# TECHNICAL MEMORANDUM

To: Andy Hrycyna, Mystic River Watershed Association; Gwen Speeth and David White, Save the Alewife Brook;

From: Nick Nelson & Andy Fallon, Inter-Fluve, Inc.

Date: FINAL June 30, 2024 (Draft issued 6/25/2024)

Project: Alewife Brook Sediment Study

Re: FINAL Sediment Sampling and Management Report

## EXECUTIVE SUMMARY

The Alewife Brook Sediment Study was conducted in May and June of 2024 by Inter-Fluve, Inc. (Inter-Fluve) to characterize accumulated sediment, evaluate the existing aquatic and riparian habitat, and explore potential sediment management options for Alewife Brook. This study included a review of existing data resources and a due diligence review of the land use history and possible contamination sources in the watershed. We used RTK-GPS survey equipment and flexible probing rods to survey the elevation of the bottom of the river channel as well as the bottom of the accumulated sediment. We analyzed the survey data and estimate that approximately 22,000 cubic yards of sediment has accumulated in the 1.4-mile reach of Alewife Brook from Rt. 2 to the Mystic River confluence.

Based on the initial field survey and existing data review, we selected six (6) locations to collect sediment samples that we then sent to a state-approved laboratory to be tested for physical and chemical analyses as recommended by the Massachusetts Department of Environmental Protection. Laboratory results show concentrations that exceed ecological and/or human health thresholds for heavy metals (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel & Zinc), Polycyclic Aromatic Hydrocarbons (PAHs), and total Polychlorinated biphenyls (PCBs).

The aquatic and riparian habitat within the Alewife Brook corridor is limited. Concrete lines the channel and channel banks through much of the study area, roads and paths are in close proximity to the channel, sediment fills much of the channel cross section, and Combined Sewer Overflows (CSOs) and other stormwater inputs continue to degrade the water quality. However, mature trees along a narrow riparian buffer provide near total canopy cover over the brook and limiting solar exposure to the water. Trees and branches that have fallen into the channel provide numerous opportunities for in-channel habitat and cover for organisms. The riparian buffer of trees and shrubs provides a narrow corridor of terrestrial habitat for animals finding refuge from the adjacent roads and urban landscape.

Options for managing the accumulated sediment are limited due to the higher concentrations of contaminants within the material. The cost of dredging and disposing of the sediment is estimated to be in the range of $23 million to $80 million, as the material would need to be transported out of the state to landfills that are licensed to process this material. Management options include: 1) Leave the sediment in place; 2) Remove the sediment and dispose of it in an out-of-state facility.

Recommended next steps may include:

1) Evaluate this study together with the concurrent hydrology and hydraulic modeling study. Modeling is being conducted by a third party and results are to be determined.

2) Advocate for the removal of the remaining CSOs and stormwater pollutant sources prior to other actions.

3) Evaluate the sediment sampling results with MassDEP and develop a second phase sediment sampling plan to more accurately define the location and extent of the more highly contaminated material.

# INTRODUCTION

In 2024, the Mystic River Watershed Association (MRWA) contracted with Inter-Fluve, Inc. (Inter-Fluve) to evaluate the quantity and quality of sediment within a portion of Alewife Brook. Save the Alewife Brook (SAB) is a partner organization that provided background information and review. Alewife Brook is a tributary of the Mystic River and one of the oldest urban waterways in the country. Historically this was part of a tidal wetland area known as the Great Swamp but was channelized in the early 20th century. The focus section of Alewife Brook for this sediment study extends from just upstream of the Route 2 bridge crossing in Cambridge downstream through Arlington and Somerville to the confluence with the Mystic River. Inter-Fluve was contracted to complete a background and due diligence review, evaluate the geomorphology and habitat within the stream, estimate accumulated sediment volume, and evaluate the character of the sediment through analysis of limited samples.

In this technical memorandum, we summarize our observations made during the field data collection activities, provide the results of the sediment quantity and quality studies, and discuss the possible alternatives and costs for managing the sediment.

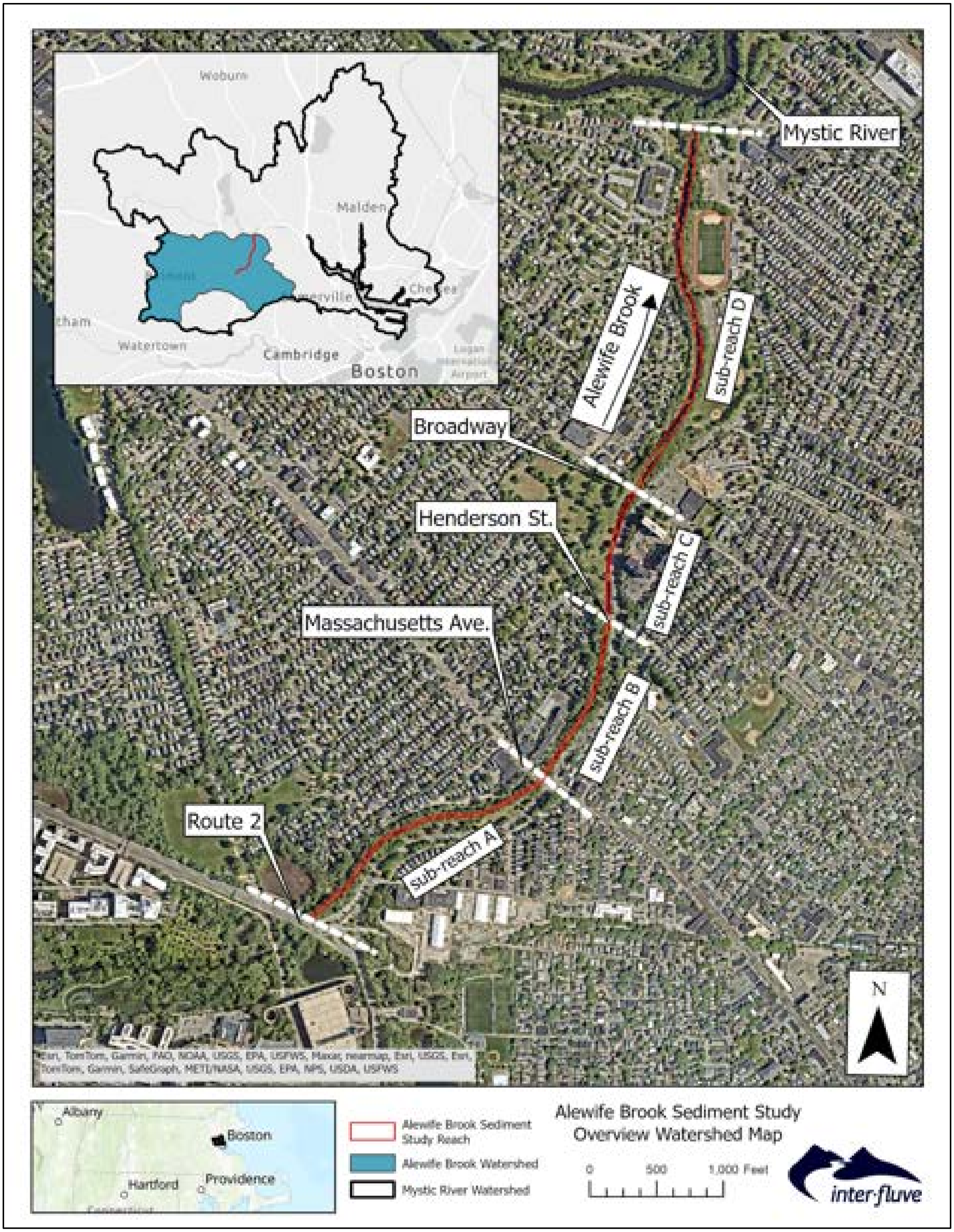


***Figure 1. Alewife Brook Sediment Study reach with sub reaches A, B, C, & D designated by dashed white lines. Top Inset shows the Alewife Brook watershed within the greater Mystic River Watershed. Bottom Left inset shows Mystic River Watershed in Massachusetts.***

# STUDY AREA

Alewife Brook flows through the towns of Cambridge, Arlington and Somerville, Massachusetts. The brook is approximately 1.6 miles long from the aboveground emergence north of Cambridgepark Drive, Cambridge to the confluence with the Mystic River at the border of Arlington and Somerville. Alewife Brook flows under five bridges: Route 2, Massachusetts Avenue, Henderson Street, Broadway, and Mystic Valley Parkway (Figure 1). The contributing watershed is approximately 9.0 mi$^2$, a subbasin of the larger 79 mi$^2$ Mystic River Watershed. Alewife Brook is the central artery of The Alewife Brook Reservation State Park, one of the largest urban green spaces in the city connecting Fresh Pond, Spy Pond, and part of the Greater Boston Metropolitan Park System established in 1893, now managed by the Department of Conservation and Recreation (DCR).

## CURRENT AND HISTORICAL CONTEXT

The green space of Alewife Brook Reservation today is a faint reminder of what this landscape once looked like prior to the settlement and development of Greater Boston. The first European settlers referred to this area between Fresh Pond and Spy Pond as The Great Swamp because it was an enormous saltmarsh wetland complex (Figure 2). Archeological evidence shows that Native Tribes set up seasonal camps to capture migrating adult alewife and blueback herring as they returned to their home waters to spawn. Regional high points throughout the marsh, like around the present-day Alewife MBTA train station, were used as hunting camps to pursue the abundant waterfowl in the region.

