout begins to set.

E. Surface Restoration

For borings performed in the upland, the upper 6 inches of the borehole that has been decommissioned will be filled with similar surface material as the surrounding area (i.e., sod, soil, asphalt, concrete) until flush with the surrounding surface.

F. Drill Cutting Management

Drill cuttings/spoils will be containerized in 55-gallon sealable drums at or near the drilling site for disposal as an IDW. Drums will be labeled accordingly and stored in a safe place until picked up for transport and disposal.

Quality Assurance/Quality Control

Entries in the field forms or field books will be reviewed by the field team staff to verify that the recorded information is accurate. It is the responsibility of the field team leader to periodically check to verify that the procedures are in conformance with those stated in this SOP.

References

Anchor QEA (Anchor QEA, LLC) and AECOM, 2021. *Pre-Design Investigation Work Plan for Reach 5A Sediment and Riverbanks*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2021.

Arcadis, 2017. *Housatonic River – Rest of River, Health and Safety Plan*. Prepared for General Electric Company, Pittsfield, Massachusetts, September 2017.

ASTM, 2015. D1587/D1587M-15. *Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes*.

ASTM, 2016. D6914/D6914M-16. *Standard Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices*.

ASTM, 2017. D2487-17. *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)*.

ASTM, 2017. D2488-17. *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)*.

ASTM (ASTM International), 2018. D1586/D1586M-18. *Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils*.

List of Attachments

Attachment 1 Boring Log

Attachment 2 Physical Description of Soil Key

Attachment 1

Boring Log

Boring Location:

Elevation: Datum:

Obs. Well Install. [Yes] [No]

Boring ______ Date ______ Sheet ______ of ______

Job ______ Job No. ______

Logged By ______ Weather ______

Drilled By ______

Drill Type/Method ______

Sampling Method ______

Bottom of Boring ______ ATD Water Level Depth ______ [No]

SIZE (%) G Max.	S Range	F Att. Limits	PID or other	DEPTH From	To	SAMPLE Type	Number	SAMPLE RECOVERY	Penetration Resistance	DESCRIPTION; Den., moist., color, minor, MAJOR CONSTITUENT. NON-SOIL SUBSTANCES: Odor, staining, sheen, scrap, slag, etc.	REMARKS; Drill action, drill and sample procedures, water conditions, heave,...etc...	SUMMARY LOG (Water & Date)
								0				
								1				
								2				
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				
								1				
								2				
								3				
								4				
								5				
								6				
								7				
								8				
								9				
								0				

Attachment 2
Physical Description of Soil Key

Sample Description Key

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in PSF
Very soft	0 - 2	< 250
Soft	2 - 4	250 - 500
Medium stiff	4 - 8	500 - 1,000
Stiff	8 - 15	1,000 - 2,000
Very stiff	15 - 30	2,000 - 4,000
Hard	>30	> 4,000

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

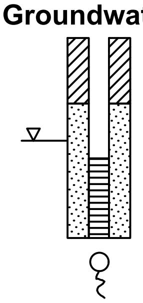
BORING SAMPLES

- ⊠ Split Spoon
- ⧅ Shelby Tube
- Cuttings
- Core Run
- ⁎ No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- ⊠ Grab (Jar)
- Bag
- Shelby Tube

Groundwater Observations



Surface Seal

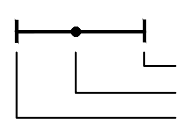
Groundwater Level on Date (ATD) At Time of Drilling

Observation Well Tip or Slotted Section

Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size
Comp	Composite
Chem	Chemistry
VST	Vane Shear Test
BD	Bulk Density
UU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer - Approximate Compressive Strength in TSF
TV	Trovane - Approximate Shear Strength in TSF
AL	Atterberg Limits



Water Content in Percent
Liquid Limit
Natural
Plastic Limit

PID	Photoionization Detector Reading
Note:	additional observation modifiers to be added as appropriate, including approximate amount (e.g. trace debris) at depth interval where encountered

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