PHOSPHORUS CONTROL PLAN (PCP)
CITY OF CAMBRIDGE

DRAFT: June 30, 2023
Revised: September 26, 2023

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PHOSPHORUS CONTROL PLAN (PCP)

1 PHASE 1

The 2016 National Pollutant Discharge Elimination System General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4) in Massachusetts ("MS4 Permit" or "the Permit") took effect on July 1, 2018. The Permit was subsequently modified on December 7, 2020. The MS4 Permit conditions the operation, regulation, and management of MS4s in subject Massachusetts municipalities. Terms and conditions include requirements across six Minimum Control Measures (also referred to as Maximum Extent Practicable or MEP provisions), and water quality-based effluent limitations (WQBEL), including requirements for waterbodies with approved Total Maximum Daily Loads (TMDLs) and other water quality-limited waters.

There are two approved nutrient TMDLs for the Charles River; one for the Lower Charles River Basin, published in 2007[1], and one for the Upper/Middle Charles River Basin, published in 2011[2]. As an element of the Permit's WQBEL provisions, communities within the Charles River watershed are obligated to address phosphorus impairments through the development and implementation of a Phosphorus Control Plan (PCP). Appendix F of the MS4 Permit describes specific requirements of the PCP, implementation of which is anticipated to achieve the TMDL-established targeted phosphorus reductions over a 20-year timeframe. PCP implementation includes structural and non-structural best management practices (BMPs) executed through programs, projects, and policies. The PCP must be fully implemented within 20 years of the Permit effective date (i.e., by 2038), as illustrated in Table 1-1. The targeted phosphorus reductions are broken out into interim mandatory milestones, culminating in achievement of the allowable TMDL phosphorus loads for each municipality at the end of the 20-year schedule.

Table 1-1. General PCP Implementation Timeline for Charles River Watershed Communities

1-5 years after permit effective date [2018-2023]	5-10 years after permit effective date [2023-2028]	10-15 years after permit effective date [2028-2033]	15-20 years after permit effective date [2033-2038]
Create Phase 1 Plan	Implement Phase 1 Plan		
	Create Phase 2 Plan	Implement Phase 2 Plan	
		Create Phase 3 Plan	Implement Phase 3 Plan

[1] *Massachusetts Department of Environmental Protection. 2007. Final TMDL for Nutrients in the Lower Charles River Basin. CN 301.1*

[2] *Massachusetts Department of Environmental Protection. 2011. Total Maximum Daily Load for Nutrients in the Upper/Middle Charles River Basin, Massachusetts. CN 272.0*

1.1 OVERVIEW OF ALL PCP PHASE 1 MILESTONES

Phase 1 of the PCP must achieve the first 25% of the City's phosphorus load reduction requirement within 10 years (i.e., by June 30, 2028), with an interim milestone of achieving the first 20% of phosphorus load reduction by Year 8 (i.e., by June 30, 2026). The detailed components of the PCP due within Phase 1 are outlined in Table 1-2.

Table 1-2. Phase 1 Component Deadlines

Permit Year #	Year-End (June 30th)	PCP Component(s) Due
Year 1	2019	N/A
Year 2	2020	Legal Analysis
Year 3	2021	Funding Source Assessment
Year 4	2022	PCP Scope
Year 5	2023	Descriptions of the following Phase 1 items: - Nonstructural controls - Structural controls - O&M program for structural controls - Implementation schedule - Phase 1 cost estimate - Written Phase 1 PCP
Year 6	2024	Performance Evaluation - Full implementation of nonstructural controls
Year 7	2025	Performance Evaluation
Year 8	2026	Performance Evaluation & Implementation of structural controls to achieve 20% of target phosphorus reduction
Year 9	2027	Performance Evaluation
Year 10	2028	Performance Evaluation & Implementation of structural controls to achieve 25% of target phosphorus reduction

1.2 WATERSHED AND COMMUNITY CHARACTERIZATION

The Charles River collects water from a total land area of 308 square miles. The Charles twists and turns on an 80-mile route from Hopkinton to Boston Harbor. The Charles flows through 23 communities and the total watershed encompasses 35 communities, adding many political complexities to watershed management. Some 80 brooks and streams, and several major aquifers, feed the Charles River. The watershed contains many lakes and ponds, most of them manmade, many through the construction of dams. The river drops about 350 feet in its unhurried journey to the sea. Lacking speed and force, the slow-moving Charles River is naturally brownish in color, because the water steeps like tea through the abundant wetlands along its path.

The Charles River watershed is home to over a million residents. As an urban river, it is impaired by multiple pollutants and has many areas with altered and degraded habitat. Three Total Maximum Daily Loads (TMDLs) have been developed for the watershed: two for nutrients and one for bacteria. The Charles has borne the brunt of much of the development in the greater Boston area through damming, pollution, and disruption from traditional development practices. A nearly five-decade cleanup effort has resulted in water quality improvements, primarily from elimination of industrial discharges and a significant reduction in untreated sewage flowing into the Charles. The primary challenge facing the Charles today is stormwater runoff. Phosphorus loading in stormwater runoff is a particular challenge to the river, leading to summertime cyanobacteria blooms and overgrowth of invasive aquatic plants in many areas of the watershed.

The City of Cambridge is subject to the Massachusetts Department of Environmental Protection's (MassDEP) 2007 Final TMDL for Nutrients in the Lower Charles River Basin. The regional context of Cambridge within the watershed is shown in Figure 1-1 below. About two-thirds of Cambridge lies within the Charles River Watershed. The City of Cambridge is approximately 7.1 square miles and is located in Middlesex County; bordered by Somerville, Arlington, Watertown, Belmont and across the Charles River from the City of Boston. The Charles River (segments MA 72-38 and MA 72-36) forms the southeastern border of the City. The population as of July 1, 2021 was 117,090[3].

The City of Cambridge was issued an NPDES permit (Permit ID # MAR041076) to discharge stormwater from its MS4, and is therefore additionally subject to specific phosphorus reduction requirements in the MS4 Permit detailed in Permit Appendix F, Part A.I.

[3] *QuickFacts Cambridge City, Middlesex County, Massachusetts." U.S. Census Bureau,* https://www.census.gov/quickfacts/fact/table/cambridgecitymassachusetts,US/PST045221

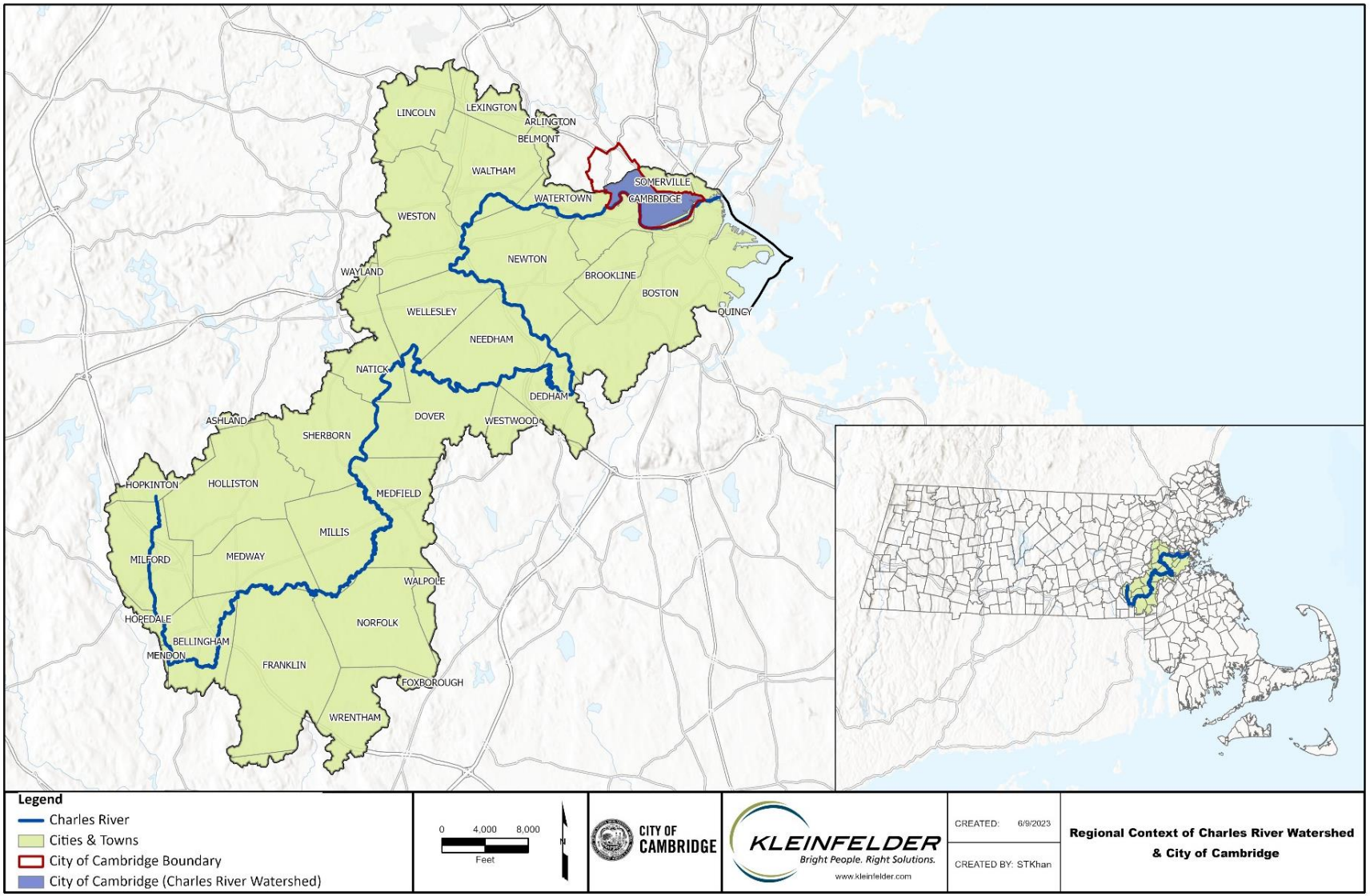

Figure 1-1: Regional Context of the City of Cambridge and the Charles River Watershed.

1.3 PCP LOAD REDUCTION TARGETS

Permit Requirement: *The permittee shall indicate the area in which it plans to implement the PCP. The permittee must choose one of the following: (1) to implement its PCP in the entire area within its jurisdiction (for municipalities this would be the municipal boundary) within the Charles River Watershed; or (2) to implement its PCP only in the urbanized area portion of the permittee's jurisdiction within the Charles River Watershed. The implementation area selected by the permittee is known as the "PCP Area" for that permittee. … The permittee shall select the Baseline Phosphorus Load, Stormwater Phosphorus Reduction Requirement and Allowable Phosphorus Load that corresponds to the PCP Area selected. The selected Stormwater Phosphorus Reduction Requirement and Allowable Phosphorus Load will be used to determine compliance with PCP milestones of this Phase and Phase 2 and Phase 3.*

1.3.1 PCP Area, Baseline Phosphorus Load, Allowable Phosphorus Load, and Stormwater Phosphorus Reduction Requirement from MS4 Permit

Within Cambridge, the entire Charles River watershed is completely within the urbanized area, therefore Cambridge will be implementing its PCP in the entire area within its jurisdiction. The Allowable Phosphorus Load reported in Appendix F of the MS4 permit determined by EPA for the area of Cambridge within the Charles River watershed is shown in Table 1-3 along with the corresponding Year 8 and Year 10 reduction requirements.

Table 1-3. PCP Timeline of Phase 1 Reduction Requirements

Condition	From Permit[4] (lbs/year)
Baseline Phosphorus Load (2005)	1,129
Allowable Phosphorus Load (2005)	430
Stormwater Phosphorus Load Reduction Requirement (62% Total Reduction)	699
Year 8 Milestone: 20% of Reduction (2026)	139.8
Year 10 Milestone: 25% of Reduction (2028)	174.8

1.3.2 Development of PCP Implementation Area

The City of Cambridge has both combined sewer areas and separated sewer areas. The City's combined sewers convey sanitary sewage and stormwater runoff and do not discharge to the Charles River except during overflow conditions. Therefore, the combined sewer areas in Cambridge are not regulated under the MS4 Permit and are generally not included in the PCP implementation area, with the exception of combined areas included by EPA in their baseline load calculations. The City included these combined

[4] *USEPA, General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts. Appendix F. issued April 4, 2016.*

areas, which were historically identified as areas planned for separation at the time of TMDL development, in the PCP implementation area to be consistent with EPA's baseline load calculations. Although Appendix F of the permit allows permittees to demonstrate compliance with their phosphorus reduction requirements on discharges that occur outside their regulated area, the City is not currently including credits for BMPs in these areas. These areas currently operate as combined sewer areas, and the City is not calculating or including phosphorus reduction credits for the existing or planned activities within these areas for the Phase 1 PCP. When these areas are separated, credits from non-structural and structural BMPs will be calculated and incorporated into this PCP. If additional areas are separated in the City, beyond those previously identified, the City will add 100% of the load from these areas to the City's allowable load and applicable credits from non-structural and structural controls in these areas will be incorporated at that time.

The City reviewed EPA[5]'s map depicting combined and separated areas developed as part of the Charles River Phosphorus TMDL in August 2013. This map details the areas that were assumed to be included in EPA's baseline load calculation for Cambridge. The City determined that EPA included separated sewer areas as well as some combined areas identified as planned for future separation.

During this review, the City also determined there are separated areas within Cambridge that were not included in EPA's baseline load calculation. Because these areas are fully separated, they are subject to MS4 Permit requirements and were included in the PCP Implementation Area. Figure 1-2 illustrates the areas included by EPA in baseline load calculations and the current separated areas in the City.

[5] *USEPA, Combined Sewer Areas Cambridge & Boston, Massachusetts, Charles River Watershed, August 15, 2013.*

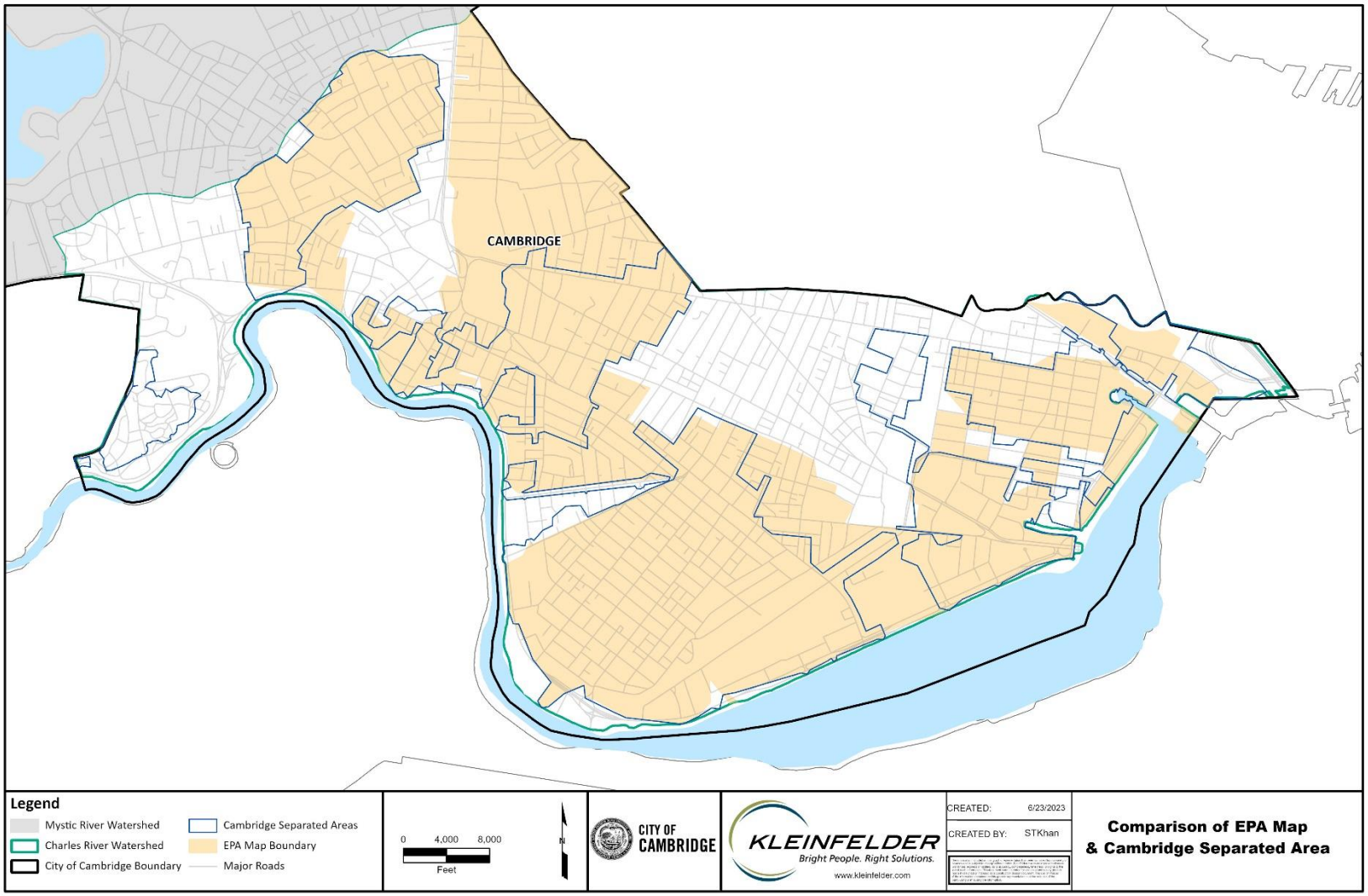

Figure 1-2: Comparison of EPA Baseline Area and City of Cambridge Separated Areas within the Charles River Watershed

To be consistent with EPA baseline load calculations, the final PCP implementation area (Figure 1-3) is a combination (union) of:

1. Areas assumed to be included by EPA in baseline load calculations, and
2. Separated areas in the City of Cambridge.

In addition, the City reviewed the Department of Conservation and Recreation (DCR) properties within Cambridge and removed these areas from the Cambridge PCP Implementation Area. DCR properties within Cambridge will be addressed under DCR's PCP as required by the MS4 Permit.