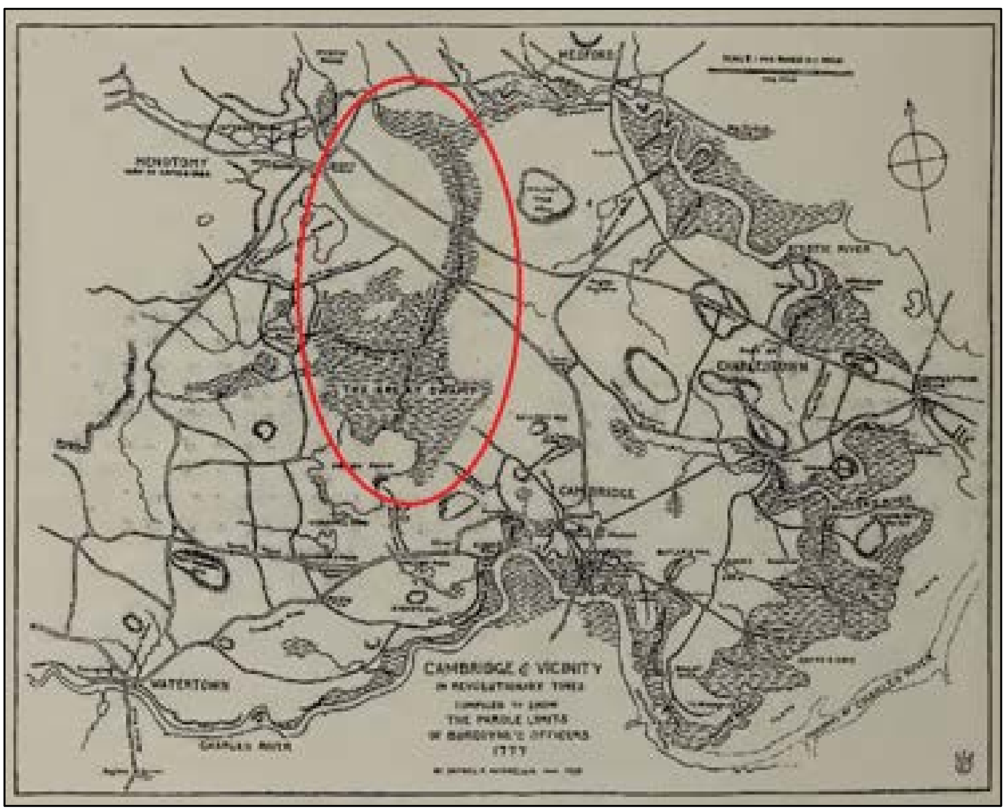


***Figure 2. Map of Cambridge and Vicinity adapted from Alewife Master Plan[1]. The Great Swamp circled in red.***

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[1] Alewife Brook Master Plan, 2003. DSpace (state.ma.us) accessed June, 2024

As the area was settled and the population of the colonists grew throughout the 17th & 18th centuries, the Great Swamp was ditched and drained, initially for pastureland for livestock, but also for farms and orchards. When industrialization began in the 19th century, tanneries, glue factories, slaughterhouses, and other industries developed along what was then known as the Menotomy River. Throughout the period of industrialization, the Great Swamp continued to shrink as industry and local populations grew. At the end of the 19th century the connection from Fresh Pond to Alewife Brook was cut off due to concerns over the contaminant impacts from Alewife Brook to Fresh Pond, which had become the drinking water source for the City of Cambridge. The once remote corner of Cambridge along Alewife Brook, known in the 19th Century as “Poverty Plain”, is now a densely populated residential area including Environmental Justice communities, with approximately 5,000 people living in the brook’s 100-Year Floodplain.

The current configuration of Alewife Brook can be attributed to two significant hydrological changes that occurred in the early 20th century, first with the damming of the Mystic River, and second the channelization of Alewife Brook. The Craddock Dam was built on the Mystic River in Medford, stopping all tidal flow in and out of the watershed, drastically changing the ecological and hydrological regime for local fish and wildlife populations. Beginning in 1910, Alewife Brook was straightened and channelized with concrete walls and a cantilevered sidewalk erected along the brook between Henderson St. and Broadway to support the construction of the Alewife Brook Parkway. A trapezoidal concrete channel was constructed between Route 2 and Henderson St. in 1955. In conjunction with centuries of ditching and development these two hydrologic changes resulted in Alewife Brook having less than 10% of the total surface water of the historical Great Swamp.

## Watershed Land Use

The contributing watershed of Alewife Brook is predominantly single family residential (49%) with roads (right-of-way) representing another 20%. Table 1 and Figure 3 present the land use and land cover characteristics of the contributing watershed area.

***Table 1. Land Use in the Contributing Watershed to Alewife Brook***

| Land Use | acres | % of total |
|---|---|---|
| Residential - single family | 1232 | 27 |
| Residential - multi-family | 1000 | 22 |
| Right-of-way | 879 | 20 |
| Tax exempt | 617 | 14 |
| Open land | 309 | 7 |
| Commercial | 226 | 5 |
| Water | 107 | 2 |
| Industrial | 63 | 1 |
| Unknown | 32 | 1 |
| Mixed use, primarily residential | 22 | <1 |
| Mixed use, other | 9 | <1 |
| Mixed use, primarily commercial | 5 | <1 |
| Total | 4501 | 100 |

We divided the project area into four (4) sub-reaches (Figure 1) for evaluation of the geomorphology and accumulated sediment (Table 2).

***Table 2. Alewife Brook Study Area sub-reach designations***

| *Sub-reach* | *Description* | *Approximate Length (ft)* | *% of total* |
|---|---|---|---|
| A | Rt. 2 Bridge to Massachusetts Ave. Bridge | 2,100 | 29 |
| B | Massachusetts Ave. Bridge to Henderson St. Bridge | 1,300 | 18 |
| C | Henderson St. Bridge to Broadway Bridge | 1,000 | 13 |
| D | Broadway Bridge to Mystic River Confluence | 2,900 | 40 |

The Brook has a natural bottom and channels upstream of Rt. 2, before entering a trapezoidal concrete-lined channel from Rt. 2 through sections A, B, and C until the Henderson St. Bridge (Figure 3). Downstream of Henderson St., the brook flows through a natural channel with concrete walls before transitioning again to a natural channel and bank setting downstream of the Broadway bridge to the confluence with the Mystic River.

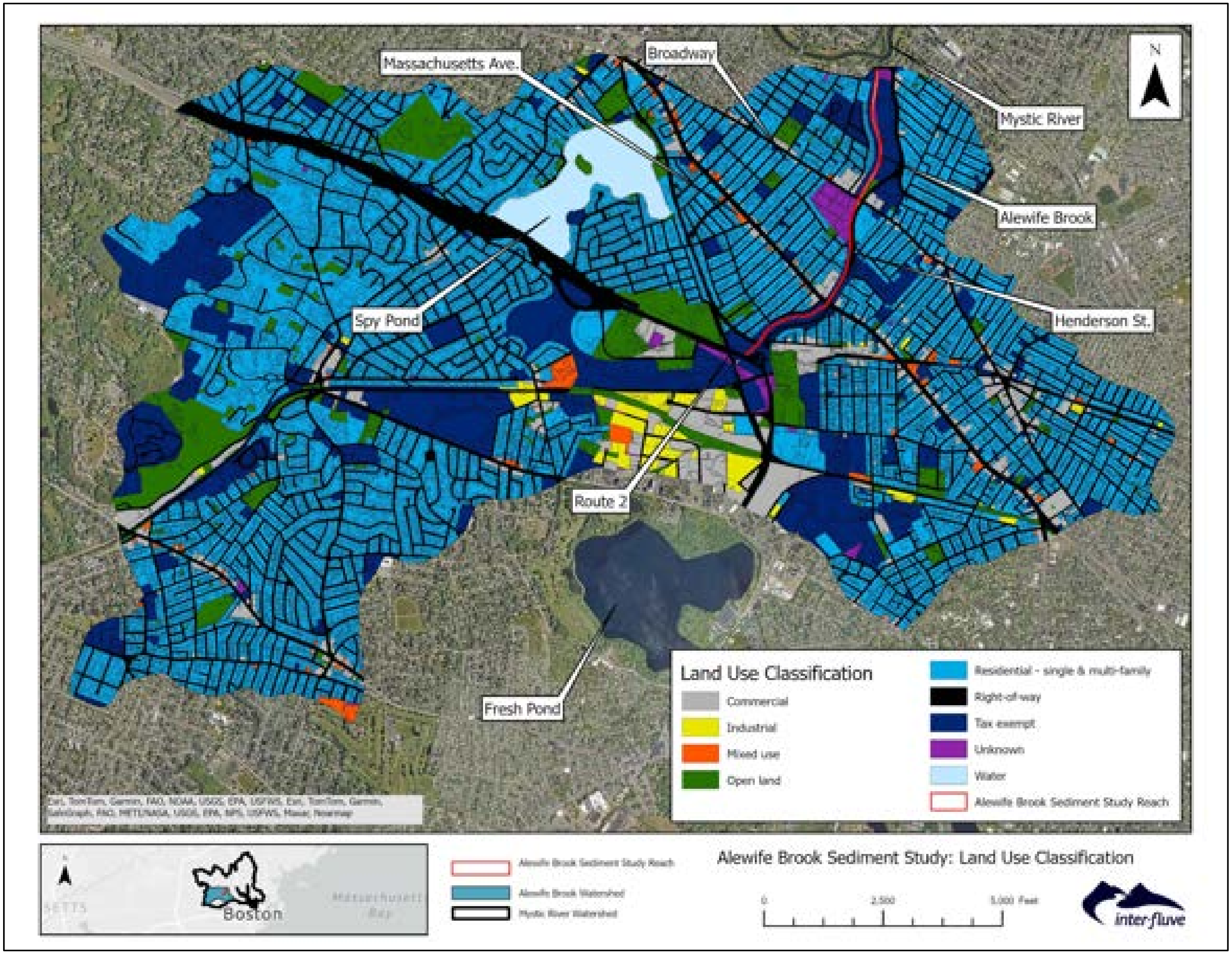


***Figure 3. Land use in the Alewife Brook Watershed***

## DUE DILIGENCE SUMMARY

Inter-Fluve queried several state and federal agency resources for information relating to potential contaminants in the contributing watershed (Figure 4). Table 3 summarizes the findings.

***Table 3a: Summary of Due Diligence Findings: Contaminants with Potential Project Impacts***

| Query | Finding | Impacts |
|---|---|---|
| Combined Sewer Overflows (CSOs)[2] | 17 CSOs in Mystic River Basin, 8 directly into Alewife Brook. Only 6 listed on MA DEEP site. | Records of these overflowing during high precipitation events. Direct impacts. |
| PFAS[3]<br>(Per- and polyfluoroalkyl substances) | PFAS in Massachusetts. 26.6 ppt total detected in Cambridge (20.2 for regulated PFAS) both over the limit of 20 ppt for drinking water. | Potential impact with known result in Cambridge. |
| Previous Sediment Sampling | 2005 USGS sediment quality report[4]<br>Little River/Alewife Brook Survey, 1988[5] | Estimated 18,500 $yd^3$ of sediment [11]<br>Sediments enriched in heavy metals, PCBs & PAHs[12] |
| SWF/LF[6]<br>(Solid Waste Facility/Landfills) | Harvey Street Sludge Landfill and Mooney Street Dump are closed and inactive; both are adjacent to Alewife Brook on either side of Rt. 2. | Potential impact from leaching into the groundwater. |

[2] MassDEP Combined Sewer Outfalls (arcgis.com)

[3] Per- and Polyfluoroalkyl Substances https://www.sierraclub.org/massachusetts/blog/2021/10/reports-show-widespread-pfas-contamination-ground-and-surface-water

[4] Breault, R. F., Durant, J. L., & Robbat, A. (2005). *Sediment quality of lakes, rivers, and estuaries in the Mystic River basin, eastern Massachusetts, 2001-03* (No. 2005). US Department of the Interior, US Geological Survey.

[5] Little River/Alewife Brook Survey, 1988. Little River/Alewife Brook Survey, 1988 – Save the Alewife Brook

[6] Solid Waste Facility/Landfills. Mass Mapper. Landfills by Waste Type. November 2023.

