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PHASE II PHOSPHORUS SOURCE IDENTIFICATION REPORT

MS4 GENERAL PERMIT COMPLIANCE

JUNE 2023
Updated June 2024



TOWN OF
Tewksbury
MASSACHUSETTS

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TABLE OF CONTENTS

1.0	INTRODUCTION.....	3
1.1	Regulatory Requirement.....	3
2.0	PROJECT BACKGROUND.....	4
2.1	Waterbody Descriptions.....	4
2.2	Phosphorus Source Identification Report.....	4
2.3	BMP Retrofit Inventory Report.....	8
3.0	EVALUATION OF STRUCTURAL BMP OPPORTUNITIES.....	10
3.1	Project Ranking Matrix Results.....	12
3.1.1	<i>Hillcrest Road at Chandler - Leaching Catch Basins/ Mini Dry Well Installations</i>	15
3.1.2	<i>Woburn and Felkner Street Drainage Improvements</i>	15
3.1.3	<i>Andover Street at Hood Road Culvert</i>	15
3.1.4	<i>Lowell Street ROW</i>	15
3.1.5	<i>Country Club Drive Parcel</i>	16
3.1.6	<i>Park Avenue Parcels</i>	16
3.1.7	<i>Chandler Street (Pine Street to Billerica Line)</i>	16
3.1.8	<i>Heath Brook Elementary School</i>	16
3.1.9	<i>Cardigan Road at Kendall Road</i>	16
3.1.10	<i>Tewksbury DPW & School Maintenance Facility</i>	16
3.1.11	<i>Chandler Street (Main Street to Foster Road)</i>	17
3.1.12	<i>Town Hall Campus (1009 Main Street & 11 Town Hall Avenue)</i>	17
3.1.13	<i>Tewksbury Public Library (300 Chandler Street)</i>	17
3.1.14	<i>Highwood Drive</i>	18
3.1.15	<i>Cobleigh Drive</i>	18
3.1.16	<i>Shawsheen Street (Foster Road to Darlene Circle)</i>	18
3.1.17	<i>East Street Athletic Fields (90 Chandler Street)</i>	18
3.1.18	<i>Andover Street (Blacksmith Lane to Trull Road)</i>	18
3.1.19	<i>Pukis Road at Coolidge Road</i>	18
3.2	Demonstration BMP Project.....	19
3.3	Implementation and Maintenance Cost.....	19
3.4	Implementation Schedule.....	19

ATTACHMENTS

Attachment A – Tewksbury Phosphorus Source Identification Report

Attachment B – BMP Assessment Matrix

Attachment C – Map of Retrofit Sites

Attachment D – Construction Drawings

1.0 INTRODUCTION

1.1 Regulatory Requirement

The 2016 Massachusetts General Permit for Small Municipal Separate Storm Sewer Systems (MS4 Permit) includes specific requirements for MS4 operators that discharge to impaired waterbodies where pollutants typically found in stormwater—specifically nutrients, solids, bacteria/pathogens, chloride, metals, and oil and grease—are the cause of the impairment and there is not a Total Maximum Daily Load (TMDL) approved by USEPA. Additional requirements for phosphorus impairments include supplementary public education efforts, specific Best Management Practice (BMP) design standards, increased street sweeping, the development of a Phosphorus Source Identification Report (PSIR) for each waterbody with a phosphorus impairment, and an evaluation of structural BMP retrofit or installation opportunities including the construction of a demonstration project by the end of Permit Year 6. During Permit Year 4, a PSIR was developed for the entire Town of Tewksbury, as most catchment areas either directly discharge to a phosphorus-impaired water body, or discharge to a water body that is tributary to a receiving water impaired for phosphorus. Waterbodies in Tewksbury that are impaired for phosphorus include Long Pond and the Merrimack River. Stormwater discharges to water bodies tributary to the Shawsheen River and Concord Rivers are also tributary to the Merrimack River, which requires the development of a TMDL for phosphorus.

Phase II of Tewksbury's PSIR has been developed to evaluate Town-owned properties or areas for structural BMP installation. In accordance with permit requirements, this report includes the following elements:

1. Next infrastructure or redevelopment activity planned for the property or the planned retrofit date;
2. Estimated cost of redevelopment or retrofit BMPs; and
3. Engineering and regulatory feasibility of implementing the redevelopment or retrofit BMPs.

This report was completed on or before the end of Permit Year 5 or June 30, 2023 in accordance with Permit requirements. By the end of Permit Year 6 (FY2024), Tewksbury is required to plan and install one of the retrofit projects identified in the PSIR as a demonstration project in a catchment area with a high phosphorus load potential. The remainder of the retrofit projects, where implementation is feasible from an engineering and permitting perspective, should be installed according to a schedule that must be included in the Year 5 Annual Report. Tewksbury will consider future availability of funding in developing the schedule. Tewksbury is also required to track any structural BMPs installed in the watershed and calculate the estimated phosphorus removal attributable to those BMPs consistent with Attachment 3 to Appendix F of the MS4 Permit. The BMP type, area treated, design storage volume, and estimated phosphorus removed in pounds per year by each BMP must be included in the Town's future MS4 annual reports.

2.0 PROJECT BACKGROUND

2.1 Waterbody Descriptions

Tewksbury is located within the Concord, Ipswich, Merrimack, and Shawsheen River Watersheds. Only a small portion of the southernmost part of town is located within the Ipswich River Watershed. Both the Concord and Shawsheen Rivers are tributary to the Merrimack River, meaning that stormwater discharges from almost every town-owned outfall are tributary to the Merrimack River. The segments of the Merrimack River downstream of where these rivers discharge to are impaired for phosphorus.

The Merrimack River begins in Franklin, New Hampshire, and travels 115 miles to the Atlantic Ocean in Newburyport, Massachusetts. A small northern portion of Tewksbury is within the Merrimack River Watershed; Trull Brook in Tewksbury is also located within the Merrimack River Watershed. The portion of the Merrimack River that borders Tewksbury (Segment MA84A-03) is on the Massachusetts Integrated List of Waters, or 303(d) list, for E. coli, mercury in fish tissue, PCBs in fish tissue, and total phosphorus.

The Shawsheen River is a tributary of the Merrimack River traveling 25 miles from Bedford to Lawrence, Massachusetts. A majority of Tewksbury is located within the Shawsheen River Watershed; the river crosses the Town from south to north. Water bodies within the Shawsheen River Watershed include Long Pond, Round Pond, Ames Pond, Richardson Pond, Meadow Brook, Strong Water Brook, Content Brook, Heath Brook, Pinnacle Brook, and Sutton Brook. This river also receives significant wastewater effluent. The portion of the river within Tewksbury (Segment MA83-18) is on the 2018/2020 303(d) list, for dissolved oxygen, E. coli and fecal coliform. The river has a bacteria TMDL under the *Total Maximum Daily Loads of Bacteria for the Shawsheen River Basin*.

The Concord River is another tributary of the Merrimack River traveling 15 miles from Concord at the confluence of the Assabet and Sudbury Rivers to Lowell, Massachusetts. A small westernmost portion of Tewksbury is located within the Concord River Watershed; Marginal Brook is tributary to the river. Total phosphorus was removed as an impairment from the three sections of the Concord River (MA82A-07, MA82A08, and MA82A-09) in the 2016 List of Integrated Waters, following a TMDL Study for total phosphorus on the Assabet River in 2004 that led to WWTP improvements and decreased nutrient flux from the four major treatment plants discharging to the river.

Long Pond (MA83010) is located in the southwestern portion of Tewksbury. The pond has a relatively small watershed and drains to Richardson Pond in Billerica, then to Content Brook and the Shawsheen River. This pond is on the 2018/2020 303(d) list for algae, chlorophyll-a, dissolved oxygen, total phosphorus, and transparency/clarity.

2.2 Phosphorus Source Identification Report

The Town developed a Phosphorus Source Identification Report (PSIR) in Permit Year 4. The report included a calculation of MS4 areas draining to the Merrimack River, screening and monitoring results targeting the receiving waters in Tewksbury, calculation of impervious area and Directly Connected Impervious Area (DCIA) for all regulated catchment areas in Tewksbury, identification

and prioritization of potential catchments with high phosphorus loadings, and identification of potential retrofit opportunities for the installation of structural BMPs in high phosphorus loading catchment areas. Tewksbury's PSIR is included in Attachment A.

Appendix H of the 2016 MA MS4 Permit requires permittees developing a PSIR to calculate impervious and directly connected impervious area (DCIA) for all catchments tributary to the waterbodies of concern. Impervious area and DCIA were calculated for each delineated catchment area in town. Phosphorus loadings for each catchment area were calculated using land use data, hydrologic soil group (HSG) data, and Phosphorus Load Export Rates (PLERs). Land use data for the properties within the MS4 catchment areas, as well as impervious area delineations for roads and other rights-of-way, were collected from MassGIS' most recent (2016) land use data layer, and was used to calculate impervious area and DCIA for each catchment area in Tewksbury. HSG, or the soil's ability to infiltrate stormwater, is ranked from A to D, with type A soils more suited for infiltration, and type D soils more likely to contribute runoff. Land use, impervious coverage, directly connected impervious area, and HSG have been utilized by EPA as part of the MS4 Permit to develop PLERs. The DCIA calculated for each catchment and PLERs were used in accordance with MS4 permit guidance to calculate an estimated phosphorus load for each catchment area.

There are currently 385 outfalls in the regulated area owned by the Town of Tewksbury. The catchment areas associated with each outfall were ranked with highest potential phosphorus load considered highest priority. The ten catchments with the highest pollutant loads that were considered High Priority in the PSIR are presented in Table 1.

Table 1: High Priority Catchment Ranking from PSIR

Rank	Receiving Outfall	Catchment P Load (lb/year)	Standardized P Load (lb/yr/ac)	Dry-Weather Phosphorus Sampling Result (mg/L) ¹	Wet-Weather Phosphorus Sampling Result (mg/L) ¹
1	AOF-6127	24.06	0.65	No flow observed	Scheduled for wet-weather sampling
2	OF-2	14.41	0.25	No flow observed	Scheduled for wet-weather sampling
3	OF-252	13.32	0.50	No flow observed	Scheduled for wet-weather sampling
4	OF-136	12.29	0.47	0.025	Scheduled for wet-weather sampling
5	OF-115	11.97	0.40	No flow observed	Scheduled for wet-weather sampling
6	OF-3038	10.67	1.17	No flow observed	Scheduled for wet-weather sampling
7	OF-290	10.37	0.25	No flow observed	Scheduled for wet-weather sampling
8	OF-56	8.81	0.33	No flow observed	Scheduled for wet-weather sampling
9	AOF-6136	8.65	0.44	No flow observed	Scheduled for wet-weather sampling
10	OF-4298	8.41	0.51	No flow observed	Scheduled for wet-weather sampling

¹Dry- and wet-weather sampling was conducted by Weston & Sampson as part of ongoing MS4 Compliance efforts. All dry-weather screening and sampling was completed before June 30, 2021. Wet-weather sampling is scheduled to begin in Permit Year 6. Outfalls that do not discharge directly to a receiving water with a phosphorus impairment were not sampled for phosphorus.

The PSIR report included a desktop analysis of Town-owned parcels for BMP retrofit opportunities. The locations identified for BMP retrofit in the PSIR, listed in order of catchment ranking, are included in Table 2.

Table 2: Potential BMP Retrofit Sites from PSIR

Site Address	Property Owner	Site Area (Ac.)	Percent Impervious Coverage	Soil Type	Existing Parcel Use	Catchment ID	Catchment Rank
Cardigan Road at Kendall Road	Right-of-Way	N/A	N/A	C, A	-	OF-2	2
Chandler Street (from Main Street to Foster Road)	Right-of-Way	N/A	N/A	A	-	OF-252	3
Park Avenue	Town of Tewksbury	1.46	0%	A	Open Space	OF-136	4
Park Avenue	Town of Tewksbury	0.06	0%	A	Open Space	OF-136	4
Woburn Street and Felkner Street Neighborhood	Right-of-Way	N/A	N/A	A	-	OF-136	4
Country Club Drive	Town of Tewksbury	1.27	0%	C/D, Unknown	Open Space	OF-115	5
Highwood Drive	Right-of-Way	N/A	N/A	C/D, Unknown	-	OF-3038	6
Chandler Street (from Pine Street to Billerica line)	Right-of-Way	N/A	N/A	A	-	OF-290	7
Andover Street (Blacksmith Lane to Trull Road)	Right-of-Way	N/A	N/A	C/D	-	OF-56	8
Andover Street at Hood Road Culvert	Right-of-Way	N/A	N/A	B/D	-	OF-56	8
Cobleigh Drive	Right-of-Way	N/A	N/A	A	-	OF-56	8
Pukis Road at Coolidge Road	Right-of-Way	N/A	N/A	A	-	AOF-6136	9
Heath Brook Elementary School (199 Shawsheen Street)	Town of Tewksbury	18.19	19%	A	School	OF-4298	10
Shawsheen Street (from Foster Road to Darlene Circle)	Right-of-Way	N/A	N/A	A	-	OF-4298	10

The PSIR included the following brief descriptions of structural BMP opportunities at each of these locations without field verification or further analysis, which have been updated and included under the Evaluation of Potential Projects in Section 3. The top ranked catchment in the PSIR (AOF-6127) which consists of Andover Street from Highwood Drive to the Andover Line contributes the highest estimated phosphorus loading in Tewksbury. However, no BMP retrofits are recommended in the PSIR, as it appears that most of the drainage in the catchment is comprised of state infrastructure. The outfall for this catchment is currently assumed and requires further investigation to determine if there is an interconnection between Town and state drainage.

2.3 BMP Retrofit Inventory Report

As part of the minimum control measure for Post-Construction Stormwater Management, Section 2.3.6 of the 2016 MS4 Permit requires regulated communities to 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. The BMP Retrofit Inventory Report was developed in Permit Year 4 by Weston & Sampson and considered all Town-owned properties to develop an inventory of BMP retrofit projects that can be implemented in future permit years as opportunities present themselves, as part of planned capital improvements to storm and sanitary sewer infrastructure, or as part of road reconstruction projects. The report identified areas within the community with the greatest feasibility for and benefits from stormwater retrofits with consideration to factors such as subsurface geology, depth to water table, proximity to aquifers and subsurface infrastructure, opportunities for public education, proximity to planned capital improvements, and control of discharges to areas of critical environmental concern such as water quality limited waters, first or second order streams, public swimming beaches, and drinking water supply sources, where applicable.

Five sites with the greatest feasibility for retrofits were considered most likely candidates for implementation based on feedback from the Town. The proposed BMP sites, soil and retrofit type, as well as the catchment area the site is within or adjacent to and the associated phosphorus loading priority ranking are included in Table 4 below.

Site Name/ Address	Soil Type	Stormwater Retrofit BMP Type	Catchment ID(s)	Catchment Rank
Tewksbury Department of Public Works (999 Whipple Road)	A, Unknown	Deep sump catch basins, infiltration basin, bioretention area	OF-309, CB-2303, CB-2304, CB-2305, CB-2472, CB-4840	N/A, all unregulated catchment areas
Town Hall Campus (1009 Main Street & 11 Town Hall Avenue)	A/D	Bioretention areas, tree trenches	AOF-6022, OF-4641	N/A, all unregulated catchment areas
Tewksbury Public Library (300 Chandler Street)	A/D	Rain gardens, detention basin	OF-254, OF-259, OF-4379	59, 27, Unregulated

Table 4: BMP Retrofit Inventory Sites

Site Name/ Address	Soil Type	Stormwater Retrofit BMP Type	Catchment ID(s)	Catchment Rank
East Street Athletic Fields (90 Chandler Street)	A	Bioretention area, permeable paving	OF-267, OF-3015, OF-3017	33, Unregulated, Unregulated
Open Space on Park Avenue (Across from 15 Park Avenue)	A	Porous pavement, subsurface infiltration, bioretention areas	OF-136	4

Out of the sites in the retrofit inventory, only the Park Avenue parcel was within a High-Priority catchment area identified in the PSIR. However, these sites were still evaluated as part of this report because they are in the Merrimack River Watershed and BMP installations with phosphorus removal would reduce the Town's overall phosphorus loading contributions to the Merrimack River.

Additional project locations identified by the Town that are planned for drainage improvements and are included in this evaluation are Wolcott Street at Tewmac Terrace, Chandler Street at Carol Ann Road, Parker Avenue at Lake Street, 68 Lake Street, Heath Street at Pupkis Road, and Dirclam Circle at Kneeland Road. The proposed BMP sites, soil and retrofit type, as well as the catchment area the site is within or adjacent to and the associated phosphorus loading priority ranking are included in Table 5 below.

Table 5: Planned BMP Retrofit Inventory Sites

Site Name/ Address	Soil Type	Stormwater Retrofit BMP Type	Catchment ID(s)	Catchment Rank
Wolcott Street at Tew Mac Terrace	A	Leaching catch basin	CB-2787 or CB-2788	N/A, Unregulated catchment areas
418 Chandler Street at Carol Ann Road	A	Leaching catch basin	OF-252	3
Parker Avenue at Lake Street	A	Leaching catch basin	N/A	Not within a catchment area
68 Lake Street	A	Leaching catch basin	CB-4010	N/A unregulated
Heath Street at Pupkis Road	A	Leaching catch basins	AOF-6136	9
Dirclam Circle at Kneeland Road	A	Leaching catch basin	CB-1895	N/A unregulated

Out of the sites planned for drainage improvements, only the Chandler Street at Carol Ann Road and Heath Street at Pupkis Road locations are within a High-Priority catchment areas identified in the PSIR. However, all sites were still evaluated as part of this report because they are in the Merrimack River Watershed and BMP installations with phosphorus removal would reduce the Town's overall phosphorus loading contributions to the Merrimack River.

3.0 EVALUATION OF STRUCTURAL BMP OPPORTUNITIES

Appendix H of the 2016 Massachusetts MS4 Permit Part II.1.c requires Tewksbury to plan and install a minimum of one structural BMP as a demonstration project within the drainage area of phosphorus-impaired water or its tributaries within six years of the permit effective date, or by June 30, 2024. The demonstration project must be installed in a catchment with high phosphorus load potential. Tewksbury must evaluate all permittee-owned properties presenting retrofit opportunities or areas for structural BMP installation identified in the BMP Retrofit Inventory Report or PSIR that are within the drainage area of the phosphorus-impaired water or its tributaries, which includes the entire Town since it is located completely within the Merrimack River watershed. To evaluate these opportunities, the matrix, included as Attachment B, was created with weighted site suitability criteria. Factors that were analyzed and ranked for each parcel to determine overall site feasibility for BMP retrofit are outlined in Table 6.

Site Suitability Criteria	Description	Prioritization Scale
MS4 Catchment Phosphorus Loading Rank	Catchment rank from PSIR based on site location within MS4 catchment areas. Targeting BMP retrofits in higher-priority catchments.	Reverse points of phosphorus loading rank Top ranked catchment (10 Pts), Low priority catchment (0 Pts)
Location: Parcel or Right-of-Way (ROW)	Parcels provide more ample space for retrofits than right-of-way locations	Parcel (10 Pts), ROW (5 Pts)
Parcel: Total Lot Size	Larger parcel lot sizes generally provide more space for retrofits	>5 acres (4 Pts), <5 acres (2 Pts)
Parcel: Pervious Space Available	A large amount of pervious area on a parcel provides opportunities for installation of more expansive retrofits that can manage flow from adjacent drainage or impervious surfaces	> 1.5 Acres (6 Pts), 1 to 1.5 Acres (4 Pts), < 1 Acre - 2 (Pts)
ROW: Next scheduled improvement	ROW locations that are planned for roadway reconstruction or improvements provide greater opportunity for retrofit	Within 5 years (5 Pts), 5-10 years (3 Pts), Done within 5 years (0 Pts)
ROW: Existing green space	ROW locations with no existing green space should be prioritized to reduce impervious cover	Yes (5 Pts), No (10 Pts)
Within National FEMA Flood Hazard layer or Town-identified flooding location	Areas within the FEMA flood hazard areas and parcels or ROW locations that could provide relief for historical flooding prone areas identified by the Town were prioritized	Yes (15 Pts), No (0 Pts)

Table 6: Project Ranking Site Suitability Criteria

Site Suitability Criteria	Description	Prioritization Scale
Within 300' of sensitive ecological receptors, wetlands areas, or source water protection areas	Projects in proximity to water resource areas, including wetlands, providing an opportunity for water quality benefits, were prioritized	Yes (5 Pts), No (0 Pts)
Dominant Hydrologic Soil Group	Group HSG A and B soils have the best infiltration properties and are best suited for BMP retrofit	A or B (10 Pts), A/D, B/D, C, D (5 Pts)
Depth to Groundwater	High water tables limit infiltration of stormwater. Projects in areas with large unsaturated thickness, or depth to groundwater, were prioritized	> 10ft (5 Pts), < 10ft (0 Pts)
Anticipated BMP Design & Construction Cost ¹	Projects with lower cost proposed BMPs were prioritized Low Cost: <\$10,000 Medium Cost: \$10,000-\$100,000 High Cost: >\$100,000	Completed Project or Low Cost (10 Pts), Medium (6 Pts), High -(2 Pts)
Anticipated Maintenance Cost/ Required Level of Effort ²	Projects with proposed BMPs that require less, or lower costing, operation and maintenance were prioritized Low: <\$3,000 /year Medium: \$3,000-\$5,000 /year High: >\$5,000 /year	Low (10 Pts), Medium (6 Pts), High (2 Pts)
Roadwork or Infrastructure Improvements Planned in Area	Project locations that are planned for roadway or infrastructure improvements provide greater opportunity and Town buy-in for retrofit	Planned (15 Pts), No (0 Pts)

¹ Cost ranges for different BMP types were developed based on recent experience with similar projects, professional judgement, and available literature. Costs are planning level and will be updated as projects become more detailed.

² Estimated annual maintenance costs were developed based on recent project experience and the costs included in the National Cooperative Highway Research Program's *Long-Term Performance and Life-Cycle Costs of Stormwater Best Management Practices* (National Academy of Sciences, 2014). Costs have been adjusted to 2023 values based on the Consumer Price Index.

Each of these criteria were weighted based on importance for feasibility. Projects on Town-owned parcels were weighted higher than right-of-way locations because they present opportunities for larger BMPs. Projects within a FEMA flood hazard zone or in flooding locations identified by the Town and projects where roadwork or infrastructure improvements are planned were weighted

highest because these locations all present opportunities for BMP retrofit with higher feasibility or larger potential impact. The results of this evaluation are summarized below.

3.1 Project Ranking Matrix Results

Projects that have been completed since the effective date of the 2016 MS4 Permit or were in progress during the completion of this report as well as possible retrofit locations identified in the PSIR and BMP Retrofit Inventory Report were included in the ranking matrix. A map of potential, proposed and ongoing BMP retrofit sites is included in Attachment C. The map depicts soil data at each location and proximity to FEMA flood zones and water resources. The results of the matrix are included in Table 7.

Project Location	Stormwater Retrofit BMP Type	Project Ranking Score	Anticipated BMP Design & Construction Cost	Anticipated Maintenance Cost/ Required Level of Effort	Project Status
Hillcrest Road at Chandler Street	Deep sump catch basin with adjoining dry well or infiltration trench	88	Low	Low	Planned
Parker Avenue at Lake Street	Deep sump catch basin with adjoining dry well or infiltration trench	85	Low	Low	Planned
Woburn Street and Felkner Street Neighborhood	Curb bump-out, infiltration trench	84	Medium	Medium	Planned
Andover Street at Hood Road Culvert	Curb bump-out, infiltration trench	75	Medium	Medium	Planned
Dirclam Circle at Kneeland Road	Deep sump catch basin with adjoining dry well or infiltration trench	75	Low	Low	Planned
Wolcott Street at Tew Mac Terrace	Deep sump catch basin with adjoining dry well or infiltration trench	70	Low	Low	Planned

Table 7: Project Ranking Sites (Continued)

Project Location	Stormwater Retrofit BMP Type	Project Ranking Score	Anticipated BMP Design & Construction Cost	Anticipated Maintenance Cost/ Required Level of Effort	Project Status
Park Avenue/ Lowell Street	Permeable pavement and/or curb bump-outs, leaching catch basins	68	Medium	High	Project Concept Developed
Country Club Drive	Tree filter pit, infiltration trench	68	Medium	Low	N/A
Heath Street at Pupkis Road	Deep sump catch basin with adjoining dry well or infiltration trench	67	Low	Low	Planned
68 Lake Street	Deep sump catch basin with adjoining dry well or infiltration trench	65	Low	Low	Planned
Park Avenue Parcels (across from 7 and 15 Park Avenue)	Bioretention Area	62	High	High	Project Concept Developed
Chandler Street (from Pine Street to Billerica line)	Tree filter pit, infiltration trench	60	Medium	Low	N/A
Heath Brook Elementary School (199 Shawsheen Street)	Bioretention area	60	High	High	N/A
Cardigan Road at Kendall Road	Curb bump-out, infiltration trench	59	Medium	Medium	N/A

Table 7: Project Ranking Sites (Continued)

Project Location	Stormwater Retrofit BMP Type	Project Ranking Score	Anticipated BMP Design & Construction Cost	Anticipated Maintenance Cost/ Required Level of Effort	Project Status
Tewksbury Department of Public Works (999 Whipple Road)	Infiltration chambers, Infiltration basins and hydrodynamic separators	59	High	High	Planned
Chandler Street (from Main Street to Foster Road)	Tree filter pit, infiltration trench	52	Medium	Low	N/A
Town Hall Campus (1009 Main Street & 11 Town Hall Avenue)	Bioretention areas, tree trenches	50	Medium	Medium	Project Concept Developed
Tewksbury Public Library (300 Chandler Street)	Detention basin, small rain gardens	50	Medium	Medium	Project Concept Developed
Highwood Drive	Tree filter pit, infiltration trench	49	Medium	Low	N/A
Cobleigh Drive	Curb bump-out, infiltration trench	48	Medium	Medium	N/A
Shawsheen Street (from Foster Road to Darlene Circle)	Tree filter pit, infiltration trench	45	Medium	Low	N/A
East Street Athletic Fields (90 Chandler Street)	Bioretention area, permeable paving	44	High	High	Project Concept Developed
Andover Street (Blacksmith Lane to Trull Road)	Tree filter pit, infiltration trench	42	Medium	Low	N/A
Pupkis Road at Coolidge Street	Curb bump out, infiltration trench	42	Medium	Medium	N/A

3.1.1 Hillcrest Road at Chandler - Leaching Catch Basins/ Mini Dry Well Installations

This right-of-way location is one of six locations proposed for leaching catch basin or mini dry well installations. The site with the highest score in the ranking matrix is Hillcrest Road at Chandler Street. The other locations proposed for leaching catch basins are not discussed in detail below. Standard details for the structures are included in Attachment D. To meet the Massachusetts Stormwater Standards requirements for phosphorus removal credit, the installations must include pretreatment in accordance with the Massachusetts Stormwater Handbook. To meet this requirement, these installations of leaching catch basins or mini dry wells should either be precluded by deep sump catch basins, or an infiltration trench could be installed where there are pre-existing catch basins (68 Lake Street, Heath Street at Pupkis Road, and Dirclam Circle at Kneeland Road), and a catch basin discharging to an infiltration trench could be installed where there is no pre-existing drainage infrastructure (Chandler Street at Hillcrest Road and Parker Avenue at Lake Street). These improvements can be funded by the Stormwater Enterprise and constructed by the Department of Public Works.