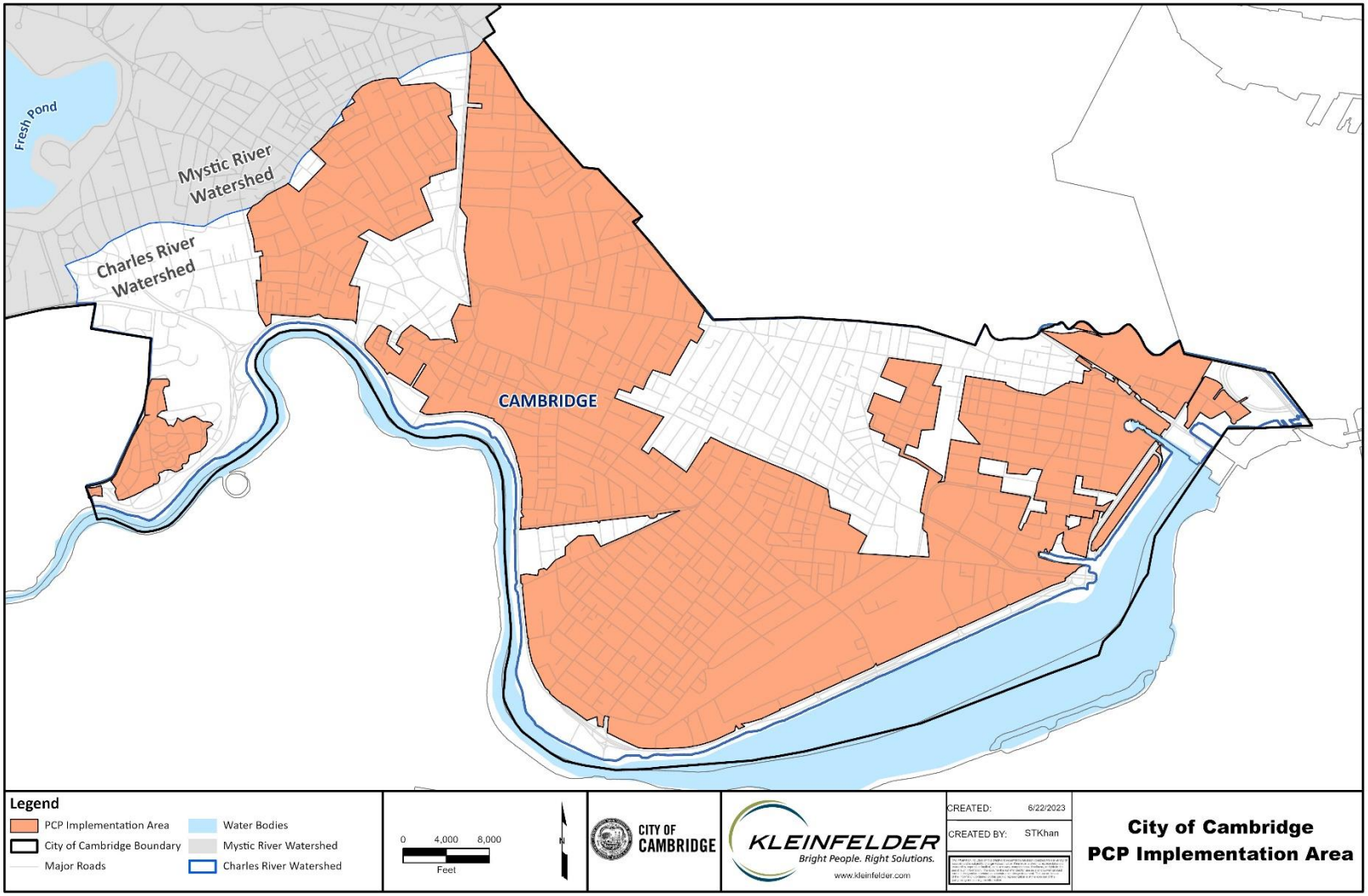

Figure 1-3: PCP Implementation Area within the Charles River Watershed

For consistency, the combined areas included by EPA in baseline load calculations were included in the PCP implementation area. However, since these areas are still combined, no credits from existing or planned non-structural and structural controls were included in Phase 1 of this PCP. As these areas are separated, credits from non-structural and structural controls will be incorporated into this PCP.

Figure 1-4 describes the approach to calculating loads and phosphorus credits under different scenarios encountered during the development of the PCP implementation area.

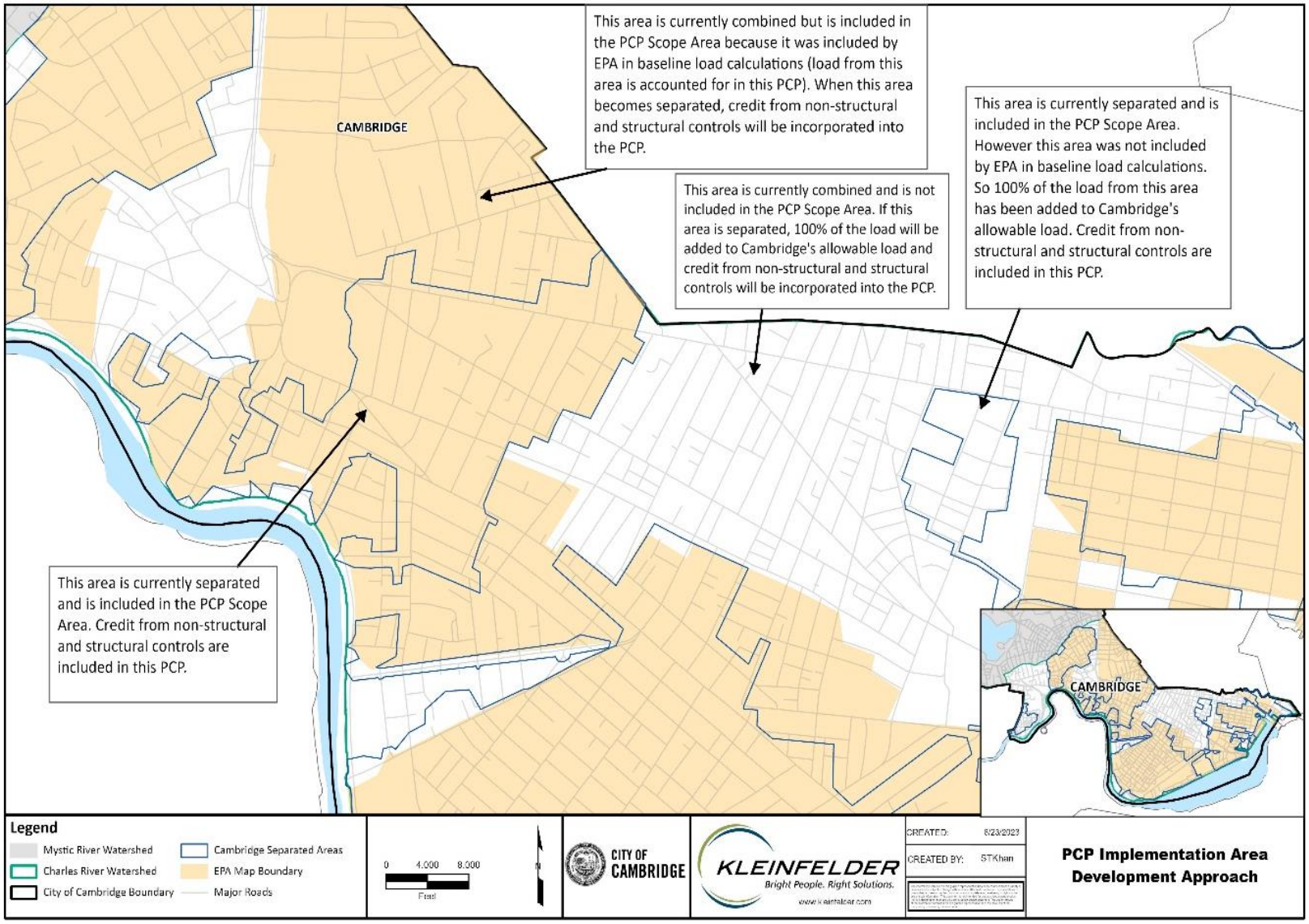

Figure 1-4: PCP Implementation Area Methodology

1.3.3 Increases or Decreases to Baseline Phosphorus Load Since 2005

The Baseline Load displayed in Table 1-3 was calculated by EPA using land use data from 2005. Due to development in Cambridge, the current phosphorus load has changed, and a reassessment of the current load is warranted. A new Land Cover/Land Use dataset for 2021 was issued by the Charles River Watershed Association (CRWA) on June 29, 2023. The City is currently using this layer to re-evaluate the current phosphorous load. The new land use data is presented in Figure 1-5.

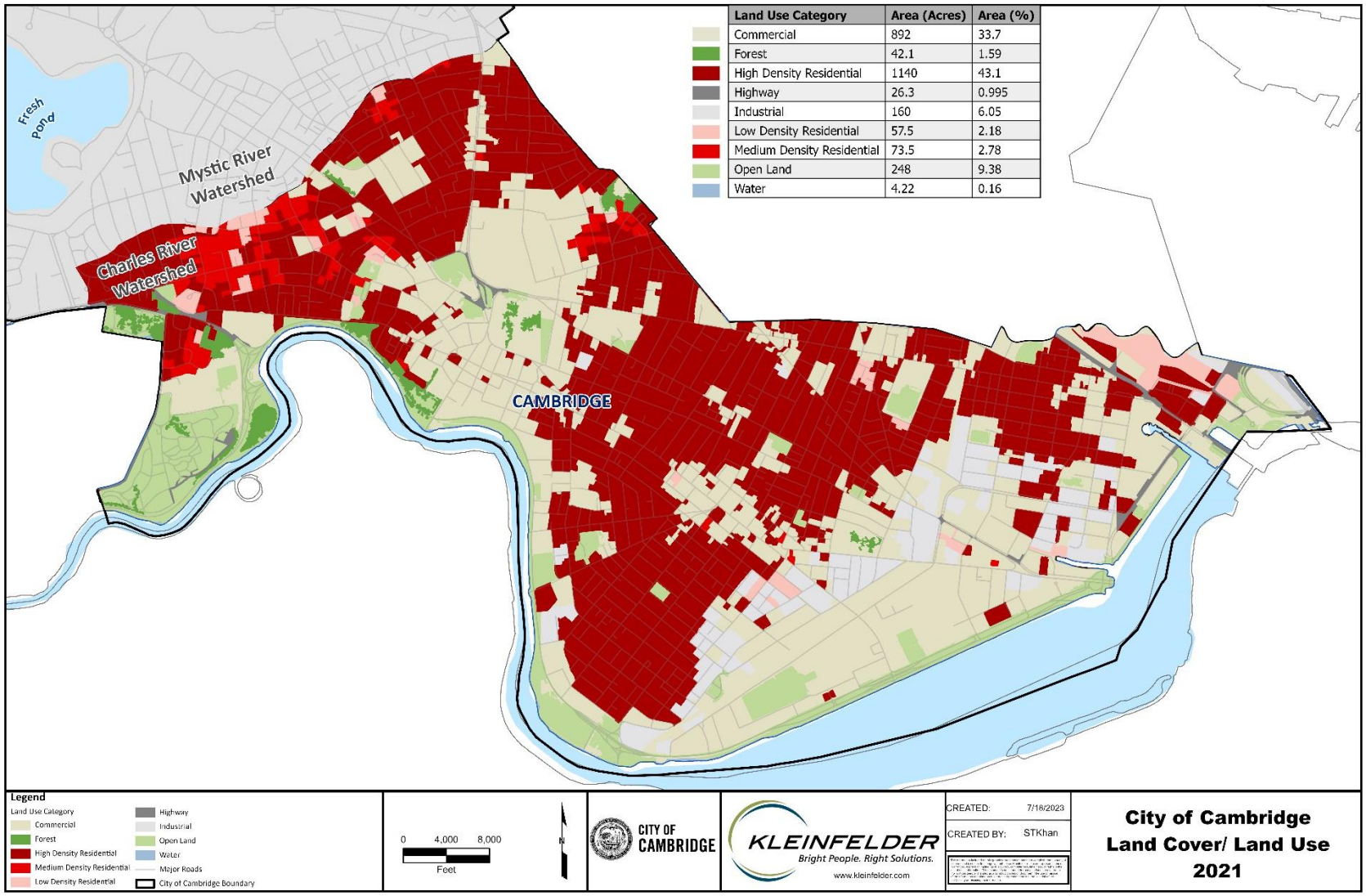

Figure 1-5: 2021 Land Cover/Land Use for the City of Cambridge within the Charles River Watershed

Based on the new Land Use/Land Cover data, the increase in annual phosphorus load due to development is 1,295 lbs/year. The City is working with EPA to understand the magnitude of this change. The current phosphorus load also increased by 125 lbs/year to account for separated areas not included in EPA's baseline load calculations (the load from these areas was added to Cambridge's allowable load). Therefore, the Current Phosphorus Load has changed from the Baseline Load of 1,129 lbs/year to 2,549 lbs/year. Table 1-4 summarizes the phosphorus load reflecting 2021 conditions and the change in phosphorus reduction requirements from 2005 to 2021 are summarized in Table 1-5. As land use, development, and impervious cover continue to change, this information will be updated, ensuring that Cambridge is on track to still achieve the required 20% and 25% reduction milestones by Years 8 and 10.

Table 1-4: Phosphorus Load Reflecting 2021 Conditions

Condition	Phosphorus Load (lbs/year)
Baseline Phosphorus Load (2005)	1,129
Allowable Phosphorus Load (2005) Based on 62% Reduction	430
Stormwater Phosphorus Load Reduction Requirement (2005)	699
Change in Phosphorus Load due to Development for areas that were included by EPA in baseline load calculations (2005-2021)	1,295
Change in Phosphorus Load due to additions to PCP Implementation Area (2021)	125
Current Phosphorus Load (2021)	2,549
Current Stormwater Phosphorus Load Reduction Requirement (2021)	2,119
Current Year 8 Milestone: 20% of Reduction	424
Current Year 10 Milestone: 25% of Reduction	530

Table 1-5: Change in Phosphorus Reduction Requirements from 2005 to 2021

Condition	Original (2005) (lbs/year)	Updated due to Land Use and Change in PCP Implementation Area (2021) (lbs/year)	Δ (lbs/year)
Baseline Phosphorus Load	1,129	--	0
Allowable Phosphorus Load Based on 62% Reduction	430	--	0
Stormwater Phosphorus Load Reduction Requirement	699	2,119	1,420
Year 8 Milestone: 20% of Reduction	140	424	284
Year 10 Milestone: 25% of Reduction	175	530	355

1.4 LEGAL ANALYSIS

Permit Requirement: *The permittee shall develop and implement an analysis that identifies existing regulatory mechanisms available to the MS4 such as bylaws and ordinances and describes any changes to regulatory mechanisms that may be necessary to effectively implement the entire PCP. This may include the creation or amendment of financial and regulatory authorities. The permittee shall adopt necessary regulatory changes by the end of the permit term.*

The City of Cambridge completed their legal analysis on June 30, 2020, and it is attached as Appendix I. Through this analysis, the City found that their current regulatory mechanisms give them the Authority to effectively implement this PCP program.

1.5 FUNDING SOURCE ASSESSMENT

Permit Requirement: *The permittee shall describe known and anticipated funding mechanisms (e.g. general funding, enterprise funding, stormwater utilities) that will be used to fund PCP implementation. The permittee shall describe the steps it will take to implement its funding plan. This may include but is not limited to conceptual development, outreach to affected parties, and development of legal authorities.*

To meet the Permit requirement, the City evaluated known and anticipated funding mechanisms (e.g., general funding, enterprise funding, stormwater utilities) that will be used to fund PCP implementation (the "Funding Source Assessment"). The City completed their funding source assessment on June 30, 2020, and it is attached as Appendix I.

While completing this assessment, the City determined that:

- The City is currently able to fund its stormwater management activities through diligent planning and budgeting using standard revenue streams (i.e., General Fund).
- If additional funding sources are determined to be necessary based on future required investments, the City may consider a combination of different funding mechanisms such as bonds, inspection fees and fines, grants, shared costs through private development, and Chapter 90 funds.

- The City already employs several of these funding mechanisms to some degree, primarily on an opportunistic basis.
- As part of Phase I of this PCP, the City estimated the cost to implement the necessary structural and non-structural controls. The City is now considering if the preferred funding mechanism (i.e. existing planning and budget processes) will be sufficient to continue to pay for the PCP.

1.6 NON-STRUCTURAL CONTROLS

Permit Requirement: *The permittee shall describe the non-structural stormwater control measures necessary to support achievement of the phosphorus export milestones in Table F-1 [of Appendix F of the MS4 Permit]. The description of non-structural controls shall include the planned measures, the areas where the measures will be implemented, and the annual phosphorus reductions that are expected to result from their implementation in units of mass/yr. Annual phosphorus reduction from non-structural BMPs shall be calculated consistent with Attachment 2 to Appendix F.*

Cambridge's approach for non-structural BMP implementation for PCP compliance is detailed in this section.

1.6.1 Current Non-Structural BMPs

Cambridge has implemented enhanced non-structural BMPs, which can qualify for phosphorus reduction credits as presented in Figure 1-6 and Table 1-6, and further detailed in Appendix III. Current non-structural BMPs are those that are anticipated to continue at current resource levels, or 'business as usual'. Credits were calculated using the phosphorus load export rates reported in Attachment 2 to Appendix F. These credits will count towards the required phosphorus reduction outlined in Table 1-4. Through discussions with regulators, the City anticipates that the methodology used to calculate street cleaning and catch basin cleaning credits may potentially change during Phase 1 implementation. The City will re-calculate credits and re-evaluate these programs when new guidance and methodologies are issued by EPA.