*Table 4b: Summary of Due Diligence Findings: Contaminants with No Anticipated Project Impacts*

| Query | Finding | Impacts |
|---|---|---|
| Aboveground (ASTs) and Leaking Aboveground Storage Tanks (LASTs) | None identified. | No anticipated impacts to the project area. |
| Asbestos[7] | Many licensed asbestos removal projects have occurred in the contributing area to the project site. No known unlicensed removals | No anticipated impacts to the project area. |
| CERCLIS/NFRAP[8] (Comprehensive Environmental Response, Compensation and Liability Information System/No Further Remedial Action Planned) | No CERCLA/NFRAP sites were identified within the contributing area to the project site. | No anticipated impacts to the project area. |
| Leaking Underground Storage Tanks (LUSTs)[4] | None identified. | No anticipated impacts to the project area. |
| NPL[9] (National Priorities List) | No NPL Sites were identified within the contributing area to the project site. | No anticipated impacts to the project area. |
| RCRA[10] (Resource Conservation and Recovery Act sites) | 20 (active), 11 (inactive) | No anticipated impacts to the project area. |
| SHWS[11] (State Hazardous Waste Sites) | One at 1 Alewife CTR (same site identified as an RCRA) | No anticipated impacts to the project area. |
| Spills[12] | None documented | No anticipated impacts to the project area. |
| USTs[13] | 12 total. 6 open, 6 closed within ~2000 ft of Alewife Brook | No anticipated impacts to the project area. |

[7] https://www.mass.gov/asbestos-project-lookup. May 2024

[8] Comprehensive Environmental Response, Compensation and Liability Information System/No Further Remedial Action Planned, USEPA SEMS Database query, May 2024

[9] National Priorities List. USEPA SEMS Database query, May 2024

[10] Resource Conservation and Recovery Act.  RCRA geospatial data, May 2024.

[11] State Hazardous Waste Sites. Mass Mapper, DEP BAW Major Facilities Hazardous Waste Recyclers, Major Facilities Hazardous Waste Treatment, Storage and Disposal, Major Facilities Large Quantity Generators of Hazardous Waste. November 2023.

[12] From the Toxic Resources Inventory

[13] Underground Storage Tanks. MassDEP Underground Storage Tank Program. https://www.mass.gov/guides/massdep-underground-storage-tank-ust-program#-usts-in-massachusetts- May 2024.

This is one of the oldest urban waterways in the country in an industrial setting. While the due diligence review suggested that the primary current source of contamination may come from Combined Sewage Overflows and landfills, we recognize the potential impact of industrial and commercial use of the brook and contributing watershed prior to record-keeping. The sampling completed in 1988 demonstrated that the sediment within Alewife Brook contained PAHs, PCBs and heavy metals (Arsenic, Cadmium, Chromium, Copper, Lead, Mercury, Nickel & Zinc). This 1988 sediment sampling effort did not include any sampling for PFAS. Every sample in Alewife Brook showed some form of contamination with particularly high PCB levels and the presence of petroleum by products. The 2005 sediment quality report showed elevated levels of heavy metals and PAHs in the Alewife Brook samples. This 2005 report cited average water depths of approximately one (1) foot and an estimate of 18,500 $yd^3$ of sediment impounded in Alewife Brook.

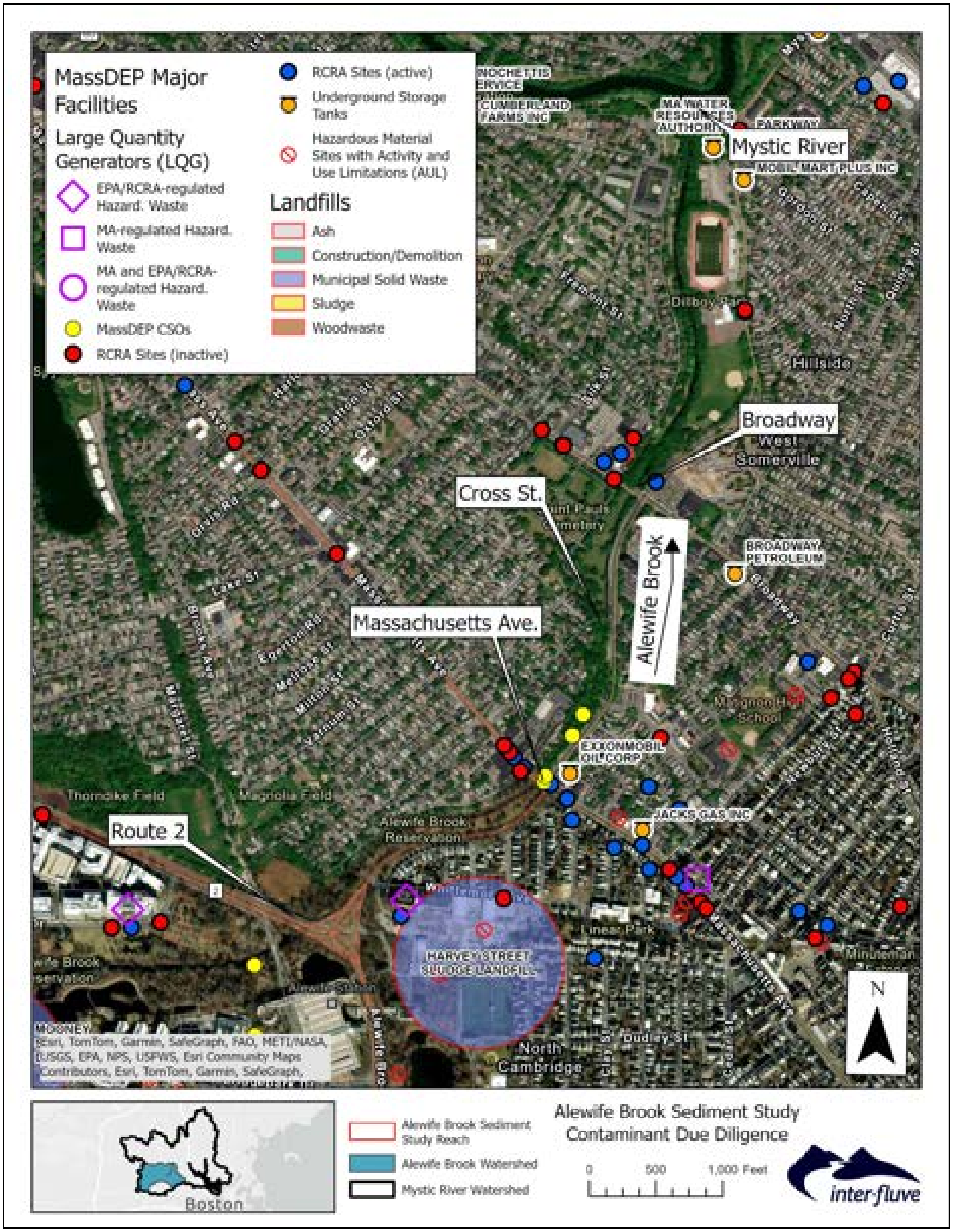


***Figure 4. Due Diligence Review Map with possible sources of contamination in the Alewife Brook Sediment Study Area***

## DEPTH OF REFUSAL AND IMPOUNDED SEDIMENT ESTIMATE

Inter-Fluve conducted a geomorphic assessment and depth of refusal probing survey on May 9th, 2024 (Photographs in Appendix 1). The survey utilized RTK GPS survey equipment combined with flexible probing rods to measure the depth of sediment accumulated within Alewife Brook. Sediment depths are estimated by inserting the probe rods through the water column, noting the depth to channel bottom, and then into the underlying substrate until the point of refusal, also noting the depth to refusal. In addition, Inter-Fluve made observations about the texture and type of the accumulated sediment as well as the material underlying the accumulated sediment (Figure 5). The area of sediment evaluation extended approximately 1.4 miles from the Route 2 crossing to the confluence with the Mystic River. We characterized the sediment within four reaches, each separated by a road crossing. The volume of sediment was estimated in each of these reaches by calculating the volume between the ground elevation under the accumulated sediment (depth of refusal layer) and the existing channel bottom (top of sediment), both of which was surveyed using RTK GPS survey equipment.

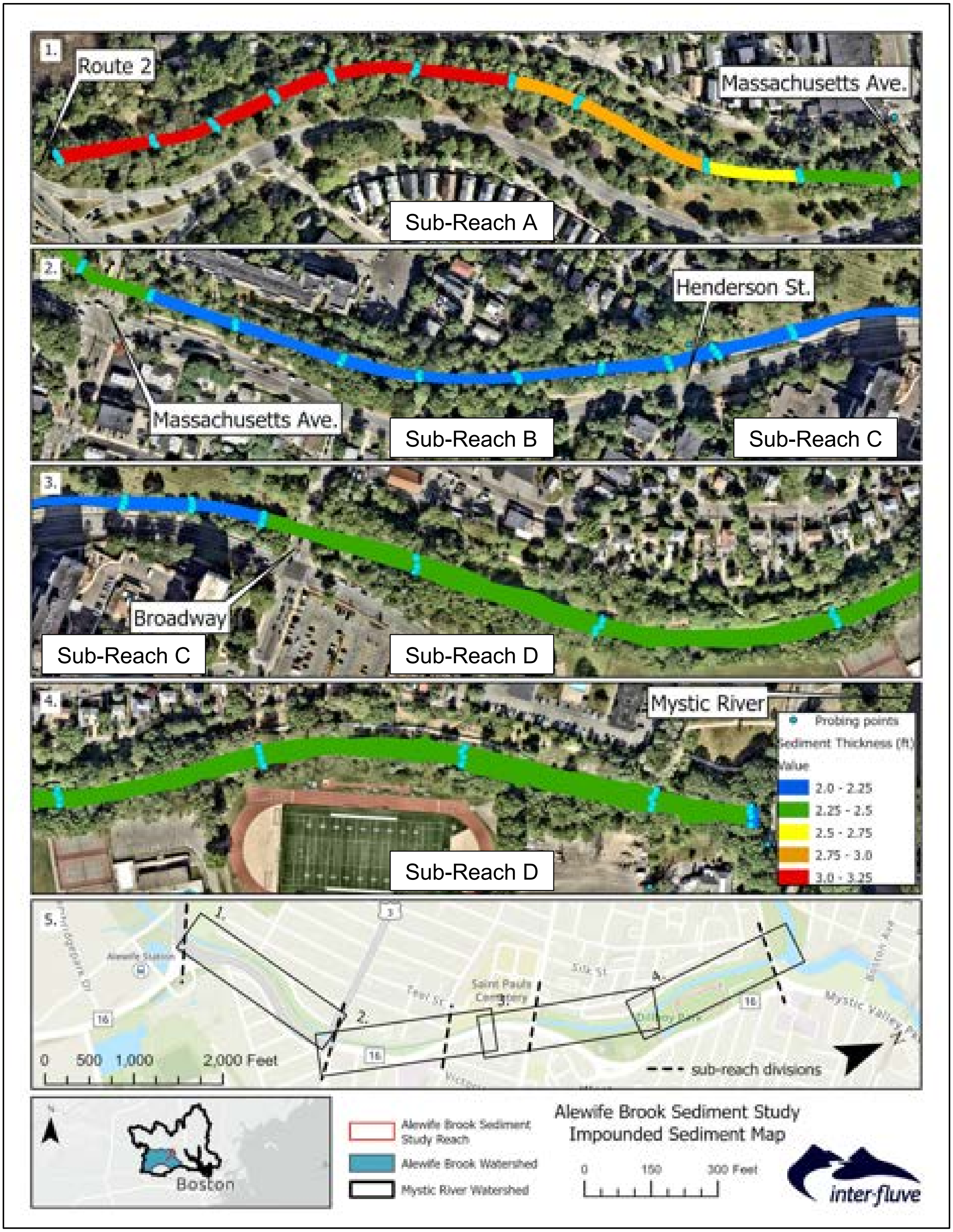


***Figure 5. Alewife Brook DOR Survey and Impounded Sediment Map. Panels 1-4 show zoomed in sections of the study reach. Panel 5 has locations of panels 1-4 and sub-reach divisions A-D denoted by dashed lines from the geomorphic assessment.***