3.1.2 Woburn and Felkner Street Drainage Improvements

The drainage system in this area in the eastern portion of Tewksbury is tentatively planned for reconstruction in FY24 as part of the Town's Capital Improvement Plan. As part of the drainage improvements, BMP retrofits should be considered. Potential retrofits may include curb bump-outs within the right-of-way, conversion of Town-owned catch basins to deep sump catch basins with adjoining dry wells or small infiltration trenches, and small surface BMPs (bioretention or similar).

3.1.3 Andover Street at Hood Road Culvert

The culvert underneath Andover Street at Hood Road is scheduled for repair as part of the Town's Capital Improvement Plan in FY25. Two outfalls discharge to Trull Brook adjacent to this culvert. If the intersection of Andover Street at Hood Road is reconstructed as part of this culvert repair, the Town should consider conversion of the adjacent catch basins to deep sump catch basins with adjoining dry wells or infiltration trenches. Additionally, curb bump outs could be utilized on either side of the street for traffic calming and to install a small surface BMP (bioretention or similar).

3.1.4 Lowell Street ROW

A parcel on Park Avenue and the Lowell Street neighborhood was included as a top ten priority area for green infrastructure. The Lowell Street neighborhood was identified as a location prone to flooding by the Town. Recommended BMPs within the right of way include permeable pavement with sub-surface infiltration systems at intersections and along Lowell Street and/or small bioretention areas in curb bump-outs along Lowell Street, and leaching catch basins along Lowell Street. The project concept also included a bioretention area within a Town-owned parcel off Park Avenue. Most of Lowell Street and the parcels off Park Avenue are within catchment OF-136, which is a high priority catchment tributary to the Concord River.

3.1.5 Country Club Drive Parcel

This parcel in the northwestern portion of Town is situated between two residential properties. The drainage system on Country Club Drive discharges to the wetland area within and adjacent to the parcel. To disconnect a portion of the drainage system on Country Club Drive, the Town should consider installing deep sump catch basins with adjoining dry wells, tree filter pits, or other subsurface systems within the parcel or the right-of-way.

3.1.6 Park Avenue Parcels

The Town-owned parcels across from 7 and 15 Park Avenue in the eastern portion of Tewksbury are wooded areas adjacent to residential properties. The larger parcel is included as a top ten priority area for green infrastructure in combination with the right-of-way on Lowell Street. Both parcels are within catchment OF-136, which is a high priority catchment tributary to the Concord River.

3.1.7 Chandler Street (Pine Street to Billerica Line)

This portion of Chandler Street in the southern portion of Town contains an extensive drainage system with many catch basins on both sides of the street and at intersections for conversion to deep sump catch basins with adjoining dry wells, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Chandler Street when planning future roadway and sidewalk improvements.

3.1.8 Heath Brook Elementary School

This Town-owned parcel in the southern portion of Town on Shawsheen Street contains Heath Brook Elementary School, parking, and recreation area. A portion of the drainage system along Shawsheen Street could be diverted to a surface BMP (bioretention or similar) or infiltration trenches along the front of the property to disconnect impervious area within catchment OF-4298. Due to heavy traffic during the school year, this site would provide great opportunities for public education.

3.1.9 Cardigan Road at Kendall Road

This intersection receives drainage flow from Cardigan Road, Kendall Road, and Greylock Road. There are various existing catch basins within the intersection that could be converted to deep sump catch basins with adjoining dry wells, tree filter pits, or infiltration trenches. The town-owned drainage could also be redirected to a small bioretention system or similar if the intersection is reconstructed.

3.1.10 Tewksbury DPW & School Maintenance Facility

This site, located between Pond Street, Pine Street, and Whipple Road, is situated on a 12-acre municipally owned parcel that includes the Department of Public Works building, parking facilities, material, vehicle, and equipment storage and maintenance buildings/areas, and the Northeastern Middlesex Regional Emergency Communication Center building and parking. Stormwater from this site does not directly discharge to a water of the United States but is within the Long Pond

Watershed. The project will include a new Department of Public Works Facility with drainage improvements including two infiltration basins, deep sump hooded catch basins, hydrodynamic separators and underground infiltration chambers. At the time of this report, the estimated construction cost of the facility is \$22,500,000. Construction is estimated to start in the summer or fall of 2023 and to end in the spring of 2025. The construction drawings are included in Attachment D.

3.1.11 Chandler Street (Main Street to Foster Road)

This portion of Chandler Street is in the center of town and contains many existing catch basins on both sides of the street to consider for conversion to deep sump catch basins with adjoining dry wells, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Main Street when planning future roadway and sidewalk improvements.

3.1.12 Town Hall Campus (1009 Main Street & 11 Town Hall Avenue)

This site is identified as a priority parcel for the installation of green infrastructure and stormwater BMPs as part of the Town's Stormwater BMP Retrofit Analysis. Stormwater runoff from the site does not discharge directly to a surface water, but the site is located in the Strong Water Brook Watershed. The site is comprised of two parcels in a "campus" area including Town Hall, the Town Hall Annex building and a Fire Department building, totaling 3 acres of municipally-owned property. There is a large green space in front of the Town Hall building between Town Hall Avenue and Main Street, and another large green space behind the Town Hall Annex building next to Dewey Street. The parcels are adjacent to residential properties and heavily trafficked Main Street and Pleasant Street. The foot and vehicular traffic in this area provide significant opportunities for public education. The proposed conceptual level BMPs at this site include a bioretention area in the northwest corner of the Town Hall Annex/ Fire Department building property and additional drainage infrastructure on Dewey Street to divert flow to the bioretention area; a tree trench along the northern edge of Town Hall Avenue with overflow to the existing drainage system on Town Hall Avenue; a bioretention planter box in the Town Hall Annex building parking lot with overflow to the existing drainage system on Town Hall Avenue; a bioretention area at the west end of the Town Hall common with overflow to the existing drainage system on Main Street; and two tree trenches in the open space at the intersection of Main Street and East Street.

3.1.13 Tewksbury Public Library (300 Chandler Street)

This site is also identified as a priority parcel for the installation of green infrastructure and stormwater BMPs as part of the Town's Stormwater BMP Retrofit Analysis. The Tewksbury Public Library is located on a 4-acre municipally owned parcel located at the corner of Main Street and Chandler Street and is adjacent to the Tewksbury Hospital and commercial properties. The site includes the library building, parking facilities and the Tewksbury 9-11 memorial. The site is located within catchment areas that discharge to Strong Water Brook. The proposed conceptual level BMPs at this site include two rain gardens near the entrance of the building, and expansion of the existing detention basin between the parking lot and Chandler Street to increase storage volume.

3.1.14 Highwood Drive

This dead-end street in the northeastern portion of Town adjacent to I-495 ramps serves a hotel and commercial/industrial buildings. There are various existing catch basins on both sides of the street to consider for conversion to leaching catch basins, tree filter pits, or infiltration trenches.

3.1.15 Cobleigh Drive

Cobleigh Drive is located mostly in HSG A and provides an opportunity for green street designs which promote infiltration of stormwater. Infiltration trenches, small bioretention areas, and rain gardens could be installed to treat stormwater along Cobleigh Drive where feasible. The cul-de-sac is currently all paved; including a central island with a bioretention area will provide treatment of sheet flow run off along Cobleigh Drive.

3.1.16 Shawsheen Street (Foster Road to Darlene Circle)

This portion of Shawsheen Street in the southern portion of Town contains an extensive drainage system with catch basins on both sides of the street and at intersections for conversion to deep sump catch basins with adjoining dry wells, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Shawsheen Street when planning future roadway and sidewalk improvements.

3.1.17 East Street Athletic Fields (90 Chandler Street)

This site is identified as a priority parcel for the installation of green infrastructure and stormwater BMPs as part of the Town's Stormwater BMP Retrofit Analysis. This site located between East Street, Chandler Street, and Livingston Street is situated on a 16-acre municipally owned parcel that includes three baseball fields, unpaved parking areas, some residential and commercial buildings and a significant amount of undeveloped, wooded space. The site is adjacent to the Tewksbury Hospital, and more commercial and residential properties. The site is located within a catchment area that discharges to Strong Water Brook. The proposed conceptual level BMPs at this site include a bioretention area in the open space in the corner of the parcel abutting East Street and Chandler Street, and permeable parking to replace the compacted gravel parking area next to the baseball fields.

3.1.18 Andover Street (Blacksmith Lane to Trull Road)

This portion of Andover Street in the northern portion of Town contains an extensive drainage system with catch basins on both sides of the street and at intersections for conversion to deep sump catch basins with adjoining dry wells, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Andover Street when planning future roadway and sidewalk improvements.

3.1.19 Pukis Road at Coolidge Road

The intersection of Pukis Road and Coolidge Road provides an opportunity for BMP retrofit. The Town should consider installing deep sump catch basins with adjoining dry wells or infiltration

trenches along the intersections. A small bioretention area may be feasible at one or more of the corners of the intersections, depending on resident input. A sample intersection design is provided in the Final Report of the Municipal Vulnerability Preparedness (MVP) Action Grant Stormwater Analysis for Nature-Based Solutions as part of the Lowell Street Neighborhood designs.

3.2 Demonstration BMP Project

The project evaluation identified Hillcrest Road at Chandler Street as the most feasible site for the structural BMP demonstration project retrofit. The project is within a high-priority catchment area identified in the PSIR. During Permit Year 6 (FY2024), the Town constructed three leaching basins in the right-of-way of Hillcrest Road at Chandler Street. To meet the Massachusetts Stormwater Standards requirements for phosphorus removal credit, these installations are precluded by deep sump catch basins for pretreatment. The total estimated phosphorus removal for these three leaching structures is 0.207 pounds of phosphorus annually. The construction and maintenance cost of the deep sump catch basin and leaching basins are estimated in Section 3.3 below. The Town of Tewksbury will be listing this project as their demonstration project for MS4 Permit Year 6. Materials for this project were purchased through funds from the Town's Stormwater Enterprise and constructed by the Tewksbury Department of Public Works prior to June 30, 2024. The Town developed their own detail for the installation of these leaching basins, which is included in Appendix D, and hopes to continue to implement similar projects throughout Town in future years.

3.3 Implementation and Maintenance Cost

Estimated construction and maintenance costs associated with the selected demonstration project are included in Table 8 below. Construction costs are actual; maintenance costs are estimated based on the available literature and past experience with similar systems.

Table 8: Construction and Maintenance Costs for Demonstration Project	
Installation of Deep Sump Catch Basin & Leaching Basin (Labor Provided By DPW)	\$7,000/Unit
Total Cost of BMP Installation (Labor Provided by DPW)	\$7,000
Estimated Annual Maintenance Cost – Cleaning & Removal of Sediment	\$500/Unit
Total Cost of Installation and Maintenance – First Year	\$7,500

3.4 Implementation Schedule

Under Appendix H of the 2016 Massachusetts MS4 Permit, the Town of Tewksbury shall provide a plan and schedule for implementation of planned structural BMPs identified in this report. Implementation timeframes for design and construction for each planned BMP are summarized in Table 9.

Table 9: Implementation Schedule for BMPs

Project Location	Proposed BMP(s)	Funding Procurement Completion	Design Completion	Construction Completion
Hillcrest Road at Chandler Street	Deep sump catch basin with adjoining dry well or infiltration trench	January 2024	March 2024	June 30, 2024
Tewksbury DPW	Infiltration chambers, Infiltration basins and hydrodynamic separators	October 2022	June 2023	Spring 2025
Parker Avenue at Lake Street	Deep sump catch basin with adjoining dry well or infiltration trench	Pending	Pending Town Funding	June 30, 2025
Dirclam Circle at Kneeland Road	Deep sump catch basin with adjoining dry well or infiltration trench	Pending	Pending As Funding Allows	June 30, 2026
Wolcott Street at Tew Mac Terrace	Deep sump catch basin with adjoining dry well or infiltration trench	Pending	Pending As Funding Allows	June 30, 2027
Heath Street at Pupkis Road	Deep sump catch basin with adjoining dry well or infiltration trench	Pending	Pending As Funding Allows	June 30, 2028
68 Lake Street	Deep sump catch basin with adjoining dry well or infiltration trench	Pending	Pending As Funding Allows	June 30, 2029

This plan and schedule will be included in Tewksbury's Year 5 annual report and the Town will install the remainder of the BMPs in accordance with this schedule. This schedule will be updated as necessary based on Town input and funding considerations.

Attachment A

Tewksbury Phosphorus Source Identification Report

Phosphorus Source Identification Report

MS4 Permit Compliance



Town of Tewksbury, MA

Department of Public Works

999 Whipple Road

Tewksbury, MA 01876

June 30, 2022

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	i
LIST OF TABLES	iii
LIST OF APPENDICES	iv
1.0 REGULATORY SUMMARY AND PURPOSE	1-1
1.1 Waterbody Descriptions	1-1
2.0 LITERATURE REVIEW	2-1
2.1 Literature Review	2-1
2.1.1 Merrimack River Watershed Assessment Study Screening Level Model	2-1
2.1.2 Merrimack River Watershed Assessment Study Final Report	2-1
2.1.3 Water Quality Data for Discrete Samples and Continuous Monitoring on the Merrimack River, Massachusetts, June to September 2020	2-2
2.1.4 Shawsheen River Watershed 2000 Water Quality Assessment Report	2-2
2.1.5 Water Quality Monitoring Program Final Report: 2018-2019 Field Seasons	2-2
2.1.6 Long Pond Environmental Status Assessment	2-3
2.1.7 Long Pond Watershed Non-Point Pollution Abatement Phase I BMP Implementation 2-3	2-3
2.2 Historic Sampling Data	2-3
3.0 CATCHMENT AREA CHARACTERISTICS	3-1
3.1 Available GIS Mapping	3-1
3.2 Directly Connected Impervious Area	3-1
4.0 POLLUTANT LOADING ANALYSIS AND PRIORITIZATION OF CATCHMENTS WITH HIGHER POTENTIAL PHOSPHORUS LOADS	4-1
4.1 Phosphorus Load Export Rates	4-1
4.2 Results	4-2
4.2.1 Catchment Descriptions	4-2
4.3 Dry and Wet Weather Outfall Screening and Sampling	4-4
4.4 Catchment Ranking Matrix	4-5
5.0 BEST MANAGEMENT PRACTICE (BMP) RETROFIT OPPORTUNITIES	5-1
5.1 Potential Retrofit Sites	5-1
5.1.1 Andover Street (Highwood Drive to Andover Line)	5-2
5.1.2 Cardigan Road at Kendall Road	5-2
5.1.3 Chandler Street (Main Street to Foster Road)	5-2
5.1.4 Park Avenue Parcels	5-2
5.1.5 Woburn and Felkner Street Drainage Improvements	5-2
5.1.6 Country Club Drive Parcel	5-2
5.1.7 Highwood Drive	5-3
5.1.8 Chandler Street (Pine Street to Billerica Line)	5-3
5.1.9 Andover Street (Blacksmith Lane to Trull Road)	5-3
5.1.10 Andover Street at Hood Road Culvert	5-3
5.1.11 Cobleigh Drive	5-3

5.1.12 Pukis Road at Coolidge Road.....5-3
5.1.13 Heath Brook Elementary School.....5-4
5.1.14 Shawsheen Street (Foster Road to Darlene Circle)5-4
5.2 Potential Retrofit Sites5-4
5.1.1 Long Pond Rain Gardens (Existing).....5-4
5.3 Implementation.....5-4
6.0 REFERENCES.....5-1

LIST OF TABLES

Table 1.....	Merrimack River 2017 Sampling Data
Table 2.....	Merrimack River Tributary 2017 Sampling Data
Table 3.....	Merrimack River 2022 Sampling Data
Table 4.....	Long Pond Sampling Data
Table 5.....	Land Use in MS4 Catchment Areas in Tewksbury
Table 6.....	Conversion of MassGIS 2016 Land Use Codes to EPA Land Use Codes
Table 7.....	EPA Land Use Classes and Corresponding Sutherland Equations
Table 8.....	DCIA and Percent Connectivity in MS4 Catchment Areas
Table 9.....	Phosphorus Load Export Rates by Land Use
Table 10.....	Pollutant Loading Analysis Results – Top 10 Catchments
Table 11.....	Phosphorus Sampling Results
Table 12.....	High Priority Catchment Ranking
Table 13.....	Potential BMP Retrofit Sites

LIST OF APPENDICES

Appendix ATewksbury MS4 Map
Appendix B Impervious Area and DCIA Results for All Catchments
Appendix C Land Use/Land Cover Grid
Appendix D Pollutant Loading Analysis Results
Appendix E Catchment Prioritization and Ranking
Appendix F BMP Retrofit Cut Sheets and Examples

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1.0 REGULATORY SUMMARY AND PURPOSE

The 2016 MS4 Permit includes specific requirements for MS4 operators that discharge to impaired waterbodies where pollutants typically found in stormwater—specifically nutrients, solids, bacteria/pathogens, chloride, metals, and oil and grease—are the cause of the impairment and there is not a Total Maximum Daily Load (TMDL) approved by USEPA. Additional requirements for phosphorus impairments include supplementary public education efforts, specific BMP design standards, increased street sweeping, and the development of a Phosphorus Source Identification Report (PSIR) for each waterbody with a phosphorus impairment. Waterbodies in Tewksbury that are impaired for phosphorus include Long Pond and the Merrimack River. Stormwater discharges to water bodies tributary to the Shawsheen River and Concord Rivers are also tributary to the Merrimack River, which requires the development of a TMDL for phosphorus.

This PSIR has been developed for the entire Town of Tewksbury, as most catchment areas either directly discharge to a phosphorus-impaired water body, or discharge to a water body that is tributary to a receiving water impaired for phosphorus. In accordance with permit requirements, this report includes the following elements:

1. A calculation of the total MS4 areas draining to the water quality limited receiving water, incorporating updating mapping of the MS4 and catchment delineations;
2. All screening and monitoring results targeting the receiving water;
3. Impervious area and Directly Connected Impervious Area (DCIA) for the target catchment area(s);
4. Identification, delineation, and prioritization of potential catchments with high phosphorus loadings; and
5. Identification of potential retrofit opportunities or opportunities for the installation of structural BMPs during redevelopment, including the removal of impervious area.

This PSIR was completed on or before the end of Permit Year 4 or June 30, 2022 in accordance with Permit requirements.

1.1 Waterbody Descriptions

Tewksbury is located within the Concord, Ipswich, Merrimack, and Shawsheen River Watersheds. Only a small portion of the southernmost part of town is located within the Ipswich River Watershed. Both the Concord and Shawsheen Rivers are tributary to the Merrimack River, meaning that stormwater discharges from almost every town-owned outfall are tributary to the Merrimack River. Since the segments of the Merrimack River downstream of where these rivers discharge to are impaired for phosphorus, the Town must develop this PSIR for the entirety of its regulated area.

The Merrimack River begins in Franklin, New Hampshire, and travels 115 miles to the Atlantic Ocean in Newburyport, Massachusetts. A small northern portion of Tewksbury is within the Merrimack River Watershed; Trull Brook in Tewksbury is also located within the Merrimack River Watershed. The river is utilized as a drinking water source for various surrounding communities including Tewksbury and receives wastewater treatment effluent, combined sewer overflows and stormwater discharges from various communities. The portion of the Merrimack River that borders Tewksbury (Segment MA84A-03) is on the Massachusetts Integrated List of Waters, or 303(d) list, for E. coli, mercury in fish tissue, PCBs in fish tissue, and total phosphorus.

The Shawsheen River is a tributary of the Merrimack River traveling 25 miles from Bedford to Lawrence, Massachusetts. A majority of Tewksbury is located within the Shawsheen River Watershed; the river crosses the Town from south to north. Water bodies within the Shawsheen River Watershed include Long Pond, Round Pond, Ames Pond, Richardson Pond, Meadow Brook, Strong Water Brook, Content Brook, Heath Brook, Pinnacle Brook, and Sutton Brook. This river also receives significant wastewater effluent. The portion of the river within Tewksbury (Segment MA83-18) is on the 2018/2020 303(d) list, for dissolved oxygen, E. coli and fecal coliform. The river has a bacteria TMDL under the *Total Maximum Daily Loads of Bacteria for the Shawsheen River Basin*.

The Concord River is another tributary of the Merrimack River traveling 15 miles from Concord at the confluence of the Assabet and Sudbury Rivers to Lowell, Massachusetts. A small western most portion of Tewksbury is located within the Concord River Watershed; Marginal Brook is tributary to the river. The river is used as a drinking water supply for Billerica, and emergency connections are maintained by Tewksbury and other municipalities. Two municipal wastewater treatment plants discharge to the river, Billerica and Concord. Total phosphorus was removed as an impairment from the three sections of the Concord River (MA82A-07, MA82A08, and MA82A-09) in the 2016 List of Integrated Waters, following a TMDL Study for total phosphorus on the Assabet River in 2004 that led to WWTP improvements and decreased nutrient flux from the four major treatment plants discharging to the river.

Long Pond (MA83010) is located in the southwestern portion of Tewksbury. The pond has a relatively small watershed and drains to Richardson Pond in Billerica, then to Content Brook and the Shawsheen River. This pond is on the 2018/2020 303(d) list for algae, chlorophyll-a, dissolved oxygen, total phosphorus, and transparency/clarity.

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2.0 LITERATURE REVIEW

2.1 Literature Review

Given that water quality in the Merrimack, Shawsheen and Concord Rivers has been an ongoing point of concern, many studies, reports, and remediation plans for the waterbodies in question have been developed. The Merrimack River Watershed Council (MRWC) is a non-profit organization that operates a water quality monitoring program collecting water quality data along the mainstem of the river from Manchester, New Hampshire to Salisbury, Massachusetts for pH, salinity, total dissolved solids, conductivity, and temperature. The EPA also maintained a water quality monitoring station in the Lower Merrimack River in Lawrence, downstream of the section of the river that runs along Tewksbury, which measured temperature, dissolved oxygen, conductivity, pH, turbidity, chlorophyll and phycocyanin every 15 minutes from December 2016 through November 2018. The Shawsheen River Watershed Association is a nonprofit organization that sponsors river cleanups, public education programs and other events. OARS is another non-profit organization which operates water quality, streamflow and aquatic plant biomass monitoring for the Assabet, Sudbury and Concord Rivers and their tributaries.

The following studies and reports were reviewed as part of the Phosphorus Source Identification Report:

- Merrimack River Watershed Assessment Study Screening Level Model; Prepared for the New England District of the U.S. Army Corps of Engineers by CDM Smith, March 2004.
- Merrimack River Watershed Assessment Study Phase III Final Monitoring Data Report; Prepared for the New England District of the U.S. Army Corps of Engineers by CDM Smith, August 2017.
- Water-Quality Data for Discrete Samples and Continuous Monitoring on the Merrimack River, Massachusetts, June to September 2020; Prepared by the Massachusetts Department of Environmental Protection and the U.S. Geological Survey (USGS), January 2022.
- Shawsheen River Watershed 2000 Water Quality Assessment Report; Prepared for the Massachusetts Department of Environmental Protection by the Department of Environmental Protection Division of Watershed Management, July 2003.
- Water Quality Monitoring Program Final Report: 2018-2019 Field Seasons; Prepared by OARS, March 2020.
- Long Pond Environmental Status Assessment; Prepared by Coughlin Environmental Services, LLC for the Town of Tewksbury, January 2008.

2.1.1 Merrimack River Watershed Assessment Study Screening Level Model

The 2004 Screening Level Model that was part of the Merrimack River Watershed Assessment Study used a Watershed Management Model (WMM) to assess the relative contribution of pollutant sources from geographic and physical source areas throughout the watershed. Annual phosphorus loading results in the Merrimack River Watershed suggest that point source discharges from surrounding communities, primarily from WWTPs, dominate the loading contribution. Stormwater runoff contributed the second largest percentage of annual phosphorus load in all scenarios evaluated. Annual septic system and combined sewer overflow (CSO) loads were determined to be inconsequential in comparison to other loads.

2.1.2 Merrimack River Watershed Assessment Study Final Report

The 2017 Final Monitoring Data Report for the Merrimack River Watershed Assessment Study includes a comprehensive water quality study performed on the Lower Merrimack River from Hooksett, New Hampshire to its confluence with the Atlantic Ocean in Newburyport, Massachusetts. The study included

data from dry weather sampling of the mainstem river and tributaries, wet weather sampling of the mainstem river, and wastewater treatment plant effluent surveys along the mainstem river. The total phosphorus concentrations were found to increase slightly from upstream to downstream. Typically wet weather sampling values (52-200 $\mu\text{g/L}$ and one result of 350 $\mu\text{g/L}$) were higher than dry weather values (15-136 $\mu\text{g/L}$). Total phosphorus concentrations were found to be greater at certain river stations downstream of wastewater treatment plants, but it was determined that these spikes are attributable to other sources as well. The phosphorus levels at the mouths of major tributaries were generally below nearby mainstem levels, being no greater than 175 $\mu\text{g/L}$, except for the Spicket and Shawsheen Rivers. The Shawsheen River tributary measured a phosphorus contribution of 385 $\mu\text{g/L}$, which is significantly greater than the EPA recommendation of 100 $\mu\text{g/L}$ for phosphorus concentrations in streams.