Table 1-6: Existing Non-Structural BMPs

Existing Non-Structural BMPs	Implementation Levels	Average Annual P-Reduction (lbs/yr)
Enhanced Street Sweeping	High-efficiency regenerative air-vacuum 3 times a year	4.6
	Mechanical broom at a monthly frequency for 6 months	2.6
	Mechanical broom at a weekly frequency for 6 months for select streets	1.3
Total Existing Non-Structural Credit		**8.5**

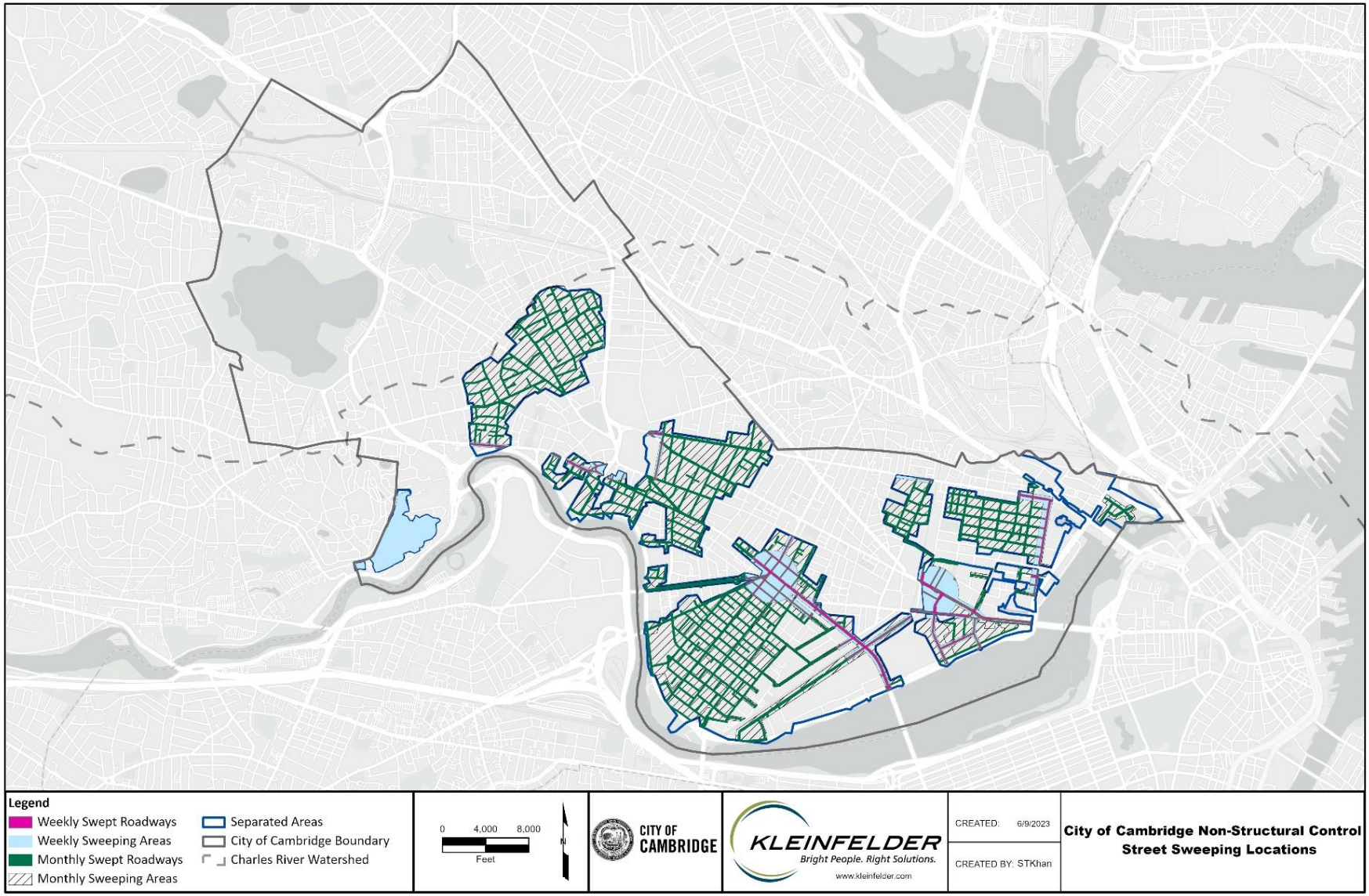

Figure 1-6: City of Cambridge Non-Structural Control (Street Sweeping Program)

1.6.2 Planned Non-Structural BMPs

Cambridge considered the following changes to their non-structural controls for implementation by the end of Permit Year 6. Although the City would like to maximize phosphorus credits from non-structural controls, they must balance cost and feasibility for implementation.

Street Sweeping: To receive additional phosphorus reduction credits for the City's street sweeping program, the City would either need to increase sweeping frequency or adjust sweeper technology. Cambridge investigated multiple scenarios including increasing mechanical broom sweeping frequency from monthly to weekly and increasing enhanced vacuum sweeping from three times per year to monthly. While the combination of these changes would equate to 13.5 pounds per year of additional phosphorus credits, these changes were not selected for Phase 1 implementation at this time. These significant changes to City operations would increase costs of the street sweeping program to over one million dollars per year, and require significant changes to residential parking and associated signage. The City will recalculate credits and reassess its street sweeping program when updated guidance and methodologies are issued by EPA.

Catch Basin Cleaning: Currently there are conflicting permit requirements for catch basin cleaning. Section 2.3.7.a.iii.2 includes the requirement that the frequency of routine cleaning will ensure that no catch basin at any time will be more than 50 percent full. This is reiterated in Appendix F Attachment 2. However, Appendix F Attachment 2 also indicates that the only allowable frequency for which to calculate and receive nutrient credits for catch basin cleaning is twice per year. This interpretation was confirmed by EPA and clarified to be the only way to receive nutrient credits for catch basin cleaning at this time.

Given that stipulation, enhanced catch basin cleaning was not selected for Phase 1 implementation at this time. The City is currently in year 2 of a 3-year plan to inspect all catch basins and develop an inspection schedule that will ensure all catch basins remain below 50% full. Based on inspection results from that program, the City will develop a catch basin cleaning schedule that ensures 100% of catch basins do not exceed 50% capacity at any time. If the City was eligible to receive phosphorus credits for maintaining 100% of catch basins at less than 50% capacity, it would equate to approximately 34 lbs/yr in phosphorus reduction credits. The City will recalculate credits and reassess its catch basin cleaning program when updated guidance and methodologies are issued by EPA.

Leaf Litter Program: According to the Appendix F of 2016 MS4 Permit "In order to earn this credit (leaf litter), the permittee must gather and remove all landscaping wastes, organic debris, and leaf litter from impervious roadways and parking lots at least once per week during the period of September 1 to December 1 of each year. Credit can only be earned for those impervious surfaces that are cleared of organic materials in accordance with the description above". Being a dense urbanized area, a weekly leaf litter collection program was not selected for Phase 1 implementation at this time.

1.7 STRUCTURAL CONTROLS

Permit Requirement: *The permittee shall develop a priority ranking of areas and infrastructure within the municipality for potential implementation of structural phosphorus controls during Phase 1. The ranking shall be developed through the use of available screening and monitoring results collected during the permit term either by the permittee or another entity and the mapping required pursuant to part 2.3.4.5 of the Permit. The permittee shall also include in this priority ranking a detailed assessment of site suitability for potential phosphorus control measures based on soil types and other factors. The permittee shall coordinate this activity with the requirements of part 2.3.6.d of the Permit. A description and the results of this priority ranking shall be included in Phase 1 of the PCP. The permittee shall describe the structural stormwater control measures necessary to support achievement of the phosphorus export milestones in Table F-1 [of Appendix F of the MS4 Permit]. The description of structural controls shall include the planned and existing measures, the areas where the measures will be implemented or are currently implemented, and the annual phosphorus reductions in units of mass/yr that are expected to result from their implementation. Structural measures to be implemented by a third party may be included in a municipal PCP. Annual phosphorus reductions from structural BMPs shall be calculated consistent with Attachment 3 to Appendix F.*

The City will employ structural BMPs to detain, treat, and better manage runoff from well-defined areas of impervious surface, such as roads, parking lots, or rooftops. Semi-structural BMPs are more passive stormwater management approaches that can still produce excellent water quality benefits such as rainwater harvesting, impervious area disconnection, conversion of impervious area to pervious, and enhancement of pervious areas. For the purposes of this document, the term structural controls refer to both structural and semi-structural BMPs.

Structural BMPs historically have been incorporated by Cambridge via stormwater compliance projects (for public and private development projects) or as part of the capital infrastructure program. The City's approach is to maximize green infrastructure whenever possible by evaluating street reconstruction projects, municipally owned parcels, and public right-of-way for opportunities. Structural BMPs that have already been implemented are evaluated in Section 1.7.1.

Structural BMP opportunities were evaluated within the City's 5 Year Sidewalk and Street Reconstruction Plan to allow for adaptive management during the development and execution of Phase 1 of the PCP, that is presented below.

The following sections describe the assessment, performance, and implementation of Current Structural BMPs (those that were built, or designed and are planned for implementation prior to development of this PCP) and Planned Structural BMPs (those that were newly identified for PCP compliance or will be implemented after this written PCP is submitted).

1.7.1 Current Structural BMPs

In order to meet the stormwater objectives of the City and enforce proper stormwater management practices, the City mandates that any project exceeding certain criteria must obtain a Stormwater Control Permit and remove 65-100% of the average annual phosphorus load generated from proposed conditions. These criteria include:

- Project disturbs one (1) or more acres of land.
- Project exceeds fifty thousand (50,000) square feet of Gross Floor Area.
- Project parcel or parcels equals or exceeds one (1) acre in size.
- Project includes outdoor parking for 10 cars or more.
- Special Permit is required by the Planning Board.
- Stormwater Control Permit is required by the City Engineer

To establish these standards, the City adopted the Stormwater Management Policy of the Massachusetts Department of Environmental Protection (MA DEP) and incorporated it into their own Stormwater Management Standards (*Section 3.3: Wastewater and Stormwater Management Guidance*). As a result, the City implemented various structural Best Management Practices (BMPs) in both publicly and privately owned properties.

The calculated phosphorus reductions from current structural BMPs are summarized in Table 1-7. All calculations were performed following the equations and requirements in Attachment 3 to Appendix F of the Permit. A copy of the calculations performed are included in Appendix III.

Table 1-7. Summary of Current Structural Controls

	Current Structural BMP Type	**Number of BMPs**	**Total Acres Managed**	**Total Annual Phosphorus Reduction (lbs/yr)**
City Owned	Biofiltration	5	0.6	0.5
	Subsurface Infiltration	20	8.4	13.4
	Porous Pavement	1	<0.1	0.04
	Rainwater Harvesting tank	2	2.4	2.2
Privately Owned	Extended Dry Detention	1	1.7	0.4
	Infiltration Basin	1	1.0	1.1
	Subsurface Infiltration	74	48.8	81.9
	Biofiltration	12	2.2	1.8
	Rainwater Harvesting tank	4	2.4	1.8
	Wet Pond	1	3.6	4.0
	Total Phosphorus Credit from Current Structural BMPs			107.1

Beyond the structural BMPs summarized above, the City completed an innovative sewer deflection project in the Talbot Street Catchment (Figure 1-7). The project deflects flow from the selected catchment that typically discharges to the Charles River and re-directs it to the Massachusetts Water Resources Authority (MWRA) collection system and ultimately to their wastewater treatment facility.

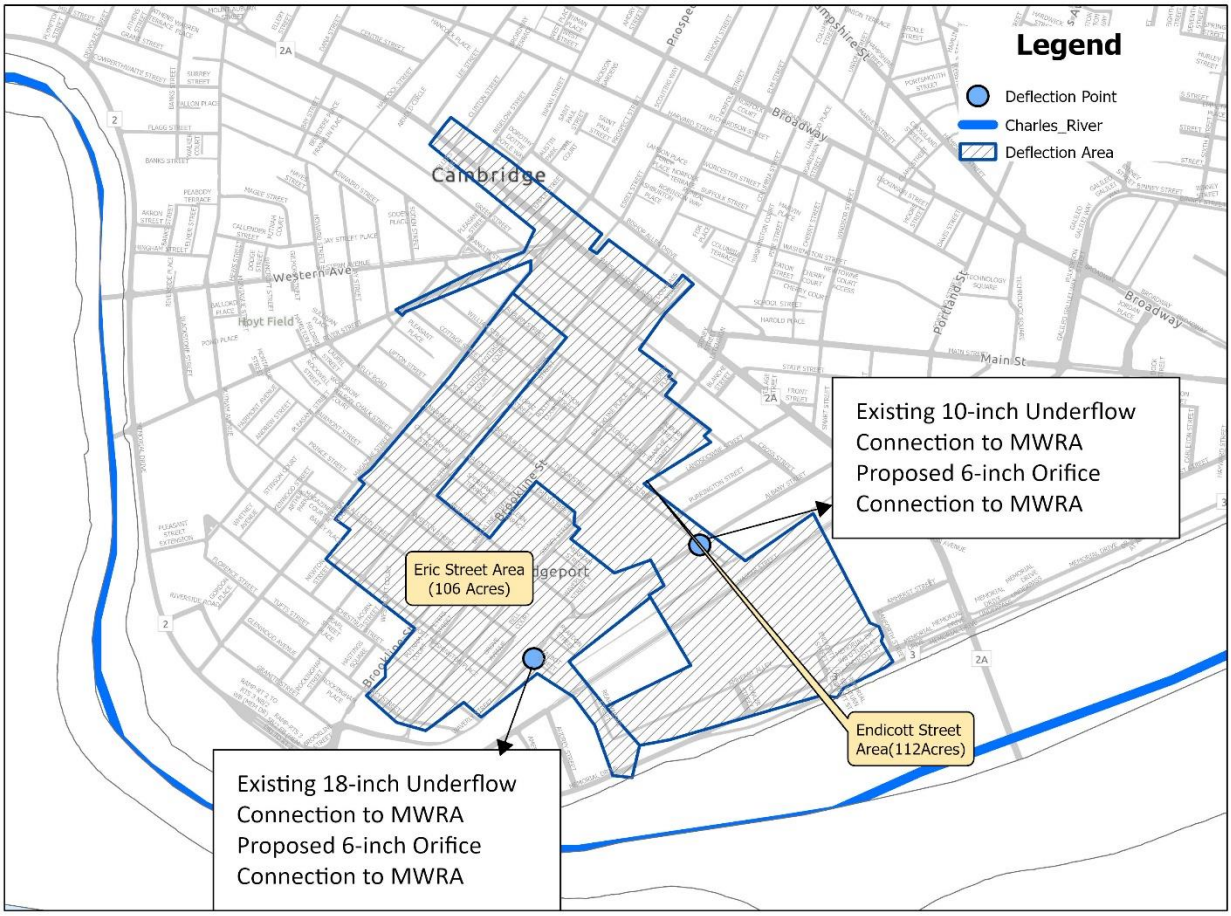

Figure 1-7: Talbot Street Sewer Deflection

Although the City believes that this project results in significant reduction in phosphorus loading to the Charles River, EPA has not issued approved methodology to calculate phosphorus credits for TMDL compliance at this time. Therefore, no phosphorus credits are currently claimed for this project, however the City is actively coordinating with EPA to develop a phosphorus reduction credit for this type of control. The City will incorporate credits for sewer deflection projects into this PCP when this methodology is issued by EPA.

1.7.2 Summary of Current Phosphorus Credits

The City's current practices and installed BMPs result in a reduction of 115.6 lbs/year of phosphorus (Table 1-8).

Table 1-8: Summary of Current Phosphorus Credits

	Phosphorus (lbs/year)
Street Sweeping (Non-Structural)	8.5
City Owned BMPs (Structural)	16.2
Privately Owned BMPs (Structural)	91.0
Sewer Deflection (Structural)	*To be determined*
Current Total	**115.6**
Year 8 Milestone: 20% of Reduction (Adjusted for 2021 Land Use)	423.8
Amount Remaining to Reach Year 8 (2026)	**308.2**
Year 10 Milestone: 25% of Reduction (Adjusted for 2021 Land Use)	529.8
Amount Remaining to Reach Year 10 (2028)	**414.2**

1.7.3 Planned Structural BMPs

Cambridge will address the remaining required phosphorus reduction credits with various types of projects and structural BMP controls.

Cambridge has two additional sewer deflection projects that are actively being designed that would address contributing areas to Binney Street and Western Avenue. Similar to the completed Talbot Street sewer deflection project, the phosphorus reduction credits are in development. However, the City expects the phosphorus reduction from these projects to be significant. Cambridge is actively coordinating with EPA to understand how and when they may be able to receive credit for these critically important and costly projects.

Cambridge is a dense urban environment, and it is not always feasible to install effective structural BMPs in the available public spaces that can make an appreciable impact on water quality or quantity. Instead, the City has been successful incorporating structural BMP controls into larger City projects where there often is more space available. The City's Capital Improvement Plan contains many projects that include stormwater control structures. These include street and sidewalk reconstruction as well as park projects that incorporate stormwater structural controls. The City's 2023 Capital Plan includes projects that total over $164 million dollars funded in part by the Sewer Projects Fund, Public Ways Fund, and the Water Projects Fund.

In 2022, the City developed a prioritized list of opportunities to install, modify, or retrofit stormwater structural controls throughout the City. This effort incorporated recent studies and City efforts including:

- Resilient Cambridge
- Cambridge Change Preparedness and Resiliency Study (CCPR)
- Five-year Sidewalk and Street Reconstruction Plan

- Climate Change Vulnerability Assessment (CCVA)
- Ten-year Sewer and Drain Infrastructure Plan

Selected sites were evaluated for soil type, site slope, site area, impervious area, proximity to open space and public use, overlap with planned work, and potential flood risk. Through this effort, the City identified fifteen candidate sites that had the potential for BMP retrofits or development. The City further prioritized these sites to create the list of five sites as required by the Permit. Since the development of that list, several projects have been completed, and the City identified additional opportunities for BMP installations. The most up to date list of sites is included in Figure 1-8 and the 2022 memorandum summarizing the methodology is included as Appendix IV.