## Geomorphic Assessment of Four sub-reaches (A, B, C, D)

Sub-reach A, which flows parallel to Lafayette St. in Arlington between the Rt. 2 and Mass Ave. bridges, has tree and shrub lined banks. Vegetation, topsoil and tree roots overtop much of the trapezoidal concrete banks in this section (Figure 6). The tree canopy covers 75-100% of the channel, providing shade that limits solar heating of the water. Branches or whole trees that fall into the channel provide in-channel habitat for fish, turtles, birds, and aquatic organisms living in and around Alewife Brook (see images for all reaches in Appendix 1). While they provide important habitat features, the large wood and low hanging branches also make it challenging to navigate the channel in a canoe or other small recreational craft. Woody debris would also increase channel roughness and restrict flow area, which may exacerbate current flooding conditions. The sediment is very organic rich, fine-grained material with some intermittent sand that is easy to probe through. Consistent hard refusal (concrete) was found below approximately 3 ft of sediment throughout section A (Panel 1, Figure 5). This section also has one CSO in the downstream portion, one groundwater pump outfall and 10 stormwater drains directly into the Brook (Figure 4).

***Figure 6. Riparian vegetation overtopping concrete banks on river left in Reach A.***

Sub-reach B, from Massachusetts Ave. to Henderson St., has a similar concrete lined geometry to section A but with several CSOs just downstream of Massachusetts Ave (Figure 4), and lots of accumulated trash floating on the surface of the brook. Sub-reach B has approximately 50% overall tree canopy cover, which results in noticeably less in-channel woody debris compared to Section A. The concrete banks are exposed throughout the majority of this section. The river left and right bank is dominated by invasive Japanese Knotweed through portions of this sub-reach (Figure 7). Sediment characteristics are very similar to the upstream section with highly organic, dark, fine-grained material with intermittent sandy lenses. Overall, sediment accumulation in sub-reach B is approximately 2 ft with some areas closer to 2.5 ft (Figure 5).

***Figure 7. Sub-reach B looking downstream towards Henderson St. Invasive Japanese Knotweed abundant on both banks.***

Sub-reach C, from Henderson St. to Broadway, is the first section in the project area that does not have a concrete lined channel throughout. Immediately downstream of Henderson St. the river left bank is exposed soil with trees and shrubs for about 60-70 ft before the beginning of a vertical concrete wall at St Paul's cemetery in Arlington. The concrete walls continue on both sides of the brook for the remainder of the sub-reach C (Figure 8). The concrete walls are built on a poured concrete base, which does not cover the bottom of the channel like in the upstream sections. The remaining substrate in this stretch is a gravel/rock river bottom with overlying fine grained, organic rich sediment consistently 2.0 - 2.25 ft thick (Figure 5). There are several large trees that overhang the channel from the cemetery as well as smaller trees growing out of cracks and ledges in the concrete. There was a large, downed tree with shrubs growing out of it on the river left bank downstream of Henderson St. prior to the cemetery.

The material impounded in this section is organic rich with significant accumulation of leaf litter trapped behind a second downed tree approximately 500 ft downstream of the Henderson St. Bridge.

***Figure 8. Sub-reach C, looking downstream with concrete lined walss on either side of the channel. St Pauls cemetery above on river left.***

Sub-reach D, from Broadway to the Mystic River confluence, also does not have a continuous concrete channel; the banks are earthen with intermittent rip rap and other stabilizing measures (Figure 9). This includes chunks of concrete and large rock that are remnants of rip rap or other concrete scattered around the banks and in the channel. This varied material creates a substrate of irregular concrete, gravel and rock with fine grained material accumulated on top. Downstream of Broadway, the concrete walls stop and the riverbanks are lined with dense trees and shrubs for the majority of the approximately 2900-ft section. The thick vegetation results in leaf litter on the banks and approximately 50-75% tree canopy cover. There are several stormwater drains into the brook and some minor in-channel woody material but no large channel-spanning wood. Sediment accumulation is approximately 2.0 - 2.5 ft throughout this section of similarly organic rich fine-grained material (Figure 5).

***Figure 9. Reach D. Looking upstream. The undercut banks and overhanging vegetation provide in-channel aquatic cover and habitat.***

Based on topographic and depth of refusal survey information, we estimate approximately 22,000 cubic yards of impounded sediment is stored in the 1.4-mile project reach of Alewife Brook. Table 4 shows an approximate breakdown of impounded sediment by sub-reach sections A, B, C, and D. The range of sediment volumes is from different interpolation settings creating a high and low estimate for each sub-reach and entire study reach.

***Table 5. Estimated Impounded sediment volume from DOR Survey May 9, 2024***

| ***sub-reach*** | ***Average Estimated Sediment Volume ($yd^3$)*** | ***Estimated Sediment Volume Range ($yd^3$)*** |
|---|---|---|
| A | 5,800 | 5,000 – 6,600 |
| B | 2,600 | 2,200 – 2,700 |
| C | 2,200 | 1,900 – 2,500 |
| D | 11,400 | 9,900 – 12,900 |
| Total | 22,000 | 19,000 - 25,000 |

## SAMPLING PLAN

We collected six (6) sediment samples. Two (2) upstream of Rt. 2; Two (2) in Section A between Rt. 2 and Massachusetts Ave; one (1) in Section B between Massachusetts Ave. and Henderson St.; and one (1) in the Section C between Henderson St. and Broadway (Table 5, Figure 6).

Inter-Fluve collected sediment core samples on foot by wading or via canoe using a custom-made manual coring device (Photographs in Appendix 2). Sample collection is in accordance with the standard protocols described in US-EPA-823-B-01-02, 2001, Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis: Technical Manual, adapted to site conditions and/or to specific instruction provided by the laboratory.

***Table 6. Sediment sample locations for chemical analysis***

| **Sample Descriptions** | **Number of Samples Submitted to the Laboratory** |
|---|---|
| Upstream of Rt. 2 | 2 |
| Between Rt. 2 & Massachusetts Ave. | 2 |
| Between Massachusetts Ave. & Henderson St. | 1 |
| Between Henderson St. & Broadway | 1 |
| ***Sample Total*** | ***6*** |

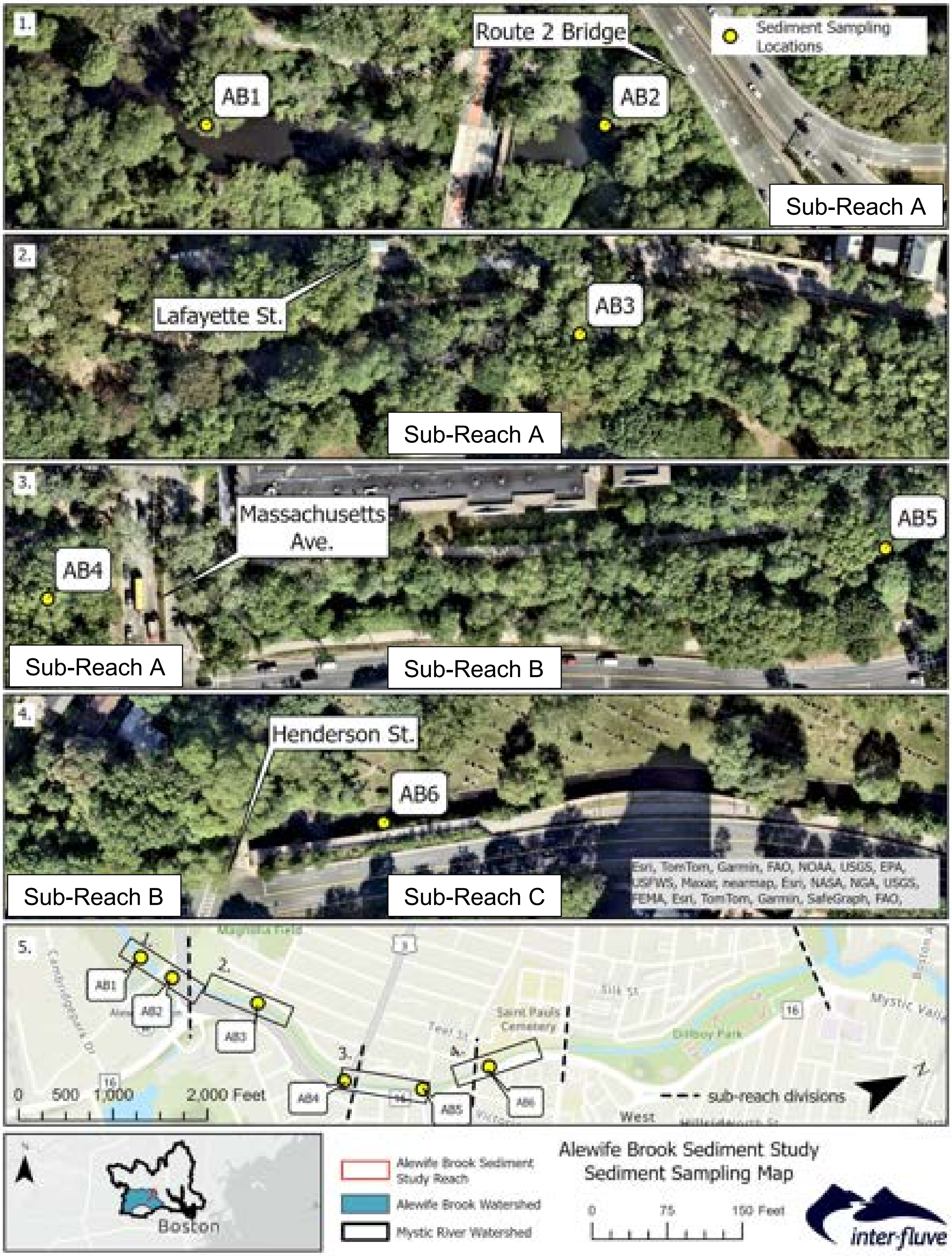


***Figure 10. Sediment sample locations for chemical analysis. Panels 1-4 show zoomed in locations for sediment samples AB1, AB2, AB3, AB4, AB5 & AB6. Panel 5 has locations of panels 1-4, sediment sample locations, and sub-reach divisions A-D denoted by dashed black lines, from the geomorphic assessment.***

# QUALITY CONTROL PLAN

Inter-Fluve followed quality control and quality assurance procedures described in:

- (Inter-Fluve, 2007). "Sediment Sampling for Dam Removal Projects: General sample collection guidelines for contaminant testing", April 25, 2007 and
- (USEPA, 2001). US-EPA-823-B-01-02, 2001, "Methods for Collection, Storage, and Manipulation of Sediments for Chemical and Toxicological Analysis: Technical Manual."