Concentrations of chlorophyll-a, which is an indicator of organic productivity, were also collected during wet and dry weather periods along the Lower Merrimack and at the mouths of major tributaries. Results in New Hampshire ranged from 4.7 to 17 $\mu\text{g/L}$, and in Massachusetts, concentrations were slightly higher in non-marine waters, ranging from 6.8 to 57 $\mu\text{g/L}$. The concentrations in New Hampshire indicate that algal growth is not excessive, but in Massachusetts the levels suggest organic activity that may lead to aquatic habitat degradation; the state of New Hampshire uses 15 $\mu\text{g/L}$ as a benchmark for maximum chlorophyll-a concentrations for primary contact recreation, but Massachusetts has no surface water quality standard for chlorophyll-a. This study indicated that the Merrimack River is phosphorus-limited due to the molar TN:TP ratio range of 26 to 153 with a mean of 52, since a molar ratio of greater than 20 indicates that phosphorus is the limiting nutrient.

2.1.3 Water Quality Data for Discrete Samples and Continuous Monitoring on the Merrimack River, Massachusetts, June to September 2020

The 2022 Study conducted by the USGS includes water quality data collected at thirteen locations along the Merrimack River and Merrimack River Estuary from Tyngsborough to Newburyport, Massachusetts from June to September 2020. The results include field measurements of water temperature, specific conductivity, pH, dissolved oxygen and laboratory concentrations of nitrogen and phosphorus, total carbon, pheophytin-a, and chlorophyll-a.

2.1.4 Shawsheen River Watershed 2000 Water Quality Assessment Report

This 2003 report summarizes water quality data in the Shawsheen watershed, for all rivers, streams, brooks, creeks, lakes, ponds, and impoundments. The report states that water quality sampling conducted along the river by USGS between September 1995 and September 2001 resulted in total phosphorus concentrations between 0.010 to 0.092 mg/L with a mean of 0.04 mg/L. This report also details extremely high total phosphorus concentrations (0.4 mg/L) in Long Pond in Tewksbury during the 200-baseline lake survey.

2.1.5 Water Quality Monitoring Program Final Report: 2018-2019 Field Seasons

This is the most recent OARS water quality report available, representing the 16th year of data collection at mainstem Concord River sites. OARS samples for water temperature, pH, conductivity, chloride, dissolved oxygen, phosphorus, nitrate, total suspended solids, ammonia, and chlorophyll-a at four sites on the Concord River, none of which are in Tewksbury. The mean of the total phosphorus concentrations sampled in the mainstem of the Concord River between March 2018 and November 2019 ranged from 0.011 to 0.1 mg/L, the highest mean concentration observed in June 2019.

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2.1.6 Long Pond Environmental Status Assessment

This 2008 Study summarizes historical pond and watershed studies, sampling and monitoring results, potential remediation strategies, and recommendations. A previous Shawsheen River watershed assessment identified bacterial contamination from septic systems, urban runoff, illicit connections to storm drains, waterfowl feces and agricultural pollution as significant sources of pollution in the Long Pond Watershed. The study states that nutrient pollution from these sources and from residential lawn fertilizer are clear contributors to the pond's pollution. Field monitoring and sampling was conducted at seven locations within the pond for parameters including water depth, temperature, dissolved oxygen, salinity, conductivity, specific conductance, total suspended solids, turbidity, alkalinity, hardness, nitrate/nitrite nitrogen, total nitrogen, total phosphorus, fecal coliform bacteria, E. coli, enterococcus, and chlorophyll-a. Total phosphorus concentrations ranged from 100 to 120 $\mu\text{g/L}$. Remediation recommendations included wetland and stream investigations to identify wetland policy violations, supplemental water level and vegetation monitoring, water quality and sediment sampling, bathymetric survey, and evaluation of aquatic weed harvesting and chemical control strategies.

2.1.7 Long Pond Watershed Non-Point Pollution Abatement Phase I BMP Implementation

The Long Pond BMP Implementation Report provides insight into the types of treatment and remediation initiatives that have been undertaken in Tewksbury. The Long Pond BMP Implementation Report details a \$450,000 project completed between 2011 and 2015 to remove priority pollutants in the Long Pond Watershed. The project was partially funded by a 319 grant from the USEPA and MassDEP. BMPs installed included 19 rain gardens and ten roadside treatment swales in the Long Pond Watershed on Town lands, within public rights-of-way and on private lots with owner permissions. Signs were installed next to the rain gardens to provide public education and awareness. It was estimated that the installed BMPs remove approximately 56 pounds of total phosphorus per year.

The Town's Stormwater Management Program webpage details the Town's participation in the Northern Middlesex Stormwater Collaborative (NMSC); stormwater management techniques for residents, business owners, and construction sites; and other public awareness initiatives. In 2019, the Town established a Stormwater Enterprise Fund, which became effective in July 2020, and supports operation, maintenance, upgrades and expansion of the stormwater system and compliance with EPA's General Permit which regulates discharges from the Town's Municipal Separate Storm Sewer System (MS4 Permit).

2.2 Historic Sampling Data

Historic in-stream sampling data for waterbodies in Tewksbury is available from the 2017 and 2022 studies discussed above. Both dry and wet-weather outfall sampling were conducted as part of the 2017 study, with sampling events spanning the period from June 2014 to August 2016. The third sampling event was a hybrid event with collection of dry and wet weather samples. Historical sampling data of the Merrimack River from the 2017 study is presented in Tables 1 and 2. Sampling data of the Merrimack River from the 2022 study is presented in Table 3. Sampling data of Long Pond from the 2000 Shawsheen Watershed Assessment is presented in Table 4. Total phosphorus sampling results in relation to river mile for the Concord and Shawsheen Rivers from the study are included in Figures 1 and 2.

Table 1: Merrimack River Sampling Data (Source: CDM Smith, 2017)

Sampling Event	Location	Total Phosphorus Concentrations ($\mu\text{g/L}$)					
		Dry Weather			Wet Weather		
		Minimum	Maximum	Average	Minimum	Maximum	Average
#1 June 24, 2014	Mainstem Freshwater	18	112	55	-	-	-
	Tributary	15	66	41	-	-	-
	WWTPs	-	-	-	-	-	-
#2 October 1, 2015	Mainstem Freshwater	-	-	-	52.3	179.8	102.2
	Tributary	-	-	-	23.0	143.7	54.5
	WWTPs	-	-	-	186.1	6693	2339
#3 August 10, 2016	Mainstem Freshwater	18.24	135.88	66.23	42.40	320.47	120.28
	Tributary	15.36	86.73	45.98	21.20	564.91	163.79
	WWTPs	722.77	6483	3757	722.77	6483	3757

Table 2: Merrimack River Tributary Sampling Data (Source: CDM Smith, 2017)

Sampling Event	Location	Total Phosphorus Concentrations ($\mu\text{g/L}$)		
		Minimum	Maximum	Average
#1 July 21, 2016	Concord River	20.93	49.14	33.22
	Shawsheen River	13.76	41.86	20.29

Table 3: Merrimack River Sampling Data (Source: USGS, 2022)

UGGS Site	Location	Sample Depth	Phosphorus Concentrations (mg/L)					
			Unfiltered			Filtered		
			Minimum	Median	Maximum	Minimum	Median	Maximum
*010965305	Tyngsborough Bridge, MA	Top	0.033	0.041	0.096	0.018	0.027	0.062
		Bottom	0.034	0.068	0.136	0.024	0.03	0.096
*01096568	Lowell Motorboat Club, MA	Top	0.029	0.05	0.079	0.019	0.03	0.035
		Bottom	0.027	0.051	0.09	0.019	0.03	0.04
*010965985	Aiken Street Bridge, Lowell, MA	Top	0.025	0.049	0.075	0.016	0.024	0.037
*01100220	Power lines, Methuen, MA	Top	0.031	0.047	0.13	0.018	0.022	0.087
		Bottom	0.029	0.053	0.099	0.014	0.035	0.083
*01100475	Bashara Boat House, Lawrence, MA	Top	0.035	0.037	0.069	0.016	0.02	0.049
		Bottom	0.031	0.041	0.082	0.015	0.02	0.057
*01100671	Stanley Island, Haverhill, MA	Top	0.036	0.046	0.071	0.015	0.023	0.056
*01100806	Power lines, Merrimac, MA	Top	0.039	0.043	0.076	0.01	0.024	0.061
		Bottom	0.034	0.047	0.081	0.013	0.021	0.061

Table 3: Merrimack River Sampling Data (Source: USGS, 2022)

UGGS Site	Location	Sample Depth	Phosphorus Concentrations (mg/L)					
			Unfiltered			Filtered		
			Minimum	Median	Maximum	Minimum	Median	Maximum
*01100823	Goodwin Creek, Amesbury, MA	Top	0.032	0.039	0.054	0.015	0.022	0.029
		Bottom	0.036	0.043	0.057	0.011	0.022	0.027
*01100871	Bridge Marina, Salisbury, MA	Top	0.025	0.036	0.052	<0.008	0.02	0.023
		Bottom	0.024	0.034	0.052	0.008	0.021	0.022

Table 4: Long Pond Sampling Data (Source: MassDEP DWM 2000)

Sampling Event	Location	Total Phosphorus Concentrations (mg/L)		
		Minimum	Maximum	Average
7/11/2000	Deep hole center of pond	0.41	0.57	0.46
8/8/2000	Deep hole center of pond	0.38	0.39	0.39
9/12/2000	Deep hole center of pond	0.39	0.42	0.40

Figure 1: Concord River Total Phosphorus Dry Weather Sampling Results (Source: CDM Smith, 2017)

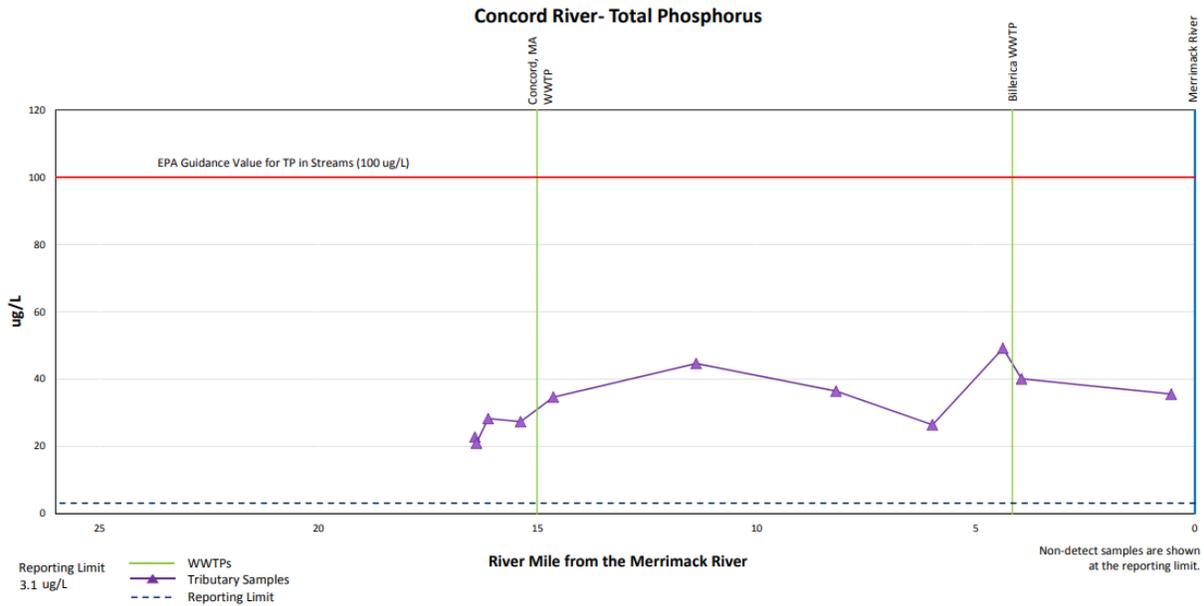
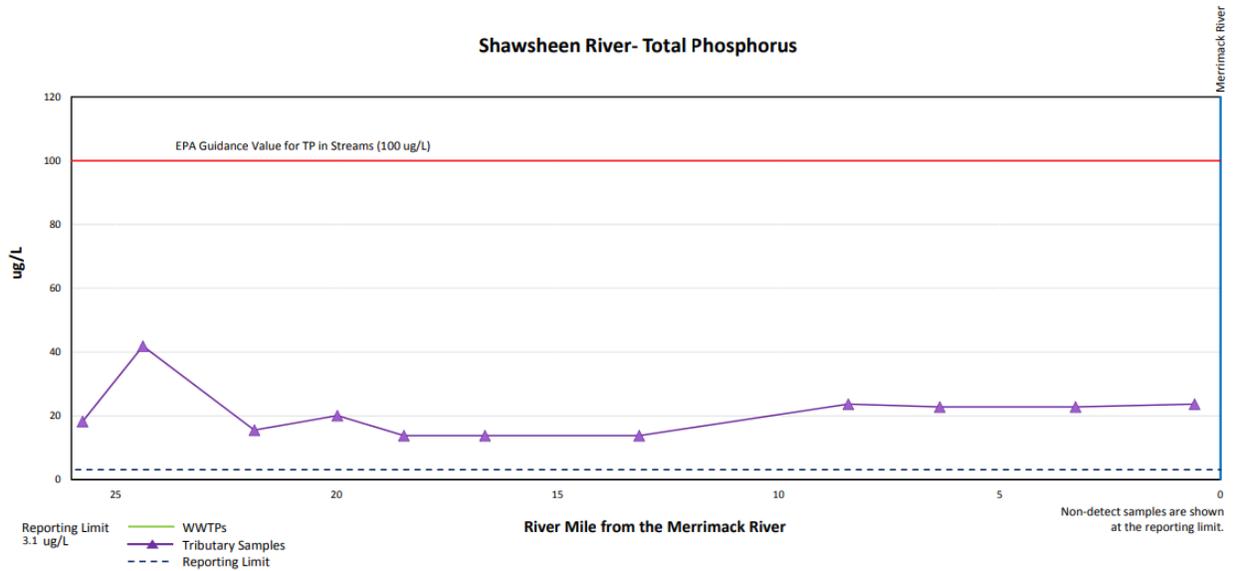


Figure 2: Shawsheen River Total Phosphorus Dry Weather Sampling Results (Source: CDM Smith, 2017)



In the 2017 study, the phosphorus concentrations during the October 2015 wet weather event were noted to be higher than those observed during the June 2014 dry weather event. The study noted that the October 2015 event concentrations are also higher than would typically be expected from a high flow wet weather event, which was attributed to possible heavy fertilizer usage during September in surrounding areas which could have been transferred to the river from land runoff. The August 2016 wet/dry weather event exhibited generally steady concentrations during dry weather in the mainstem river and more variability throughout the mainstem and tributaries during wet weather. Total phosphorus concentrations from the July 2016 dry weather event were generally consistent in the Concord and Shawsheen Rivers and remained below the 100 $\mu\text{g/L}$ EPA standard for concentrations in streams. The samples from the Concord River were generally greater than those observed in the Shawsheen or Spicket Rivers.

In the 2022 study, the phosphorus concentrations in the Merrimack River ranged from 0.024 to 0.136 mg/L, or 24 to 136 $\mu\text{g/L}$ for the unfiltered samples and between 0.008 to 0.096 mg/L, or 8 to 96 $\mu\text{g/L}$ for the filtered samples. The only samples over the 100 $\mu\text{g/L}$ EPA standard for concentrations in streams were at USGS stations near the Tyngsborough Bridge and near the power lines in Methuen on September 28 and September 29, 2020, respectively.

3.0 CATCHMENT AREA CHARACTERISTICS

Appendix H of the 2016 MA MS4 Permit requires permittees developing a Phosphorus Source Identification Report to calculate impervious and directly connected impervious area (DCIA) for all catchments tributary to the waterbodies of concern. As a majority of Tewksbury is considered tributary to the Merrimack River, impervious area and DCIA were calculated for each delineated catchment area in town. This section discusses the procedure for and results of these calculations.

3.1 Available GIS Mapping

Tewksbury's GIS includes extensive mapping of the Town's drainage system, including catchment delineations, which has been continuously updated as the Town conducts outfall sampling and catchment investigations. There are currently 385 outfalls that are owned by the Town of Tewksbury and considered to be regulated under the permit. The total regulated drainage area—area discharging to a municipally-owned outfall or interconnection that reaches a water of the United States—in Tewksbury is 3,933 acres (6.15 square miles), or approximately 30% of the Town's total area. The Town has installed multiple stormwater BMPs to date, which are inspected annually and maintained as needed. A map of Tewksbury's MS4 is included in Appendix A.

The impervious area on all parcels in Tewksbury was delineated based on recently available aerial imagery, some of which was made available from the Town's recent stormwater enterprise planning efforts. Land use data for the properties within the MS4 catchment areas, as well as impervious area delineations for roads and other rights-of-way, was collected from MassGIS' most recent (2016) land use data layer. Table 5 presents a summary of land use across all regulated catchment areas in Tewksbury:

Land Use	Acres	Percent of Overall Area
Agriculture	1.54	0.04%
Commercial	106.05	2.70%
Industrial	45.02	1.14%
Mixed use, primarily residential	15.09	0.38%
Open land	116.13	2.95%
Recreation	3.10	0.08%
Residential - multi-family	84.67	2.15%
Residential - other	0.97	0.02%
Residential - single family	2607.36	66.30%
Right-of-way	719.37	18.29%
Tax exempt	232.97	5.92%
Unknown	0.63	0.02%

3.2 Directly Connected Impervious Area

The land use data and impervious area delineation were used to calculate the percent of Directly Connected Impervious Area (DCIA) for each MS4 catchment area. Percent DCIA is calculated by applying the Sutherland Equation developed in the 1995 publication *Methodology for Estimating the*

*Effective Impervious Area of Urban Watersheds*¹ and updated in the 2014 memorandum titled *Overview of Methodology to Calculate Baseline Stormwater Phosphorus Loads and Phosphorus Load Reduction Requirements for the Charles River*². In order to properly use the Sutherland Equations, the MassGIS land use codes were converted to EPA land use codes using the conversion methodology recommended by EPA and included in Table 6. Properties with an “Unknown” land use were considered as Commercial or Medium-Density Residential, which have the same Sutherland Equation. Weston & Sampson determined the amount and percent of impervious area in each MS4 catchment area for each land use, then used the appropriate Sutherland Equation to determine the percent DCIA for each land use in each catchment. These percentages were used to determine the total DCIA for each catchment. Table 7 lists the Sutherland Equation that was used for each land use type. Table 8 presents impervious area and DCIA statistics for the ten regulated catchments with the most acreage of directly connected impervious area in Tewksbury. DCIA statistics for all regulated catchments in Tewksbury are included in Appendix B.

Table 6: Conversion of MassGIS 2016 Land Use Codes to EPA Land Use Codes

MassGIS 2016 Code	MassGIS 2016 Use	EPA Code	EPA Use
1	Agriculture	7	Agriculture
3	Commercial	1	Commercial
4	Industrial	2	Industrial
2	Open Land	9	Open Land
12	Residential- Multi-Family	5	High-Density Residential
11	Residential- Single Family	4	Medium-Density Residential*
10	Mixed use, primarily residential	5	High-Density Residential
20	Mixed use, other	1	Commercial
13	Residential, other	4	Medium-Density Residential*
8	Recreation	9	Open Land
55	Right-of-Way (Roads)	2	Industrial**
9	Tax-Exempt	6	Urban Public/Institutional
0	Unknown	4	Medium Density Residential*

*EPA designates Medium-Density Residential as residential areas with parcel sizes between ¼ and ½ acre, which most closely matches this area³

**EPA considers all transportation uses, including roads, to be industrial uses.

Table 7: Land Use Classes and Corresponding Sutherland Equations (Source: EPA)

EPA Code	Land Use	Watershed Selection Criteria	Sutherland Equation (where IA(%) > 1)
1	Commercial	<u>Average</u> : Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected	$DCIA\% = 0.4(IA\%)^{1.2}$

¹ Sutherland, R.C., “Methodology for Estimating the Effective Impervious Area of Urban Watersheds”, Watershed Protection Techniques, Vol. 2, No. 1, Fall 1995.

² Voorhees, Mark. Overview of Methodology to Calculate Baseline Stormwater Phosphorus Loads and Phosphorus Load Reduction Requirements for the Charles River. January 14, 2014.

³ United States Environmental Protection Agency., “Methodology to Calculate Baseline Estimates of Impervious Area and Directly Connected Impervious Area for Massachusetts Communities”. March 2010.
<https://www3.epa.gov/region1/npdes/stormwater/ma/IA-DCIA-Calculation-Methodology.pdf>

Table 7: Land Use Classes and Corresponding Sutherland Equations (Source: EPA)

EPA Code	Land Use	Watershed Selection Criteria	Sutherland Equation (where IA(%) > 1)
2	Industrial	<u>Average</u> : Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected	$DCIA\% = 0.4(IA\%)^{1.2}$
3	Low Density Residential	<u>Somewhat connected</u> : 50% not storm sewered, but open section roads, grassy swales, residential rooftops not connected, some infiltration	$DCIA\% = 0.1(IA\%)^{1.5}$
4	Medium Density Residential	<u>Average</u> : Mostly storm sewered with curb and gutter, no dry wells or infiltration, residential rooftops not directly connected	$DCIA\% = 0.1(IA\%)^{1.5}$
5	High Density Residential	<u>Highly Connected</u> : Same as above, but residential rooftops are connected	$DCIA\% = 0.4(IA\%)^{1.2}$
6	Urban Public/ Institutional	<u>Average</u> : Mostly storm sewered with curb and gutter, no dry wells or infiltration, rooftops are directly connected	$DCIA\% = 0.1(IA\%)^{1.5}$
7	Agriculture	<u>Mostly Disconnected</u> : Small Percentage of urban area is storm sewered, or 70% or more infiltrated/disconnected	$DCIA\% = 0.01(IA\%)^2$
8	Forest	<u>Mostly Disconnected</u> : Small Percentage of urban area is storm sewered, or 70% or more infiltrated/disconnected	$DCIA\% = 0.01(IA\%)^2$
9	Open Land	<u>Average</u> : Mostly storm sewered with curb and gutter, no dry wells or infiltration, residential rooftops not directly connected	$DCIA\% = 0.1(IA\%)^{1.5}$
10	Water	n/a	n/a

Table 8: DCIA and Percent Connectivity in MS4 Catchment Areas

Catchment Area	Catchment Size (Ac.)	DCIA (Ac.)	IA (Acres)	Percent Connectivity (%)
AOF-6127	37.07	11.11	18.59	59.78
OF-2	58.06	1.85	7.53	24.55
OF-252	26.76	4.23	11.20	37.74
OF-136	26.27	5.88	11.36	51.77
OF-115	30.09	3.37	10.28	32.76
OF-3038	9.14	5.78	7.24	79.80
OF-290	41.70	3.96	10.37	38.20
OF-56	26.86	2.06	5.77	35.69
AOF-6136	19.60	2.92	7.32	39.92
OF-4298	16.58	4.30	7.43	57.87

Note: Percent Connectivity is the percent of total impervious area which is connected.

Many studies have been published in the past 15 years discussing the relationship between urban, impervious land cover and waterbody hydrology, habitat, biology, and ecosystem function. These studies have more recently included correlations between DCIA and biological indicators such as fish assemblages and algal blooms. Watersheds with as low as 4-6% IA and 1-5% DCIA typically begin to

show water quality impacts. While the DCIA in Town exceeds this threshold, the calculated range of percent DCIA is expected for municipalities similar to Tewksbury⁴.

⁴ Obropta, C.C. & Del Monaco, N. "Reducing Directly Connected Impervious Areas with Green Stormwater Infrastructure". *Journal of Sustainable Water in the Built Environment*. 2018. <https://ascelibrary.org/doi/pdf/10.1061/JSWBAY.0000833>

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4.0 POLLUTANT LOADING ANALYSIS AND PRIORITIZATION OF CATCHMENTS WITH HIGHER POTENTIAL PHOSPHORUS LOADS

The 2016 MS4 Permit requires all Phosphorus Source Identification Reports to include the identification, delineation, and prioritization of potential catchments with high phosphorus loadings. The potential for a particular site or area to contribute phosphorus to stormwater varies based on land use, impervious coverage, directly connected impervious area, and soil type. Hydrologic Soil Group (HSG), or the soil's ability to infiltrate stormwater, is the most important soil characteristic for the purposes of this analysis. HSG is ranked from A to D, with Group A soils more suited for infiltration, and Group D soils more likely to contribute runoff.

To identify catchment areas with higher potential phosphorus loads, a model for each catchment area was developed using land use data (MassGIS, 2016), impervious area delineations from recent aerial imagery, and soil HSG data from the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS). A land use/land cover grid was developed for the catchment areas in Tewksbury. That grid, which calculated the areas of each combination of land use, land cover, and soil type in each catchment, is included as Appendix C.

4.1 Phosphorus Load Export Rates

Land use, impervious coverage, directly connected impervious area, and HSG have been utilized by EPA as part of the MS4 Permit to develop Phosphorus Load Export Rates (PLERs) for different combinations of those attributes in close geographical areas where there is no considerable difference in average annual rainfall. Table 9 presents the PLERs that are included in Attachment 1 of Appendix F of the 2016 Massachusetts MS4 Permit. Medium-density residential is the most prevalent land use in Tewksbury, followed by commercial and industrial, and tax-exempt land. Tax-exempt land was assigned the same PLER as commercial and industrial land in accordance with permit guidance.