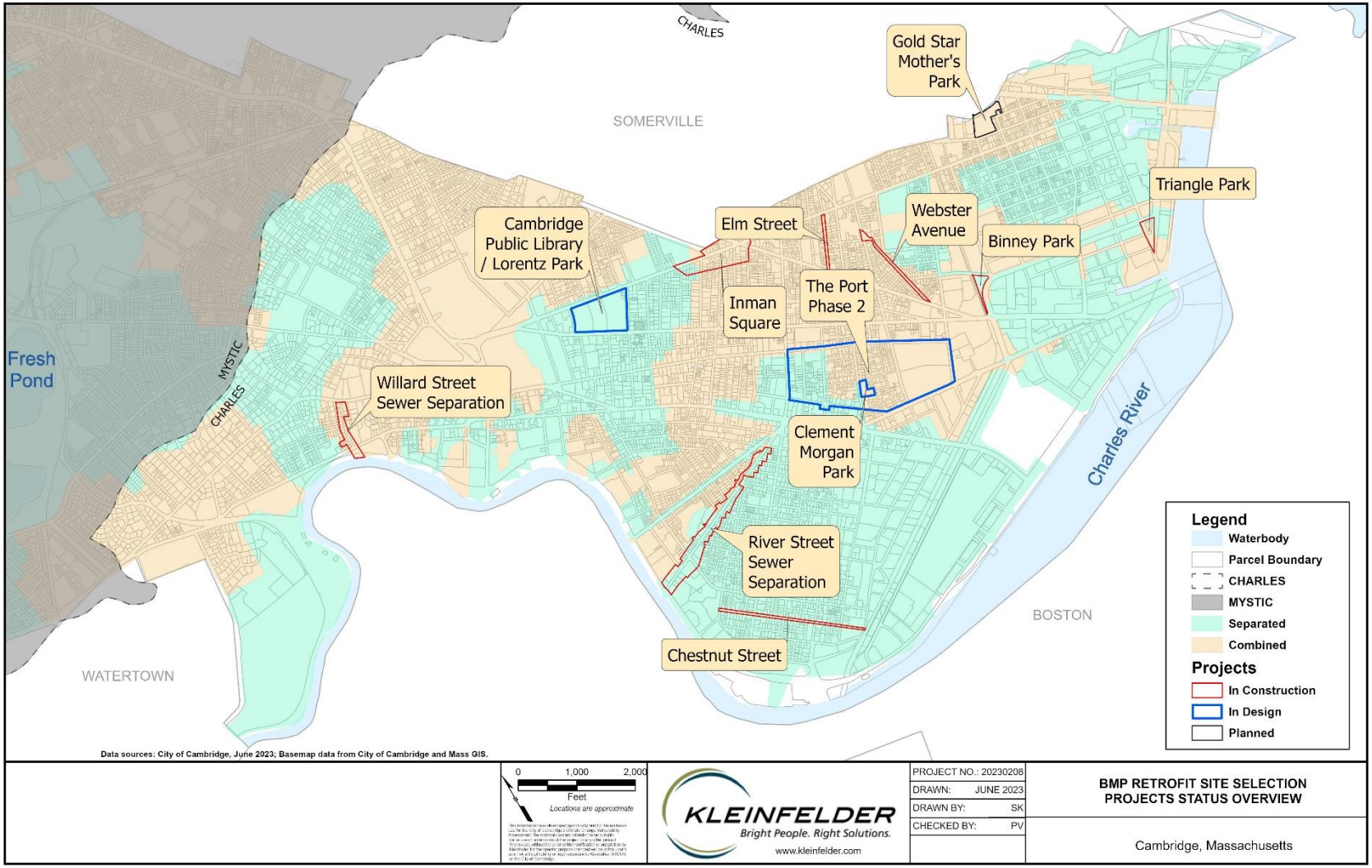

Figure 1-8: Prioritized Sites for Installation of Structural BMPs

Beyond structural controls planned by the City, private developers are often required to include structural controls on their sites. Certain projects in Cambridge require a special permit from either the Planning Board or the Zoning Board of Appeals. A special permit subsequently triggers a Stormwater Control Permit which requires that new and re-development projects remove between 65 - 100% of the average annual phosphorus load generated from total post-construction impervious area. Based on this requirement, the City can estimate the total phosphorus reduction expected from planned private development projects. Currently, there are 42 sites in the City's PCP implementation area that have applied for, been permitted, or are under construction with a special permit. Based on current trends, the City estimates that approximately half of those sites will be constructed within Phase 1 implementation and will provide similar phosphorus reduction as sites constructed within the last 5 years. The City has the most detailed information including plans and construction timeline for the planned North Point Park Project, also referred to as Cambridge Crossing. Based on those plans, more specific phosphorus reduction credits were calculated and included in the Table 1-9 summary. Some of the planned BMPs will be constructed after 2028 and thus will be included in Phase 2 of this PCP.

Table 1-9: Planned Private Structural BMPs

Planned Private Development	**Estimated Phosphorus Reduction (lbs/year)**	**Estimated Date of Completion**
North Point/Cambridge Crossing	6.6	2028
	5.3	2030 *(To be included in Phase 2)*
Other Planned Projects	20 - 40	2028
Total Planned by Year 10 Milestone	27 - 47	2028

Currently EPA has only issued methodologies for calculating phosphorus reduction credits from certain types of structural BMPs. The City will continue to evaluate credit for additional structural controls, such as proprietary flow through devices, as additional methodologies are issued by EPA.

Based on the planned private development, the City's projects must account for at least 377.2 lbs of phosphorus reduction credits to meet the year 10 reduction requirement in 2028. The City estimates that private development will continue at approximately the same rate that it has historically, which is roughly 7.4 lbs per year of additional phosphorus reduction. To meet the remaining target, the City must install structural BMPs that equal 377.2 lbs over the next five years, which is about 75.4 lbs per year of phosphorus credit. The estimated credits planned for both City-owned and privately-owned BMPs are shown in Table 1-10.

Table 1-10: Structural BMPs to Meet Phase 1 Requirements

	2024 Phosphorus (lbs/year)	2025 Phosphorus (lbs/year)	**2026 Phosphorus (lbs/year)**	2027 Phosphorus (lbs/year)	**2028 Phosphorus (lbs/year)**
Structural BMPs included in Planned City Projects	*To be determined*				
Sewer Deflection	*To be determined*				
Anticipated Private Development Phosphorus Reduction Credits	7.4	7.4	7.4	7.4	7.4
Current Total Phosphorus Reduction Credits	123	130.4	**137.8**	145.2	**152.6**
Year 8 Milestone: 20% of Reduction	**423.8**				
Amount Remaining to Reach Year 8 (2026)	300.8	293.4	286.0		
Year 10 Milestone: 25% of Reduction	**529.8**				
Amount Remaining to reach Year 10 (2028)	406.8	399.4	392.0	384.6	377.2

1.8 DESCRIPTION OF OPERATION AND MAINTENANCE (O&M) PROGRAM FOR ALL PLANNED AND EXISTING STRUCTURAL BMPS

Permit Requirement: *The permittee shall establish an Operation and Maintenance Program for all structural BMPs being claimed for phosphorus reduction credit as part of Phase 1 of the PCP. This includes BMPs implemented to date as well as BMPs to be implemented during Phase 1 of the PCP. The Operation and Maintenance Program shall become part of the PCP and include: (1) inspection and maintenance schedule for each BMP according to BMP design or manufacturer specification and (2) program or department responsible for BMP maintenance.*

1.8.1 City-Owned Structural BMPs

Cambridge has existing contracts with subcontractors to complete routine operation and maintenance of select BMP types including bioretention systems and tree filters. The City's existing contracts are managed by the Department of Public Works Staff and are typically multi-year contracts.

The City uses DPW crews to complete BMP and catch basin cleaning. The City has considered, and has adequate budget for, a dedicated catch basin cleaning contract that would also include BMP cleaning as needed. If the City were to pursue this contract, they would continue to dedicate at least one DPW crew to facilitate cleaning as necessary. The City uses a data driven performance-based approach to facilitate efficient BMP maintenance. All BMPs are inspected annually, and the results of the inspection inform what maintenance is required to maintain functionality. Inspections are recorded by DPW Staff in the field using hand-held tablets. Inspectors record sediment accumulation, BMP condition, and necessary follow-up actions. When maintenance is completed, this information is recorded. All data is recorded in Cambridge's asset management system which is accessible both in the office and in the field.

1.8.2 Privately-Owned Structural BMPs

All privately-owned structural BMPs are tracked by the City because they were part of a project that required a permit. One of the key Stormwater Control Permit requirements is an Operation and Maintenance (O&M) Plan. Each plan must include the following specific elements:

- The individual who will serve as the O&M point of contact and a 24-hour contact.
- The individual(s) who will serve as the qualified inspector(s) and proof of qualification.
- Description of how the site will be managed and kept clean each day. Including a description of how adjacent public and private roadways will be kept clean.
- The inspection and maintenance schedule for each BMP.
- Inspection checklists for weekly inspections and for after rain events and the plan for maintaining recordkeeping.

Beyond these items, the City tracks the receipt of project as-builts and finalized O&M plans in the City's permitting software. Stormwater Control Permits are not considered closed until these materials are received and DPW Staff have performed a post-construction inspection of the stormwater features.

The City is establishing a way to continue to check on the performance of the BMPs after the post-construction inspection and the BMPs are in use, through the creation of a self-certification program. This program for private BMP inspections will be started in Permit Year 6 and requires DPW Staff support. The City will audit a specified number of submitted inspections from private operators annually and visit and inspect a select number of those. If any issues with the operation and maintenance of the BMPs arise, the City will require operators to make improvements accordingly.

1.9 PHASE 1 IMPLEMENTATION SCHEDULE

Permit Requirement: *A schedule for implementation of all planned Phase 1 BMPs, including, as appropriate: obtaining funding, training, purchasing, construction, inspections, monitoring, operation and maintenance activities, and other assessment and evaluation components of implementation. Implementation of planned BMPs must begin upon completion of the Phase 1 Plan, and all non-structural BMPs shall be fully implemented within six years of the permit effective date. Structural BMPs shall be designed and constructed to ensure the permittee will comply with the 8 and 10 year phosphorus load milestones established in Table F-1 [of Appendix F of the MS4 Permit]. The Phase 1 plan shall be fully implemented as soon as possible, but no later than 10 years after the effective date of permit.*

The City of Cambridge acknowledges that to meet the phosphorus reduction deadlines set forth in the MS4 Permit, significant preparation is required. In order to plan, allocate funds to, design, and construct structural controls to meet the Year 8 and Year 10 reduction deadlines, there is significant work required during the initial years of PCP implementation.

To achieve the target of reducing phosphorus loads by 529.8 lbs/yr by 2028, Cambridge is planning and implementing a series of structural BMPs, evaluating funding mechanisms and costs, and developing its O&M and recordkeeping programs to ensure continued compliance and functionality of all installed BMPs.

The City is prioritizing the installation of additional sewer deflection projects and working together with EPA to understand how to calculate the resulting phosphorus credits. The City has a significant phosphorus reduction goal and has committed substantial funds and effort into their ongoing sewer deflection work. It is not reasonable for the City to address the remaining phosphorus reduction credits with singular BMPs alone, especially considering the dense urban nature of the City and the lack of adequate space. The City will continue to add structural BMPs with planned infrastructure work and will track the resulting credits. This effort in addition to the estimated planned private BMPs with an historic installation rate that equals approximately 7.4 lbs per year of phosphorus reduction credits is anticipated to meet the City's required year 8 and year 10 reduction milestones. For planning purposes, the City averaged the requirements over the five years, understanding that each year may be slightly above or below the target. This is summarized in Table 1-10 in Section 1.7.3.

Since the City intends to install stormwater controls as part of projects included in the City's Capital Improvement Plan, additional planning for siting, permitting, and design is not warranted. These considerations are included in the overall Capital Improvement Plan schedule. Once EPA issues approved methodology for calculating sewer deflection credits, the City will calculate and incorporate the appropriate phosphorus reduction credits and adjust this plan accordingly.

By 2026 (Permit Year 8), the City plans to have a phosphorus reduction credit that exceeds the milestone requirement of 423.8 lbs per year that was established based on the 2021 Land Use Data. In 2028 (Permit Year 10), the City plans to have a phosphorus reduction credit that meets the milestone requirement of 529.8 lbs per year. The City will diligently track the credits received from both City and private projects and adjust the number and types of projects that the City will install if necessary. The planned private reduction credit was calculated to be conservative and will be adjusted to reflect finalized installations and the resulting credits. The implementation schedule in Appendix V further details the schedule for BMP implementation.

1.10 ESTIMATED COST FOR IMPLEMENTING PHASE 1 OF THE PCP

Permit Requirement: *The permittee shall estimate the cost of implementing the Phase 1 non-structural and structural controls and associated Operation and Maintenance Program. This cost estimate can be used to assess the validity of the funding source assessment completed by year 3 after the permit effective date and to update funding sources as necessary to complete Phase 1.*

Cambridge developed an estimated cost to implement Phase 1 of the PCP. This cost estimate is included in Appendix VI.

1.10.1 Current Non-Structural BMP Costs

The City pays subcontractors to complete street sweeping. There is Cambridge staff support time required to facilitate these contracts, and the City dedicates two crews to catch basin cleaning. There is a separate contract for the hauling and disposal of all street sweeping and catch basin cleaning materials. These current costs are summarized in Table 1-11.

Table 1-11: Current Non-Structural BMP Costs

Current Non-Structural BMPs	Annual Cost* (Subcontractor, City Personnel, Hauling, and Disposal)	Removed Phosphorus Load (lbs/year)	Annual Cost per lb of Phosphorus Removed ($/P lb)
Enhanced Street Sweeping	$290,000	8.5	$34,120

*This is the estimated cost of enhanced street sweeping in the PCP implementation area only.

1.10.2 Considered Non-Structural BMP Costs

The City considered increasing the frequency of street sweeping and catch basin cleaning as part of this PCP development. If the City were to increase mechanical broom sweeping from monthly to weekly from April to December, streets within the watershed would be swept approximately thirty-four times per year instead of the eight times per year that they are currently swept. High efficiency regenerative air vacuum sweeping would increase from three times per year to eight. This escalates street sweeping costs to over one million dollars. This represents a significant increase in cost to the City to facilitate this program.

The City's planned catch basin cleaning program does not currently meet the requirements to receive phosphorus reduction credits under the current permit. Despite not receiving credit, the City continues to pursue maintaining 100% of their catch basins at less than 50% full. This effort is estimated to cost the City approximately $295,000 per year using two dedicated DPW crews for just the PCP implementation area.

1.10.3 Structural BMP Costs

The City owns and operates four types of structural BMPs eligible for phosphorus reduction credits. These BMPs were installed at different times, but to approximate the cost per pound of phosphorus removed, costs were estimated in 2023 dollars. Using many sources including the University of New Hampshire Stormwater Center Stormwater Calculator, the Minnesota Stormwater Manual, the Maryland Department of the Environment Stormwater BMP Unit Cost Calculator, vendor quotes, and current construction cost estimates, approximate construction and rehabilitation costs were established for the City owned BMPs. City staff also estimated the annual cost for O&M which includes potential subcontractor support if needed and City staff time. Total construction cost includes pre-construction considerations including, site survey, design, planning, and permitting.

Table 1-12: Current City-Owned Structural BMP Costs

Current Structural BMP Type	Number of Existing BMPs	Total Annual Phosphorus Reduction (lbs/yr)	Average Phosphorus Reduction Credit per Structure (lbs/year)	Annual O&M (Total for all structures)	Construction Cost Range (per each structure)	Construction Cost $/P lb (per each structure)
Biofiltration	5	0.5	0.1	$10,500	$10,000 – 90,000	$900,000
Subsurface Infiltration	20	13.4	0.7	$42,000	$10,000 -17,000	$26,000
Porous Pavement	1	0.04	0.04	$2,100	$10,000 – 20,000	$500,000
Rainwater Harvesting Tank	2	2.2	1.1	$4,200	$60,000 – 91,000	$42,000
Total	**28**	**16.1**	**0.1 – 1.1 (per structure)**	**$58,800**	**$10,000 – 91,000**	**$26,000 – 900,000**

Cambridge is a dense, urban environment with limited available locations for the installation of effective structural BMPs. Table 1-12 helps to highlight the relatively small phosphorus removal credits per each structure.

The three sewer deflection projects have significant capital and O&M costs. The capital costs for just the sewer deflection structure and the annal O&M costs are presented in Table 1-13. The O&M costs for these projects are associated with the typical operation, cleaning, and maintenance of the structure, but also the fees incurred by the City from the Massachusetts Water Resources Authority (MWRA) based on the acceptance of the deflected flow. These structures alone do not account for the total costs of these projects to the City. There is significant sewer separation and infrastructure improvements that are necessary for the projects and the costs exceed $20 – 40 million per each sewer deflection project. The City looks forward to working with EPA to receive the appropriate phosphorus reduction credits for these extensive and impactful investments.

Table 1-13: Sewer Deflection Costs

Sewer Deflection Project	Capital Cost of Deflection Structure	Annual O&M
Talbot Street (Cambridgeport)	$333,000	$257,000
Project 9ab (Binney Street)	$417,000	$30,000
Western Avenue	$248,000	$73,000

The City evaluated how they could meet their remaining reduction requirement using the estimated range of costs per phosphorus credit for structural BMPs which is approximately $26,000 to $900,000 per lb of phosphorus. Using that range, the City could pay up to $11.1 million over the next five years to meet their target, and it could require the construction of many structural BMPs given the average credit per structure shown in Table 1-12. This is not a cost effective solution compared to the ongoing sewer deflection efforts already underway in the City. The City still plans to prioritize including green infrastructure in planned City projects, as feasible, but these costs are not included in Table 1-14. The City anticipates that the credit from the existing and planned sewer deflection projects will meet the remaining Phase 1 reduction milestones.

The annual O&M costs for all of the Phase 1 non-structural and structural BMPs is summarized in Table 1-14.

Table 1-14: Anticipated Phase I PCP Costs

	Construction Cost	**Annual Cost**	**Total Cost** (Construction Cost + Annual Cost for 5 years)
Enhanced Street Sweeping	--	$290,000	$1,450,000
Existing Structural BMP O&M	--	$58,800	$294,000
Existing Talbot Street Sewer Deflection	--	$257,000	$1,285,000
Planned Structural BMPs from Private Development	--	$16,800 (City time for permitting and inspections)	$84,000
Planned Sewer Deflections (Project 9ab and Western Avenue)	$665,000 (Deflection Structures Only)	$103,000	$1,180,000
Total Costs	**$665,000**	**$725,600**	**$4,293,000**

1.11 PUBLIC COMMENT

Permit Requirement: *The permittee shall make the Phase 1 Plan available to the public for public comment during Phase 1 Plan development. EPA encourages the permittee to post the Phase 1 Plan online to facilitate public involvement.*

In conformance with the Permit's requirements, Cambridge made the Draft Phase 1 PCP available for public comment as well as a fact sheet that provided a high-level summary of the requirements the City needs to address and their strategy to meet them. The fact sheet was posted to the City's website on September 8, 2023. The fact sheet is included in Appendix VII.