Quality control measures described in Inter-Fluve, 2007 include:

- Considerations for specific equipment used to collect the samples
- Considerations for the sequence in which the samples were collected
- Procedures and materials for decontaminating equipment between sample collection events
- Methods for preserving the samples for storage and shipment
- Procedures for labeling the properly and delivering them to the laboratory

As part of the sediment sampling, Inter-Fluve performed the following work.

Inter-Fluve coordinated with the analytical laboratory, Alpha Analytical (M-MA030[14]), prior to performing the sediment data collection task to obtain the appropriate containers, preservatives, and documentation.

Inter-Fluve collected the samples in the following order from upstream to downstream in the study reach: (2) upstream of Rt. 2, (2) between the Rt. 2 & Massachusetts Ave., (1) between Massachusetts Ave. & Henderson St., (1) between Henderson St. & Broadway.

Inter-Fluve used the sampling equipment to collect material to the full depth of refusal. Material above this depth is considered to be deposited sediment. Material below this depth is concrete and rock rip rap from the construction of the channel and is not considered a concern for the purposes of this study.

Sample collection for VOCs was conducted to minimize the exposure (and volatilization) of the compounds.  VOC sample collection was performed by (laboratory-provided) syringe. The syringe was inserted into the interior of undisturbed/unexposed material prior to mixing or compositing activities.

Inter-Fluve cleaned the sampling equipment using the methods described in Inter-Fluve, 2007. The cleaning procedure includes washing the equipment with scrub brushes using a non-phosphate detergent that leaves no residue when rinsed and rinsing the equipment several times with water.

Inter-Fluve stored the samples in a temperature-controlled container (a cooler with ice) and arranged for a courier to deliver the samples to the analytical laboratory (Mansfield, MA) on the day that the samples were collected.

[14] https://eeaonline.eea.state.ma.us/DEP/Labcert/labcert.aspx

# LABORATORY ANALYSIS

The sediment samples were sent to Alpha Analytical Laboratories, a state-approved laboratory, for analyses of a range of parameters and associated reporting limits as required by the MassDEP 401 Water Quality Certification[15] (Table 6).

***Table 7. Laboratory Parameters for sediment sample testing***

| Parameters | Reporting Limit mg/kg* (dry weight) |
|---|---|
| Arsenic | 0.5 |
| Cadmium | 0.1 |
| Chromium | 1.0 |
| Copper | 1.0 |
| Lead | 1.0 |
| Mercury | 0.02 |
| Nickel | 1.0 |
| Zinc | 1.0 |
| Polychlorinated Biphenyls (PCBs)-by NOAA Summation of Cogeners | 0.01 |
| Extractable Petroleum Hydrocarbons | 25 |
| Polycyclic Aromatic Hydrocarbons (PAHs) | 0.02 |
| Volatile Organic Compounds (VOCs) | 0.1 |
| Organochlorine Pesticides | 0.0014 |
| PFAS | .0003 |
| Total Organic Carbon | 0.1% |
| Percent Water | 1.0% |
| Grain Size Distribution-wet sieve (ASTM D422) | Sieve numbers 4, 10, 40, 60, 200 |

**Unless otherwise noted (e.g., percentages, sieve numbers).*

## RESULTS

In this section, we review the chemical results for the six (6) sediment samples from Alewife Brook. The focus of this section is on the results that exceeded ecological and human health thresholds. We reviewed three different thresholds to evaluate the sediment results. We have listed the official definitions for these chemical thresholds with underlying clarifications of what these thresholds indicate. Chemical results that do not have these three threshold parameters are shown in the sediment testing table, but do not have a focused discussion in this summary of results.

[15] 314 CMR 9.07 (2) (b) (6)

1. Human Health MCP S1/GW1[16] - the MCP Method 1 Cleanup Standards for S-1 (soils) and GW-1 (groundwater). The S-1 Soil Category thresholds are based on what MassDEP considers for soil that would readily come into contact with humans, such as in a yard, playground, or garden.
    a. It should be noted that MassDEP does not provide thresholds for sediment (soil material under water), only soil and water. S-1/GW-1 is the most conservative threshold.
    b. Soil with contaminant concentrations above this threshold may be harmful to humans and should not be reused or disposed of in readily-accessible areas such as yards, playgrounds, or gardens.
2. Freshwater Ecological PEC[17] (Probable Effect Concentration) – "Concentrations ***above*** these thresholds provide an accurate basis for predicting sediment toxicity."
    a. Sediment with contaminant concentrations exceeding these thresholds is considered harmful for the environment and living organisms
3. Freshwater Ecological TEC[2] (Threshold Effect Concentration) – "Concentrations ***below*** these thresholds provide an accurate basis for predicting the absence of sediment toxicity."
    a. Sediment with contaminant concentrations below these thresholds is not considered harmful to the environment and living organisms.
    b. Sediment with concentrations between Freshwater Ecological PEC and TEC could be harmful to the environment and living organisms. Further analysis of the specific chemical impacts on specific organisms would be necessary to verify the impact to ecological health.

### Physical Properties

The sediment accumulated within Alewife Brook is primarily fine-grained. Samples AB1, AB2, AB3, & AB4 contained very fine-grained sediment (70-88% fines) and samples AB5 & AB6 were slightly more coarse (43 & 49% fines). These results align with our observations during the field sampling. Material of this composition is characteristic of a very hydrologically low energy environment, more typical of a lacustrine depositional setting (pond or lake) with fine grain sizes and high organic material indicating little downstream transport power. Alewife Brook functions as an impoundment due to the concrete channels, very low gradient, and backwatering effects of the Amelia Earhart Dam downstream on the Mystic River. The laboratory analyses also included total organic carbon, which provides one metric for evaluating the amount of organic material within the sediment. High TOC loads is highly correlated to low dissolved oxygen levels[18]. Total organic carbon ranged from 1-10% across the six samples, all of which are considered contaminated by drinking water standards[19]. More specific testing is necessary to quantify overall impacts on dissolved oxygen levels in the brook.

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16 310cmr40.pdf | Mass.gov

17 Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems (epa.gov)

18 Dissolved oxygen, total organic carbon and temperature relationships in southeastern U.S. coastal plain watersheds - ScienceDirect

19 Disinfectants and Disinfection Byproducts Rules (Stage 1 and Stage 2) What Do They Mean to You? (epa.gov)

**Total Metals**

The total metals testing showed sediment concentrations of lead elevated above the S1/GW1 human health thresholds in all samples. Concentrations for arsenic (samples AB1 through AB 4), chromium (AB1, AB3, AB4), and zinc (AB4) also exceeded the S1/GW1 human health threshold (see top of results section for full definition). Samples AB1, AB2, AB3 & AB4 were elevated above the Freshwater Ecological TEC thresholds for all heavy metals tested, while AB 5 & 6 were elevated above the Freshwater Ecological TEC thresholds for some but not all metals (Appendix 3).

**Per- and Polyfluoroalkyl substances (PFAS)**

The laboratory evaluated the sediment samples for 40 PFA substances and detected concentrations of some PFAS in all six (6) of these sediment samples (Appendix 3). MassDEP provides human health thresholds for six of the PFA substances[20], but not thresholds for the other PFAS substances. None of the six sediment samples showed concentrations of these parameters exceeding the S1/GW1 thresholds (see top of results section for full definition). The conversation around PFAS testing, evaluating, and disposal is rapidly evolving and state and federal guidance continues to evolve as well. At this time EPA recommends the destruction of sediment containing PFAS over human health thresholds, greatly increasing the costs of soil or sediment disposal[21]. Based on this current EPA guidance and our sediment contaminant results these sediments contain PFAS and will likely need to be disposed of through destruction protocols at select facilities.

**Polycyclic Aromatic Hydrocarbons (PAHs)**

PAH concentrations are elevated above the Freshwater Ecological PEC threshold for all six sediment samples with select PAHs above the Human Health MCP S1/GW1 thresholds in all samples except AB5 (Appendix 3).

**Polychlorinated Biphenyls (PCBs)**

The lab tested the six (6) sediment samples for PCBs. For total PCBs, Samples AB2 & AB6 both had concentrations above the Freshwater Ecological TEC threshold, and Samples AB1, AB3 & AB4 were above the Freshwater Ecological PEC concentration thresholds. AB5 was below all threshold levels for total PCBs.

# CONCLUSIONS

The sediment volume estimate and contaminant concentration results verified earlier studies completed over the last 30+ years. Specifically, there was a 1988 study where sediment cores were extracted and divided into top and bottom samples, and a 2005 USGS study where both sediment cores and grab samples were sampled. These different sampling methods should be considered when comparing to our sediment study results from composite core samples. The 1988 sediment contaminant study of the Little River and Alewife Brook also found sediment samples with elevated concentrations of PCBs, PAHs and

[20] 310cmr40.pdf | Mass.gov

[21] Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances (epa.gov)

Heavy Metals[22]. Total PAHs in the Alewife Brook sediment sample were in the range of 50,000 – 400,000 µg/kg, which is comparable to the 2024 Inter-Fluve sediment study finding concentrations ranging from 17,000 – 1,000,000 µg/kg. The 2005 USGS report also tested for PAHs and found levels similar to the 1988 and 2024 studies.[23] Heavy metals and PCBs were also elevated in 1988 with heavy metals elevated in 2005. Sediment concentrations in these earlier years were comparable to those found in 2024. The 2005 USGS study sampled the tops and bottoms or sediment cores and although both were contaminated the top portion had lower contaminant levels than the bottom of cores. We recognize there were differences in collection and testing protocols across the various study efforts, but overall the comparison of the results shows that this waterway has been contaminated since testing of Alewife Brook began. More testing is needed to verify if contaminants vary with depth due to changes in land use practices over the last 100 plus years.

Accumulated sediment was estimated at 18,500 cubic yards (CY) in the 2005 USGS report for Alewife Brook. This estimate is approximately 3,500 CY less than Inter-Fluve's 2024 estimate of 22,000 CY. This indicates an average annual increase of approximately 175 CY of material each year. Input sources include but are not limited to leaf litter, upstream inorganic and organic fluvial deposition, stormwater, and overland flow. The 2005 report does not state what defines the exact project boundaries (upstream, downstream and lateral extent) for the sediment volume estimate. Recognizing that the two estimates were done by different methods and potentially over a slightly different area, it is fair to consider that the Alewife Brook is continuing to accumulate sediment. More extensive sampling and contaminant testing is needed to verify how the contaminants are distributed across the impoundment and with depth.