Table 9: Phosphorus Load Export Rates (PLERs) by Land Use

Land Use Category	Land Surface Cover	PLER (lb/acre/year)
Commercial and Industrial	Directly Connected Impervious	1.78
	Pervious	*See Developed Pervious
Multi-Family and High Density Residential	Directly Connected Impervious	2.32
	Pervious	*See Developed Pervious
Medium Density Residential	Directly Connected Impervious	1.96
	Pervious	*See Developed Pervious
Low Density Residential	Directly Connected Impervious	1.52
	Pervious	*See Developed Pervious
Highway	Directly Connected Impervious	1.34
	Pervious	*See Developed Pervious
Forest	Directly Connected Impervious	1.52
	Pervious	0.13
Open Land	Directly Connected Impervious	1.52
	Pervious	*See Developed Pervious
Agriculture	Directly Connected Impervious	1.52
	Pervious	0.45
*Developed Pervious – HSG A	Pervious	0.03
*Developed Pervious – HSG B	Pervious	0.12
*Developed Pervious – HSG C	Pervious	0.21

Table 9: Phosphorus Load Export Rates (PLERs) by Land Use

Land Use Category	Land Surface Cover	PLER (lb/acre/year)
*Developed Pervious – HSG C/D	Pervious	0.29
*Developed Pervious – HSG D	Pervious	0.37

4.2 Results

The land use/land cover grid shown in Appendix C, the directly connected impervious area (DCIA) determined for each catchment, and the PLERs included in Table 7 were used to calculate an estimated phosphorus load for each catchment area. Disconnected impervious area, or the difference between impervious area and DCIA, was considered pervious coverage in HSG D to account for the fact that some runoff from disconnected impervious surfaces will be infiltrated before reaching the MS4. Each distinct area of the land use/land cover grid was multiplied by the appropriate PLER to determine its yearly phosphorus load, and the results were summed by catchment area. The ten catchments with the highest pollutant loading are presented in Table 10. The results of the pollutant loading analysis for all of the catchment areas are included in Appendix D.

Table 10: Pollutant Loading Analysis Results – Top 10 Catchments

Catchment Area	Catchment Size (Ac.)	DCIA (Ac.)	Relative Phosphorus Loading (lb/yr/ac)	Phosphorus Loading (lb/yr)
AOF-6127	37.07	11.11	0.65	24.06
OF-2	58.06	1.85	0.25	14.41
OF-252	26.76	4.23	0.50	13.32
OF-136	26.27	5.88	0.47	12.29
OF-115	30.09	3.37	0.40	11.97
OF-3038	9.14	5.78	1.17	10.67
OF-290	41.70	3.96	0.25	10.37
OF-56	26.86	2.06	0.33	8.81
AOF-6136	19.60	2.92	0.44	8.65
OF-4298	16.58	4.30	0.51	8.41

4.2.1 Catchment Descriptions

The characteristics of the ten catchments with the highest estimated phosphorus loading are summarized below:

1. AOF-6127 – Tributary to Ames Pond

The catchment tributary to AOF-6127 includes 37 acres in the northern portion of town, including part of Andover Street and I-495 on and off ramps. The assumed outfall is in an area tributary to Ames Pond which drains to the Shawsheen River. The most prominent land uses in this catchment are industrial and commercial. The catchment is comprised of 50% impervious area and 30% directly connected impervious area; the soils are primarily HSG B or unknown. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, failing septic systems, and other sediment and debris that accumulates on roadways.

2. OF-2 – Tributary to the Shawsheen River

The catchment tributary to OF-2 includes 58 acres in the northern portion of town, including Greylock Road and parts of Cardigan Road and Kendall Road. The outfall is in an area tributary to Meadow Brook which drains to the Shawsheen River via Strong Meadow Brook. The most prominent land use in this catchment is medium-density residential. The catchment is comprised of 13% impervious area and 3% directly connected impervious area; the soils are mostly HSG A, C, and unknown. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, pet waste, failing septic systems, and other sediment and debris that accumulate on roadways.

3. OF-252 – Tributary to the Shawsheen River

The catchment tributary to OF-252 covers 27 acres in the central portion of town, including Hillcrest Road, Christine Drive, Carol Ann Road, parts of Jay Street, Chandler Street, and Helvetia Street. The outfall is in an area tributary to Strong Water Brook which drains to the Shawsheen River. The most prominent land uses in this catchment are tax-exempt and medium-density residential. The catchment is 42% impervious area and 16% directly connected impervious area; the soils are mostly HSG A/D, and C/D. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, pet waste, failing septic systems, and other sediment and debris that accumulate on roadways.

4. OF-136 – Tributary to the Concord River

The catchment tributary to OF-136 covers 26 acres in the eastern most portion of town, including Melrose Avenue, most of the portion of Woburn Street in Tewksbury, and parts of Park Avenue, Kenwood Avenue, James Avenue, Highland Avenue, and Lowell Street. This outfall is in an area tributary to the Concord River. The most prominent land uses in this catchment are medium-density residential, industrial and commercial. The catchment is 43% impervious area and 22% directly connected impervious area. The soils are mostly HSG A. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, fertilizer, pet waste, failing septic systems, and other sediment and debris that accumulate on roadways.

5. OF-115 – Tributary to the Merrimack River

The catchment tributary to OF-115 covers 30 acres in the northern portion of town, including Country Club Road. The outfall is in an area tributary to Trull Brook which drains to the Merrimack River. The most prominent land use in this catchment is medium-density residential. The catchment is 34% impervious area and 11% directly connected impervious area. The soils are HSG C/D, and unknown. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, pet waste, fertilizer, failing septic systems, and other sediment and debris that accumulate on roadways.

6. OF-3038 – Tributary to Ames Pond

The catchment tributary to OF-3038 covers 9 acres in the northern portion of town, including Highwood Drive. The outfall is in an area tributary to Ames Pond which drains to the Shawsheen River. The land uses in this catchment are primarily commercial and industrial. The catchment is 79% impervious area and 63% directly connected impervious area; the soils are mostly unknown HSG type. Potential sources of phosphorus in this catchment include leaf litter, grass clippings, failing septic systems, and other sediment and debris that accumulate on roadways.

7. OF-290 – Tributary to the Shawsheen River

The catchment tributary to OF-290 covers 42 acres on the southwestern portion of town, including Eleanor Road and the part of Chandler Street from the town line at Billerica to Indian Hill Road. The outfall is in an area tributary to Heath Brook which drains to the Shawsheen River. The most prominent land uses in this catchment are medium-density residential and industrial. The catchment is 25% impervious area and 10% directly connected impervious area; the soils are HSG A and B. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, fertilizers, failing septic systems, and other sediment and debris that may accumulate on roadways.

8. OF-56 – Tributary to the Merrimack River

The catchment tributary to OF-56 covers 27 acres in the northern portion of town, including Cooney Road and parts of Andover Street, Trull Road and Mt. Joy Drive. The outfall is in an area tributary to Trull Brook which drains to the Merrimack River. The most prominent land uses in this catchment are medium-density residential and industrial. The catchment is 21% impervious area and 8% directly connected impervious area; the soils are mostly HSG A, C and C/D. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, fertilizers, failing septic systems, and other sediment and debris that may accumulate on roadways.

9. AOF-6136 – Tributary to the Shawsheen River

The catchment tributary to AOF-6136 covers 20 acres on the Tewksbury-Billerica boundary line – less than half of the mapped catchment area is in Tewksbury. The area includes parts of Pupkis Road and Coolidge Street. The assumed outfall is in an area tributary to the Shawsheen River. The most prominent land use in this catchment is medium-density residential. Impervious area covers 37% of the catchment, directly connected impervious area covers 15%, and the soils are HSG A and A/D. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, failing septic systems, and other sediment and debris that may accumulate on roadways.

10. OF-4298 – Tributary to the Shawsheen River

The catchment tributary to OF-4298 covers 17 acres in the southern portion of town, including the portion of Shawsheen Street between Beech Street and Patriot Road, and Amos Street. The outfall is in an area tributary to Heath Brook which drains to the Shawsheen River. The most prominent land uses in this catchment are medium-density residential and industrial. The catchment is 45% impervious coverage and 26% directly connected impervious area; the soils are HSG A. Potential sources of phosphorus in the catchment include leaf litter, grass clippings, pet waste, fertilizers, failing septic systems, and other sediment and debris that may accumulate on roadways.

4.3 Dry and Wet Weather Outfall Screening and Sampling

Tewksbury has a total of 385 outfalls and interconnections that are under the Town's jurisdiction and regulated under the 2016 MS4 permit. Dry weather screening and sampling was conducted at each regulated outfall under the Town's jurisdiction in Tewksbury between September 2020 and June 2021, in accordance with MS4 Permit requirements. The results of these sampling events were recorded in the Town's GIS and summarized in a separate report, *2020-2021 Dry Weather Outfall and Interconnection*

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Screening & Sampling. Wet weather screening and sampling is scheduled to begin in 2022 and will be complete by the end of Permit Year 10, or June 30, 2028.

Flow was observed at 46 of the outfalls inspected during dry weather, two of which were sampled for phosphorus. Field kits were used to analyze samples for ammonia, chlorine, surfactants, temperature, salinity, and conductivity, and samples were sent to a laboratory to analyze samples for *Escherichia coli* (E. coli) and total phosphorus, if applicable to the receiving water. Outfalls that do not discharge directly to a receiving water with a phosphorus impairment were not sampled for phosphorus during dry-weather screening and sampling. The available sampling results for phosphorus are presented in Table 11.

Outfall ID	Dry-Weather Phosphorus Sampling Result (mg/L)
OF-136	0.025
OF-4113	<0.05

While there is no benchmark criteria for phosphorus concentrations in the Massachusetts Surface Water Quality Standards, 0.1 mg/L has been used as a placeholder by the town for outfall screening based on available literature. Neither of the dry weather phosphorus sampling results exceeds this benchmark.

4.4 Catchment Ranking Matrix

The purpose of performing the pollutant loading analysis was to develop a priority ranking of the delineated catchments in Tewksbury, with catchments with the highest potential phosphorus load considered highest priority. Since observed phosphorus concentrations in stormwater discharges can vary depending on the time of year the sampling is conducted, the size of the storm event, and other factors, the sample phosphorus concentrations were not considered when ranking the catchment areas. Other data collected during outfall inspections, such as the distance from the outfall to the receiving water were also considered.

The catchments with the highest potential pollutant loads, presented in Table 9 above, were all considered High Priority. The remaining 375 catchments in Tewksbury were determined to be lower priority. The ranking of high priority catchments is presented in Table 12; the ranking of all catchments in Tewksbury is included in Appendix E. A figure highlighting the High Priority catchments is also included in Appendix E.

Rank	Receiving Outfall	Catchment P Load (lb/year)	Relative P Load (lb/yr/ac)	Dry-Weather Phosphorus Sampling Result (mg/L)	Wet-Weather Phosphorus Sampling Result (mg/L)
1	AOF-6127	24.06	0.65	No flow observed	Scheduled for wet-weather sampling
2	OF-2	14.41	0.25	No flow observed	Scheduled for wet-weather sampling
3	OF-252	13.32	0.50	No flow observed	Scheduled for wet-weather sampling

Table 12: High Priority Catchment Ranking

Rank	Receiving Outfall	Catchment P Load (lb/year)	Relative P Load (lb/yr/ac)	Dry-Weather Phosphorus Sampling Result (mg/L)	Wet-Weather Phosphorus Sampling Result (mg/L)
4	OF-136	12.29	0.47	0.025	Scheduled for wet-weather sampling
5	OF-115	11.97	0.40	No flow observed	Scheduled for wet-weather sampling
6	OF-3038	10.67	1.17	No flow observed	Scheduled for wet-weather sampling
7	OF-290	10.37	0.25	No flow observed	Scheduled for wet-weather sampling
8	OF-56	8.81	0.33	No flow observed	Scheduled for wet-weather sampling
9	AOF-6136	8.65	0.44	No flow observed	Scheduled for wet-weather sampling
10	OF-4298	8.41	0.51	No flow observed	Scheduled for wet-weather sampling

5.0 BEST MANAGEMENT PRACTICE (BMP) RETROFIT OPPORTUNITIES

In addition to a community-wide BMP retrofit inventory, the 2016 MS4 Permit requires permittees with discharges tributary to a phosphorus-impaired waterbody to identify potential retrofit opportunities in the sub-catchments tributary to those receiving waters as part of the PSIR. Retrofit opportunities may include the installation of structural BMPs during redevelopment or the removal of impervious area.

5.1 Potential Retrofit Sites

A number of factors were considered when identifying potential retrofit sites in the higher priority sub-catchments in Tewksbury. In addition to municipal parcels, areas within the right-of-way were also considered for impervious area disconnection and/or reduction. Municipal ownership was considered the most important factor, as it is unlikely that the Town will be able to install a structural BMP on land that is privately owned unless the Town plans to acquire the property in question. Soils and available open space were also considered as site suitability characteristics. Projects within the right-of-way may be considered in conjunction with the Town's existing schedule for roadway and sidewalk improvements in the area. The top locations for potential BMP retrofit, listed in order of catchment rank, are included in Table 13, and discussed in more detail below.

Site Address	Property Owner	Site Area (Ac.)	Percent Impervious Coverage	Soil Type	Existing Parcel Use	Catchment ID	Catchment Rank
Cardigan Road at Kendall Road	Right-of-Way	N/A	N/A	C, A	-	OF-2	2
Chandler Street (from Main Street to Foster Road)	Right-of-Way	N/A	N/A	A	-	OF-252	3
Park Avenue	Town of Tewksbury	1.46	0%	A	Open Space	OF-136	4
Park Avenue	Town of Tewksbury	0.06	0%	A	Open Space	OF-136	4
Woburn Street and Felkner Street Neighborhood	Right-of-Way	N/A	N/A	A	-	OF-136	4
Country Club Drive	Town of Tewksbury	1.27	0%	C/D, Unknown	Open Space	OF-115	5
Highwood Drive	Right-of-Way	N/A	N/A	C/D, Unknown	-	OF-3038	6
Chandler Street (from Pine Street to Billerica line)	Right-of-Way	N/A	N/A	A	-	OF-290	7
Cobleigh Drive	Right-of-Way	N/A	N/A	A	-	OF-56	8
Pukis Road at Coolidge Road	Right-of-Way	N/A	N/A	A	-	AOF-6136	9
Heath Brook Elementary School (199 Shawsheen Street)	Town of Tewksbury	18.19	19%	A	School	OF-4298	10

Table 13: Potential BMP Retrofit Sites

Site Address	Property Owner	Site Area (Ac.)	Percent Impervious Coverage	Soil Type	Existing Parcel Use	Catchment ID	Catchment Rank
Shawsheen Street (from Foster Road to Darlene Circle)	Right-of-Way	N/A	N/A	A	-	OF-4298	10

5.1.1 Andover Street (Highwood Drive to Andover Line)

This portion of Andover Street contributes the highest estimated phosphorus loading in Tewksbury. However, no BMP retrofits are recommended in Table 13, as it appears that most of the drainage in the catchment is comprised of state infrastructure. The outfall for this catchment is currently assumed and requires further investigation to determine if there is an interconnection between Town and state drainage. No BMP retrofits are recommended at this time.

5.1.2 Cardigan Road at Kendall Road

This intersection receives drainage flow from Cardigan Road, Kendall Road, and Greylock Road. There are various existing catch basins within the intersection that could be converted to leaching catch basins, tree filter pits, or infiltration trenches. The town-owned drainage could also be redirected to a small bioretention system or similar if the intersection is reconstructed. Cut sheets for bioretention areas and tree filter pits as well as examples of these BMPs in the right-of-way are included in Appendix F.

5.1.3 Chandler Street (Main Street to Foster Road)

This portion of Chandler Street is in the center of town and contains many existing catch basins on both sides of the street to consider for conversion to leaching catch basins, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Main Street when planning future roadway and sidewalk improvements.

5.1.4 Park Avenue Parcels

These Town-owned parcels off Park Avenue in the eastern portion of Tewksbury are wooded areas adjacent to residential properties. The larger parcel is included as a top ten priority area for green infrastructure in combination with the right-of-way on Lowell Street; the Lowell Street neighborhood was identified as a location prone to flooding. Recommended BMPs include porous pavement at intersections with sub-surface infiltration systems and/or bioretention along Lowell Street, porous pavement along certain roadways in this neighborhood, leaching catch basins along Lowell Street and a bioretention area within the larger parcel off Park Avenue.

5.1.5 Woburn and Felkner Street Drainage Improvements

The drainage system in this area in the eastern portion of Tewksbury is tentatively planned for reconstruction as part of the Town's Capital Improvement Plan. As part of the drainage improvements, BMP retrofits should be considered. Potential retrofits may include curb bump-outs within the right-of-way, conversion of Town-owned catch basins to leaching catch basins or small infiltration trenches, and small surface BMPs (bioretention or similar).

5.1.6 Country Club Drive Parcel

This parcel in the northwestern portion of Town is situated between two residential properties. The drainage system on Country Club Drive discharges to the wetland area within and adjacent to the parcel.

To disconnect a portion of the drainage system on Country Club Drive, the Town should consider installing leaching catch basins, tree filter pits, or other subsurface systems within the parcel or the right-of-way.

5.1.7 *Highwood Drive*

This dead-end street in the northeastern portion of Town adjacent to I-495 ramps serves a hotel and commercial/industrial buildings. There are various existing catch basins on both sides of the street to consider for conversion to leaching catch basins, tree filter pits, or infiltration trenches.

5.1.8 *Chandler Street (Pine Street to Billerica Line)*

This portion of Chandler Street in the southern portion of Town contains an extensive drainage system with many catch basins on both sides of the street and at intersections for conversion to leaching catch basins, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Chandler Street when planning future roadway and sidewalk improvements.

5.1.9 *Andover Street (Blacksmith Lane to Trull Road)*

This portion of Andover Street in the northern portion of Town contains an extensive drainage system with catch basins on both sides of the street and at intersections for conversion to leaching catch basins, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Andover Street when planning future roadway and sidewalk improvements.

5.1.10 *Andover Street at Hood Road Culvert*

The culvert underneath Andover Street at Hood Road is scheduled for repair as part of the Town's Capital Improvement Plan. Two outfalls discharge to Trull Brook adjacent to this culvert. If the intersection of Andover Street at Hood Road is reconstructed as part of this culvert repair, the Town should consider conversion of the adjacent catch basins to leaching catch basins or infiltration trenches. Additionally, curb bump outs could be utilized on either side of the street for traffic calming and to install a small surface BMP (bioretention or similar).

5.1.11 *Cobleigh Drive*

Cobleigh Drive is located mostly in HSG A and provides an opportunity for green street designs which promote infiltration of stormwater. Infiltration trenches, small bioretention areas, and rain gardens could be installed to treat stormwater along Cobleigh Drive where feasible. The cul-de-sac is currently all paved; including a central island with a bioretention area will provide treatment of sheet flow run off along Cobleigh Drive.

5.1.12 *Pukis Road at Coolidge Road*

The intersection of Pukis Road and Coolidge Road provides an opportunity for BMP retrofit. The Town should consider installing leaching catch basins or infiltration trenches along the intersections. A small bioretention area may be feasible at one or more of the corners of the intersections, depending on resident input. A sample intersection design is provided in the Final Report of the Municipal Vulnerability Preparedness (MVP) Action Grant Stormwater Analysis for Nature-Based Solutions as part of the Lowell Street Neighborhood designs.

5.1.13 Heath Brook Elementary School

This Town-owned parcel in the southern portion of Town on Shawsheen Street contains Heath Brook Elementary School, parking, and recreation area. A portion of the drainage system along Shawsheen Street could be diverted to a surface BMP (bioretention or similar) or infiltration trenches along the front of the property to disconnect impervious area within catchment OF-4298. Due to heavy traffic during the school year, this site would provide great opportunities for public education.

5.1.14 Shawsheen Street (Foster Road to Darlene Circle)

This portion of Shawsheen Street in the southern portion of Town contains an extensive drainage system with catch basins on both sides of the street and at intersections for conversion to leaching catch basins, tree filter pits, or infiltration trenches. The Town should look for specific locations to implement green infrastructure as well as infiltration trenches on Shawsheen Street when planning future roadway and sidewalk improvements.

5.2 Potential Retrofit Sites

The Town has completed stormwater retrofit projects in catchment areas tributary to Long Pond prior to the development of this report, which are detailed below. This section should be updated as stormwater retrofit projects are completed in both high priority catchments and Town-wide.

5.1.1 Long Pond Rain Gardens (Existing)

Through a collaboration with MassDEP, the Town utilized over \$270,000 dollars in Section 319 grant funding to install rain gardens and roadside treatment swales throughout the Long Pond watershed area. A total of 19 rain gardens and 10 roadside treatment swales were installed as part of this effort in 19 locations of concentrated stormwater runoff. Signs were installed at rain gardens to identify them to the public and information pamphlets located in outdoor plastic holders were also located at each location for educational purpose. In total, an estimated 56 pounds per year of phosphorus are removed through these structural BMPs.

5.3 Implementation

The Town of Tewksbury will begin addressing the findings of this Phosphorus Source Identification Report in Permit Year 5 (FY2023). The Town must first evaluate each potential retrofit opportunity identified in the previous section through the following actions:

- Determine a planned retrofit date for each potential retrofit site identified in Section 5.1 based on the next planned infrastructure, resurfacing, or redevelopment activity planned for the site.
- Determine an estimated cost for each potential retrofit project discussed in Section 5.1.
- Determine the engineering and regulatory feasibility of implementing each potential retrofit project.

A list of planned BMP retrofit projects and schedule for their implementation will be included in the Town's Year 5 MS4 Annual Report.

By the end of Permit Year 6 (FY2024), the Town will plan and install one of the retrofit projects identified in Section 5.1 as a demonstration project. The remainder of the retrofit projects, where implementation is feasible from an engineering and permitting perspective, will be installed according to the schedule included in the Year 5 Annual Report. Future availability of funding will also be considered in developing the schedule. Tewksbury will track any structural BMPs installed in the watershed and calculate the

estimated phosphorus removal attributable to those BMPs consistent with Attachment 3 to Appendix F of the MS4 Permit. The BMP type, area treated, design storage volume, and estimated phosphorus removed in pounds per year by each BMP will be included in the Town's future MS4 annual reports.

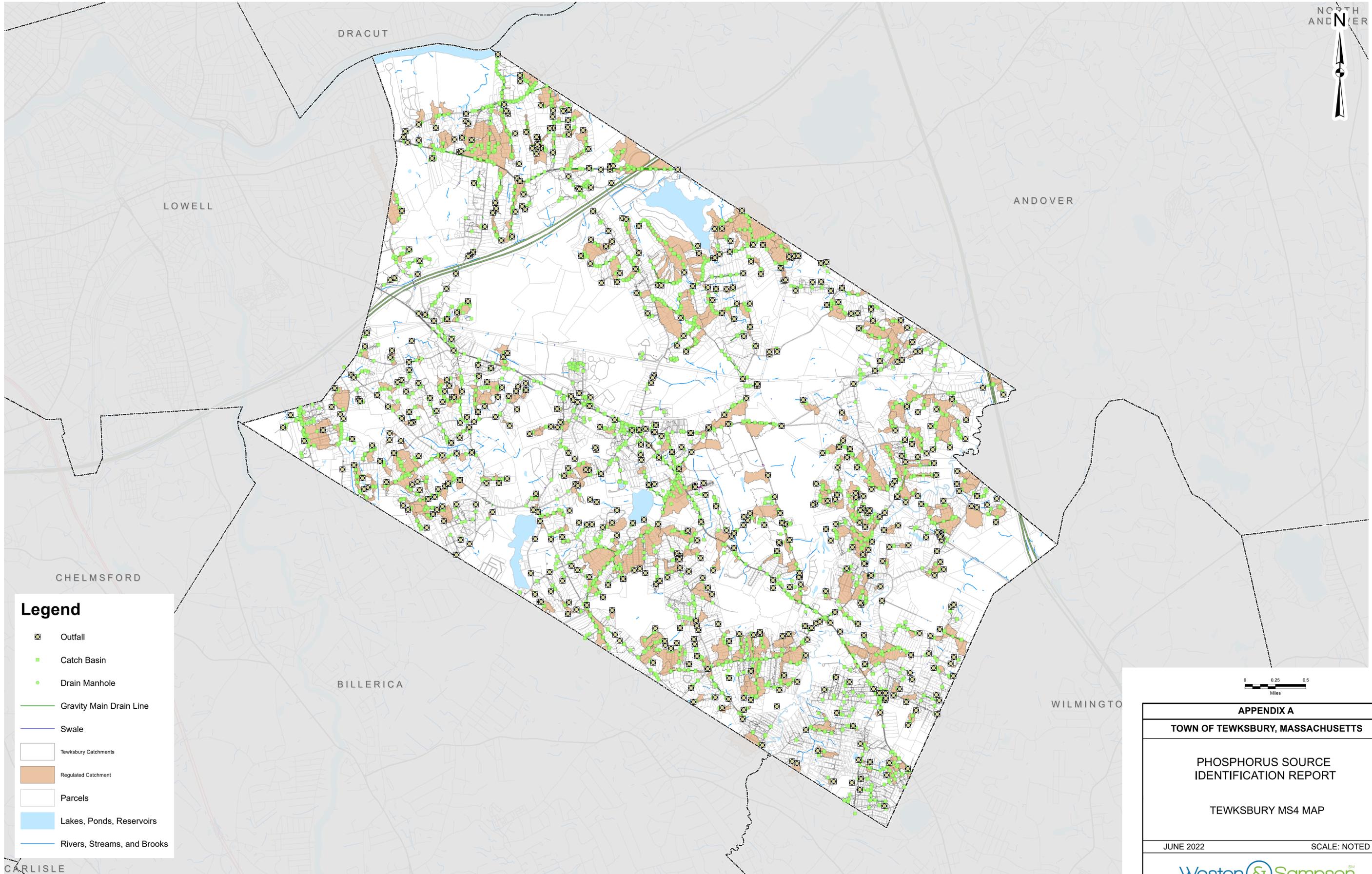
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APPENDIX A

Tewksbury MS4 Map



Legend

- ☒ Outfall
- Catch Basin
- Drain Manhole
- Gravity Main Drain Line
- Swale
- Tewksbury Catchments
- Regulated Catchment
- Parcels
- Lakes, Ponds, Reservoirs
- Rivers, Streams, and Brooks