Ultimately the City received one (1) comment requesting the definition of the term "tree box filters".

2 DOCUMENTATION AND REPORTING

The most current information for annual updates to the City of Cambridge's PCP progress can be found in the following appendices:

- For non-structural controls: Appendix II
- For structural controls: Appendix III
- For the operations and maintenance program: City's Good Housekeeping Manual

This data is also tracked in each year's Annual Reports, which can be found online at: https://www.cambridgema.gov/Departments/publicworks/Initiatives/stormwatermanagement

APPENDIX I

LEGAL ANALYSIS & FUNDING SOURCE ASSESSMENT

MEMORANDUM

TO: Catherine Woodbury, City of Cambridge

FROM: Adria Fichter and Betsy Frederick, Kleinfelder

DATE : June 30, 2020

SUBJECT: **FY20 MS4 Services, Task 5 - Phosphorus Control Plan Legal Analysis and Funding Source Assessment**

CC: Andrew Goldberg and Kirsten Ryan, Kleinfelder

1.0 Background

The City of Cambridge is a Charles River Watershed community and as such, is subject to the Massachusetts Department of Environmental Protection's (MassDEP) 2007 *Final TMDL for Nutrients in the Lower Charles River Basin.* It is additionally subject to specific phosphorus reduction requirements in the 2016 General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts (the MS4 Permit) detailed in Permit Appendix F, Part A.I. To address phosphorus reduction requirements, the City must develop a Phosphorus Control Plan (PCP) in three (3) distinct phases, each with multiple milestones and deadlines. The focus of this memorandum is on the initiation of Phase I of the PCP plan which is to be completed by the City in Permit years 1 through 5 (July 1, 2018 – June 30, 2023). This memorandum satisfies the first and second requirements of the PCP, a "Legal Analysis" and "Funding Source Assessment" and provides guidance and recommendations for subsequent requirements.

2.0 Legal Analysis

The first element of the PCP, the legal analysis (**Item 1-1**), is required two (2) years after the Permit effective date or by June 30, 2020. The requirement is as follows:

> ***Legal Analysis: A.I.1.a.3 MS4 Permit***
> *'Legal analysis identifies existing regulatory mechanisms available to the MS4 such as by-laws and ordinances, and gaps (changes to regulatory mechanisms) that may be necessary to implement PCP. Adoption of necessary regulatory changes is required prior to the end of the permit term.'*

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2.1 Applicable Regulatory Mechanisms

The City has several different documents, regulations, ordinances, guidance documents, and permits that relate to the proper management of stormwater in the City. To understand current requirements, the following documents were reviewed:

- *Wastewater and Stormwater Management Guidance, May 2008*
  Appendix A: Best Management Practices – Draft – March 2008
  Appendix B: Common Pollutants – Draft – January 2008
  Appendix C: TMDL Information – Draft – January 2008
  Appendix D: Technical Basis for Quantity Guidelines - Draft – January 2008
  Appendix E: Example Calculations for Water Quality Runoff Volume – Draft – January 2008
  Appendix F: NRCS Design Storm Distributions – Draft – January 2008
  Appendix G: Stormwater Control Permit Checklists – September 2019

- *Stormwater Control Permit*

- *Chapter 13.16 Wastewater and Stormwater Drainage System*

- *Department of Public Works Land Disturbance Regulations*

- *Cambridge Zoning Ordinance*

Beyond the existing regulations, proposed amendments to the Zoning Ordinance have been in progress since January 2019. A Zoning Task Force was created to assess climate resiliency opportunities based on feedback from citizens advocating for decreased development in the Alewife Area. The Task Force has investigated multiple climate resiliency strategies on a city-wide basis and will likely issue a memorandum with their findings in Summer 2020. The memorandum is not expected to include legal language but will be used to inform the amendments to the Zoning Ordinance which are expected in Fall 2020. The City should ensure that amendments to the Zoning Ordinance do not hinder the implementation of the PCP.

To adequately understand if the current regulatory mechanisms are sufficient, the City will need to outline specific actions to be implemented to meet phosphorus reduction requirements. The Permit set a specific phosphorus reduction target for the City and included potential best management practices (BMPs) for which phosphorus reduction credits would be obtained upon implementation. Note that the legal analysis must address all aspects of “the entire” PCP implementation, which extends through additional phases over a period of 20 years. Realistically, this analysis can only address the likely approach undertaken by the City in this initial phase. Phase 2 (beginning 5 – 10 years after the permit’s effective date) includes an obligation to update the legal analysis given then-current conditions and programs.

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2.2 Potential PCP Components

The Permit describes structural and non-structural BMPs, implementation of which will qualify for phosphorus credits. (**Attachments 2 and 3 to Appendix F**). It is important that these BMPs are not legally restricted. Potential BMPs that the City may select and the current relevant action that the City is taking, the local regulations that allow for the BMP, and an assessment of the adequacy of the enabling regulations are included in **Table 1**.

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Table 1: Potential Best Management Practices

Potential Best Management Practices for the City's Phosphorus Control Plan	Applicable Action or Regulation	
Non-Structural BMPs		
Enhanced Sweeping Program: *Increasing the frequency and selecting a more effective sweeper technology*	City is already mechanically sweeping once per month and vacuum sweeping three times per year.	Current mechanism sufficient to allow enhancement if selected
Catch Basin Cleaning: *Increasing the frequency of catch basin cleaning when necessary to ensure that no catch basin is ever more than 50% full*	City is developing a catch basin cleaning optimization program.	
Organic Waste and Leaf Litter Collection Program: *Removing all landscaping wastes, organic debris, and leaf litter at least weekly from September 1st to December 1st*	City offers free weekly pick-up of yard waste from April through mid-December	
Structural BMPs		
Infiltration Trench	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	Current mechanism sufficient to allow action if selected
Infiltration Basin or other surface infiltration practice	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	
Bio-filtration practice	*Wastewater and Stormwater Management Guidance Version 1, May 2008 (Referred to as Bioretention Area and Grassed Channel/Biofilter Swale)*	
Gravel Wetland System	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	
Porous Pavement	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	
Wet Pond or wet detention basin	*Wastewater and Stormwater Management Guidance Version 1, May 2008 (Referred to as a Wet Basin)*	
Dry pond or detention basin	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	
Dry water quality swale/grass swale	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	
Semi-Structural/Non-structural BMPs		
Impervious area disconnection through storage (e.g., rain barrels, cisterns, etc.)	*Wastewater and Stormwater Management Guidance Version 1, May 2008*	Current mechanism sufficient to allow action if selected
Impervious area disconnection	*Cambridge Zoning Ordinance*	
Conversions of Impervious Area to Permeable Pervious Area	*Cambridge Zoning Ordinance*	
Soil Amendments to Enhance Permeability of Pervious Areas	This is not explicitly restricted	

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As summarized in the **Table 1**, many of these BMPs are already included in the City's management of stormwater and their infrastructure. The City operates a robust street cleaning program that includes mechanically sweeping each street in the City once per month from April through December, and three times-yearly vacuum sweeping. The City developed and is actively working to implement a catch basin cleaning optimization program to meet the Permit requirements that none are ever over 50% full. Beyond street sweeping, City squares are cleaned daily with sweepers and by hand. Many structural BMPs are already in use throughout the City

The PCP allows the City to receive credit for phosphorus reduction performed by third parties that install stormwater BMPs, such as private property owners and non-MS4 permit holders. The continued operation and maintenance of these BMPs is imperative to successful phosphorus reduction. Permittees under the City's Stormwater Control Permit must submit a Stormwater Control Checklist (Appendix G of the Stormwater Control Permit). As part of the Checklist, the permittee must sign the Owner's Certification that includes accepting responsibility for maintenance of the BMPs, in the event of transfer of ownership, informing prospective new owners and filing a new O&M plan, funding the O&M activities, and understanding that City DPW staff is authorized to conduct inspections and determine regulatory compliance.

The Wastewater and Stormwater Management Guidance Document (Guidance Document), which informs the Stormwater Control Permittee and the Land Disturbance Permittee, specifically includes performance standards for all the possible structural BMPs and for the use of rain barrels/cisterns included in Section 1. Furthermore, the Zoning Ordinance includes requirements and restrictions for Green Areas and Permeable Open Space in specific overlay districts. Although these requirements are not city-wide, they illustrate the City's ability to include and promote these public use spaces with dual stormwater management benefits. At this time, the City's regulations do not inhibit the implementation of any of the BMPs included in Section 2.2 of the Guidance Document. The Permit does require that this legal analysis be updated as part of Phase II of the PCP if necessary.

3.0 Funding Source Assessment

As part of Phase I of the PCP, a funding source assessment (**Item 1-2**) is required three years after the permit effective date (June 2021). The requirement is as follows:

> ***Funding Source Assessment: A.I.1.a.3 MS4 Permit***
> "*The permittee shall describe known and anticipated funding mechanisms (e.g. general funding, enterprise funding, stormwater utilities) that will be used to fund PCP implementation. The permittee shall describe the steps it will take to implement its funding plan. This may include but is not limited to conceptual development, outreach to affected parties, and development of legal authorities."*

Although the funding source assessment is not required this year, the City has addressed this requirement and established how they plan to afford the design and implementation of the PCP.

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The City is currently able to fund its stormwater management activities through diligent planning and budgeting using standard revenue streams (i.e. General Fund). The City plans to continue their current practices to pay for the PCP and anticipates existing revenue sources can provide the necessary future funding. If additional funding sources are determined to be necessary based on future required investments, the City may consider a combination of the following funding mechanisms:

- General Fund
- Bonds
- Shared Costs/Private Development
- Inspection Fees / Fines
- Grants
- Chapter 90

The City already employs several of these funding mechanisms to some degree, primarily on an opportunistic basis. Initial steps to evaluate any necessary gap funding would address scaling one or more of these approaches to a greater contributing percentage of the overall need. At this time the City does not intend to enact any enterprise system or utility specifically for stormwater management. At the end of year 5 of the permit term, the City must estimate the cost for implementing Phase I of the PCP (**Item 1-9**) and establish if the preferred funding mechanism (i.e. existing planning and budget processes) will be sufficient to pay for the PCP. That re-evaluation will determine if any of the mechanisms cited above must be revisited as a more integral and formalized element of funding strategies to maintain appropriate program funding.

4.0 Define Scope of PCP Baseline Phosphorus Load and Reduction Requirement

In December 2019, the EPA issued proposed permit modifications to the 2016 MS4 General Permit. Currently, these modifications are in draft form. However, EPA has requested permit certification from MassDEP and expects that these modifications will be certified in the coming months (the comment period ended on June 8, 2020). These changes do have implications regarding the final PCP, the timeline of certain items such as the implementation of nonstructural controls, and specific phosphorus reduction requirements.

During the development of the 2014 Draft MS4 Permit, EPA issued an attachment to Appendix F that details how phosphorus loads and reductions were calculated. EPA estimated that illicit sanitary discharges accounted for approximately 10% of the phosphorus load to the Charles River, but noted that this value would be re-evaluated and refined if necessary. Furthermore, EPA stated that although specific illicit phosphorus loads were calculated for each community, the calculated illicit load reductions should be viewed as watershed-wide credits that are not specific to the community.

The proposed permit modifications increase the required phosphorus reduction target. EPA removed the presumptive watershed-wide Illicit Discharge Detection and Elimination (IDDE) phosphorus reduction which results in the increased reduction requirements for all permittees. EPA will recalculate the watershed-wide phosphorus reduction associated with IDDE program

implementation by each permittee following the completion of each permittee's Program, 10 years after the permit effective date (July 1, 2018 – June 30, 2028). This part of the PCP (**Item 1-3**) is not due until June 2022, but the changes to the reduction requirements may frame the City's approach to addressing required phosphorus reduction moving forward.

5.0 Next Steps

Based on the types of potential BMPs and the City's current procedures, the City does not require additional legal support for their PCP at this time. It is possible that enhancing regulations such as the Zoning Ordinance could promote new/redevelopment and increase the use of the structural BMPs and ultimately yield additional phosphorus reduction credits for the City. Additionally, the City plans to continue funding their stormwater management program through their current budgeting practices and extend this funding to cover the PCP.

Due to the size and complexity of Cambridge, many BMPs could be necessary to meet the Permit prescribed phosphorus reductions. Creating and maintaining a way to manage and track these BMPs will be critical to a successful program. The City is implementing their own BMP inspection program, and this is a good opportunity to track progress through GIS and Cartegraph. We recommend a meeting to discuss updates to the guidance documents to promote the City's internal regulatory review process.

As discussed, Appendix F of the MS4 Permit specifies a detailed, sequential list of items for the City's development of their PCP. This memorandum meets the requirements for items, 1-1 and 1-2, the legal analysis and funding source assessment. The memorandum also provides the framework for the development of the first Phase of the PCP, specifically item 1-3, defining the scope and required reductions of the PCP, which we recommend that the City continues to develop to meet the deadlines established in the Permit.

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APPENDIX II
SUPPORTING CALCULATIONS FOR NON-STRUCTURAL CONTROLS

State	MASSACHUSETTS
Municipality	CAMBRIDGE
Permit Type	MS4
Permit Number	MAR041169
Major Watershed	CHARLES
TP Load Reduction Target	N/A
TN Load Reduction Target	N/A
TSS Load Reduction Target	N/A

Table 1. Project Summary Non-structural BMP Credit for CAMBRIDGE, MASSACHUSETTS

Project Type	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)
Non-Structural	8.5	66.54	0

Table 2. Non-Structural Project Summary for CAMBRIDGE, MASSACHUSETTS

Project ID	BMP Type	BMP Storage Capacity	Phosphorus BMP Efficiency (%)	Nitrogen BMP Efficiency (%)	Sediment BMP Efficiency (%)	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)	Impervious Area Treated (ac)	Runoff Depth (in.)
High-efficiency regenerative air-vacuum 3 times a year	ENHANCED SWEEPING PROGRAM	N/A	8	8	0	4.56	34.58	0	170	N/A
Mechanical broom at a monthly frequency for 6 months	ENHANCED SWEEPING PROGRAM	N/A	3	3	0	2.62	19.91	0	130.5	N/A
Mechanical broom at a weekly frequency for 6 months for select streets	ENHANCED SWEEPING PROGRAM	N/A	5	6	0	1.32	12.05	0	39.5	N/A

APPENDIX III
SUPPORTING CALCULATIONS FOR STRUCTURAL CONTROLS

State	MASSACHUSETTS
Municipality	CAMBRIDGE
Permit Type	MS4
Permit Number	MAR041169
Major Watershed	CHARLES
TP Load Reduction Target	N/A
TN Load Reduction Target	N/A
TSS Load Reduction Target	N/A

Table 1. Project Summary Structural Credit for CAMBRIDGE, MASSACHUSETTS

Project Type	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)
City Owned Structural	16.1	92.6	2466
Privately Owned Structural	90.97	756.5	21312
Total	107.1	849	23778

Table 2. Structural Project Summary for CAMBRIDGE, MASSACHUSETTS

Project ID	Location	BMP Type	BMP Storage Capacity (ft^3)/ Filter Depth (in.)	Phosphorus BMP Efficiency (%)	Nitrogen BMP Efficiency (%)	Sediment BMP Efficiency (%)	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)	Impervious Area Treated (ac)	Runoff Depth (in.)	Date of Last Inspection	Date of Last Maintenance
	City Owned Structural BMPs												
D01UGS0061	850 Cambridge Street	INFILTRATION TRENCH	6463	98	100	100	1.89	16.29	407.58	1.08	1.65	6/7/2023	
STR_BMP4	850 Cambridge Street	INFILTRATION TRENCH	11076	98	100	100	1.89	16.32	408.58	1.08	2.50	6/29/2023	
D01UGS0037	54 Binney Street	INFILTRATION TRENCH	172	70	91	92	0.14	1.51	38.22	0.11	0.43	5/18/2023	
D01UGS0036	125 Binney Street	INFILTRATION TRENCH	172	73	92	94	0.13	1.39	35.32	0.1	0.47	5/18/2023	
D01UGS0038	75 Binney Street	INFILTRATION TRENCH	172	89	98	99	0.09	0.89	22.41	0.06	0.79	5/18/2023	
D01UGS0039	100 Binney Street	INFILTRATION TRENCH	172	77	93	95	0.12	1.26	32.41	0.09	0.53	5/15/2023	
D01UGS0040	300 Third Street	INFILTRATION TRENCH	172	89	98	99	0.09	0.89	22.41	0.06	0.79	5/15/2023	
D01UGS0041	300 Third Street	INFILTRATION TRENCH	172	89	98	99	0.09	0.89	22.41	0.06	0.79	5/15/2023	
D01UGS0042	125 Binney Street	INFILTRATION TRENCH	172	57	84	80	0.15	1.90	45.56	0.15	0.32	5/18/2023	
D01UGS0043	100 Binney Street	INFILTRATION TRENCH	172	70	91	92	0.14	1.51	38.22	0.11	0.43	5/15/2023	