We have evaluated two alternatives for managing the accumulated sediment within Alewife Brook: 1) do nothing, leaving the sediment in place; 2) active removal of the sediment and off-site disposal.

*Alternative 1: Leave Sediment in Place*

Alewife Brook is a heavily engineered stream that has been degrading in ecological health and function since it was first constructed out of the historical marshlands. Contaminants have become trapped in sediment that has accumulated in the channel bottom and contaminants continue to flow into Alewife Brook through the stormwater from the roads as well as the remaining CSOs. The habitat within the Alewife Brook corridor includes limited aquatic habitat within the water column and around the trees and branches that have fallen into the channel. Terrestrial habitat can be found in the narrow riparian buffer on either side of the stream where trees and shrubs grow, providing birds and other terrestrial animals places to forage, hide, nest, hunt, and sleep. The Do Nothing alternative would not remove the accumulated sediment. The status quo of a heavily modified stream channel with limited habitat would remain. The accumulated sediment would remain a potential health hazard to organisms and humans that disturb and interact with the sediment. This alternative would have no construction cost. While this

[22] sediment_study_combined_files.pdf (savethealewifebrook.org)
[23] USGS_2005_Sediment_Quality_report.pdf

alternative would do nothing to address the accumulated sediment, project partner time and resources could be spent working to eliminate the remaining CSOs and managing stormwater runoff. This effort would focus on elimination of further contamination, so that a future effort that includes sediment removal would not have contaminants immediately flowing into the stream.

*Alternative 2: Active Removal and Off-Site Disposal of impounded material.*

Active removal and off-site disposal of the accumulated sediment would include mechanical removal of some or all of the accumulated sediment through dredging or excavation and trucking of the sediment to a facility outside of Massachusetts that accepts this material. The benefit of this management alternative is the channel might have improved hydraulic capacity (pending results from study completed by others in July 2024). The additional space within the channel would provide additional area for aquatic organisms, such as fish and turtles, to survive, but it would not necessarily provide improved habitat or living conditions. CSOs and stormwater will still be conveying contaminant-laden water in Alewife Brook and a concrete-lined channel does not provide many habitat opportunities for fish or other aquatic organisms.

The financial cost of removing accumulated sediment will vary depending on the chosen extent of removal and the final determination regarding the disposal location. We discussed disposal options for contaminated sediment with construction contractors who have been disposing of similar sediment in recent years. While other disposal options outside of Massachusetts are likely available, the recommendations we received were for landfills in Canada and in Alabama. No landfills in Massachusetts or New England have the capacity or ability to store this type of material. We have summarized the approximate costs for excavating, trucking, and disposing of the material for a landfill in Canada (Table 7) and in Alabama (Table 8). We have broken the cost estimates down by excavation, trucking and disposal costs per cubic yard of material for each sub-reach and the total study reach.

For material not contaminated with PFAS, the total cost of removing all sediment is nearly $25 million, with a range of $3 to $12 million for individual sub-reach removal. If state and federal guidelines require treatment and disposal due to PFAS concentrations, the total costs escalate to approximately $80 million, with a range of $8 to $42 million for individual sub reaches. These costs are based on 2024 dollars, and escalation of approximately 8% should be assumed for each year after 2024 until the implementation occurs. The cost to complete studies, engineering designs, permitting, and construction observation could range between $500,000 and $1 million.

In addition to the cost of doing this work, other considerations should be evaluated.

- Access to Alewife Brook to remove the accumulated sediment will be challenging and could involve the removal of many trees, damaging the limited riparian buffer that currently exists. Careful consideration to limit this damage would be an important element of the design and planning phases.
- The impact of the work on the community could also be significant with construction traffic on already-busy roads. Typical 18-wheel tractor trailer dump trucks can carry approximately 18 cubic yards of soil. More than 320 of these trucks would be needed to remove just the 5,800 cubic yards of sediment from Section A (Route 2 to Massachusetts Ave).

- The impact of trucking the dredged material to an off-site location consumes a lot of diesel fuel and results in the release of fossil fuel pollution into the air. Consideration of this broader impact should be balanced with the evaluation of the benefits of local ecological uplift and community access.

The high cost and wide variance of disposal costs provides additional rationale to encourage more extensive sediment sampling and contaminant testing that would include sampling at different depths to provide insight to how contamination varies stratigraphically in the substrate. The combination of better lateral and vertical understanding of contaminant distribution within the impoundment reach will help clarify areas where dredging may be more beneficial and cost effective.

*Table 8. Disposal Cost Estimates in Canada for Sediment Impounded in Alewife Brook*

| **Option 1: Canada** | | | **Cost per sub-reach** | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **cost/ton** | **cost/CY** | **Sub-reach A** | **Sub-reach B** | **Sub-reach C** | **Sub-reach D** | **Total** | **Notes** |
| Excavation | $ 37.50 | $ 75 | $ 435,000 | $ 195,000 | $ 165,000 | $ 855,000 | $ 1,650,000 | Excavating material from channel (for all options). Assumed $25/ton with 20% mob/demob, 20% water control, and 10% site remediation/planting, etc. |
| Trucking | $ 270.00 | $ 540 | $ 3,132,000 | $ 1,404,000 | $ 1,188,000 | $ 6,156,000 | $ 11,880,000 | Transportation to Canada |
| Disposal Cost in Canada | $ 220.00 | $ 440 | $ 2,552,000 | $ 1,144,000 | $ 968,000 | $ 5,016,000 | $ 9,680,000 | Landfill Burial cost |
| Disposal Option 1: Disposal in landfill in Canada | $ 527.50 | $ 1,055 | $ 6,119,000 | $ 2,743,000 | $ 2,321,000 | $ 12,027,000 | $ 23,210,000 | Excavating, Transport and Disposal in Canada |

| **Option 2: Canada with PFAS treatment** | | | **Cost per sub-reach** | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **cost/ton** | **cost/CY** | **Sub-reach A** | **Sub-reach B** | **Sub-reach C** | **Sub-reach D** | **Sub-reach** | **Notes** |
| Excavation | $ 37.50 | $ 75 | $ 435,000 | $ 195,000 | $ 165,000 | $ 855,000 | $ 1,650,000 | Excavating material from channel (for all options). Assumed $25/ton with 20% mob/demob, 20% water control, and 10% site remediation/planting, etc. |
| Trucking | $ 270.00 | $ 540 | $ 3,132,000 | $ 1,404,000 | $ 1,188,000 | $ 6,156,000 | $ 11,880,000 | Transportation to Canada |
| Disposal Cost in Canada | $ 220.00 | $ 440 | $ 2,552,000 | $ 1,144,000 | $ 968,000 | $ 5,016,000 | $ 9,680,000 | Landfill Burial cost |
| EPA Recommended PFAS Destruction | $ 1,500.00 | $ 3,000 | $ 17,400,000 | $ 7,800,000 | $ 6,600,000 | $ 34,200,000 | $ 66,000,000 | Cost to Incinerate PFAS material in Canada |
| Disposal Option 2: Disposal in Canada and EPA Recommended PFAS Destruction | $ 1,807.50 | $ 3,615 | $ 20,967,000 | $ 9,399,000 | $ 7,953,000 | $ 41,211,000 | $ 79,530,000 | Excavating, Transport and PFAS destruction in Canada |

***Table 9. Disposal Cost Estimates in Alabama for Sediment Impounded in Alewife Brook***

| **Option 3: Alabama** | | | **Cost per sub-reach** | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **cost/ton** | **cost/CY** | **Sub-reach A** | **Sub-reach B** | **Sub-reach C** | **Sub-reach D** | **Total** | **Notes** |
| Excavation | $ 37.50 | $ 75 | $ 435,000 | $ 195,000 | $ 165,000 | $ 855,000 | $ 1,650,000 | Excavating material from channel (for all options). Assumed $25/ton with 20% mob/demob, 20% water control, and 10% site remediation/planting, etc. |
| Trucking | $ 320.00 | $ 640 | $ 3,712,000 | $ 1,664,000 | $ 1,408,000 | $ 7,296,000 | $ 14,080,000 | Transportation to Alabama |
| Disposal Cost in Alabama | $ 210.00 | $ 420 | $ 2,436,000 | $ 1,092,000 | $ 924,000 | $ 4,788,000 | $ 9,240,000 | Landfill Burial cost |
| Disposal Option 3: Disposal in landfill in Alabama | $ 567.50 | $ 1,135 | $ 6,583,000 | $ 2,951,000 | $ 2,497,000 | $ 12,939,000 | $ 24,970,000 | Excavating, Transport and Disposal in Alabama |

| **Option 4: Alabama with PFAS treatment** | | | **Cost per sub-reach** | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Item** | **cost/ton** | **cost/CY** | **Sub-reach A** | **Sub-reach B** | **Sub-reach C** | **Sub-reach D** | **Total** | **Notes** |
| Excavation | $ 37.50 | $ 75 | $ 435,000 | $ 195,000 | $ 165,000 | $ 855,000 | $ 1,650,000 | Excavating material from channel (for all options). Assumed $25/ton with 20% mob/demob, 20% water control, and 10% site remediation/planting, etc. |
| Trucking | $ 320.00 | $ 640 | $ 3,712,000 | $ 1,664,000 | $ 1,408,000 | $ 7,296,000 | $ 14,080,000 | Transportation to Alabama |
| Disposal Cost in Alabama | $ 210.00 | $ 420 | $ 2,436,000 | $ 1,092,000 | $ 924,000 | $ 4,788,000 | $ 9,240,000 | Landfill Burial cost |
| EPA Recommended PFAS Destruction | $ 1,500.00 | $ 3,000 | $ 17,400,000 | $ 7,800,000 | $ 6,600,000 | $ 34,200,000 | $ 66,000,000 | Cost to Incinerate PFAS material in Alabama |
| Disposal Option 4: Disposal in Alabama and EPA Recommended PFAS Destruction | $ 1,857.50 | $ 3,715 | $ 21,547,000 | $ 9,659,000 | $ 8,173,000 | $ 42,351,000 | $ 81,730,000 | Excavating, Transport and PFAS destruction in Alabama |

# Appendix 1: Alewife Brook Sediment Study: Geomorphic Reach Assessment Photos.

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*Figure 1. Reach A. Looking upstream at the Rt 2 Bridge with trees and shrubs growing on the concrete banks.*

*Figure 2. Reach A Looking upstream at the Route 2 bridge with fallen trees creating large wood habitat within the channel.*

*Figure 3. Reach A. Looking downstream at large wood fallen from the channel banks providing in-channel aquatic habitat.*

*Figure 4. Reach A. Combined Sewer Outflow (CSO) CAM401B just upstream of Massachusetts Ave.*