APPENDIX A

TOWN OF TEWKSBURY, MASSACHUSETTS

PHOSPHORUS SOURCE IDENTIFICATION REPORT

TEWKSBURY MS4 MAP

JUNE 2022 SCALE: NOTED

Weston & SampsonSM

APPENDIX B

Impervious Area and DCIA Results for All Catchments

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
AOF-6127	Yes	37.07	11.11	18.59	59.78	29.98	50.15
OF-2	Yes	58.06	1.85	7.53	24.55	3.18	12.96
OF-252	Yes	26.76	4.23	11.20	37.74	15.80	41.88
OF-136	Yes	26.27	5.88	11.36	51.77	22.39	43.25
OF-115	Yes	30.09	3.37	10.28	32.76	11.19	34.15
OF-3038	Yes	9.14	5.78	7.24	79.80	63.20	79.20
OF-290	Yes	41.70	3.96	10.37	38.20	9.50	24.87
OF-56	Yes	26.86	2.06	5.77	35.69	7.66	21.47
AOF-6136	Yes	19.60	2.92	7.32	39.92	14.90	37.34
OF-4298	Yes	16.58	4.30	7.43	57.87	25.92	44.80
AOF-6086	Yes	6.57	3.54	4.83	73.43	53.93	73.44
OF-4426	Yes	18.89	4.02	7.21	55.75	21.27	38.15
OF-29	Yes	21.37	0.74	2.20	33.67	3.47	10.30
OF-32	Yes	21.51	1.78	4.63	38.49	8.29	21.53
OF-55	Yes	16.59	2.00	5.16	38.77	12.06	31.10
OF-4238	Yes	11.16	3.28	6.72	48.83	29.41	60.22
OF-132	Yes	24.41	1.52	4.15	36.64	6.23	17.00
OF-4447	Yes	15.13	2.90	5.80	49.98	19.17	38.36
OF-319	Yes	5.26	3.14	4.19	74.97	59.72	79.65
OF-178	Yes	4.72	3.35	3.73	89.85	70.97	78.99
OF-218	Yes	20.26	2.32	5.89	39.44	11.46	29.06
OF-4099	Yes	16.35	1.59	4.30	37.00	9.74	26.33
OF-3029	Yes	6.89	2.17	2.94	73.68	31.49	42.73
OF-382	Yes	16.48	2.77	5.31	52.19	16.80	32.20
OF-328	Yes	17.79	2.76	5.38	51.22	15.50	30.26
OF-229	Yes	11.02	2.36	4.47	52.79	21.44	40.62
OF-259	Yes	10.80	2.08	4.93	42.30	19.30	45.62
OF-4101	Yes	12.66	0.97	2.53	38.38	7.67	20.00
OF-4231	Yes	9.74	1.22	2.71	45.03	12.52	27.81
OF-3005	Yes	16.46	1.03	2.67	38.64	6.26	16.19
OF-4602	Yes	12.58	2.35	4.44	53.02	18.72	35.30
OF-4500	Yes	9.73	1.45	2.78	52.06	14.89	28.59
OF-267	Yes	16.78	2.02	5.18	39.00	12.05	30.89
OF-4152	Yes	17.44	1.77	4.21	41.99	10.14	24.14
OF-61	Yes	9.75	1.13	2.66	42.31	11.54	27.27
OF-4233	Yes	14.59	0.62	2.22	28.12	4.28	15.23
OF-4113	Yes	7.81	1.44	2.70	53.41	18.45	34.54

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-4406	Yes	11.41	1.94	3.74	51.86	17.01	32.80
OF-4096	Yes	8.28	1.78	3.26	54.52	21.49	39.41
OF-3096	Yes	9.34	1.02	2.22	45.64	10.87	23.82
OF-3060	Yes	20.58	1.79	3.85	46.60	8.71	18.69
AOF-6076	Yes	8.82	1.58	3.76	41.94	17.89	42.64
OF-367	Yes	11.04	1.08	2.89	37.52	9.81	26.15
OF-54	Yes	8.84	0.80	2.09	38.19	9.05	23.70
OF-25	Yes	11.02	0.82	2.28	35.90	7.44	20.74
AOF-6125	Yes	6.84	1.32	2.46	53.54	19.28	36.01
OF-4638	Yes	11.12	0.71	2.02	34.94	6.36	18.21
OF-4631	Yes	12.39	0.40	1.41	28.79	3.27	11.35
OF-3	Yes	10.61	0.76	2.19	34.55	7.12	20.62
AOF-6008	Yes	3.99	1.17	1.50	78.08	29.35	37.59
OF-4032	Yes	5.38	0.96	1.67	57.55	17.84	30.99
OF-4322	Yes	6.55	1.18	2.55	46.51	18.09	38.88
OF-3083	Yes	8.65	0.60	1.51	40.05	6.97	17.41
OF-4358	Yes	7.73	0.78	1.82	43.10	10.13	23.49
OF-373	Yes	14.19	0.92	2.55	36.04	6.46	17.94
OF-50	Yes	5.39	1.20	2.37	50.68	22.30	44.00
OF-4024	Yes	10.54	0.83	2.50	33.15	7.87	23.74
OF-222	Yes	11.99	1.45	2.81	51.64	12.08	23.40
OF-254	Yes	6.47	1.35	2.87	47.27	20.94	44.31
AOF-6055	Yes	3.64	1.46	2.13	68.29	40.01	58.58
OF-360	Yes	7.07	1.44	2.56	56.34	20.41	36.23
AOF-6054	Yes	2.86	1.49	2.06	72.28	52.09	72.06
OF-4389	Yes	7.62	0.66	1.66	39.67	8.66	21.82
OF-323	Yes	4.80	1.13	2.13	52.78	23.42	44.37
AOF-6071	Yes	12.19	1.18	2.96	39.98	9.71	24.29
OF-378	Yes	6.81	0.43	1.26	34.18	6.33	18.51
OF-4405	Yes	6.53	1.34	2.34	57.39	20.55	35.81
OF-4291	Yes	4.98	0.98	1.81	54.34	19.73	36.31
OF-281	Yes	5.54	1.06	2.19	48.15	19.06	39.57
OF-4299	Yes	5.63	1.29	2.26	57.27	22.95	40.08
AOF-6017	Yes	5.56	1.05	2.33	45.24	18.95	41.89
OF-4269	Yes	3.80	1.11	1.83	60.90	29.34	48.17
OF-288	Yes	5.00	1.28	2.17	59.02	25.60	43.38
OF-228	Yes	7.36	1.18	2.32	50.58	15.96	31.56

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-130	Yes	6.09	0.63	1.22	51.73	10.33	19.97
OF-4533	Yes	5.06	0.99	1.83	54.00	19.50	36.12
OF-4361	Yes	7.86	0.73	1.80	40.69	9.30	22.86
OF-131	Yes	6.39	0.59	1.49	39.34	9.21	23.40
OF-4574	Yes	10.36	0.13	0.52	25.51	1.27	4.98
OF-3051	Yes	5.41	0.71	1.58	45.15	13.14	29.10
OF-240	Yes	5.68	1.15	2.10	54.87	20.29	36.98
OF-3021	Yes	8.00	1.13	2.26	49.91	14.11	28.28
OF-4095	Yes	6.59	0.44	1.16	37.66	6.60	17.53
OF-278	Yes	1.61	1.26	1.53	81.81	78.17	95.55
OF-4639	Yes	5.75	1.14	2.08	54.61	19.79	36.24
AOF-6021	Yes	3.04	1.11	1.87	59.28	36.60	61.74
OF-18	Yes	6.59	0.26	0.68	37.93	3.92	10.34
OF-4038	Yes	2.45	1.18	2.02	58.44	48.14	82.38
OF-17	Yes	5.27	0.49	1.18	41.45	9.27	22.36
OF-338	Yes	6.45	0.83	1.91	43.79	12.95	29.57
AOF-6013	Yes	9.87	0.19	0.68	27.63	1.92	6.93
OF-4114	Yes	5.67	0.32	0.89	35.56	5.59	15.71
AOF-6082	Yes	10.27	1.03	1.75	58.95	10.05	17.04
OF-314	Yes	5.45	1.08	1.96	55.25	19.89	35.99
OF-313	Yes	5.98	1.07	2.00	53.49	17.92	33.51
OF-1	Yes	9.98	0.61	1.78	34.49	6.14	17.79
OF-27	Yes	5.25	0.60	1.47	40.76	11.42	28.03
OF-3031	Yes	1.63	0.86	1.00	85.75	52.71	61.47
OF-4329	Yes	1.60	1.13	1.27	89.14	70.83	79.46
OF-4486	Yes	3.42	0.73	1.41	51.60	21.31	41.29
OF-4576	Yes	4.14	0.80	1.40	57.36	19.44	33.89
OF-4301	Yes	11.87	0.94	2.10	44.87	7.92	17.66
OF-4512	Yes	4.56	0.94	1.86	50.54	20.58	40.73
OF-340	Yes	3.56	1.06	1.45	73.07	29.70	40.65
OF-187	Yes	4.42	0.59	1.36	43.24	13.28	30.70
AOF-6080	Yes	5.50	0.41	1.00	41.08	7.46	18.17
OF-333	Yes	3.70	0.82	1.71	48.16	22.27	46.23
OF-85	Yes	5.14	0.81	1.47	55.08	15.77	28.62
OF-377	Yes	6.38	0.15	0.62	24.58	2.40	9.78
OF-157	Yes	4.12	0.72	1.85	38.93	17.54	45.05
AOF-6066	Yes	2.53	0.93	1.31	70.89	36.62	51.66

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-4331	Yes	3.91	0.75	1.31	57.76	19.27	33.36
OF-381	Yes	1.89	1.02	1.36	75.10	54.05	71.96
OF-4519	Yes	6.26	0.43	1.10	38.95	6.82	17.51
OF-282	Yes	4.60	0.88	1.71	51.79	19.23	37.13
OF-388	Yes	5.10	0.65	1.54	42.04	12.69	30.19
OF-224	Yes	3.67	0.55	1.23	45.12	15.07	33.41
OF-102	Yes	3.32	0.54	0.93	58.25	16.27	27.93
OF-4012	Yes	3.99	0.66	1.23	53.17	16.42	30.88
OF-4508	Yes	5.52	0.46	1.01	45.42	8.31	18.30
OF-4305	Yes	2.41	0.90	1.39	64.78	37.51	57.91
AOF-6091	Yes	4.89	0.83	1.58	52.48	16.97	32.34
OF-3000	Yes	3.74	0.64	1.30	49.54	17.21	34.75
OF-4313	Yes	4.09	0.85	1.52	55.71	20.79	37.32
OF-4603	Yes	4.12	0.82	1.52	54.40	20.00	36.77
OF-4128	Yes	5.60	0.62	1.18	52.64	11.06	21.00
AOF-6006	Yes	2.40	0.85	1.34	63.38	35.37	55.80
OF-391	Yes	4.54	0.77	1.39	55.57	17.03	30.64
OF-45	Yes	1.73	0.75	1.18	63.75	43.53	68.29
OF-141	Yes	3.57	0.82	1.44	56.79	22.91	40.35
OF-145	Yes	2.93	0.64	1.15	55.63	21.73	39.06
OF-3070	Yes	1.06	0.88	0.93	94.64	82.82	87.51
OF-53	Yes	3.35	0.59	1.04	57.40	17.75	30.92
OF-158	Yes	2.25	0.59	0.93	63.68	26.19	41.13
OF-4127	Yes	6.14	0.52	1.12	46.06	8.43	18.31
OF-312	Yes	6.23	0.75	1.57	48.09	12.10	25.16
OF-47	Yes	3.44	0.41	0.90	46.13	12.05	26.12
OF-4503	Yes	9.82	0.30	1.13	26.29	3.03	11.52
AOF-6134	Yes	4.63	0.45	1.23	36.18	9.63	26.62
OF-3014	Yes	3.99	0.30	0.68	44.14	7.46	16.91
OF-3080	Yes	0.86	0.63	0.67	94.41	72.90	77.22
OF-20	Yes	4.24	0.61	1.16	52.74	14.44	27.38
OF-3082	Yes	2.12	0.63	0.89	70.67	29.60	41.88
OF-3084	Yes	3.82	0.39	0.97	40.16	10.23	25.47
OF-203	Yes	4.09	0.70	1.30	53.72	17.10	31.82
OF-337	Yes	3.20	0.35	0.84	42.10	11.08	26.33
OF-4288	Yes	2.94	0.45	0.89	50.40	15.33	30.42
OF-133	Yes	2.20	0.56	0.87	64.62	25.68	39.74

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-342	Yes	5.42	0.59	1.22	48.43	10.92	22.55
OF-301	Yes	7.77	0.16	0.76	21.54	2.10	9.76
OF-4397	Yes	1.99	0.58	0.87	66.48	28.86	43.42
OF-3062	Yes	4.12	0.62	1.30	47.54	15.03	31.61
OF-3059	Yes	4.67	0.62	1.22	50.62	13.24	26.16
OF-62	Yes	1.91	0.57	0.90	63.55	29.77	46.85
OF-4187	Yes	2.34	0.48	0.65	73.60	20.47	27.81
OF-4319	Yes	2.46	0.64	1.08	58.94	25.94	44.00
OF-69	Yes	2.51	0.33	0.72	45.13	13.01	28.83
AOF-6118	Yes	2.79	0.55	0.98	55.79	19.53	35.00
OF-64	Yes	2.33	0.51	1.12	45.19	21.78	48.20
AOF-6106	Yes	2.00	0.47	0.86	55.14	23.63	42.84
OF-52	Yes	3.95	0.29	0.92	31.46	7.37	23.44
OF-4517	Yes	3.86	0.44	0.88	49.42	11.32	22.91
OF-270	Yes	4.13	0.60	1.17	51.00	14.44	28.32
OF-135	Yes	2.21	0.48	0.81	59.69	21.77	36.47
OF-4544	Yes	2.32	0.39	0.73	54.20	16.98	31.33
OF-134	Yes	2.39	0.39	0.75	51.79	16.14	31.17
AOF-6129	Yes	3.00	0.26	0.56	46.54	8.70	18.70
OF-19	Yes	2.22	0.50	0.94	53.36	22.55	42.26
OF-162	Yes	2.64	0.43	0.82	52.23	16.24	31.09
OF-76	Yes	2.13	0.33	0.63	51.75	15.33	29.61
OF-4274	Yes	5.60	0.38	1.12	34.12	6.81	19.95
OF-4365	Yes	1.47	0.52	0.85	61.23	35.47	57.94
OF-263	Yes	1.12	0.59	0.88	67.19	52.43	78.04
OF-4620	Yes	3.98	0.50	1.11	45.43	12.67	27.89
AOF-6072	Yes	3.30	0.56	1.01	55.71	17.04	30.59
OF-233	Yes	2.60	0.55	1.02	53.53	21.02	39.26
OF-4434	Yes	1.77	0.59	0.85	69.51	33.50	48.19
OF-3052	Yes	1.47	0.42	0.57	72.91	28.40	38.95
OF-4267	Yes	2.09	0.53	0.96	55.86	25.61	45.85
OF-191	Yes	1.77	0.43	0.78	54.84	24.22	44.16
OF-196	Yes	2.82	0.30	0.66	44.95	10.54	23.45
OF-122	Yes	0.65	0.58	0.65	89.48	89.10	99.57
AOF-6010	Yes	1.57	0.48	0.70	68.41	30.35	44.36
OF-3061	Yes	2.76	0.53	0.94	56.90	19.35	34.01
OF-4502	Yes	2.04	0.41	0.76	53.70	19.96	37.17

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-30	Yes	2.48	0.28	0.64	43.99	11.43	25.98
OF-109	Yes	1.97	0.40	0.75	54.22	20.60	37.99
AOF-6092	Yes	3.41	0.51	1.00	50.75	14.85	29.27
OF-4228	Yes	4.96	0.36	0.89	40.77	7.28	17.86
OF-4514	Yes	7.90	0.32	0.83	38.19	4.01	10.50
AOF-6104	Yes	0.67	0.41	0.47	87.97	61.24	69.61
OF-4287	Yes	1.86	0.34	0.69	49.83	18.43	36.99
OF-4523	Yes	1.32	0.41	0.63	64.39	30.83	47.88
OF-248	Yes	2.19	0.52	0.89	58.79	23.78	40.46
OF-4202	Yes	4.68	0.39	0.98	39.92	8.33	20.86
OF-4055	Yes	2.42	0.49	0.89	55.16	20.38	36.96
OF-3064	Yes	3.43	0.40	0.95	42.39	11.76	27.74
OF-212	Yes	2.85	0.49	0.85	57.09	17.05	29.86
OF-4547	Yes	2.63	0.49	0.81	60.78	18.65	30.68
OF-230	Yes	1.49	0.38	0.54	69.47	25.30	36.42
OF-4232	Yes	2.21	0.37	0.78	47.22	16.68	35.33
OF-389	Yes	2.02	0.49	0.77	63.92	24.41	38.19
OF-3073	Yes	3.04	0.46	0.90	51.48	15.20	29.53
OF-129	Yes	1.64	0.39	0.65	59.55	23.78	39.94
OF-246	Yes	2.13	0.34	0.76	44.45	15.84	35.63
OF-208	Yes	2.13	0.38	0.70	54.12	17.76	32.81
OF-4598	Yes	2.86	0.44	0.96	45.65	15.29	33.49
OF-273	Yes	1.13	0.50	0.71	70.02	43.89	62.68
OF-101	Yes	2.78	0.18	0.41	44.80	6.61	14.76
OF-108	Yes	1.72	0.32	0.58	54.38	18.36	33.76
OF-95	Yes	1.56	0.42	0.71	58.63	26.76	45.64
OF-4446	Yes	4.40	0.40	0.95	42.74	9.20	21.53
OF-239	Yes	2.45	0.45	0.82	55.34	18.46	33.36
OF-4289	Yes	1.51	0.36	0.63	57.92	24.11	41.62
OF-9	Yes	1.84	0.37	0.76	48.86	20.07	41.08
OF-4546	Yes	6.51	0.37	0.89	41.49	5.67	13.67
OF-4135	Yes	1.49	0.41	0.81	50.11	27.26	54.41
OF-3020	Yes	3.70	0.27	0.98	27.78	7.34	26.40
OF-4007	Yes	1.99	0.29	0.54	53.57	14.59	27.24
OF-332	Yes	1.39	0.38	0.64	59.91	27.57	46.01
OF-8	Yes	5.17	0.30	0.85	35.45	5.85	16.50
OF-3086	Yes	3.17	0.10	0.35	27.05	3.02	11.15

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-48	Yes	3.47	0.30	0.71	42.64	8.78	20.60
OF-4431	Yes	1.31	0.43	0.64	66.86	32.72	48.93
OF-4548	Yes	3.27	0.36	0.69	51.92	10.91	21.02
OF-79	Yes	1.11	0.36	0.56	63.99	32.22	50.35
OF-354	Yes	3.52	0.31	0.74	41.49	8.77	21.14
OF-100	Yes	1.44	0.31	0.49	62.38	21.31	34.17
OF-3035	Yes	0.93	0.43	0.59	72.72	45.92	63.15
OF-257	Yes	1.33	0.41	0.60	67.51	30.54	45.23
OF-96	Yes	1.23	0.37	0.62	60.32	30.34	50.30
OF-272	Yes	12.44	0.23	0.66	34.41	1.82	5.30
OF-4501	Yes	1.43	0.31	0.54	57.53	21.82	37.93
OF-3034	Yes	1.85	0.21	0.46	45.06	11.21	24.88
OF-4053	Yes	2.57	0.35	0.69	51.12	13.79	26.98
OF-223	Yes	3.04	0.37	0.74	49.39	12.07	24.43
OF-4148	Yes	1.65	0.38	0.66	58.48	23.19	39.65
OF-4390	Yes	1.83	0.23	0.46	50.05	12.53	25.03
AOF-6119	Yes	1.06	0.34	0.49	70.48	32.38	45.94
OF-4328	Yes	5.12	0.31	0.78	39.81	6.10	15.32
OF-4160	Yes	1.37	0.29	0.48	60.69	21.34	35.16
AOF-6036	Yes	1.58	0.36	0.62	57.91	22.80	39.38
OF-4577	Yes	1.78	0.22	0.48	46.50	12.52	26.92
OF-385	Yes	2.21	0.35	0.62	56.59	15.87	28.04
OF-390	Yes	1.61	0.35	0.62	57.03	21.91	38.42
AOF-6094	Yes	4.21	0.31	0.72	43.37	7.42	17.11
AOF-6050	Yes	1.40	0.26	0.46	56.37	18.57	32.94
OF-4516	Yes	2.35	0.33	0.59	55.41	13.85	25.00
OF-375	Yes	1.61	0.19	0.44	43.11	11.70	27.14
OF-148	Yes	1.42	0.25	0.44	56.68	17.60	31.05
OF-330	Yes	0.55	0.37	0.46	79.78	66.72	83.62
OF-125	Yes	1.64	0.27	0.44	60.28	16.20	26.87
OF-184	Yes	1.17	0.31	0.50	61.83	26.29	42.51
OF-4229	Yes	1.41	0.34	0.51	66.67	23.94	35.91
OF-172	Yes	1.16	0.34	0.51	66.41	29.25	44.05
OF-4292	Yes	1.91	0.32	0.57	55.53	16.72	30.10
OF-4408	Yes	1.24	0.33	0.52	63.64	26.87	42.23
OF-253	Yes	2.38	0.31	0.60	50.67	12.84	25.34
AOF-6064	Yes	0.62	0.31	0.36	87.20	50.52	57.94

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-183	Yes	1.27	0.24	0.41	57.46	18.61	32.39
OF-4525	Yes	1.75	0.17	0.33	52.09	9.86	18.92
OF-344	Yes	1.14	0.32	0.51	63.06	28.20	44.72
AOF-6053	Yes	1.07	0.32	0.48	67.57	30.05	44.47
OF-22	Yes	1.19	0.30	0.44	68.54	25.61	37.36
OF-87	Yes	0.88	0.29	0.42	68.23	32.78	48.04
AOF-6063	Yes	1.17	0.22	0.40	56.65	19.07	33.66
OF-4456	Yes	0.75	0.28	0.44	62.72	36.88	58.80
OF-142	Yes	0.98	0.23	0.40	57.53	23.46	40.78
OF-97	Yes	0.88	0.30	0.42	71.60	34.32	47.93
OF-124	Yes	1.10	0.21	0.35	61.32	19.53	31.85
OF-199	Yes	0.93	0.27	0.43	62.76	28.82	45.93
OF-235	Yes	1.18	0.23	0.41	56.82	19.65	34.59
OF-311	Yes	1.35	0.28	0.47	59.02	20.66	35.01
AOF-6139	Yes	0.59	0.23	0.32	70.09	38.26	54.59
OF-343	Yes	0.78	0.28	0.42	66.84	36.17	54.12
OF-93	Yes	0.87	0.20	0.36	55.49	22.63	40.77
OF-315	Yes	1.08	0.28	0.44	62.71	25.65	40.90
OF-169	Yes	2.15	0.25	0.52	47.95	11.69	24.38
OF-4197	Yes	1.46	0.26	0.45	58.42	18.10	30.99
OF-265	Yes	0.70	0.24	0.33	72.51	34.66	47.80
OF-4324	Yes	0.78	0.28	0.37	74.43	35.59	47.81
OF-3090	Yes	0.74	0.21	0.31	66.67	28.44	42.66
OF-12	Yes	0.62	0.24	0.35	67.06	37.96	56.60
OF-98	Yes	0.86	0.20	0.31	62.37	22.71	36.41
OF-336	Yes	1.78	0.24	0.47	51.29	13.48	26.28
OF-4054	Yes	1.00	0.26	0.45	56.59	25.83	45.65
OF-231	Yes	1.00	0.22	0.38	56.75	21.69	38.22
AOF-6132	Yes	0.71	0.26	0.36	72.54	36.56	50.40
OF-357	Yes	0.72	0.26	0.37	69.68	35.97	51.62
OF-4593	Yes	1.37	0.24	0.43	56.74	17.84	31.44
OF-185	Yes	1.02	0.21	0.38	54.80	20.19	36.85
OF-88	Yes	0.45	0.21	0.29	71.89	45.51	63.30
OF-364	Yes	0.53	0.20	0.26	75.99	37.35	49.15
OF-92	Yes	1.10	0.23	0.41	55.12	20.67	37.50
OF-4205	Yes	1.16	0.23	0.42	56.26	20.13	35.78
OF-198	Yes	0.82	0.19	0.31	62.15	23.30	37.49

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-4424	Yes	0.70	0.22	0.31	69.08	30.83	44.62
OF-31	Yes	0.78	0.21	0.32	66.26	27.03	40.80
OF-3056	Yes	0.70	0.17	0.26	64.28	23.60	36.71
OF-4511	Yes	0.63	0.21	0.34	61.17	32.33	52.85
AOF-6003	Yes	0.68	0.23	0.33	68.39	33.40	48.84
OF-221	Yes	1.61	0.07	0.24	31.20	4.63	14.86
OF-207	Yes	0.37	0.23	0.33	70.02	61.79	88.25
OF-3081	Yes	0.33	0.18	0.22	81.16	54.46	67.11
OF-4097	Yes	0.68	0.22	0.32	69.02	32.23	46.70
OF-4563	Yes	0.99	0.13	0.27	47.06	12.77	27.12
OF-349	Yes	4.42	0.15	0.41	36.77	3.38	9.19
OF-14	Yes	0.64	0.15	0.25	60.49	24.23	40.05
OF-4109	Yes	0.66	0.19	0.26	73.10	28.16	38.53
OF-4386	Yes	0.32	0.20	0.24	84.98	64.24	75.60
OF-317	Yes	1.43	0.19	0.31	61.32	13.12	21.40
OF-65	Yes	0.73	0.14	0.25	54.31	18.58	34.21
AOF-6109	Yes	1.76	0.12	0.28	41.74	6.74	16.14
OF-316	Yes	1.10	0.16	0.32	50.12	14.63	29.18
OF-3030	Yes	0.17	0.14	0.15	97.38	83.26	85.50
OF-40	Yes	0.72	0.17	0.27	63.43	23.64	37.27
OF-99	Yes	0.41	0.15	0.19	75.75	35.79	47.24
OF-355	Yes	0.44	0.17	0.26	64.67	37.81	58.47
AOF-6102	Yes	0.53	0.17	0.26	65.04	31.98	49.17
OF-362	Yes	0.43	0.13	0.18	73.46	30.36	41.33
OF-274	Yes	1.16	0.15	0.25	59.07	12.58	21.29
OF-4146	Yes	0.41	0.17	0.23	73.13	41.04	56.12
OF-249	Yes	0.31	0.17	0.23	73.76	54.27	73.58
OF-152	Yes	0.72	0.05	0.10	52.89	7.58	14.33
OF-3012	Yes	0.42	0.13	0.19	68.44	31.62	46.20
OF-297	Yes	0.33	0.14	0.23	62.24	44.43	71.39
OF-346	Yes	0.52	0.15	0.22	67.93	28.78	42.36
OF-4418	Yes	0.44	0.15	0.22	69.35	34.46	49.69
OF-154	Yes	0.46	0.13	0.18	69.14	27.46	39.72
OF-4102	Yes	0.35	0.12	0.16	77.42	35.22	45.49
OF-3095	Yes	0.54	0.14	0.24	57.65	25.38	44.03
OF-286	Yes	0.64	0.14	0.25	56.75	21.65	38.14
OF-66	Yes	0.23	0.14	0.15	89.95	59.52	66.17

Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-256	Yes	0.36	0.15	0.22	67.40	41.47	61.52
OF-75	Yes	0.25	0.15	0.18	81.93	58.10	70.91
OF-171	Yes	0.67	0.13	0.21	64.31	19.70	30.64
AOF-6103	Yes	0.31	0.09	0.11	76.53	27.85	36.39
OF-293	Yes	0.28	0.13	0.19	64.88	44.80	69.04
OF-3007	Yes	0.62	0.12	0.21	57.74	19.61	33.97
OF-4236	Yes	0.14	0.13	0.13	97.96	94.35	96.31
AOF-6110	Yes	0.62	0.00	0.01	14.21	0.29	2.02
OF-112	Yes	0.23	0.12	0.16	74.85	50.53	67.51
AOF-6048	Yes	0.39	0.12	0.16	75.93	31.31	41.24
AOF-6131	Yes	0.70	0.09	0.17	49.78	12.34	24.80
OF-4637	Yes	0.35	0.07	0.12	62.22	21.03	33.80
OF-234	Yes	0.16	0.11	0.14	77.92	71.07	91.21
OF-215	Yes	0.55	0.10	0.19	52.84	18.05	34.17
OF-3006	Yes	0.60	0.05	0.10	46.68	8.14	17.44
OF-226	Yes	0.18	0.10	0.11	89.27	54.34	60.87
OF-206	Yes	0.39	0.10	0.15	64.14	25.23	39.33
OF-4507	Yes	0.14	0.10	0.11	94.95	72.97	76.85
OF-94	Yes	0.11	0.10	0.10	95.08	88.81	93.41
OF-374	Yes	0.22	0.08	0.12	64.48	35.69	55.35
AOF-6113	Yes	0.15	0.09	0.10	91.46	57.83	63.23
AOF-6099	Yes	0.14	0.09	0.11	83.16	63.42	76.27
OF-15	Yes	0.20	0.07	0.08	83.68	35.06	41.89
OF-51	Yes	0.43	0.00	0.00	0.00	0.00	0.00
OF-353	Yes	0.27	0.08	0.13	66.13	31.58	47.76
OF-232	Yes	0.11	0.08	0.09	94.16	73.25	77.79
OF-268	Yes	0.12	0.08	0.09	94.18	68.65	72.89
OF-161	Yes	0.33	0.06	0.10	57.08	17.89	31.33
OF-275	Yes	0.18	0.06	0.09	70.34	33.09	47.04
OF-72	Yes	0.12	0.07	0.09	79.46	57.41	72.25
OF-4330	Yes	0.11	0.07	0.10	67.00	59.36	88.60
OF-219	Yes	0.09	0.07	0.07	92.98	75.49	81.19
OF-4463	Yes	0.12	0.06	0.08	78.15	49.66	63.54
OF-83	Yes	0.08	0.06	0.07	93.58	76.66	81.92
OF-4058	Yes	0.09	0.06	0.06	93.53	65.37	69.89
OF-291	Yes	0.08	0.06	0.06	93.93	67.05	71.39
OF-307	Yes	0.09	0.05	0.06	92.31	60.43	65.47

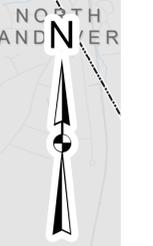
Town of Tewksbury, MA Phosphorus Source Identification Report

Appendix B - Impervious Area and DCIA Statistics for All Catchments

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	IA (Acres)	Percent Connectivity	Percent DCIA	Percent IA
OF-345	Yes	0.10	0.05	0.06	86.64	53.51	61.76
OF-4	Yes	0.08	0.05	0.05	91.85	65.10	70.88
OF-3001	Yes	0.44	0.00	0.00	0.00	0.00	0.00
OF-4320	Yes	0.07	0.04	0.05	91.54	57.45	62.76
OF-188	Yes	0.04	0.03	0.03	96.97	81.17	83.71
AOF-6002	Yes	0.17	0.01	0.02	62.48	5.81	9.30
AOF-6009	Yes	0.08	0.03	0.03	81.97	31.01	37.84
OF-322	Yes	0.03	0.03	0.03	94.81	94.47	99.64
OF-321	Yes	0.06	0.02	0.03	80.98	39.12	48.30
AOF-6128	Yes	0.13	0.01	0.02	41.16	5.66	13.76
OF-82	Yes	0.07	0.02	0.02	82.16	30.04	36.56
AOF-6145	Yes	0.05	0.02	0.03	79.91	46.51	58.20
OF-299	Yes	0.03	0.01	0.01	79.06	23.85	30.17
OF-279	Yes	0.06	0.01	0.01	64.30	12.02	18.69
OF-3057	Yes	0.04	0.00	0.00	0.00	0.00	0.68

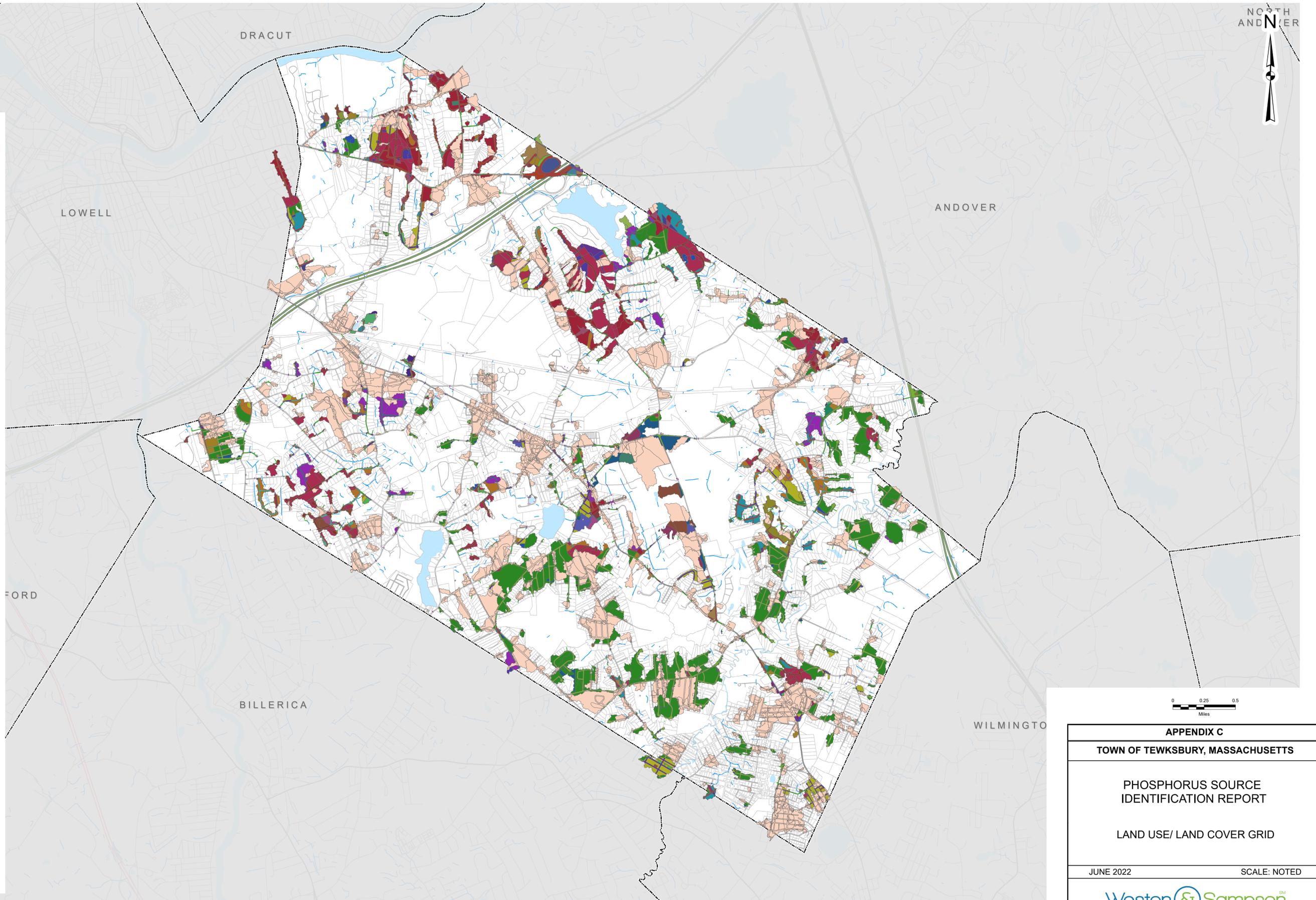
APPENDIX C

Land Use/Land Cover Grid



Legend

- Non-Regulated Catchments
- Agriculture, A
- Commercial, <Null>
- Commercial, A
- Commercial, A/D
- Commercial, B
- Commercial, B/D
- Commercial, C
- Commercial, C/D
- Commercial, D
- Industrial, <Null>
- Industrial, A
- Industrial, B
- Industrial, B/D
- Industrial, D
- Open land, <Null>
- Open land, A
- Open land, A/D
- Open land, B
- Open land, B/D
- Open land, C
- Open land, C/D
- Open land, D
- Recreation, A
- Recreation, B/D
- Recreation, C
- Residential - multi-family, <Null>
- Residential - multi-family, A
- Residential - multi-family, A/D
- Residential - multi-family, B
- Residential - multi-family, B/D
- Residential - multi-family, C
- Residential - multi-family, C/D
- Residential - multi-family, D
- Residential - single family, <Null>
- Residential - single family, A
- Residential - single family, A/D
- Residential - single family, B
- Residential - single family, B/D
- Residential - single family, C
- Residential - single family, C/D
- Residential - single family, D
- Right-of-way, <Null>
- Right-of-way, A
- Right-of-way, A/D
- Right-of-way, B
- Right-of-way, B/D
- Right-of-way, C
- Right-of-way, C/D
- Right-of-way, D
- Tax exempt, <Null>
- Tax exempt, A
- Tax exempt, A/D
- Tax exempt, B
- Tax exempt, B/D
- Tax exempt, C
- Tax exempt, C/D
- Tax exempt, D
- Unknown, A
- Unknown, A/D
- Parcels
- Lakes, Ponds, Reservoirs
- Rivers, Streams, and Brooks



APPENDIX C
TOWN OF TEWKSBURY, MASSACHUSETTS

PHOSPHORUS SOURCE
IDENTIFICATION REPORT

LAND USE/ LAND COVER GRID

JUNE 2022 SCALE: NOTED



APPENDIX D

Pollutant Loading Analysis Results

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
AOF-6127	Yes	37.07	11.11	24.06	0.65
OF-2	Yes	58.06	1.85	14.42	0.25
OF-252	Yes	26.76	4.23	13.32	0.50
OF-136	Yes	26.27	5.88	12.29	0.47
OF-115	Yes	30.09	3.37	11.97	0.40
OF-3038	Yes	9.14	5.78	10.67	1.17
OF-290	Yes	41.70	3.96	10.37	0.25
OF-56	Yes	26.86	2.06	8.81	0.33
AOF-6136	Yes	19.60	2.92	8.65	0.44
OF-4298	Yes	16.58	4.30	8.41	0.51
AOF-6086	Yes	6.57	3.54	8.31	1.26
OF-4426	Yes	18.89	4.02	7.94	0.42
OF-29	Yes	21.37	0.74	7.24	0.34
OF-32	Yes	21.51	1.78	7.15	0.33
OF-55	Yes	16.59	2.00	6.84	0.41
OF-4238	Yes	11.16	3.28	6.59	0.59
OF-132	Yes	24.41	1.52	6.40	0.26
OF-4447	Yes	15.13	2.90	6.29	0.42
OF-319	Yes	5.26	3.14	6.23	1.19
OF-178	Yes	4.72	3.35	6.17	1.31
OF-218	Yes	20.26	2.32	6.15	0.30
OF-4099	Yes	16.35	1.59	5.76	0.35
OF-3029	Yes	6.89	2.17	5.61	0.81
OF-382	Yes	16.48	2.77	5.58	0.34
OF-328	Yes	17.79	2.76	5.56	0.31
OF-229	Yes	11.02	2.36	5.24	0.48
OF-259	Yes	10.80	2.08	5.14	0.48
OF-4101	Yes	12.66	0.97	4.95	0.39
OF-4231	Yes	9.74	1.22	4.80	0.49
OF-3005	Yes	16.46	1.03	4.79	0.29
OF-4602	Yes	12.58	2.35	4.76	0.38
OF-4500	Yes	9.73	1.45	4.71	0.48
OF-267	Yes	16.78	2.02	4.60	0.27
OF-4152	Yes	17.44	1.77	4.56	0.26
OF-61	Yes	9.75	1.13	4.18	0.43
OF-4233	Yes	14.59	0.62	4.18	0.29
OF-4113	Yes	7.81	1.44	4.11	0.53

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-4406	Yes	11.41	1.94	3.98	0.35
OF-4096	Yes	8.28	1.78	3.96	0.48
OF-3096	Yes	9.34	1.02	3.92	0.42
OF-3060	Yes	20.58	1.79	3.80	0.18
AOF-6076	Yes	8.82	1.58	3.80	0.43
OF-367	Yes	11.04	1.08	3.71	0.34
OF-54	Yes	8.84	0.80	3.67	0.42
OF-25	Yes	11.02	0.82	3.59	0.33
AOF-6125	Yes	6.84	1.32	3.53	0.52
OF-4638	Yes	11.12	0.71	3.34	0.30
OF-4631	Yes	12.39	0.40	3.28	0.26
OF-3	Yes	10.61	0.76	3.28	0.31
AOF-6008	Yes	3.99	1.17	3.20	0.80
OF-4032	Yes	5.38	0.96	3.11	0.58
OF-4322	Yes	6.55	1.18	3.09	0.47
OF-3083	Yes	8.65	0.60	3.05	0.35
OF-4358	Yes	7.73	0.78	3.04	0.39
OF-373	Yes	14.19	0.92	3.02	0.21
OF-50	Yes	5.39	1.20	3.01	0.56
OF-4024	Yes	10.54	0.83	2.95	0.28
OF-222	Yes	11.99	1.45	2.93	0.24
OF-254	Yes	6.47	1.35	2.91	0.45
AOF-6055	Yes	3.64	1.46	2.91	0.80
OF-360	Yes	7.07	1.44	2.88	0.41
AOF-6054	Yes	2.86	1.49	2.84	0.99
OF-4389	Yes	7.62	0.66	2.82	0.37
OF-323	Yes	4.80	1.13	2.77	0.58
AOF-6071	Yes	12.19	1.18	2.67	0.22
OF-378	Yes	6.81	0.43	2.60	0.38
OF-4405	Yes	6.53	1.34	2.60	0.40
OF-4291	Yes	4.98	0.98	2.58	0.52
OF-281	Yes	5.54	1.06	2.54	0.46
OF-4299	Yes	5.63	1.29	2.52	0.45
AOF-6017	Yes	5.56	1.05	2.51	0.45
OF-4269	Yes	3.80	1.11	2.51	0.66
OF-288	Yes	5.00	1.28	2.49	0.50
OF-228	Yes	7.36	1.18	2.48	0.34

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-130	Yes	6.09	0.63	2.48	0.41
OF-4533	Yes	5.06	0.99	2.48	0.49
OF-4361	Yes	7.86	0.73	2.47	0.31
OF-131	Yes	6.39	0.59	2.37	0.37
OF-4574	Yes	10.36	0.13	2.33	0.23
OF-3051	Yes	5.41	0.71	2.33	0.43
OF-240	Yes	5.68	1.15	2.30	0.40
OF-3021	Yes	8.00	1.13	2.30	0.29
OF-4095	Yes	6.59	0.44	2.30	0.35
OF-278	Yes	1.61	1.26	2.27	1.41
OF-4639	Yes	5.75	1.14	2.26	0.39
AOF-6021	Yes	3.04	1.11	2.23	0.74
OF-18	Yes	6.59	0.26	2.20	0.33
OF-4038	Yes	2.45	1.18	2.20	0.90
OF-17	Yes	5.27	0.49	2.19	0.41
OF-338	Yes	6.45	0.83	2.19	0.34
AOF-6013	Yes	9.87	0.19	2.15	0.22
OF-4114	Yes	5.67	0.32	2.14	0.38
AOF-6082	Yes	10.27	1.03	2.13	0.21
OF-314	Yes	5.45	1.08	2.13	0.39
OF-313	Yes	5.98	1.07	2.13	0.36
OF-1	Yes	9.98	0.61	2.10	0.21
OF-27	Yes	5.25	0.60	2.09	0.40
OF-3031	Yes	1.63	0.86	2.09	1.28
OF-4329	Yes	1.60	1.13	2.08	1.30
OF-4486	Yes	3.42	0.73	2.07	0.60
OF-4576	Yes	4.14	0.80	2.06	0.50
OF-4301	Yes	11.87	0.94	2.03	0.17
OF-4512	Yes	4.56	0.94	2.01	0.44
OF-340	Yes	3.56	1.06	1.96	0.55
OF-187	Yes	4.42	0.59	1.95	0.44
AOF-6080	Yes	5.50	0.41	1.94	0.35
OF-333	Yes	3.70	0.82	1.93	0.52
OF-85	Yes	5.14	0.81	1.92	0.37
OF-377	Yes	6.38	0.15	1.91	0.30
OF-157	Yes	4.12	0.72	1.90	0.46
AOF-6066	Yes	2.53	0.93	1.89	0.75

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-4331	Yes	3.91	0.75	1.89	0.48
OF-381	Yes	1.89	1.02	1.87	0.99
OF-4519	Yes	6.26	0.43	1.87	0.30
OF-282	Yes	4.60	0.88	1.86	0.41
OF-388	Yes	5.10	0.65	1.83	0.36
OF-224	Yes	3.67	0.55	1.80	0.49
OF-102	Yes	3.32	0.54	1.80	0.54
OF-4012	Yes	3.99	0.66	1.80	0.45
OF-4508	Yes	5.52	0.46	1.78	0.32
OF-4305	Yes	2.41	0.90	1.74	0.72
AOF-6091	Yes	4.89	0.83	1.72	0.35
OF-3000	Yes	3.74	0.64	1.68	0.45
OF-4313	Yes	4.09	0.85	1.67	0.41
OF-4603	Yes	4.12	0.82	1.67	0.40
OF-4128	Yes	5.60	0.62	1.66	0.30
AOF-6006	Yes	2.40	0.85	1.60	0.67
OF-391	Yes	4.54	0.77	1.59	0.35
OF-45	Yes	1.73	0.75	1.58	0.91
OF-141	Yes	3.57	0.82	1.58	0.44
OF-145	Yes	2.93	0.64	1.57	0.54
OF-3070	Yes	1.06	0.88	1.57	1.48
OF-53	Yes	3.35	0.59	1.57	0.47
OF-158	Yes	2.25	0.59	1.56	0.69
OF-4127	Yes	6.14	0.52	1.56	0.25
OF-312	Yes	6.23	0.75	1.55	0.25
OF-47	Yes	3.44	0.41	1.55	0.45
OF-4503	Yes	9.82	0.30	1.53	0.16
AOF-6134	Yes	4.63	0.45	1.53	0.33
OF-3014	Yes	3.99	0.30	1.51	0.38
OF-3080	Yes	0.86	0.63	1.50	1.74
OF-20	Yes	4.24	0.61	1.50	0.35
OF-3082	Yes	2.12	0.63	1.48	0.70
OF-3084	Yes	3.82	0.39	1.44	0.38
OF-203	Yes	4.09	0.70	1.38	0.34
OF-337	Yes	3.20	0.35	1.38	0.43
OF-4288	Yes	2.94	0.45	1.30	0.44
OF-133	Yes	2.20	0.56	1.30	0.59

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-342	Yes	5.42	0.59	1.29	0.24
OF-301	Yes	7.77	0.16	1.28	0.16
OF-4397	Yes	1.99	0.58	1.28	0.64
OF-3062	Yes	4.12	0.62	1.28	0.31
OF-3059	Yes	4.67	0.62	1.26	0.27
OF-62	Yes	1.91	0.57	1.26	0.66
OF-4187	Yes	2.34	0.48	1.26	0.54
OF-4319	Yes	2.46	0.64	1.25	0.51
OF-69	Yes	2.51	0.33	1.24	0.49
AOF-6118	Yes	2.79	0.55	1.23	0.44
OF-64	Yes	2.33	0.51	1.23	0.53
AOF-6106	Yes	2.00	0.47	1.22	0.61
OF-52	Yes	3.95	0.29	1.22	0.31
OF-4517	Yes	3.86	0.44	1.22	0.32
OF-270	Yes	4.13	0.60	1.20	0.29
OF-135	Yes	2.21	0.48	1.19	0.54
OF-4544	Yes	2.32	0.39	1.19	0.51
OF-134	Yes	2.39	0.39	1.19	0.50
AOF-6129	Yes	3.00	0.26	1.19	0.40
OF-19	Yes	2.22	0.50	1.18	0.53
OF-162	Yes	2.64	0.43	1.17	0.44
OF-76	Yes	2.13	0.33	1.16	0.55
OF-4274	Yes	5.60	0.38	1.16	0.21
OF-4365	Yes	1.47	0.52	1.15	0.78
OF-263	Yes	1.12	0.59	1.12	1.00
OF-4620	Yes	3.98	0.50	1.11	0.28
AOF-6072	Yes	3.30	0.56	1.11	0.34
OF-233	Yes	2.60	0.55	1.10	0.42
OF-4434	Yes	1.77	0.59	1.10	0.62
OF-3052	Yes	1.47	0.42	1.07	0.73
OF-4267	Yes	2.09	0.53	1.07	0.51
OF-191	Yes	1.77	0.43	1.07	0.60
OF-196	Yes	2.82	0.30	1.06	0.38
OF-122	Yes	0.65	0.58	1.04	1.61
AOF-6010	Yes	1.57	0.48	1.04	0.66
OF-3061	Yes	2.76	0.53	1.04	0.38
OF-4502	Yes	2.04	0.41	1.04	0.51

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-30	Yes	2.48	0.28	1.03	0.42
OF-109	Yes	1.97	0.40	1.03	0.52
AOF-6092	Yes	3.41	0.51	1.03	0.30
OF-4228	Yes	4.96	0.36	1.02	0.21
OF-4514	Yes	7.90	0.32	1.01	0.13
AOF-6104	Yes	0.67	0.41	1.00	1.48
OF-4287	Yes	1.86	0.34	1.00	0.54
OF-4523	Yes	1.32	0.41	1.00	0.76
OF-248	Yes	2.19	0.52	0.99	0.45
OF-4202	Yes	4.68	0.39	0.99	0.21
OF-4055	Yes	2.42	0.49	0.97	0.40
OF-3064	Yes	3.43	0.40	0.96	0.28
OF-212	Yes	2.85	0.49	0.94	0.33
OF-4547	Yes	2.63	0.49	0.94	0.36
OF-230	Yes	1.49	0.38	0.94	0.63
OF-4232	Yes	2.21	0.37	0.93	0.42
OF-389	Yes	2.02	0.49	0.93	0.46
OF-3073	Yes	3.04	0.46	0.93	0.31
OF-129	Yes	1.64	0.39	0.92	0.56
OF-246	Yes	2.13	0.34	0.92	0.43
OF-208	Yes	2.13	0.38	0.92	0.43
OF-4598	Yes	2.86	0.44	0.91	0.32
OF-273	Yes	1.13	0.50	0.91	0.80
OF-101	Yes	2.78	0.18	0.91	0.33
OF-108	Yes	1.72	0.32	0.90	0.52
OF-95	Yes	1.56	0.42	0.90	0.57
OF-4446	Yes	4.40	0.40	0.89	0.20
OF-239	Yes	2.45	0.45	0.88	0.36
OF-4289	Yes	1.51	0.36	0.87	0.58
OF-9	Yes	1.84	0.37	0.85	0.46
OF-4546	Yes	6.51	0.37	0.85	0.13
OF-4135	Yes	1.49	0.41	0.85	0.57
OF-3020	Yes	3.70	0.27	0.84	0.23
OF-4007	Yes	1.99	0.29	0.84	0.42
OF-332	Yes	1.39	0.38	0.84	0.60
OF-8	Yes	5.17	0.30	0.83	0.16
OF-3086	Yes	3.17	0.10	0.81	0.26