D01UGS0044	54 Binney Street	INFILTRATION TRENCH	172	70	91	92	0.14	1.51	38.22	0.11	0.43	5/18/2023	
STR_BMP16	65 Franklin Street	POROUS PAVEMENT	12	62	76	92	0.04	0.46	13.89	0.04	0.08	5/15/2023	
STR_BMP5	850 Cambridge Street	BIOFILTRATION	9632	63	86	100	0.33	3.78	110.09	0.29	6.98	6/22/2023	
STR_BMP6	850 Cambridge Street	BIOFILTRATION	4036	63	86	100	0.07	0.79	23.14	0.06	8.55	6/7/2023	
STR_BMP17	20 Pleasant Street	BIOFILTRATION	200	53	76	99	0.06	0.54	21.77	0.05	1.10	5/23/2023	
D01UGS0062	850 Cambridge Street	Rainwater Harvesting Tank	4010	40			1.11			1.56	0.71	6/17/2022	
STR-93	100 Putnam Ave	Rainwater Harvesting Tank	2673	72			1.12			0.87	0.85		
STR-94	100 Putnam Ave	INFILTRATION TRENCH	1573	100			0.39			0.22	1.97	6/20/2023	
STR-95	100 Putnam Ave	INFILTRATION TRENCH	6748	100			1.66			0.93	2.00	6/20/2023	
STR-96	100 Putnam Ave	INFILTRATION TRENCH	7305	100			1.80			1.01	1.99	6/20/2023	
CityHall1	795 Massachusetts Ave	INFILTRATION TRENCH	54	39	74	62	0.06	0.89	18.82	0.08	0.19	6/29/2023	
CityHall2	796 Massachusetts Ave	INFILTRATION TRENCH	54	39	74	62	0.06	0.89	18.82	0.08	0.19	6/26/2023	
D13UGS0001	1 Cambridge Street	INFILTRATION TRENCH	2205	77	94	96	1.60	11.94	379.74	0.9	0.67	6/1/2023	
D13UGS0002	2 Canal Park	INFILTRATION TRENCH	788	79	95	97	0.55	4.01	127.54	0.3	0.72	5/18/2023	
D13UGS0003	2 Canal Park	INFILTRATION TRENCH	3938	75	94	96	2.25	23.73	606.66	1.68	0.65	5/18/2023	
Filterra_brookline1	171 Brookline Street	BIOFILTRATION	28	52	32	99	0.01	0.04	2.98	0.008	1.65	6/26/2023	
Filterra_brookline2	187 Brookline Street	BIOFILTRATION	28	52	32	99	0.01	0.04	2.98	0.008	2.50	6/26/2023	
CRLS	1640 Cambridge Street	INFILTRATION TRENCH	146	75	93	95	0.11	1.12	28.56	0.08	0.43	6/29/2023	

Privately Owned Structural BMP										
Project ID	**BMP Type**	**BMP Storage Capacity (ft^3)/ Filter Depth (in.)**	**Phosphorus BMP Efficiency (%)**	**Nitrogen BMP Efficiency (%)**	**Sediment BMP Efficiency (%)**	**Removed Phosphorus Load (lb/yr)**	**Removed Nitrogen Load (lb/yr)**	**Removed Sediment Load (lb/yr)**	**Impervious Area Treated (ac)**	**Runoff Depth (in.)**
D03BB0001	BIOFILTRATION	653	63	74	99	0.01			0.01	0.80
D31UGS0014	INFILTRATION TRENCH	87	92	97	99	0.01	0.14	4.35	0.01	2.40
D31UGS0022	INFILTRATION TRENCH	87	92	97	99	0.01	0.14	4.35	0.01	2.40
D31UGS0015	INFILTRATION TRENCH	87	92	97	99	0.01	0.14	4.35	0.01	2.40
D31UGS0020- 21	INFILTRATION TRENCH	42	92	98	99	0.02	0.14	4.36	0.01	1.16
PVT-79	INFILTRATION TRENCH	134	92	97	99	0.04	0.41	13.04	0.03	2.68
D16UGS0003	INFILTRATION TRENCH	67	94	99	100	0.04	0.28	8.78	0.02	0.92
D16UGS0004	INFILTRATION TRENCH	67	94	99	100	0.04	0.28	8.78	0.02	0.92
D08UGS0020	INFILTRATION TRENCH	134	93	98	99	0.05	0.45	11.26	0.03	1.23
TF-I-4	BIOFILTRATION	547	63	40	100	0.06	0.32	20.11	0.05	1.64
D21UGS0014	INFILTRATION TRENCH	960	95	98	100	0.07	0.44	14.05	0.03	8.26
D21UGS0011	INFILTRATION TRENCH	944	95	98	100	0.07	0.44	14.05	0.03	8.13
D21UGS0012	INFILTRATION TRENCH	425	95	98	100	0.07	0.44	14.05	0.03	3.66

Project ID	BMP Type	BMP Storage Capacity (ft^3)/ Filter Depth (in.)	Phosphorus BMP Efficiency (%)	Nitrogen BMP Efficiency (%)	Sediment BMP Efficiency (%)	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)	Impervious Area Treated (ac)	Runoff Depth (in.)
D21UGS0013	INFILTRATION TRENCH	510	95	98	100	0.07	0.44	14.05	0.03	4.39
D07UGS0008	INFILTRATION TRENCH	348	99	100	100	0.07	0.63	15.85	0.04	2.28
D08UGS0018	INFILTRATION TRENCH	134	74	93	95	0.08	0.84	21.56	0.06	0.62
D08UGS0019	INFILTRATION TRENCH	134	74	93	95	0.08	0.84	21.56	0.06	0.62
D10UGS0021	INFILTRATION TRENCH	229	96	99	100	0.09	0.77	19.25	0.05	1.24
TF-J/K-2	BIOFILTRATION	496	59	37	100	0.09	0.49	32.89	0.09	1.55
D31UGS0008	INFILTRATION TRENCH	66	84	95	96	0.10	0.68	21.51	0.05	0.36
TF-Q-1	BIOFILTRATION	314	46	29	97	0.10	0.55	45.74	0.12	0.69
D07UGS0014	INFILTRATION TRENCH	697	99	100	100	0.11	0.90	22.64	0.06	3.20
D31UGS0007	INFILTRATION TRENCH	86	91	98	99	0.11	0.70	22.21	0.05	0.46
D31UGS0010	INFILTRATION TRENCH	457	92	97	99	0.11	0.82	26.07	0.06	2.10
D16UGS0005	INFILTRATION TRENCH	179	96	99	100	0.11	0.68	21.51	0.05	1.01
D08UGS0037	INFILTRATION TRENCH	660	94	98	100	0.11	0.97	24.79	0.07	2.75

Project ID	BMP Type	BMP Storage Capacity (ft^3)/ Filter Depth (in.)	Phosphorus BMP Efficiency (%)	Nitrogen BMP Efficiency (%)	Sediment BMP Efficiency (%)	Removed Phosphorus Load (lb/yr)	Removed Nitrogen Load (lb/yr)	Removed Sediment Load (lb/yr)	Impervious Area Treated (ac)	Runoff Depth (in.)
TF-W-1	BIOFILTRATION	405	51	32	99	0.11	0.58	45.56	0.12	0.89
D08UGS0038	INFILTRATION TRENCH	912	93	97	99	0.12	1.02	26.15	0.07	3.59
D08UGS0035	INFILTRATION TRENCH	912	94	98	100	0.12	1.03	26.29	0.07	3.59
TF-W-2	BIOFILTRATION	587	58	37	100	0.12	0.63	46.70	0.11	1.04
TF-I-2	BIOFILTRATION	385	46	29	97	0.13	0.68	56.69	0.15	0.68
D21UGS0016	Rainwater Harvesting Tank	668	40			0.13			0.16	1.1
D07UGS0006	INFILTRATION TRENCH	648	92	97	99	0.13	1.17	29.89	0.08	2.23
D21UGS0016	INFILTRATION TRENCH	292	90	98	99	0.14	1.11	34.77	0.08	1.01
D10UGS0065	INFILTRATION TRENCH	392	94	99	100	0.17	1.54	38.87	0.10	1.05
TF-I-1	BIOFILTRATION	840	56	35	100	0.18	0.99	70.35	0.18	0.96
D08UGS0024	INFILTRATION TRENCH	1175	92	97	99	0.19	1.67	42.59	0.11	2.84
D31UGS0011	INFILTRATION TRENCH	320	88	97	99	0.19	1.29	40.72	0.09	0.94
D31UGS0009	INFILTRATION TRENCH	628	98	99	100	0.19	1.40	43.90	0.10	1.73
TF-E/F	BIOFILTRATION	668	48	31	98	0.20	1.11	88.60	0.24	0.72
D16UGS0006	INFILTRATION TRENCH	627	99	100	100	0.21	1.30	40.38	0.09	1.88

D07UGS0005	INFILTRATION TRENCH	1075	92	97	99	0.23	2.06	52.68	0.14	2.10
D07UGS0004	INFILTRATION TRENCH	823	98	99	100	0.24	2.05	51.70	0.14	1.65
TF-I-3	BIOFILTRATION	942	53	32	99	0.24	1.25	96.33	0.26	0.99
TF-G	BIOFILTRATION	608	41	26	95	0.24	1.32	120.08	0.32	0.41
TF-J/K-1	BIOFILTRATION	1002	52	32	99	0.27	1.41	109.80	0.29	0.89
D08UGS0027	INFILTRATION TRENCH	473	67	91	91	0.30	3.42	85.54	0.25	0.52
D02UGS0002	INFILTRATION TRENCH	590	82	96	98	0.31	3.03	77.36	0.21	0.77
D10UGS0060	INFILTRATION TRENCH	652	97	100	100	0.33	2.88	72.42	0.19	0.62
D10UGS0066	INFILTRATION TRENCH	1350	99	100	100	0.33	2.87	71.70	0.19	1.96
Broadway RW Tank	Rainwater Harvesting Tank	5988	40			0.41			0.58	2.85
D06UGS0001	EXTENDED DRY DETENTION POND	12720	14	23	49	0.43	6.07	321.76	1.74	2.01
D12UGS0007	INFILTRATION TRENCH	704	85	96	98	0.45	3.13	99.16	0.23	0.84
D31UGS0013	INFILTRATION TRENCH	1276	95	99	100	0.48	3.62	113.79	0.26	1.35
D03UGS0044	Rainwater Harvesting Tank	1320	40			0.50			0.70	0.52
D24UGS0011	INFILTRATION TRENCH	1637	99	100	100	0.55	3.38	105.35	0.24	1.88
D02USG0008	INFILTRATION TRENCH	523	47	78	70	0.60	8.50	190.62	0.73	0.20

D08UGS0034	INFILTRATION TRENCH	1518	93	99	100	0.67	5.95	150.96	0.40	1.05
D08UGS0036	INFILTRATION TRENCH	3703	94	98	100	0.67	5.88	150.23	0.40	2.55
D08UGS0032	INFILTRATION TRENCH	2091	100	100	100	0.67	5.69	142.28	0.38	1.53
D10UGS0067	INFILTRATION TRENCH	1700	95	99	100	0.68	5.99	150.96	0.40	1.17
D10UGS0019	INFILTRATION TRENCH	1727	95	99	100	0.69	6.05	152.47	0.40	1.18
PVT-37	Rainwater Harvesting Tank	2807	40			0.73			0.93	0.83
D01UGS0057	INFILTRATION TRENCH	3045	95	98	100	0.74	4.62	146.61	0.33	2.51
D20UGS0006	INFILTRATION TRENCH	1600	94	99	100	0.74	4.73	148.64	0.34	1.30
D02USG0005	INFILTRATION TRENCH	1002	81	95	97	0.76	7.56	192.35	0.53	0.52
D10UGS0068	INFILTRATION TRENCH	4008	95	98	100	0.85	7.39	188.70	0.50	2.21
D03UGS0050	INFILTRATION TRENCH	884	53	82	76	0.85	11.08	258.17	0.90	0.27
D07UGS0013	INFILTRATION TRENCH	2091	98	100	100	1.06	9.17	230.21	0.61	0.94
D21UGS0015	INFILTRATION BASIN	862	65	81	94	1.11	11.68	342.97	0.96	0.25
D01UGS0017	INFILTRATION TRENCH	11582	92	97	99	1.15	7.39	234.66	0.54	5.91
D03UGS0049	INFILTRATION TRENCH	2547	96	99	100	1.20	10.45	264.17	0.70	1.00

D08UGS0030	INFILTRATION TRENCH	2297	80	95	97	1.22	12.30	314.29	0.86	0.74
D10UGS0007	INFILTRATION TRENCH	3528	100	100	100	1.23	7.53	234.40	0.53	1.82
D07UGS0007	INFILTRATION TRENCH	4966	100	100	100	1.40	11.84	296.25	0.79	1.74
D03UGS0040	INFILTRATION TRENCH	3424	99	100	100	1.42	8.71	271.27	0.62	1.53
D08UGS0017	INFILTRATION TRENCH	1239	43	75	65	1.45	21.36	463.98	1.90	0.18
D10UGS0010	INFILTRATION TRENCH	1699	86	97	99	1.52	10.39	330.11	0.76	0.62
D01UGS0048	INFILTRATION TRENCH	3870	92	98	99	1.52	13.78	348.49	0.93	1.15
PVT-62	INFILTRATION TRENCH	1811	76	93	95	1.70	12.56	400.44	0.96	0.52
D10UGS0069	INFILTRATION TRENCH	6950	99	100	100	1.77	15.20	381.16	1.01	1.90
D01UGS0070	INFILTRATION TRENCH	3250	96	99	100	2.00	12.56	395.06	0.90	0.99
D01UGS0049	INFILTRATION TRENCH	4863	87	97	99	2.26	21.40	543.21	1.46	0.92
D03UGS0043	INFILTRATION TRENCH	6253	99	100	100	2.56	15.69	488.55	1.11	1.55
D03UGS0027	INFILTRATION TRENCH	13079	78	95	97	3.13	72.75	1859.19	2.42	1.49
PVT-77	INFILTRATION TRENCH	6046	94	99	100	3.83	33.92	860.45	2.28	0.73

WP1	WET POND/CREATED WETLAND	18018	57	36	82	3.98	18.27	1273.54	3.60	1.38
D08UGS0016	INFILTRATION TRENCH	4177	43	75	65	4.89	71.50	1559.07	6.33	0.18
D01UGS0069	INFILTRATION TRENCH	8500	96	99	100	5.21	32.66	1027.14	2.34	1.00
D03UGS0035	INFILTRATION TRENCH	14478	91	98	100	8.40	76.43	1951.94	5.18	0.77
Child Street Park IS	INFILTRATION TRENCH	5548	98	100	100	8.95	15.37	479.33	1.09	1.40
D03UGS0028	INFILTRATION TRENCH	18832	84	96	98	9.42	91.69	2339.89	6.32	0.82

APPENDIX IV
2022 PRIORITY RANKING OF BMPS AND IMPLEMENTATION PLANNING

M E M O R A N D U M

TO: Catherine Woodbury - Program Manager, City of Cambridge

FROM: Peter Varga, Kleinfelder

DATE: June 28, 2022

SUBJECT: MS4 Services Task 5D, BMP retrofit opportunities

CC: Kirsten Ryan, Jonnas Jacques, and Adria Fichter

I. Introduction

As part of its implementation of the current MS4 stormwater permitting program, the City of Cambridge (the City) has created a prioritized list of opportunities to install, modify, or retrofit stormwater Best Management Practices (BMPs) on various City-owned properties. This Technical Memorandum includes a description of how identified projects will serve to advance MS4 objectives, any additional potential sites to consider as well as feasibility and constraints and permitting requirements. This memorandum serves the purpose of documenting BMP Retrofit Opportunities for Year 4 in accordance with Part 2.3.6.d of the Massachusetts MS4 Permit; "…the permittee shall identify a minimum of 5 permittee-owned properties that could potentially be modified or retrofitted with BMPs designed to reduce the frequency, volume, and pollutant loads of stormwater discharges to and from its MS4 through the reduction of impervious area".

Over the last few years, the City has completed a number of studies related to the implementation of BMPs, such as Resilient Cambridge and the Climate Change Preparedness and Resiliency Study (CCPR). While not specifically targeted towards meeting stormwater quality improvement goals, nevertheless some proposed improvements serve these goals while also addressing other priorities relating to climate resiliency. Cambridge's Year 3 Annual Report identifies 10 potential candidate sites that could serve as locations for the implementation of stormwater BMPs. Combining the information from these various past efforts, a total of 15 sites are included in this analysis.

This technical memorandum aggregates and prioritizes 10 sites already identified by the City, with an additional 5 included by Kleinfelder, where stormwater BMPs will serve to advance MS4 objectives to the extent practicable (minimum 5 to meet permit requirements).

II. Objectives for BMP Retrofits

Stormwater BMPs are designed to reduce frequency, volume, and pollutant loads of stormwater discharges to and from Cambridge's MS4 area and directly to surface waters. A structural stormwater

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BMP is defined in the MS4 General permit as "a stationary and permanent BMP that is designed, constructed and operated to prevent or reduce the discharge of pollutants in stormwater".

Many different types of structural BMPs exist, from underground storage in oversized pipes and tanks, to green infrastructure / low impact development (GI/LID) designs that use nature-based solutions to control the quantity and quality of stormwater runoff that directly discharges to the underground drainage system or directly to surface waters. They accomplish this by offering pervious area where stormwater can infiltrate, vegetation and stone barriers to slow the velocity of stormwater flow and allow the sedimentation of solids and the contaminants that travel with them. This memorandum considers opportunities both for GI, and buried BMP implementation at each of the selected sites.

Parking lot drainage swale – example of green infrastructure, structural BMP

III. Background and Methodology for GIS Analysis of Candidate Sites

The City is progressive in its plan to manage post construction stormwater runoff. This includes updating regulations and design guidelines to reflect climate change adaptation and allowing the construction of green infrastructure. In addition, the City:

- Maintains a database of privately owned BMPs.
- Developed a Five-Year Sidewalk and Street Reconstruction Plan that includes opportunities for innovative stormwater management.
- Evaluates City-owned properties for retrofits as part of its Climate Change Vulnerability Assessment (CCVA).

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- Developed a Ten-Year Sewer and Drain Infrastructure Plan that describes the City's upcoming capital and maintenance programs for these systems.

While the CCVA and Resilient Cambridge have focused mainly on flooding prone areas, water quality is a co-benefit identified in both reports. Much of the basis of the GIS analysis in prior efforts (topography, soil characteristics, groundwater, open space, etc.) can be used to evaluate City-owned properties within the MS4 service area of the City that can be modified or retrofitted from a water quality perspective as well.