*Figure 5. Reach A. Looking downstream at the Massachusetts Ave. bridge.*

*Figure 6. Reach B. Looking downstream. Note the invasive Japanese knotweed growing on top of both concrete banks.*

*Figure 7. Reach B. Looking downstream at in-channel wood from fallen trees and branches.*

*Figure 8. Reach B. Somerville CSO,CAM001 river right.*

*Figure 9. Reach B. River right bank with stormwater drain. Throughout this reach, tree roots and topsoil overtop the concrete banks.*

*Figure 10. Reach B. Looking downstream towards the Cross St. bridge. Both banks are overgrown with the invasive Japanese knotweed.*

*Figure 11. Reach C. Looking upstream towards bridge at Cross St. The elevated boardwalk along Alewife Brook Parkway is seen in the top left.*

*Figure 12. Reach C. Looking downstream with a large downed tree and log jam river left and the elevated boardwalk along Alewife Brook Parkway in the top right.*

*Figure 13. Reach C. Looking downstream at the vertical concrete wall on the left below St. Paul's Cemetery and the vertical and overhanging concrete walls on river right. Note the trees growing out of cracks within the concrete walls on river right.*

*Figure 14. Reach C. Looking downstream towards a large fallen branch.*

*Figure 15. Reach C. Looking downstream towards the bridge at Broadway. Concrete walls line both sides of the channel throughout most of Reach C.*

*Figure 16. Reach D. Looking upstream towards the bridge at Broadway and river right bank. The stormwater drain on the river right bank is surrounded by concrete rip rap and the invasive Japanese knotweed.*

*Figure 17. Reach D. Looking upstream towards the bridge at Broadway with abundant in-channel large wood from trees fallen from the highly vegetated banks.*

*Figure 18. Reach D. Looking downstream towards river left at a stormwater drain and bank erosion.*

*Figure 19. Reach D. Looking upstream. The undercut banks and overhanging vegetation provide in-channel aquatic cover and habitat.*

*Figure 20. Reach D. Looking downstream toward the Mystic River Parkway and confluence with the Mystic River.*

# Appendix 2: Alewife Brook Sediment Study: Depth of Refusal Survey & Sediment Sampling Photos

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*Figure 1. Reach A, looking downstream. Measuring the depth to refusal in the channel using a flexible probing rod.*

*Figure 2. Reach B, looking downstream. Measuring the bed elevation using RTK-GPS survey equipment.*

*Figure 3. Reach C, looking toward river right. Measuring depth to refusal and sediment thickness using the RTK-GPS and probing rod.*

*Figure 4. Reach D, looking toward river left. Measuring the bed elevation at river right next to a downed tree limb.*

*Figure 5. Reach D, looking upstream. Collecting sediment for Sample AB6 using sediment coring tools.*

*Figure 6. AB1 sediment sample.*

*Figure 7. Sediment core for sample AB2 upstream of Rt. 2.*

*Figure 8. Sediment sample AB2.*

*Figure 9. Reach B. Sediment core extracted for Sample AB3.*

*Figure 10. Sediment sample AB3.*

*Figure 11. Sediment core extracted for Sample AB4.*

*Figure 12. Sediment sample AB4.*

*Figure 13. Sediment sample AB5.*

*Figure 14. Sediment core extracted for AB6.*

*Figure 15. Sediment sample AB6.*

Appendix 3: Laboratory results of contaminant concentrations for six sediment samples.