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-48	Yes	3.47	0.30	0.81	0.23
OF-4431	Yes	1.31	0.43	0.80	0.61
OF-4548	Yes	3.27	0.36	0.80	0.24
OF-79	Yes	1.11	0.36	0.79	0.72
OF-354	Yes	3.52	0.31	0.79	0.22
OF-100	Yes	1.44	0.31	0.78	0.54
OF-3035	Yes	0.93	0.43	0.78	0.84
OF-257	Yes	1.33	0.41	0.78	0.58
OF-96	Yes	1.23	0.37	0.78	0.63
OF-272	Yes	12.44	0.23	0.77	0.06
OF-4501	Yes	1.43	0.31	0.76	0.53
OF-3034	Yes	1.85	0.21	0.76	0.41
OF-4053	Yes	2.57	0.35	0.75	0.29
OF-223	Yes	3.04	0.37	0.75	0.25
OF-4148	Yes	1.65	0.38	0.74	0.45
OF-4390	Yes	1.83	0.23	0.74	0.40
AOF-6119	Yes	1.06	0.34	0.74	0.70
OF-4328	Yes	5.12	0.31	0.72	0.14
OF-4160	Yes	1.37	0.29	0.71	0.52
AOF-6036	Yes	1.58	0.36	0.70	0.44
OF-4577	Yes	1.78	0.22	0.69	0.39
OF-385	Yes	2.21	0.35	0.69	0.31
OF-390	Yes	1.61	0.35	0.68	0.43
AOF-6094	Yes	4.21	0.31	0.68	0.16
AOF-6050	Yes	1.40	0.26	0.67	0.48
OF-4516	Yes	2.35	0.33	0.67	0.29
OF-375	Yes	1.61	0.19	0.67	0.42
OF-148	Yes	1.42	0.25	0.66	0.47
OF-330	Yes	0.55	0.37	0.66	1.20
OF-125	Yes	1.64	0.27	0.65	0.40
OF-184	Yes	1.17	0.31	0.64	0.55
OF-4229	Yes	1.41	0.34	0.63	0.45
OF-172	Yes	1.16	0.34	0.63	0.54
OF-4292	Yes	1.91	0.32	0.63	0.33
OF-4408	Yes	1.24	0.33	0.63	0.51
OF-253	Yes	2.38	0.31	0.62	0.26
AOF-6064	Yes	0.62	0.31	0.62	0.99

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-183	Yes	1.27	0.24	0.61	0.48
OF-4525	Yes	1.75	0.17	0.61	0.35
OF-344	Yes	1.14	0.32	0.61	0.53
AOF-6053	Yes	1.07	0.32	0.60	0.56
OF-22	Yes	1.19	0.30	0.60	0.50
OF-87	Yes	0.88	0.29	0.58	0.65
AOF-6063	Yes	1.17	0.22	0.58	0.49
OF-4456	Yes	0.75	0.28	0.58	0.77
OF-142	Yes	0.98	0.23	0.58	0.59
OF-97	Yes	0.88	0.30	0.57	0.64
OF-124	Yes	1.10	0.21	0.56	0.51
OF-199	Yes	0.93	0.27	0.55	0.59
OF-235	Yes	1.18	0.23	0.55	0.47
OF-311	Yes	1.35	0.28	0.54	0.40
AOF-6139	Yes	0.59	0.23	0.53	0.90
OF-343	Yes	0.78	0.28	0.53	0.68
OF-93	Yes	0.87	0.20	0.53	0.60
OF-315	Yes	1.08	0.28	0.52	0.48
OF-169	Yes	2.15	0.25	0.52	0.24
OF-4197	Yes	1.46	0.26	0.51	0.35
OF-265	Yes	0.70	0.24	0.51	0.73
OF-4324	Yes	0.78	0.28	0.51	0.65
OF-3090	Yes	0.74	0.21	0.50	0.68
OF-12	Yes	0.62	0.24	0.49	0.79
OF-98	Yes	0.86	0.20	0.48	0.56
OF-336	Yes	1.78	0.24	0.48	0.27
OF-4054	Yes	1.00	0.26	0.48	0.48
OF-231	Yes	1.00	0.22	0.48	0.48
AOF-6132	Yes	0.71	0.26	0.48	0.67
OF-357	Yes	0.72	0.26	0.48	0.66
OF-4593	Yes	1.37	0.24	0.48	0.35
OF-185	Yes	1.02	0.21	0.47	0.46
OF-88	Yes	0.45	0.21	0.47	1.03
OF-364	Yes	0.53	0.20	0.47	0.89
OF-92	Yes	1.10	0.23	0.46	0.42
OF-4205	Yes	1.16	0.23	0.45	0.39
OF-198	Yes	0.82	0.19	0.45	0.55

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-4424	Yes	0.70	0.22	0.44	0.63
OF-31	Yes	0.78	0.21	0.44	0.56
OF-3056	Yes	0.70	0.17	0.43	0.61
OF-4511	Yes	0.63	0.21	0.42	0.66
AOF-6003	Yes	0.68	0.23	0.42	0.62
OF-221	Yes	1.61	0.07	0.42	0.26
OF-207	Yes	0.37	0.23	0.41	1.11
OF-3081	Yes	0.33	0.18	0.41	1.22
OF-4097	Yes	0.68	0.22	0.40	0.60
OF-4563	Yes	0.99	0.13	0.40	0.41
OF-349	Yes	4.42	0.15	0.40	0.09
OF-14	Yes	0.64	0.15	0.39	0.62
OF-4109	Yes	0.66	0.19	0.38	0.58
OF-4386	Yes	0.32	0.20	0.38	1.19
OF-317	Yes	1.43	0.19	0.37	0.26
OF-65	Yes	0.73	0.14	0.36	0.49
AOF-6109	Yes	1.76	0.12	0.35	0.20
OF-316	Yes	1.10	0.16	0.35	0.31
OF-3030	Yes	0.17	0.14	0.33	1.96
OF-40	Yes	0.72	0.17	0.32	0.45
OF-99	Yes	0.41	0.15	0.32	0.78
OF-355	Yes	0.44	0.17	0.32	0.73
AOF-6102	Yes	0.53	0.17	0.32	0.60
OF-362	Yes	0.43	0.13	0.31	0.73
OF-274	Yes	1.16	0.15	0.31	0.27
OF-4146	Yes	0.41	0.17	0.31	0.75
OF-249	Yes	0.31	0.17	0.30	0.97
OF-152	Yes	0.72	0.05	0.29	0.40
OF-3012	Yes	0.42	0.13	0.29	0.68
OF-297	Yes	0.33	0.14	0.28	0.87
OF-346	Yes	0.52	0.15	0.28	0.54
OF-4418	Yes	0.44	0.15	0.28	0.65
OF-154	Yes	0.46	0.13	0.28	0.61
OF-4102	Yes	0.35	0.12	0.28	0.79
OF-3095	Yes	0.54	0.14	0.28	0.51
OF-286	Yes	0.64	0.14	0.27	0.42
OF-66	Yes	0.23	0.14	0.27	1.19

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-256	Yes	0.36	0.15	0.27	0.76
OF-75	Yes	0.25	0.15	0.27	1.05
OF-171	Yes	0.67	0.13	0.25	0.37
AOF-6103	Yes	0.31	0.09	0.24	0.77
OF-293	Yes	0.28	0.13	0.24	0.84
OF-3007	Yes	0.62	0.12	0.24	0.38
OF-4236	Yes	0.14	0.13	0.23	1.68
AOF-6110	Yes	0.62	0.00	0.23	0.36
OF-112	Yes	0.23	0.12	0.22	0.96
AOF-6048	Yes	0.39	0.12	0.22	0.58
AOF-6131	Yes	0.70	0.09	0.21	0.31
OF-4637	Yes	0.35	0.07	0.21	0.61
OF-234	Yes	0.16	0.11	0.20	1.31
OF-215	Yes	0.55	0.10	0.20	0.37
OF-3006	Yes	0.60	0.05	0.20	0.33
OF-226	Yes	0.18	0.10	0.20	1.07
OF-206	Yes	0.39	0.10	0.19	0.48
OF-4507	Yes	0.14	0.10	0.18	1.31
OF-94	Yes	0.11	0.10	0.17	1.61
OF-374	Yes	0.22	0.08	0.17	0.76
AOF-6113	Yes	0.15	0.09	0.16	1.08
AOF-6099	Yes	0.14	0.09	0.16	1.18
OF-15	Yes	0.20	0.07	0.16	0.80
OF-51	Yes	0.43	0.00	0.16	0.37
OF-353	Yes	0.27	0.08	0.16	0.59
OF-232	Yes	0.11	0.08	0.16	1.37
OF-268	Yes	0.12	0.08	0.15	1.23
OF-161	Yes	0.33	0.06	0.14	0.43
OF-275	Yes	0.18	0.06	0.13	0.74
OF-72	Yes	0.12	0.07	0.13	1.11
OF-4330	Yes	0.11	0.07	0.12	1.09
OF-219	Yes	0.09	0.07	0.12	1.38
OF-4463	Yes	0.12	0.06	0.12	0.96
OF-83	Yes	0.08	0.06	0.11	1.37
OF-4058	Yes	0.09	0.06	0.11	1.27
OF-291	Yes	0.08	0.06	0.10	1.21
OF-307	Yes	0.09	0.05	0.10	1.09

Town of Tewksbury Phosphorus Source Identification Report

Appendix D - Pollutant Loading Analysis Results

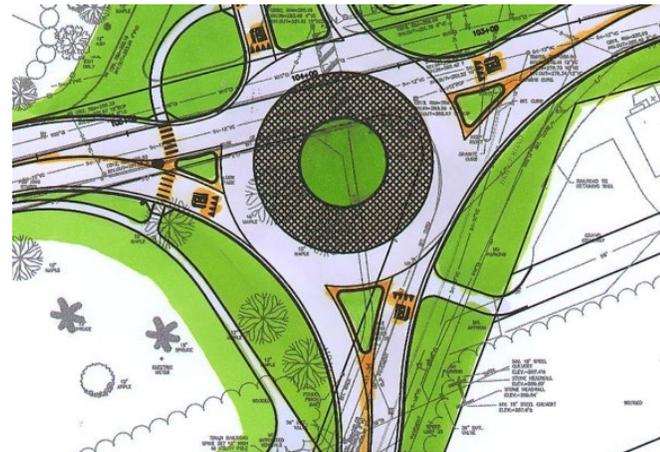
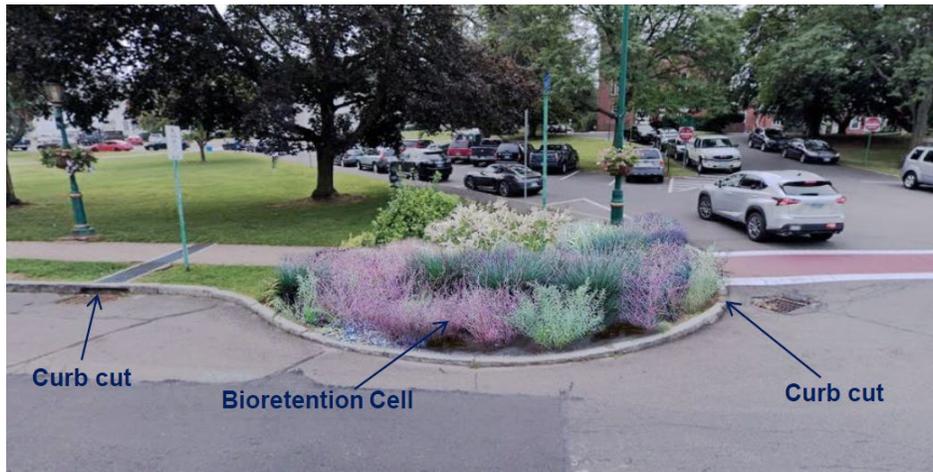
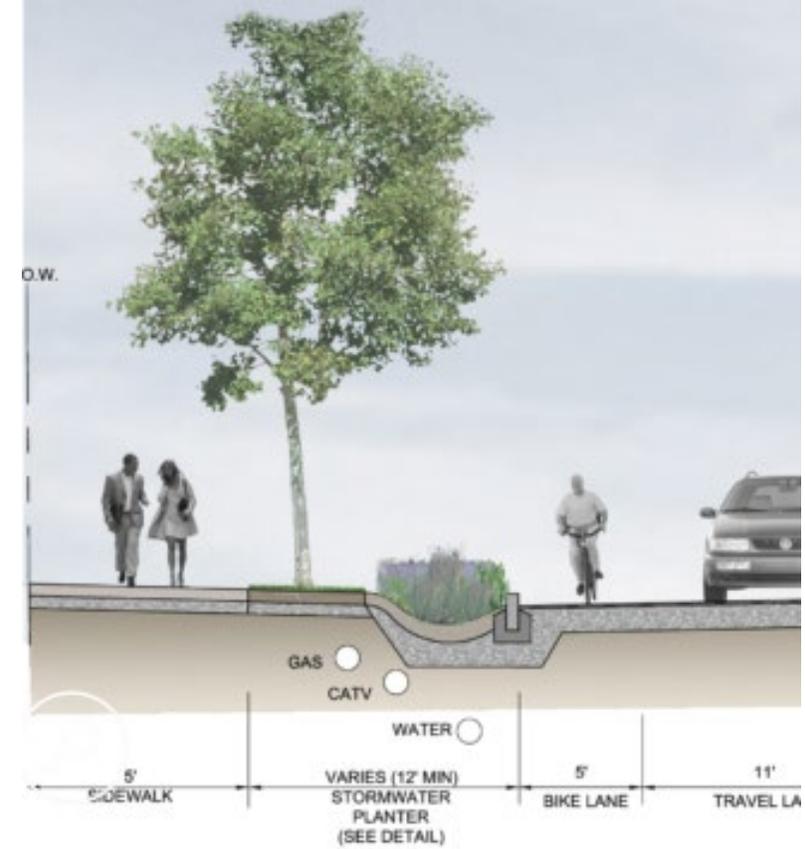
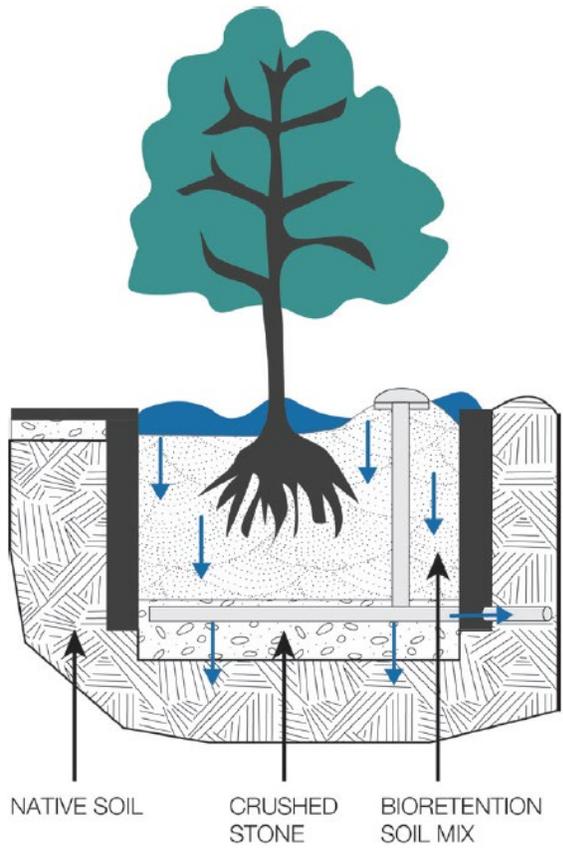
Catchment	Regulated Status	Catchment Size (Ac)	DCIA (Acres)	Phosphorus Loading (lb/yr)	Relative Phosphorus Loading (lb/yr/ac)
OF-345	Yes	0.10	0.05	0.09	0.96
OF-4	Yes	0.08	0.05	0.09	1.17
OF-3001	Yes	0.44	0.00	0.08	0.19
OF-4320	Yes	0.07	0.04	0.08	1.10
OF-188	Yes	0.04	0.03	0.06	1.48
AOF-6002	Yes	0.17	0.01	0.06	0.37
AOF-6009	Yes	0.08	0.03	0.06	0.69
OF-322	Yes	0.03	0.03	0.05	1.72
OF-321	Yes	0.06	0.02	0.05	0.82
AOF-6128	Yes	0.13	0.01	0.05	0.35
OF-82	Yes	0.07	0.02	0.04	0.67
AOF-6145	Yes	0.05	0.02	0.04	0.90
OF-299	Yes	0.03	0.01	0.02	0.68
OF-279	Yes	0.06	0.01	0.02	0.35
OF-3057	Yes	0.04	0.00	0.01	0.22

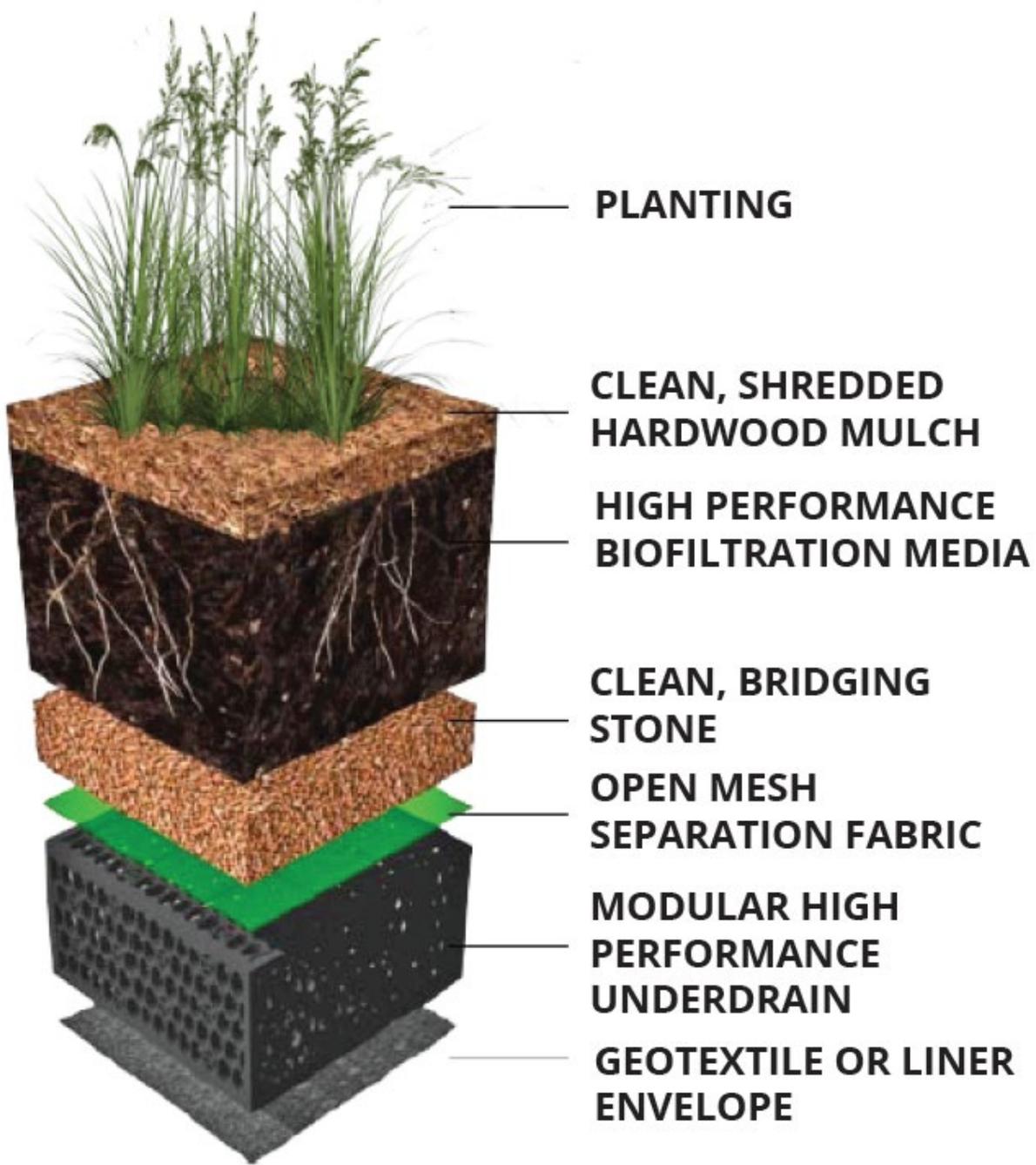
APPENDIX E

Catchment Prioritization and Ranking

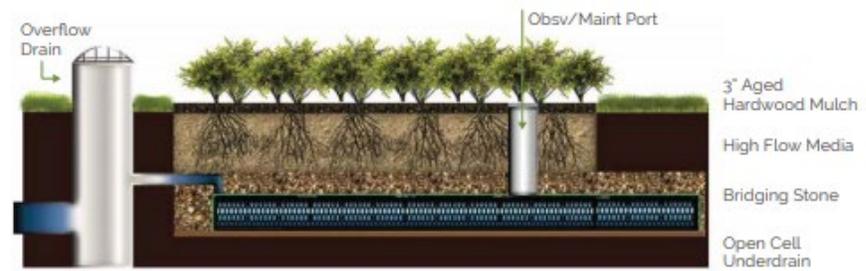
APPENDIX F

BMP Retrofit Cut Sheets and Examples

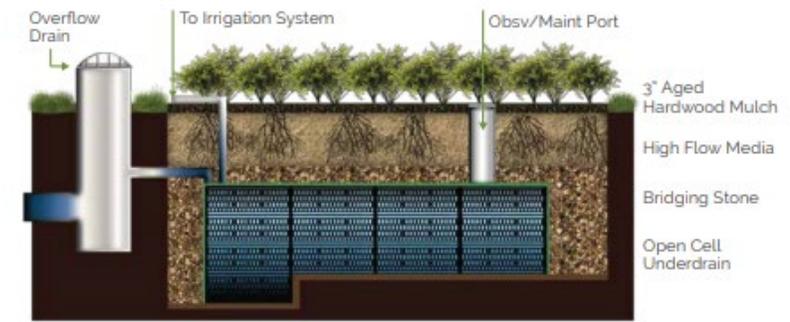




Expanded Detention



Expanded Infiltration



Rainwater Harvesting



Bioretention Areas & Rain Gardens



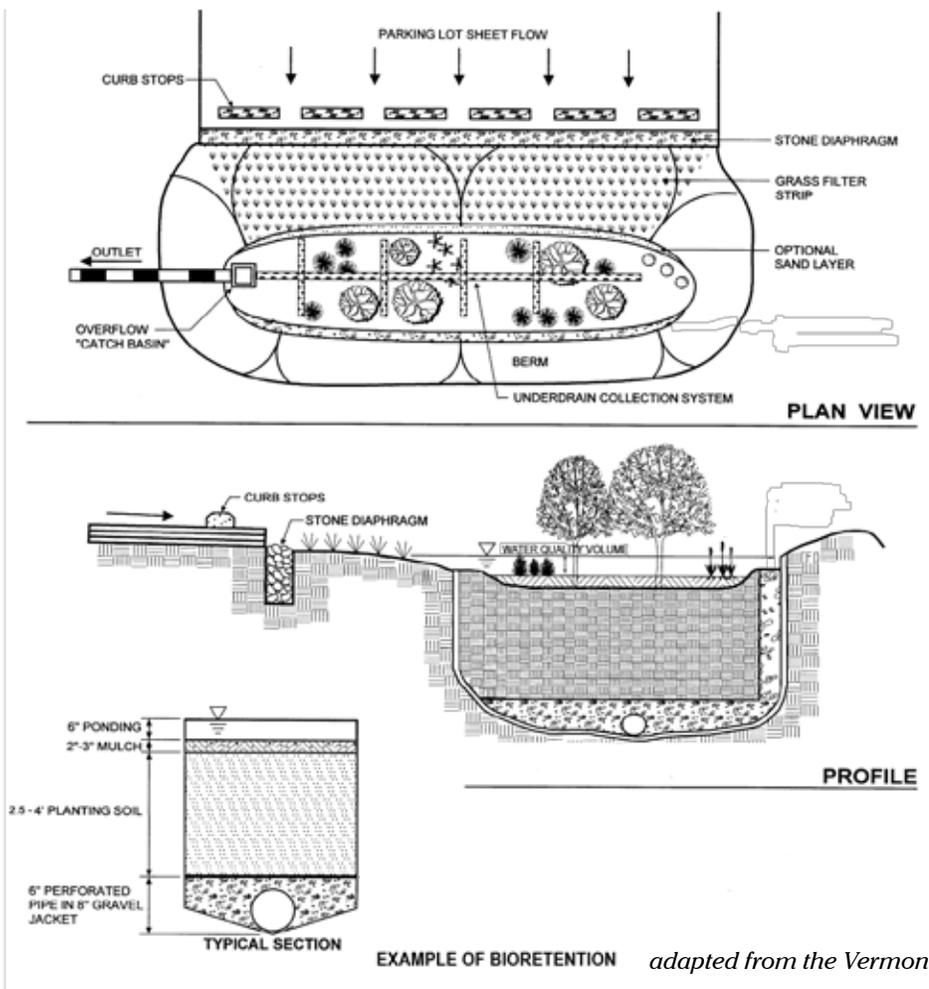
Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter. There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 90% with vegetated filter strip or equivalent
- Total Nitrogen 30% to 50% if soil media at least 30 inches
- Total Phosphorus 30% to 90%
- Metals (copper, lead, zinc, cadmium) 40% to 90%
- Pathogens (coliform, e coli) Insufficient data



Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

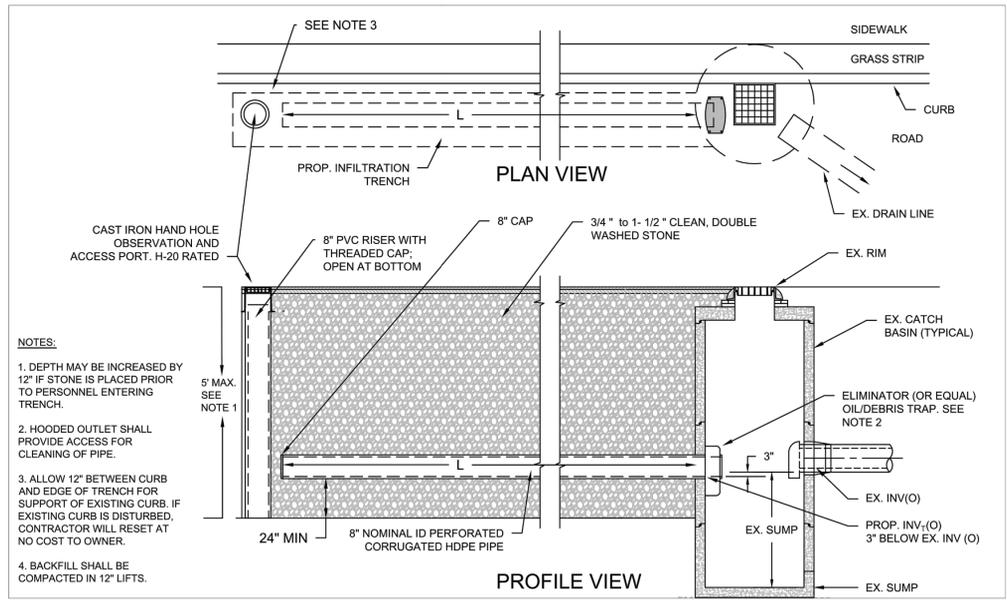
- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