As part of the Five Year Sidewalk and Street Reconstruction Plan the City evaluates each street that is scheduled for reconstruction for green infrastructure retrofit opportunities and identifies plazas and other hardscape areas where plantings can be enhanced and pavement removed. The City is tracking the expansion of planting beds and installation of rain gardens/biobasins during street reconstruction and landscape improvement efforts. In addition, the City is looking at opportunities within capital improvement plans for municipal properties for ways to reduce imperviousness on site during reconstruction and/or retrofit with BMPs.

The City has also developed a strategic plan, Ten Year Sewer and Drain Infrastructure Plan, to manage the infrastructure improvements of the sewer and storm water mains, manholes, catch basins, pumping stations and CSO outfalls that carry waste and storm water to treatment plants and discharge locations This 10-year plan serves as a guidance document to prioritize construction and rehabilitation of these complex systems.

Both the 5 Year Sidewalk and Street Reconstruction Plan, and 10 Year Sewer and Drain Infrastructure Plan were included in this analysis as additional selection criteria. Those parcels that are located in areas where work is planned can be future candidates for BMP retrofit development as the City invests in the implementation of sidewalk and drainage priority improvements in parallel.

Candidate Site Prioritization and Ranking

The candidate sites identified in these past studies were further developed and screened using several selection criteria. The remaining sites were then intersected with the SSURGO USGS Soils data which includes key information such as hydrologic soil classification, slope, and available groundwater storage. Area of impervious surface was also considered for each potential BMP location. The sites were overlayed with the latest 10-year 2070 flood extent modeled as part of the Resilient Cambridge Study to see if they are located in areas prone to flooding.

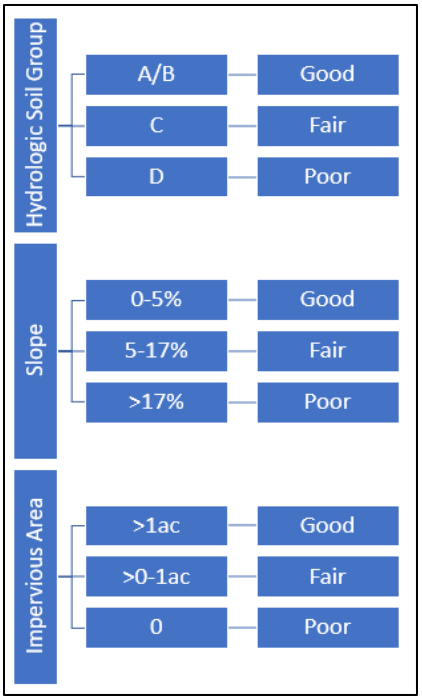

Figure 1. BMP suitability workflow.

Figure 1 depicts the quantifiable parameters that were used to prioritize the sites for BMP retrofit compatibility. A qualitative ranking was then further applied to account for proximity to open space (the reasoning being that open space will have further opportunities for education and outreach, green infrastructure solutions, and underground storage) past and future planning efforts, and other criteria as shown in Table 1 .

Using the 2021 Assessor Parcels data, a selection was made to only include parcels owned by the City. Next, another selection was run to filter the Cambridge-owned parcels down to those that were roughly an acre or larger in area. The one-acre threshold was chosen because although half of the 28 City-owned parcels are under an acre, smaller sites containing buildings have limited space for BMP installation, particularly for water quality improvements; candidate parcel size may shrink as the City continues to consider candidate sites in future permit years. Next, those remaining parcels were intersected with the USGS SSUGRO Soils data and then selected for parcels that were majority A or B soils as those are ideal for groundwater infiltration projects. The remaining parcels were then further filtered by selecting those that had a representative slope of 5% or lower.

Qualitative considerations for site selection and prioritization are summarized in the table below.

Table 1 – Evaluation Criteria

Screening Criteria	Description
Soil Type	Help evaluate area's ability to infiltrate stormwater

Screening Criteria	Description
Available Water Storage 0-25 cm	Related to soils data, help evaluate area's ability to retain water.
Available Area	Targeted sites that are at least an acre in area
Proximity to Open Space	Green locations with good public education opportunities
Opportunities for Public Use and Education	Considers proximity to open spaces, schools.
MS4 - Area	Area of jurisdiction
5-Year and 10-Year Plan (Overlap)	Areas of future investment where additional work could be more feasibly planned in parallel
BMP Design Status	Existing plans for areas already set aside for BMPs
10-Year, 2070, Flooding in vicinity of Project Site	Important considerations for flood mitigation/climate resilience.

IV. Summary and Conclusions

The combined 15 candidate sites for potential BMP retrofit / development were prioritized in this analysis and are listed in ranking order in Table 2 based the evaluation against screening criteria.

Table 2 – Final Site Ranking based on screening criteria

Site	Ranking
River Street	1
The Port Phase 1/ Parking Lot 6	2
Inman Square	3
Tobin School	4
Willard Street	5
Triangle Park	6
Timothy Toomey Jr. Park	7
Cushing Street Plaza	8
The Port Phase 2	9
Cambridge Public Library / Lorentz Park	10
CHA Cambridge Hospital	11

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Site	Ranking
Clement Morgan Park	12
King Open School	13
Hoyt Recreation Area	14
Chetwynd Road	15

From the table above, the top 5 sites; River Street, The Port, Inman Square, Tobin School, and Willard Street are depicted on the map below along with the locations of the other sites in the analysis. It should be noted that while some of the selected sites are outside the designated MS4 area, there is a benefit to incorporating them as the City systematically continues to separate its stormwater infrastructure. With the City's limited areas of suitable and available space within the dense and highly urbanized area, the City feels that all sites would serve the intended purpose of improving water quality outcomes in the Charles River and serve Permit goals.

A discussion of each of the 5 top sites is included in Attachment A.

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ATTACHMENT A – SUMMARY OF FIVE TOP-RANKED SITES FOR BMP RETROFITS

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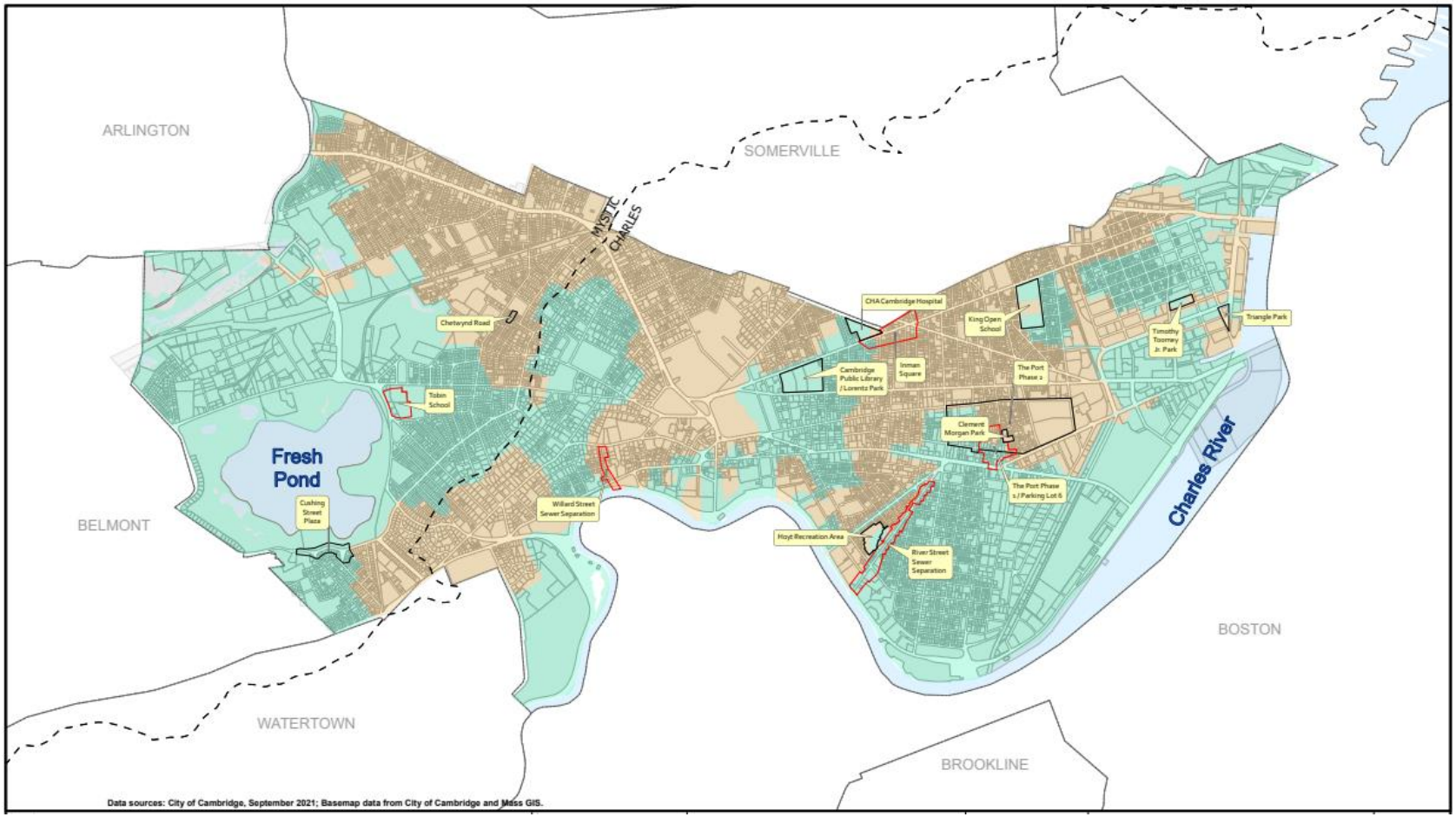
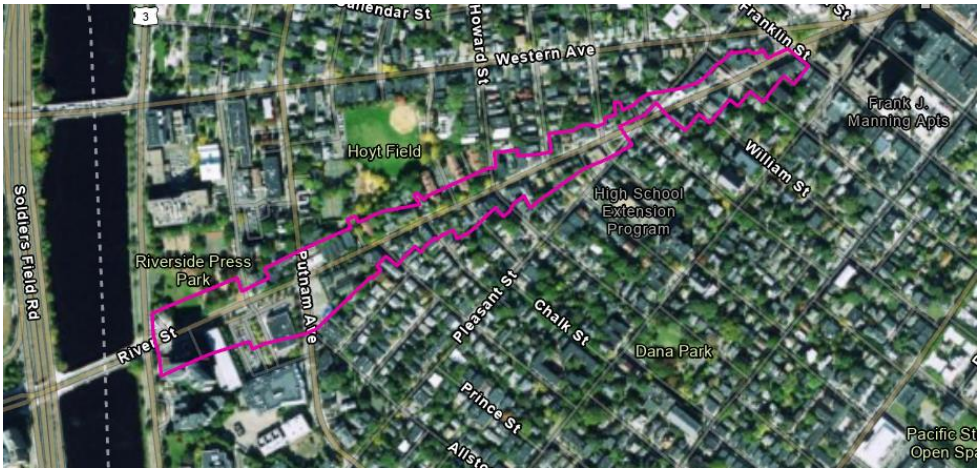


Figure 2 – Location map for prioritized BMP installation – 5 top-ranked sites in red

Attachment A – Site-Specific Details

1. River Street

The River Street project consists of upgrades to all infrastructure in its corridor, including subsurface utilities, and surface elements. Sewer separation is required for a portion of the project area, and the project also includes drainage improvements to reduce flooding. Final street design is to be to complete street standards, including a separated bicycle facility, stormwater improvements and additional tree plantings. Project also includes redesign and reconstruction of Carl Barron Plaza in Central Square, Tubman Plaza and Blackstone Street. Installed BMPs include: replacement of all catch basins with deep sump catch basins with hoods and incorporation of green infrastructure features, including a pervious asphalt bicycle lane the full length of River Street. Estimated impervious reduction is approximately 30,000 sf.

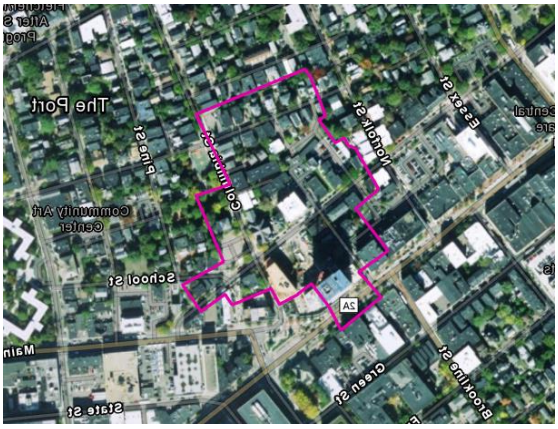


- Land Area – 13.8 acres
- Land Use – High density residential
- Topography – Relatively flat
- Soil Characteristics – Well-draining soils
- Open Space – close to Riverside Press Park
- Groundwater Storage (USGS Soils data layer) – can store over 5 cm of precipitation

2. The Port

The Port neighborhood is vulnerable to flooding, and climate change is increasing the risk of flooding due to more frequent, short, very intense rainstorms. This project will reduce the frequency and severity of stormwater flooding and sewer backups in the neighborhood, and upgrade the neighborhood's surface infrastructure, including streets, sidewalks, shade trees, landscaping, and open spaces. The Port Phase 1 project, consisting of the PL6 stormwater storage tank and pump station, was completed in early 2021, Phase 2 and Phase 3 will include completion of storm/sanitary separation in the

neighborhood, construction of additional underground sanitary storage and pump stations, connections to existing storm and sewer systems for post-storm discharge, and full reconstruction of neighborhood streets including green infrastructure.



- Land Area – 10.62 acres
- Land Use – Urban, mixed, high density residential
- Topography – relatively flat
- Soil Characteristics – well-draining soils
- Open Space – close to Morgan Park
- Groundwater Storage (USGS Soils data layer) – capacity to store over 5cm of precipitation

3. Inman Square

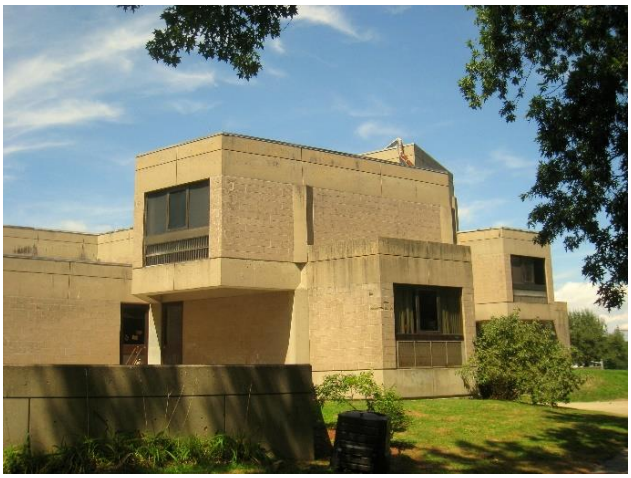
The completion of this project has decreased impervious surface by approximately 7,000 SF with the installation of porous cycle tracks, permeable pavers, and planting beds. Overflow from the infiltration systems discharge to a combined sewer system, however the majority of which is planned for separation in the future. Additionally, the infiltration systems are designed to promote plant and tree growth.

- Land Use – mixed use/commercial/residential
- Land Area – 11.6 acres
- Topography – relatively flat

- Soil Characteristics – well-draining soils
- Open Space – Vellucia plaza offers a small open space in the square
- Groundwater Storage (USGS Soils data layer) – can store over 5 cm of precipitation

4. Tobin Montessori / Vassal Lane Schools

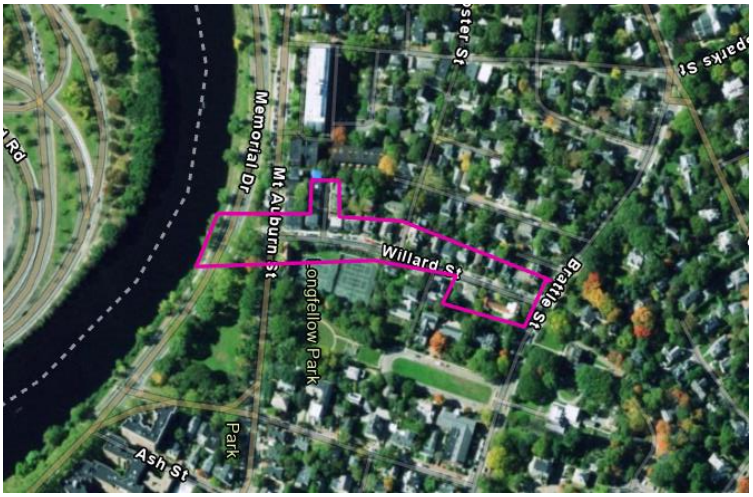
This project will demolish and rebuild the existing school facility and adjacent recreational facilities. The project began construction in July 2021 and will include a 1.25 MG stormwater storage tank and 100,000 gallon bioretention system to manage flooding and treat stormwater in the neighborhood from extreme and high intensity rain events. The site will also include a number of bioretention raingardens to treat stormwater. The site is built on a historic landfill and is relatively impervious due to the landfill cap. All infiltration from any newly installed BMPs will require an underdrain system that will ultimately discharge to the drainage system.



- Land Use – mixed use/high density residential
- Land Area – 6.7 acres
- Topography – relatively flat
- Soil Characteristics – moderately to poorly draining soils
- Open Space – site includes open space
- Groundwater Storage (USGS Soils data layer) – Poor groundwater storage capability of due to location on capped landfill

5. Willard Street

The Willard Street neighborhood is a combined sewer system and has experienced flooding on several occasions. Sewer separation in this area will include replacing and/or rehabilitating the sewer and stormwater infrastructure and the construction of a new stormwater pipe and outfall at the Charles River, evaluation and implementation of stormwater best management practices, and water main replacement. Following subsurface work, the street will be reconstructed along "complete streets" principles, including traffic calming elements and improvements to bicycle and pedestrian accessibility. The new outfall project will be constructed in 2022. Planned BMPs will include deep sump catch basins with hoods for pre-treatment; tree pits with extended underground infiltration trenches; and permeable surface strips over subsurface gravel infiltration trenches. The infiltration trenches are sized to store/infiltrate runoff exceeding ½-inch across the contributing impervious area. A subsurface infiltration system in Longfellow Park, sized to infiltrate runoff from up to the 10-year storm was completed in fall 2019 and reduces stormwater inflow into the combined sewer system.