| Analysis | Units | Method ID | 310CMR40, Table 2: Human Health MCP S1/GW1 | Freshwater Ecological TEC | Freshwater Ecological PEC | TCLP | AB1 | AB2 | AB3 | AB4 | AB5 | AB6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Metals** | | | | | | | | | | | | |
| Arsenic, Total | mg/kg | 6020B | 20.0 | 9.8 | 33.0 | 100.0 | 59.2 | 31.1 | 83.1 | 125 | 4.72 | 11.1 |
| Cadmium, Total | mg/kg | 6020B | 70.0 | 1.0 | 5.0 | 20.0 | 3.67 | 1.96 | 3.54 | 7.34 | 0.899 | 0.813 |
| Chromium, Total | mg/kg | 6020B | 100.0 | 43.4 | 111.0 | 100.0 | 123 | 65.5 | 429 | 1560 | 20.9 | 44.2 |
| Copper, Total | mg/kg | 6020B | NC | 31.6 | 149.0 | | 182 | 131 | 402 | 1340 | 47.9 | 80.3 |
| Lead, Total | mg/kg | 6020B | 200.0 | 35.8 | 128.0 | 100.0 | 491 | 568 | 563 | 1300 | 201 | 295 |
| Mercury, Total | mg/kg | 7474 | 20.0 | 0.2 | 1.1 | 4.0 | 7.59 | 1.46 | 2.59 | 5.14 | 0.565 | 0.974 |
| Nickel, Total | mg/kg | 6020B | 600.0 | 22.7 | 48.6 | | 39.6 | 24.4 | 37.5 | 54 | 14.6 | 13 |
| Zinc, Total | mg/kg | 6020B | 1,000.0 | 121.0 | 459.0 | | 793 | 548 | 601 | 1180 | 263 | 221 |
| **VOCs** | | | | | | | | | | | | |
| Tetrachloroethene | ug/kg | 8260D | | | | | 0.0001 | 2.6 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Chlorobenzene | ug/kg | 8260D | | | | | 1.1J | 0.0001 | 0.89J | 5.3 | 4.1 | 0.0001 |
| Toluene | ug/kg | 8260D | 40.0 | 4.5 | 4.5 | | 0.0001 | 0.0001 | 6.1 | 0.0001 | 0.0001 | 0.0001 |
| Ethylbenzene | ug/kg | 8260D | 30.0 | NC | NC | | 0.0001 | 0.0001 | 0.44J | 0.95J | 0.0001 | 0.0001 |
| 1,2-Dichlorobenzene | ug/kg | 8260D | | | | | 6.7J | 1.6J | 3.8J | 16 | 0.0001 | 0.32J |
| 1,3-Dichlorobenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 0.50J | 2.4J | 0.0001 | 0.0001 |
| 1,4-Dichlorobenzene | ug/kg | 8260D | | | | | 1.6J | 0.74J | 1.3J | 9.9J | 1.0J | 0.40J |
| p/m-Xylene | ug/kg | 8260D | 400.0 | NC | NC | | 0.0001 | 1.3J | 2.0J | 0.0001 | 0.0001 | 0.0001 |
| o-Xylene | ug/kg | 8260D | 400.0 | NC | NC | | 1.8J | 0.62J | 2.3J | 4.1J | 0.0001 | 0.0001 |
| Xylenes, Total | ug/kg | 8260D | | | | | 1.8J | 1.9J | 4.3J | 4.1J | 0.0001 | 0.0001 |
| cis-1,2-Dichloroethene | ug/kg | 8260D | | | | | 0.0001 | 0.37J | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| 1,2-Dichloroethene, Total | ug/kg | 8260D | | | | | 0.0001 | 0.37J | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Acetone | ug/kg | 8260D | | | | | 410 | 660E | 320 | 260 | 29J | 170 |
| Carbon disulfide | ug/kg | 8260D | | | | | 0.0001 | 11J | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| 2-Butanone | ug/kg | 8260D | | | | | 110 | 170 | 80 | 65 | 6.3J | 46 |
| n-Butylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 1.2J | 5.2J | 0.0001 | 0.0001 |
| sec-Butylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 1.5J | 5.3J | 0.0001 | 0.0001 |
| tert-Butylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 0.53J | 2.3J | 0.0001 | 0.18J |
| Isopropylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 0.80J | 1.2J | 0.0001 | 0.17J |
| p-Isopropyltoluene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 1.4J | 1.0J | 0.0001 | 0.0001 |
| Naphthalene | ug/kg | 8260D | | | | | 4.8J | 2.0J | 2.2J | 9.2J | 0.0001 | 0.0001 |
| n-Propylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 0.77J | 0.0001 | 0.0001 | 0.0001 |
| 1,3,5-Trimethylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 0.78J | 1.3J | 0.0001 | 0.0001 |
| 1,2,4-Trimethylbenzene | ug/kg | 8260D | | | | | 0.0001 | 0.0001 | 2.3J | 4.0J | 0.0001 | 0.63J |
| 1,2-Dichloroethane-d4 | % | 8260D | | | | | 107 | 107 | 112 | 109 | 113 | 113 |
| Toluene-d8 | % | 8260D | | | | | 98 | 97 | 107 | 109 | 99 | 99 |
| 4-Bromofluorobenzene | % | 8260D | | | | | 113 | 125 | 128 | 141 | 104 | 112 |
| Dibromofluoromethane | % | 8260D | | | | | 104 | 103 | 100 | 98 | 101 | 100 |
| **PFAs** | | | | | | | | | | | | |
| Perfluorooctanoic Acid (PFOA) | ug/kg | 1633 | 0.72 | | | | 0.073J | 0.0001 | 0.0001 | 0.090J | 0.0001 | 0.0001 |
| Perfluorooctanesulfonic Acid (PFOS) | ug/kg | 1633 | 2 | | | | 0.199J | 0.146J | 0.144J | 0.228J | 0.0001 | 0.0001 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA) | ug/kg | 1633 | | | | | 0.722 | 0.116J | 0.538 | 0.617 | 0.0001 | 0.170J |
| Perfluorodecanesulfonic Acid (PFDS) | ug/kg | 1633 | | | | | 0.255 | 0.0001 | 0.033J | 0.318 | 0.071J | 0.148J |
| Perfluorooctanesulfonamide (PFOSA) | ug/kg | 1633 | | | | | 0.147J | 0.0001 | 0.0001 | 0.195J | 0.0001 | 0.0001 |
| N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA) | ug/kg | 1633 | | | | | 1.64 | 1.46 | 1.72 | 1.72 | 0.153J | 0.543 |
| Perfluorododecanoic Acid (PFDoA) | ug/kg | 1633 | | | | | 0.081J | 0.0001 | 0.0001 | 0.099J | 0.057J | 0.0001 |
| Perfluorotridecanoic Acid (PFTrDA) | ug/kg | 1633 | | | | | 0.081J | 0.0001 | 0.0001 | 0.084J | 0.0001 | 0.0001 |
| N-Ethyl Perfluorooctane Sulfonamide (NEtFOSA) | ug/kg | 1633 | | | | | 0.0001 | 0.0001 | 0.112J | 0.0001 | 0.0001 | 0.0001 |
| **PAHs** | | | | | | | | | | | | |
| Naphthalene | ug/kg | 8270E-SIM/680(M) | 4,000 | 176.0 | 561.0 | | 12,600 | 8,800 | 260 | 655 | 68 | 380 |
| 2-Methylnaphthalene | ug/kg | 8270E-SIM/680(M) | 700 | NC | NC | | 6,530 | 4,760 | 214 | 519 | 40 | 193 |
| Acenaphthylene | ug/kg | 8270E-SIM/680(M) | 1,000 | | | | 746 | 1,290 | 214 | 432 | 64 | 582 |
| Acenaphthene | ug/kg | 8270E-SIM/680(M) | 4,000 | | | | 18,000 | 11,600 | 375 | 1,240 | 96 | 783 |
| Fluorene | ug/kg | 8270E-SIM/680(M) | 1,000,000 | 77.4 | 536.0 | | 21,900 | 20,500E | 464 | 1,550 | 75 | 1,290 |
| Phenanthrene | ug/kg | 8270E-SIM/680(M) | 10,000 | 204.0 | 1,170.0 | | 138,000E | 123,000E | 4,300 | 12,800 | 2,180E | 10,200E |
| Anthracene | ug/kg | 8270E-SIM/680(M) | 1,000,000 | 57.2 | 845.0 | | 24,400E | 30,500E | 832 | 2,900 | 260 | 2,480 |
| Fluoranthene | ug/kg | 8270E-SIM/680(M) | 1,000,000 | 423.0 | 2,230.0 | | 141,000E | 108,000E | 7,040 | 17,600 | 3,110E | 16,400E |
| Pyrene | ug/kg | 8270E-SIM/680(M) | 1,000,000 | 195.0 | 1,520.0 | | 122,000E | 99,800E | 6,580 | 17,300 | 2,830E | 15,800E |
| Benz(a)anthracene | ug/kg | 8270E-SIM/680(M) | 7,000 | 108.0 | 1,050.0 | | 105,000E | 79,200E | 3,610 | 9,350 | 1,430E | 10,100E |
| Chrysene | ug/kg | 8270E-SIM/680(M) | 70,000 | 166.0 | 1,290.0 | | 58,800E | 38,500E | 3,830 | 8,660 | 1,590E | 7320E |
| Benzo(b)fluoranthene | ug/kg | 8270E-SIM/680(M) | 7,000 | 27.3 | 13,400.0 | | 100,000E | 65,300E | 4,240 | 8,710 | 1,780E | 9,920E |
| Benzo(k)fluoranthene | ug/kg | 8270E-SIM/680(M) | 70,000 | | | | 36,700E | 19,200E | 2,250 | 6,960 | 844 | 4,020 |
| Benzo(a)pyrene | ug/kg | 8270E-SIM/680(M) | 2,000 | 150.0 | 1,450.0 | | 55,400E | 35,000E | 3,240 | 7,440 | 1,270E | 6,040E |
| I.0001eno(1,2,3-cd)Pyrene | ug/kg | 8270E-SIM/680(M) | 7,000 | | | | 29,800E | 24,200E | 2,470 | 5,930 | 925 | 4,440 |
| Dibenz(a,h)anthracene | ug/kg | 8270E-SIM/680(M) | 700 | 33.0 | 260.0 | | 7,480 | 4,490 | 531 | 1,110 | 216 | 903 |
| Benzo(ghi)perylene | ug/kg | 8270E-SIM/680(M) | 1,000,000 | | | | 29100E | 28400E | 2,600 | 6,070 | 930 | 4,460 |
| **PCBs** | | | | | | | | | | | | |
| Cl2-BZ#8 | ug/kg | 8270E-SIM/680(M) | | | | | 0.0001 | 0.0001 | 6.95 | 36.3 | 0.0001 | 1.37J |
| Cl3-BZ#18 | ug/kg | 8270E-SIM/680(M) | | | | | 66.2 | 12.8 | 33.7 | 144 | 1.85 | 9.64 |
| Cl3-BZ#28 | ug/kg | 8270E-SIM/680(M) | | | | | 72.1 | 14.9 | 63.7 | 217 | 1.81 | 18.2 |
| Cl4-BZ#44 | ug/kg | 8270E-SIM/680(M) | | | | | 29.4 | 18 | 33.7 | 104 | 0.771 | 6.44 |
| Cl4-BZ#49 | ug/kg | 8270E-SIM/680(M) | | | | | 40.5 | 16.4 | 24.4 | 73.2 | 0.695 | 3.8 |
| Cl4-BZ#52 | ug/kg | 8270E-SIM/680(M) | | | | | 109 | 84.9 | 88.6 | 216 | 3.38 | 21 |
| Cl4-BZ#66 | ug/kg | 8270E-SIM/680(M) | | | | | 47.5 | 28.8 | 27.4 | 110 | 1.33 | 13.1 |
| Cl5-BZ#87 | ug/kg | 8270E-SIM/680(M) | | | | | 25.1 | 25.3 | 27.8 | 52.6 | 1.14 | 4.34 |
| Cl5-BZ#101 | ug/kg | 8270E-SIM/680(M) | | | | | 83.1 | 71 | 62.2 | 137 | 2.11 | 12.2 |
| Cl5-BZ#105 | ug/kg | 8270E-SIM/680(M) | | | | | 19.6 | 17.2 | 32.7 | 62.5 | 0.0001 | 0.0001 |
| Cl5-BZ#118 | ug/kg | 8270E-SIM/680(M) | | | | | 60 | 40.9 | 62.6 | 106 | 2.44 | 8.3 |
| Cl6-BZ#128 | ug/kg | 8270E-SIM/680(M) | | | | | 34.9 | 11.2 | 22.4 | 30.5 | 0.0001 | 0.0001 |
| Cl6-BZ#138 | ug/kg | 8270E-SIM/680(M) | | | | | 46.9 | 62.6 | 69.3 | 168 | 3.8 | 12.7 |
| Cl6-BZ#153 | ug/kg | 8270E-SIM/680(M) | | | | | 42 | 39.9 | 50.4 | 108 | 1.94 | 8.18 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cl7-BZ#170 | ug/kg | 8270E-SIM/680(M) | | | | | 19.7 | 14.5 | 24.9 | 48.5 | 1.19 | 0.0001 |
| Cl7-BZ#180 | ug/kg | 8270E-SIM/680(M) | | | | | 27.2 | 23.4 | 40.4 | 88.4 | 1.69 | 4.99 |
| Cl7-BZ#183 | ug/kg | 8270E-SIM/680(M) | | | | | 0.0001 | 5.30J | 10.7 | 21 | 0.367J | 0.0001 |
| Cl7-BZ#187 | ug/kg | 8270E-SIM/680(M) | | | | | 17.4 | 15.8 | 27.1 | 62.2 | 0.691 | 2.45J |
| Cl8-BZ#195 | ug/kg | 8270E-SIM/680(M) | | | | | 0.0001 | 0.0001 | 6.78 | 15.4 | 0.0001 | 0.0001 |
| Cl9-BZ#206 | ug/kg | 8270E-SIM/680(M) | | | | | 15.8 | 12.8 | 13.6 | 17 | 0.430J | 0.0001 |
| Cl10-BZ#209 | ug/kg | 8270E-SIM/680(M) | | | | | 12.6 | 14 | 5.7 | 7.41J | 0.361J | 1.47J |
| Total PCBs | ug/kg | | 2,000.0 | 59.8 | 676.0 | | 769 | 524 | 735 | 1818 | 25 | 123 |
| 2-Methylnaphthalene-d10 | % | 8270E-SIM/680(M) | | | | | 66 | 73 | 59 | 67 | 66 | 59 |
| Pyrene-d10 | % | 8270E-SIM/680(M) | | | | | 73 | 85 | 69 | 76 | 77 | 75 |
| Benzo(b)fluoranthene-d12 | % | 8270E-SIM/680(M) | | | | | 67 | 71 | 63 | 69 | 70 | 70 |
| DBOB | % | 8270E-SIM/680(M) | | | | | 63 | 74 | 70 | 74 | 75 | 74 |
| BZ 198 | % | 8270E-SIM/680(M) | | | | | 95 | 109 | 93 | 102 | 88 | 108 |
| **EPHs** | | | | | | | | | | | | |
| TPH (C10-C36) | ug/kg | 8015D(M) | | | | | 1,410,000 | 1,920,000 | 738,000 | 2,300,000 | 3,340,000 | 1,690,000 |
| o-Terphenyl | % | 8015D(M) | | | | | 70 | 85 | 88 | 92 | 99 | 97 |
| C9-C18 Aliphatics | mg/kg | EPH-19-2.1 | 1,000.0 | NC | NC | | 381 | 135 | 108 | 161 | 0.0001 | 47.3 |
| C19-C36 Aliphatics | mg/kg | EPH-19-2.1 | 3,000.0 | NC | NC | | 1440 | 478 | 342 | 767 | 49.9 | 316 |
| C11-C22 Aromatics | mg/kg | EPH-19-2.1 | NC | NC | NC | | 1060 | 1080 | 159 | 241 | 57.1 | 246 |
| C11-C22 Aromatics, Adjusted | mg/kg | EPH-19-2.1 | 1,000.0 | NC | NC | | 885 | 777 | 146 | 218 | 47.2 | 194 |
| Chloro-Octadecane | % | EPH-19-2.1 | | | | | 58 | 51 | 43 | 43 | 53 | 54 |
| o-Terphenyl | % | EPH-19-2.1 | | | | | 65 | 96 | 53 | 48 | 55 | 65 |
| 2-Fluorobiphenyl | % | EPH-19-2.1 | | | | | 70 | 101 | 74 | 70 | 66 | 75 |
| 2-Bromonaphthalene | % | EPH-19-2.1 | | | | | 73 | 101 | 75 | 71 | 68 | 77 |
| **Physical Properties** | | | | | | | | | | | | |
| Solids, Total | % | 2540G | | | | | 33.8 | 50.8 | 43.6 | 28.1 | 60 | 70.4 |
| Total Organic Carbon (Rep1) | % | 9060A | | | | | 10.1 | 6.68 | 6.47 | 9.28 | 1.27 | 1.96 |
| Total Organic Carbon (Rep2) | % | 9060A | | | | | 9.81 | 6.25 | 6.67 | 9.15 | 1.19 | 2.38 |
| Total Organic Carbon (Average) | % | 9060A | | | | | 9.94 | 6.47 | 6.57 | 9.21 | 1.23 | 2.17 |
| Moisture | % | 2540G | | | | | 66.2 | 49.2 | 56.4 | 71.9 | 40 | 29.6 |
| Cobbles | % | D6913/D7928 | | | | | | | | | | |
| % Coarse Gravel | % | D6913/D7928 | | | | | | | | | | |
| % Fine Gravel | % | D6913/D7928 | | | | | | | | | | 1 |
| % Coarse Sa.0001 | % | D6913/D7928 | | | | | | 1 | | 1 | 2 | 3 |
| % Medium Sa.0001 | % | D6913/D7928 | | | | | 2 | 8 | 5 | 2 | 30 | 21 |
| % Fine Sa.0001 | % | D6913/D7928 | | | | | 18 | 17 | 25 | 9 | 25 | 26 |
| % Total Fines | % | D6913/D7928 | | | | | 80 | 74 | 70 | 88 | 43 | 49 |