- Land Use – mixed use/high density residential
- Topography – relatively flat
- Soil Characteristics – well-draining soils
- Open Space - close to Longfellow Park and Riverbend Park
- Groundwater Storage – can store over 5 cm of precipitation

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APPENDIX V
BMP IMPLEMENTATION SCHEDULE

Appendix V: BMP Implementation Schedule
City of Cambridge PCP

Planned Controls	Before 6/30/2023	7/1/23 - 6/30/2024	7/1/24 - 6/30/2025	7/1/25 - 6/30/2026	7/1/26 - 6/30/2027	7/1/27 - 6/30/2028	7/1/28 - 6/30/2029	7/1/29 - 6/30/2030
Enhanced Street Sweeping	Ongoing City Effort							
Private Structural BMPs								
North Point/Cambridge Crossing Phase 1	Ongoing Private Development Scheduled to be Complete 2028							
North Point/Cambridge Crossing Phase 2							Private Development to be Complete 2030	
Other Private BMPs				*Year 8 - 20% Reduction Milestone*				
City-Owned Structural BMPs						*Year 10 - 25% Reduction Milestone*		
Sewer Deflection Talbot Street	Existing. Credits Pending							
Sewer Deflection Project 9ab (Binney Street)		City Project Scheduled to be Complete 2028						
Sewer Deflection Western Avenue		City Project Scheduled to be Complete 2028						
City-Owned Structural BMPs								

APPENDIX VI
SUPPORTING COST RESOURCES

Type	SOURCE1	FACILITYID	Watershed	Site/Project	BMP Description	BMP Type	Soil Type (at BMP)	Treatment Depth (in, calculated)	Storage Volume (cu ft)	Catchment Area (Total, sq ft)	Catchment Area Impervious (sq ft)	ACRE	Land Use of Catchment Area	Install Date	Date of Last Inspection	Child Structures	Annual O&M Cost + City Personnel	Construction Cost Reference (Maryland)	Pre Construction Cost	Construction Cost	TOTAL	Rehabilitation	ESCALATED TOTAL CONSTRUCTION COST	P Reduction	$/ Phosphorus Reduction Credit
CULTEC SYSTEM	1640 Camb St Cultech Inspection 20110512	D21UGS0018	Charles	Cambridge Rindge and Latin School	Cultech System	Underground Infiltration System	0.52 in/hr	0.5		3500	3500	0.080348944	Institutional	2011			$ 2,100.00	$ 16,000.00	$ 1,285.58	$ 3,213.96	$ 4,499.54	$ 449.95	$ 7,000.00	1.88966369	$ 3,704.36
CULTEC SYSTEM	850 Cambridge St Asbuilt 20170321	D01UGS0061	Charles	King Open School	Underground Detention System #1 (NE corner)	Detention?		1.6	6463	47011	47011	1.079224059	Institutional	2018	6/15/2022	D01DMH3335, D01DMH3350	$ 2,100.00	$ 16,000.00	$ 17,267.58	$ 43,168.96	$ 60,436.55	$ 6,043.65	$ 90,000.00	1.89379217	$ 47,523.69
STORAGE TANK	850 Cambridge St Asbuilt 20170321	D01UGS0062	Charles	King Open School	Rainwater Harvesting Tank (courtyard)	Retention (30,000 gallons tank)	--	0.7	4010	68000	68000	1.561065197	Institutional	2018	6/15/2022	D01DMH0237, D01DMH0239, D01DMH024	$ 2,100.00	$ 9,000.00	$ 14,049.59	$ 46,831.96	$ 60,881.54	$ 6,088.15	$ 91,000.00	1.1	$ 82,727.27
INFILTRATION SYSTEM	BBinney St Asbuilt .dwg 20151112	D01UGS0037	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.4	172	4700	4700	0.107897153	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,888.20	$ 4,315.89	$ 6,204.09	$ 620.41	$ 10,000.00	0.068607	$ 145,757.72
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0036	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.5	172	4500	4500	0.103305785	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,807.85	$ 4,132.23	$ 5,940.08	$ 594.01	$ 9,000.00	0.1537768	$ 58,526.38
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0038	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.8	172	2700	2700	0.061983471	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,084.71	$ 2,479.34	$ 3,564.05	$ 356.40	$ 6,000.00	0.1436308	$ 41,773.77
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0039	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.5	172	3800	3800	0.087235996	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,526.63	$ 3,489.44	$ 5,016.07	$ 501.61	$ 8,000.00	9.80E-02	$ 81,632.65
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0040	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.7	172	2800	2800	0.064279155	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,124.89	$ 2,571.17	$ 3,696.05	$ 369.61	$ 6,000.00	0.1334848	$ 44,948.94
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0041	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.8	172	2500	2500	0.057392103	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,004.36	$ 2,295.68	$ 3,300.05	$ 330.00	$ 5,000.00	9.80E-02	$ 51,020.41
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0042	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.3	172	6600	6600	0.151515152	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 2,651.52	$ 6,060.61	$ 10,890.15	$ 871.21	$ 17,000.00	9.80E-02	$ 173,469.39
INFILTRATION SYSTEM	Binney St Asbuilt .dwg 20151112	D01UGS0043	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.4	172	4700	4700	0.107897153	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,888.20	$ 4,315.89	$ 6,204.09	$ 620.41	$ 10,000.00	0.18200868	$ 54,942.44
INFILTRATION SYSTEM	Binney St Conformed Plans 20130529 SW02	D01UGS0044	Charles	Binney Street	Infiltration Unit	Leaching Basin	0.52 in/hr	0.4	172	4700	4700	0.107897153	Commercial	2015	6/15/2022	See ParentChild tab	$ 2,100.00	$ 17,500.00	$ 1,888.20	$ 4,315.89	$ 6,204.09	$ 620.41	$ 10,000.00	0.1537768	$ 65,029.32
INFILTRATION SYSTEM	City Hall Site Plan - 3/3/2000	D10UGS0002	Charles	City Hall	Infiltration Bed - Cultec C-4 Chambers (2 rows)	Underground Infiltration System	0.52 in/hr	0.0		3500	3500	0.080348944	Commercial	2000	5/2/2022	D10DMH4100	$ 2,100.00	$ 17,500.00	$ 1,406.11	$ 3,213.96	$ 4,620.06	$ 462.01	$ 7,000.00	0.1537768	$ 45,520.52
INFILTRATION SYSTEM	City Hall Site Plan - 3/3/2000	D10UGS0003	Charles	City Hall	Infiltration Bed - Cultec C-4 Chambers (2 rows)	Underground Infiltration System	0.52 in/hr	0.0		3500	3500	0.080348944	Commercial	2000	5/2/2022	D10DMH4005	$ 2,100.00	$ 17,500.00	$ 1,406.11	$ 3,213.96	$ 4,620.06	$ 462.01	$ 7,000.00	0.044144	$ 158,571.95

Planning Level Unit Cost Development for Stormwater Best Management Practices (BMPs)[1]
PART 1: Initial Costs Per Impervious Acre Treated

Stormwater BMP	2023 Initial Project Costs (Escalated to 2023 from 2011)				
	Pre-Construction Costs[2]	Construction Costs[3]	Land Costs[4]	Total Initial Costs	Annualized Initial Costs5
Impervious Urban Surface Reduction	$ 13,100	$ 130,100	$ -	$ 143,100	$ 9,700
Urban Forest Buffers	$ 4,500	$ 44,700	$ -	$ 49,100	$ 3,300
Urban Grass Buffers	$ 3,200	$ 32,000	$ -	$ 35,200	$ 2,400
Urban Tree Planting	$ 4,500	$ 44,700	$ -	$ 49,100	$ 3,300
Wet Ponds and Wetlands (New)	$ 8,300	$ 27,600	$ -	$ 35,900	$ 2,500
Wet Ponds and Wetlands (Retrofit)	$ 31,800	$ 63,500	$ -	$ 95,200	$ 6,400
Dry Detention Ponds (New)	$ 13,400	$ 44,700	$ -	$ 58,000	$ 3,900
Hydrodynamic Structures (New)	$ 10,500	$ 52,100	$ -	$ 62,500	$ 4,200
Dry Extended Detention Ponds (New)	$ 13,400	$ 44,700	$ -	$ 58,000	$ 3,900
Dry Extended Detention Ponds (Retrofit)	$ 33,500	$ 67,000	$ -	$ 100,400	$ 6,800
Infiltration Practices w/o Sand, Veg. (New)	$ 24,900	$ 62,100	$ -	$ 86,900	$ 5,900
Infiltration Practices w/ Sand, Veg. (New)	$ 26,100	$ 65,100	$ -	$ 91,100	$ 6,200
Filtering Practices (Sand, above ground)	$ 20,900	$ 52,100	$ -	$ 72,900	$ 4,900
Filtering Practices (Sand, below ground)	$ 23,800	$ 59,500	$ -	$ 83,300	$ 5,600
Erosion and Sediment Control	$ 9,000	$ 29,800	$ -	$ 38,700	$ 2,600
Urban Nutrient Management[6]	$ -	$ 90,700	$ -	$ 90,700	$ 6,100
Street Sweeping[7]	$ -	$ 9,000	$ -	$ 9,000	$ 700
Urban Stream Restoration	$ 32,000	$ 64,000	$ -	$ 95,900	$ 6,500
Bioretention (New - Suburban)	$ 14,000	$ 55,800	$ -	$ 69,700	$ 4,700
Bioretention (Retrofit - Highly Urban)	$ 78,100	$ 195,200	$ -	$ 273,200	$ 18,400
Vegetated Open Channels	$ 6,000	$ 29,800	$ -	$ 35,700	$ 2,400
Bioswale (New)	$ 17,900	$ 44,700	$ -	$ 62,500	$ 4,200
Permeable Pavement w/o Sand, Veg. (New)	$ 32,400	$ 323,900	$ -	$ 356,200	$ 24,000
Permeable Pavement w/ Sand, Veg. (New)	$ 45,400	$ 453,400	$ -	$ 498,700	$ 33,600

[1] All costs are expressed per acre of impervious area treated, not per acre of BMP. Initial costs are assumed to take place in year T=0; annual costs are incurred from year T= 1 through year T= 20.

[2] Includes cost of site discovery, surveying, design, planning, permitting, etc. which, for various BMPs tend to range from 10% to 40% of BMP construction costs.

[3] Includes capital, labor, material and overhead costs, but not land costs, associated implementation; for street sweeping includes only capital cost of purchasing a mechanical sweeper. Nutrient management construction costs refer to the cost of an outreach campaign, not to any construction costs.

[4] For all stormwater BMPs that require land it is assumed that: 1) the opportunity cost of developable land is $100,000 per acre and 2) 50% of projects that require land take place on developable land with the rest taking place on land that is not developable. This brings the opportunity cost of land for stormwater BMPs that require land to $50,000 per acre. Actual county-specific land cost and percent developable land values can be filled in to the right.
NOTE: The area of a BMP project may be greater or less than the impervious area treated.

[5] Initial BMP costs, including preconstruction, construction, and land costs, are amortized over 20 years at 3% to arrive at annualized initial costs.

[6] Best available data indicate that "retail" (i.e., direct mail) public outreach campaigns cost about $15 per household contacted. For an illustrative county, we assumed that each household has 5,941 sq ft of turf and 2,406 sq ft of impervious cover (medium density development). This means that 7.33 households need to adopt this BMP to potentially result in an acre of turf being treated, at a cost $109.98 per turf acre. Based on a review of direct mail response rates, we assumed that 2% of households contacted will respond positively to this outreach effort, bringing the cost per turf acre treated to $5,497.50/acre. The equivalent on a per-impervious-acre was based on the MDE June 2011 stormwater guidance document, which provides an equivalent for this practice of .09 acres impervious area per one acre of this practice. This estimate does not include any additional costs for soil tests by the homeowner to determine the appropriate amount of fertilizer required.

[7] Capital acquisition cost per impervious acre treated.

Stormwater BMP Unit Cost Estimates, Maryland Department of the Environment, https://mde.maryland.gov/programs/water/319NonPointSource/Documents/MD_Stormwater_BMP_Cost_Worksheets_King_Hagan_12Oct2011.xls

Source: 2010 Minnesota SW Manual	Average Construction Cost per WQV/ft3	Standard deviation	Average O&M Cost per WQV/ft3	Standard deviation	Minimum Construction Cost per WQV/ft3	Maximum Construction Cost per WQV/ft3
Bioretention Basin	15	9	1.25	1.18	10.1	11.3
Biofiltration Basins	58	61				
Large Wet Detention Basins treating more than 100,000 ft3	2	2	0.07	0.1		
Small Detention Basins treating less than 10,000 ft3	145	42				
Constructed Wetlands	1	1.5			0.2	2.4
Infiltration Trenches	11	30	0.39	0.11	3.4	16.8
Infiltration Basins	21	15				
Underground Infiltration	213	372	1.26	2.16		
Pervious Pavement	16	8				

Minnesota Stormwater Manual, BMP practices construction costs maintenance costs and land requirements - Minnesota Stormwater Manual (state.mn.us)

APPENDIX VII
CAMBRIDGE PCP FACTSHEET

PHOSPHORUS CONTROL PLANNING

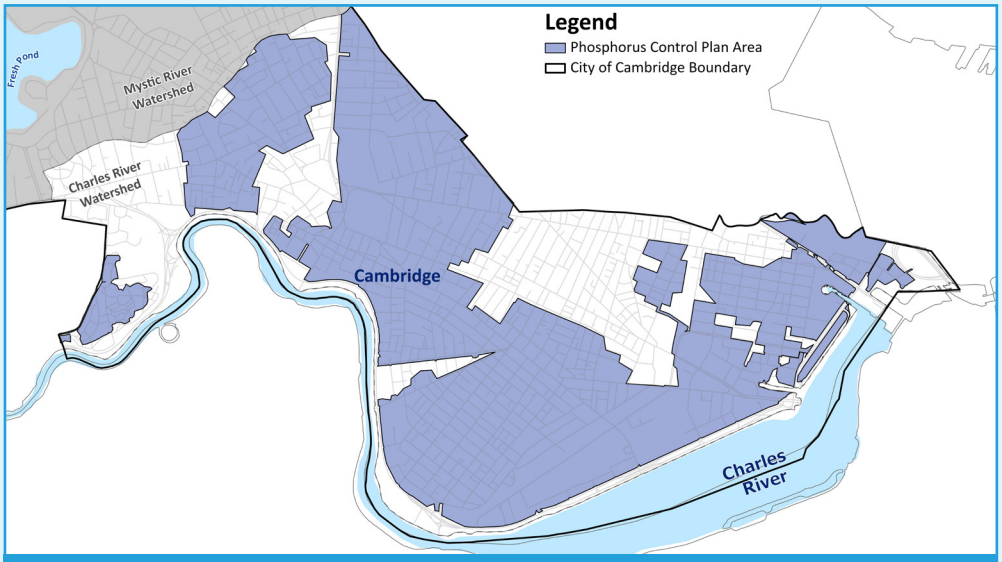
THE CHARLES RIVER IS IMPACTED BY ELEVATED LEVELS OF PHOSPHOROUS, WHICH CAUSES WATER QUALITY PROBLEMS.

What is Phosphorus?

Phosphorus is a naturally occurring nutrient. However, excess phosphorus in the environment is a source of pollution.

Where do excessive levels of Phosphorus come from?

High levels of Phosphorus can come from excessive or improper use of fertilizers, deteriorating leaves and yard waste, improper disposal of pet waste, and illicit connections where sewage can enter the drainage systems.



The City's Phosphorus Control Plan includes areas within the Charles River Watershed. Some of these areas have separated sewer systems, where stormwater and wastewater are conveyed through two distinct sets of pipes. While other areas are not separated yet, there are plans for them to be separated in the future.

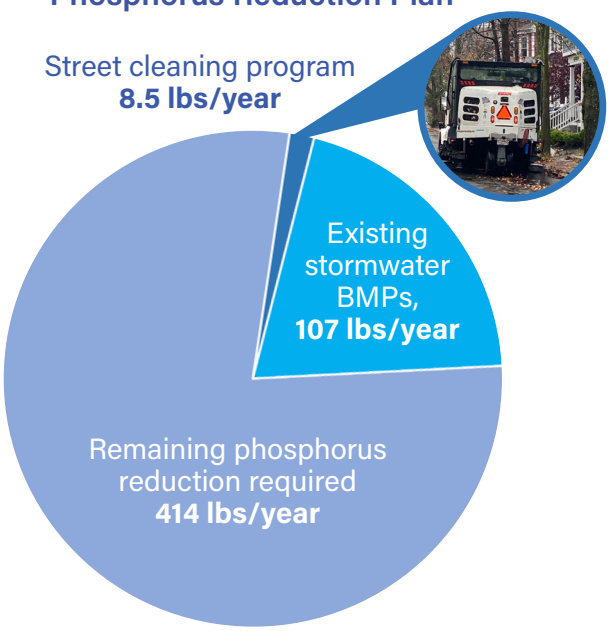
How does Phosphorus travel to our waterways?

As stormwater flows over hard surfaces, like streets, roofs and parking lots, it collects various pollutants like phosphorus. In Cambridge, stormwater enters drainage systems through storm drains on streets, and discharges to the Charles River and Alewife Brook.

Why is Phosphorus bad for our waterways?

Too much Phosphorous can cause algae growth in our waterways. This can produce harmful algal blooms that affect public health, deplete oxygen levels, and harm the marine ecosystem.

Phosphorus Reduction Plan



What is the City doing to lower Phosphorus levels?

As part of the City's stormwater program, Cambridge is working to reduce its phosphorus loading by 529 pounds per year by 2028. This equates to a 25% reduction in current phosphorus loads to the Charles River. The City plans to achieve this by:

- Continuing current street cleaning program.
- Focusing on inspection and maintenance of existing stormwater Best Management Practices (BMPs) Implementing additional green infrastructure, such as infiltration trenches, tree box filters, and rain gardens.
- Evaluating various types of projects other than traditional Best Management Practices to reduce Phosphorus loading.
- Spending upwards of $4.1 Million over the next five years to achieve these goals.

THINK BLUE CAMBRIDGE

CAMBRIDGE DEPARTMENT OF PUBLIC THE WORKS

For more information, visit: CambridgeMA.gov/Stormwater