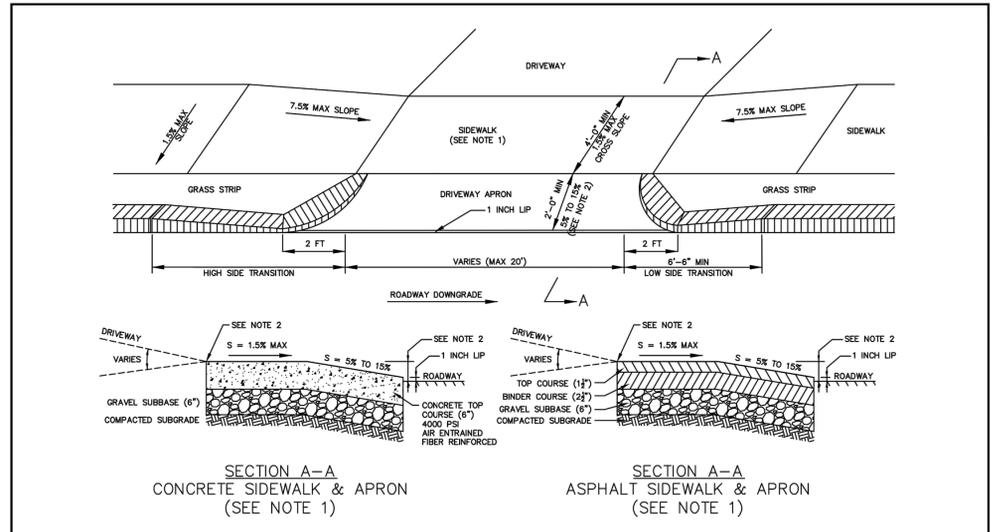
Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually



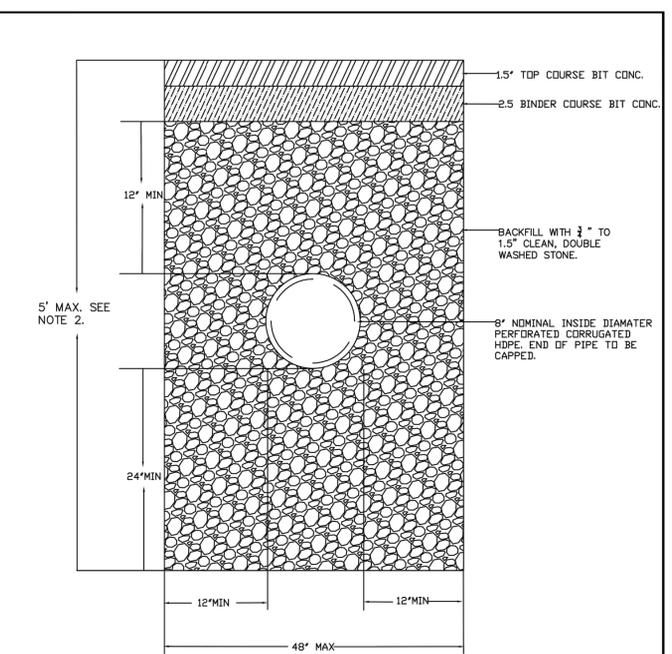
- NOTES:**
1. DEPTH MAY BE INCREASED BY 12" IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING TRENCH.
 2. HOODED OUTLET SHALL PROVIDE ACCESS FOR CLEANING OF PIPE.
 3. ALLOW 12" BETWEEN CURB AND EDGE OF TRENCH FOR SUPPORT OF EXISTING CURB. IF EXISTING CURB IS DISTURBED, CONTRACTOR WILL RESET AT NO COST TO OWNER.
 4. BACKFILL SHALL BE COMPACTED IN 12" LIFTS.

	STANDARD PIPE TRENCH INFILTRATION SYSTEM		DEC. 2020	D-1
			NOT TO SCALE	
			REVISION ②	



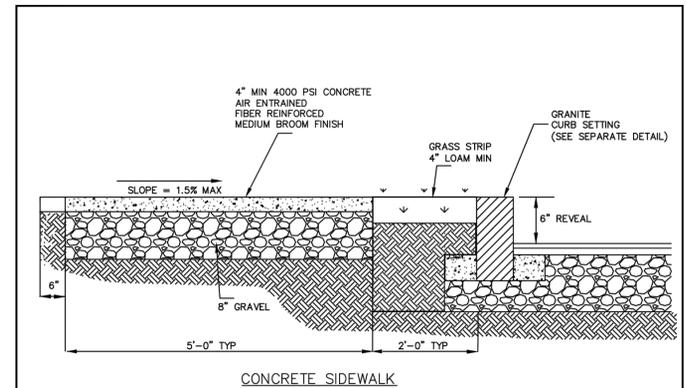
- NOTES:**
1. MATCH DRIVEWAY APRON MATERIALS WITH EXISTING SIDEWALK MATERIAL
 2. DOWNWARD SLOPING DRIVEWAYS REQUIRE A SIDEWALK HEIGHT AT LEAST 3" ABOVE THE ROADWAY

	TYPICAL DRIVEWAY APRON WITH GRASS STRIP		SEPT. 2016	D-3
			NOT TO SCALE	
			REVISION ②	



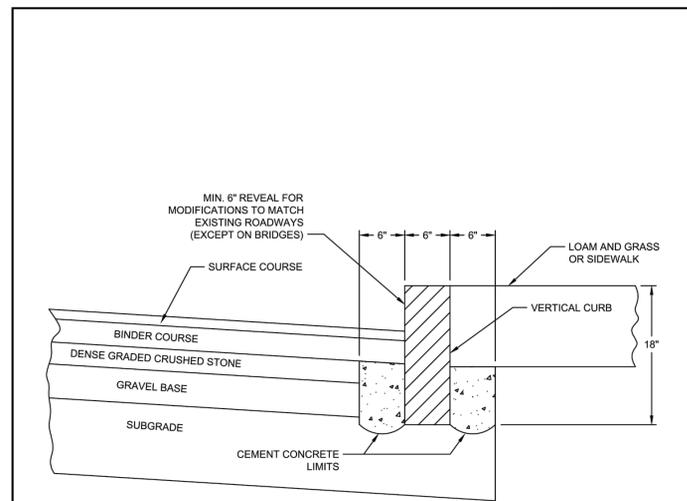
- NOTES:**
1. ALL BACKFILL SHALL BE COMPACTED IN 12 INCH LIFTS.
 2. DEPTH MAY BE INCREASED BY 1 FOOT IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING THE TRENCH.
 3. MEASURES SHALL BE TAKEN TO PREVENT MIGRATION OF FINES INTO BACKFILL.
 4. PIPE SPECS BASED OFF HD100EC PIPE MANUFACTURED BY LANE ENTERPRISES.

	STREET INFILTRATION TRENCH CROSS SECTION VIEW		DEC. 2020	D-2
			NOT TO SCALE	
			REVISION ①	



- NOTES:**
1. EXPANSION JOINTS SHALL BE INSTALLED EVERY 20 FEET MINIMUM. CONTROL JOINTS TO BE APPROXIMATELY 5 FEET.
 2. 1/2" PREFORMED POLYMER FOAM JOINT FILLER INSTALLED TO FULL DEPTH OF CONCRETE.
 3. GRASS STRIP CAN BE REDUCED TO 18 INCHES IF EXISTING WALKWAY CANNOT MAINTAIN A 5 FOOT SIDEWALK WITH 2 FOOT GRASS STRIP.
 4. SIDEWALK SURFACE SHALL SLOPE TOWARD STREET TO AVOID STANDING WATER OR PUDDLING.
 5. SIDEWALK TO BE BROOM FINISHED.

	TYPICAL SIDEWALK SECTIONS WITH GRASS STRIP		OCT. 2020	D-4
			NOT TO SCALE	
			REVISION ②	



- NOTES:**
1. SAW-CUT NEAT LINE 6" FROM CURB LINE AND REMOVE BASE AND SUBGRADE, REPLACE WITH CEMENT CONCRETE. COVER WITH BINDER AND TOP COURSE TO CURB.
 2. ANY DESIGNATED CEMENT CONCRETE THAT IS ACCEPTABLE UNDER SECTION M4 OF THE STANDARD MHD SPECIFICATIONS MAY BE USED; ALL TEST REQUIREMENTS ARE WAIVED. BITUMINOUS CONCRETE SHALL NOT BE USED AS A SUBSTITUTE.

	VERTICAL GRANITE CURB INSTALLATION		JAN. 2015	D-5
			NOT TO SCALE	
			REVISION ①	

NOTES

1. PLANS WERE DEVELOPED USING AVAILABLE AERIAL IMAGERY, EXISTING PLANS, AND ON-SITE OBSERVATIONS. A FORMAL SURVEY OF THE PROJECT AREAS WAS NOT CONDUCTED. UTILITY LOCATIONS AND INVERT MEASUREMENTS ARE APPROXIMATE.
2. CONTRACTOR IS RESPONSIBLE FOR NOTIFYING DIG-SAFE AND ALL APPLICABLE UTILITIES OF THE PROPOSED WORK PRIOR TO ANY EXCAVATION. THE TOWN OF ARLINGTON IS NOT A MEMBER OF DIG-SAFE AND MUST BE NOTIFIED DIRECTLY AT LEAST 72 HOURS PRIOR TO EXCAVATION BY CALLING 781-316-3310.
3. TRENCHES HAVE BEEN PROPOSED IN LOCATIONS WHERE NO UTILITY CONFLICTS WERE APPARENT. THE CONTRACTOR IS RESPONSIBLE FOR CONTACTING ALL APPLICABLE UTILITIES FOR APPROPRIATE MARK-OUTS AND CONFIRMING NO CONFLICTS ARE PRESENT. THE CONTRACTOR IS RESPONSIBLE FOR NOTIFYING THE ENGINEER SHOULD ANY EXISTING UTILITY CONFLICTS BE IDENTIFIED WITHIN PROPOSED TRENCH LIMITS.
4. CONTRACTOR IS RESPONSIBLE FOR NOTIFYING RESIDENTS AND ABUTTERS OF ANY WORK THAT MAY INTERFERE WITH DRIVEWAY AND WALKWAY ACCESS.
5. A RELATIVE LOCAL DATUM HAS BEEN SET FOR EACH TRENCH LOCATION. THE CATCHBASIN RIM ELEVATION HAS BEEN SET TO ZERO FEET (0.0') AT EACH LOCATION.
6. EXISTING ASPHALT SHOULD BE SAWCUT PRIOR TO EXCAVATION.
7. TRENCHES SHOULD BE BACKFILLED AND COMPACTED IN 12 INCH LIFTS.
8. CONTRACTOR IS RESPONSIBLE FOR APPROPRIATE CONSTRUCTION SIGNAGE AND BARRIERS AS NEEDED AND SHALL BE INCIDENTAL TO THE CONTRACT.
9. CONTRACTOR TO MAINTAIN CLEAN WORK ZONE AND SWEEP WORK SITE DAILY.
10. PAVING TO BE COMPLETED WEEKLY.
11. EROSION CONTROL SHALL BE USED WHEN NECESSARY AND CONSIDERED INCIDENTAL TO THE CONTRACT. ANY SEDIMENT THAT ENTERS THE TOWN'S STORMWATER SYSTEM AS A RESULT OF CONSTRUCTION SHALL BE REMOVED AT THE EXPENSE OF THE CONTRACTOR.
12. CONTRACTOR SHOULD TAKE CARE TO NOT IMPACT NEARBY TREES DURING CONSTRUCTION.
13. ANY AREA DISTURBED BY THE CONTRACTOR OUTSIDE OF THE LIMITS OF WORK SHALL BE RESTORED TO ORIGINAL CONDITION AT NO COST TO THE OWNER.

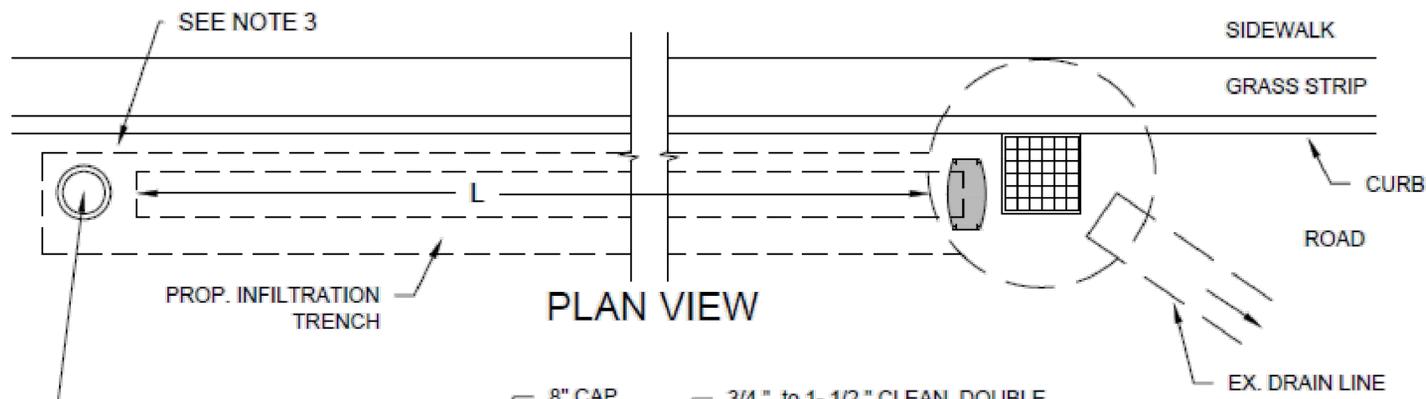
No.	Revision/Issue	Date

Town of
ARLINGTON
 Engineering Division
 51 Grove Street
 Arlington, MA 02476

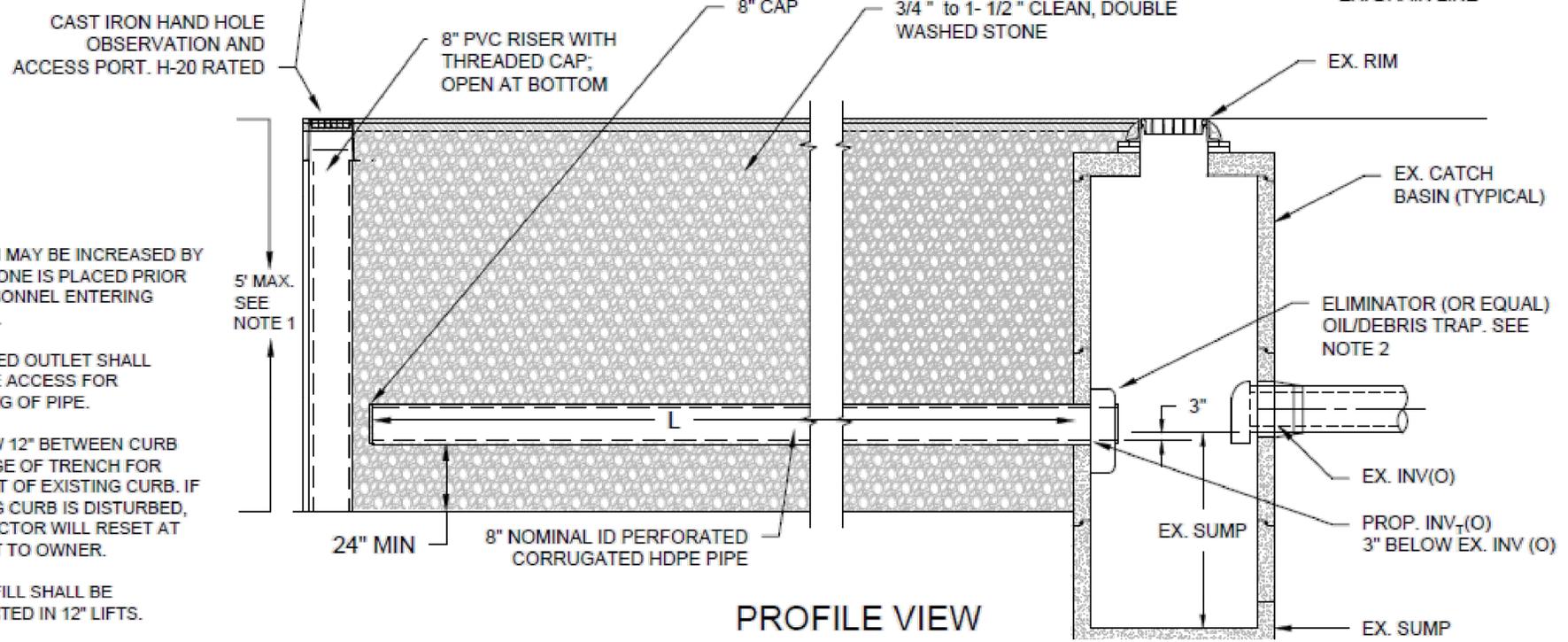
2021 GREEN INFRASTRUCTURE IMPROVEMENTS PROJECT

ARLINGTON CONSTRUCTION DETAILS

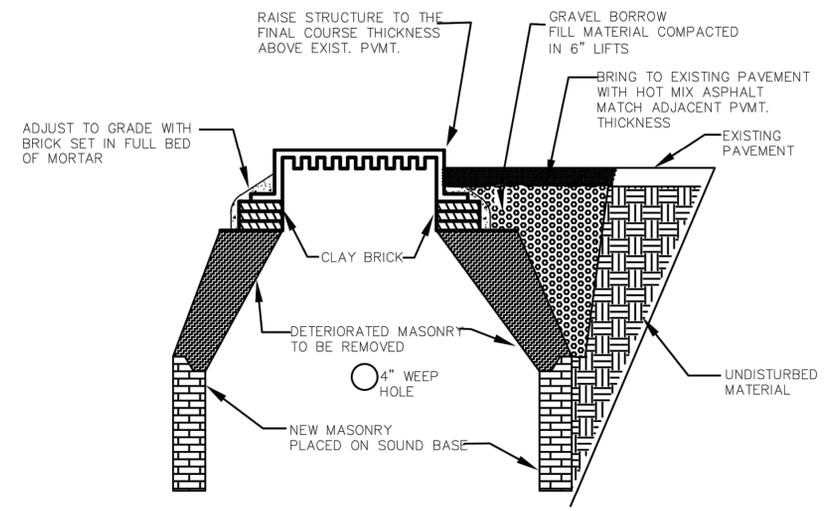
Dr:	S:	13
WCC		
NTS		
FEBRUARY 2021		



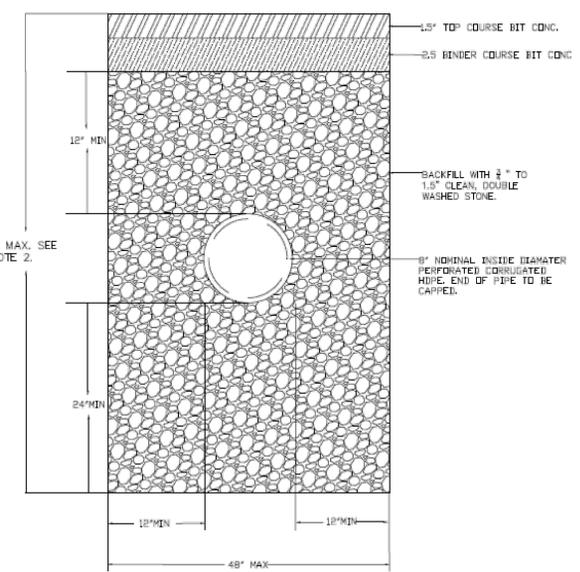
PLAN VIEW



PROFILE VIEW



TYPICAL REBUILD OF DRAINAGE/SEWER STRUCTURE



NOTES:

1. DEPTH MAY BE INCREASED BY 12" IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING TRENCH.
2. HOODED OUTLET SHALL PROVIDE ACCESS FOR CLEANING OF PIPE.
3. ALLOW 12" BETWEEN CURB AND EDGE OF TRENCH FOR SUPPORT OF EXISTING CURB. IF EXISTING CURB IS DISTURBED, CONTRACTOR WILL RESET AT NO COST TO OWNER.
4. BACKFILL SHALL BE COMPACTED IN 12" LIFTS.

NOTES:

1. ALL BACKFILL SHALL BE COMPACTED IN 12 INCH LIFTS.
2. DEPTH MAY BE INCREASED BY 1 FOOT IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING THE TRENCH.
3. MEASURES SHALL BE TAKEN TO PREVENT MIGRATION OF FINES INTO BACKFILL.
4. PIPE SPECS BASED OFF HD100EC PIPE MANUFACTURED BY LANE ENTERPRISES.

NOTES:

1. PLANS WERE DEVELOPED USING AVAILABLE AERIAL IMAGERY, EXISTING PLANS, AND ON-SITE OBSERVATIONS. A FORMAL SURVEY OF THE PROJECT AREAS WAS NOT CONDUCTED. UTILITY LOCATIONS AND INVERT MEASUREMENTS ARE APPROXIMATE.
2. CONTRACTOR IS RESPONSIBLE FOR NOTIFYING DIG-SAFE AND ALL APPLICABLE UTILITIES OF THE PROPOSED WORK PRIOR TO ANY EXCAVATION. THE TOWN OF LEXINGTON IS NOT A MEMBER OF DIG-SAFE AND MUST BE NOTIFIED DIRECTLY AT LEAST 72 HOURS PRIOR TO EXCAVATION BY CALLING THE TOWN OF LEXINGTON OPERATIONS AT 781-274-8300.
3. TRENCHES HAVE BEEN PROPOSED IN LOCATIONS WHERE NO UTILITY CONFLICTS WERE APPARENT. THE CONTRACTOR IS RESPONSIBLE FOR CONTACTING ALL APPLICABLE UTILITIES FOR APPROPRIATE MARK-OUTS AND CONFIRMING NO CONFLICTS ARE PRESENT. THE CONTRACTOR IS RESPONSIBLE FOR NOTIFYING THE ENGINEER SHOULD ANY EXISTING UTILITY CONFLICTS BE IDENTIFIED WITHIN PROPOSED TRENCH LIMITS.
4. CONTRACTOR IS RESPONSIBLE FOR NOTIFYING RESIDENTS AND ABUTTERS OF ANY WORK THAT MAY INTERFERE WITH DRIVEWAY AND WALKWAY ACCESS.
5. A RELATIVE LOCAL DATUM HAS BEEN SET FOR EACH TRENCH LOCATION. THE CATCHBASIN RIM ELEVATION HAS BEEN SET TO ZERO FEET (0.0') AT EACH LOCATION.
6. EXISTING ASPHALT SHOULD BE SAWCUT PRIOR TO EXCAVATION.
7. TRENCHES SHOULD BE BACKFILLED AND COMPACTED IN 12 INCH LIFTS.
8. CONTRACTOR IS RESPONSIBLE FOR APPROPRIATE CONSTRUCTION SIGNAGE AND BARRIERS AS NEEDED AND SHALL BE INCIDENTAL TO THE CONTRACT.
9. CONTRACTOR TO MAINTAIN CLEAN WORK ZONE AND SWEEP WORK SITE DAILY.
10. PAVING TO BE COMPLETED WEEKLY.
11. EROSION CONTROL SHALL BE USED WHEN NECESSARY AND CONSIDERED INCIDENTAL TO THE CONTRACT. ANY SEDIMENT THAT ENTERS THE TOWN'S STORMWATER SYSTEM AS A RESULT OF CONSTRUCTION SHALL BE REMOVED AT THE EXPENSE OF THE CONTRACTOR.
12. CONTRACTOR SHOULD TAKE CARE TO NOT IMPACT NEARBY TREES DURING CONSTRUCTION.
13. ANY AREA DISTURBED BY THE CONTRACTOR OUTSIDE OF THE LIMITS OF WORK SHALL BE RESTORED TO ORIGINAL CONDITION AT NO COST TO THE OWNER.
14. DO NOT PARK, IMPEDE ACCESS TO, OR STORE EQUIPMENT BEYOND RIGHT OF WAY, UNLESS PERMISSION HAS BEEN GRANTED IN WRITING BY THE TOWN AND/OR LAND OWNER.

DATE	REVISION	BY	
1/22/21	VIEWPORTS	ML	<i>STREET TRENCH DESIGNS AND LOCATIONS</i>
1/25/21	DESIGN TABLES	ML	
1/26/21	TRENCH LENGTHS	ML	
<i>Town of Lexington</i>			
<i>ENGINEERING</i>			
<i>DIVISION</i>			
DRAWN BY: ML		DATE: 1/20/21	SCALE: N.T.S
DESIGNED BY: ML		CHECKED BY: MS	
APPROVED BY: _____			
			SHEET 14

sediment, trash and debris. Eventually a layer of sediment will accumulate on the top of the sand, which can be easily scraped off using rakes or other devices. Finer sediments will penetrate deeper into the sand over time, necessitating replacement of some (several inches) or all of the sand. Discolored sand indicates the presence of fine sediments. De-water and properly dispose of sand removed from the filter.

References

Erickson, Andrew J., et al., Enhanced Sand Filtration for Storm Water Phosphorus Removal, Journal of Environmental Engineering. Volume 133, Issue 5, pp. 485-497, May 2007.

Tree Box Filter

Description: The Tree Box Filter consists of an open bottom concrete barrel filled with a porous soil media, an underdrain in crushed gravel, and a tree. Stormwater is directed from surrounding impervious surfaces through the top of the soil media. Stormwater percolates through the media to the underlying ground. Treated stormwater beyond the design capacity is directed to the underdrain where it may be directed to a storm drain, other device, or surface water discharge.



Advantages/Benefits:

- May be used as a pretreatment device
- Provides decentralized stormwater treatment
- Ideal for redevelopment or in the ultra-urban setting

Disadvantages/Limitations:

- Treats small volumes

Special Features

Reduces volume and rate of runoff.

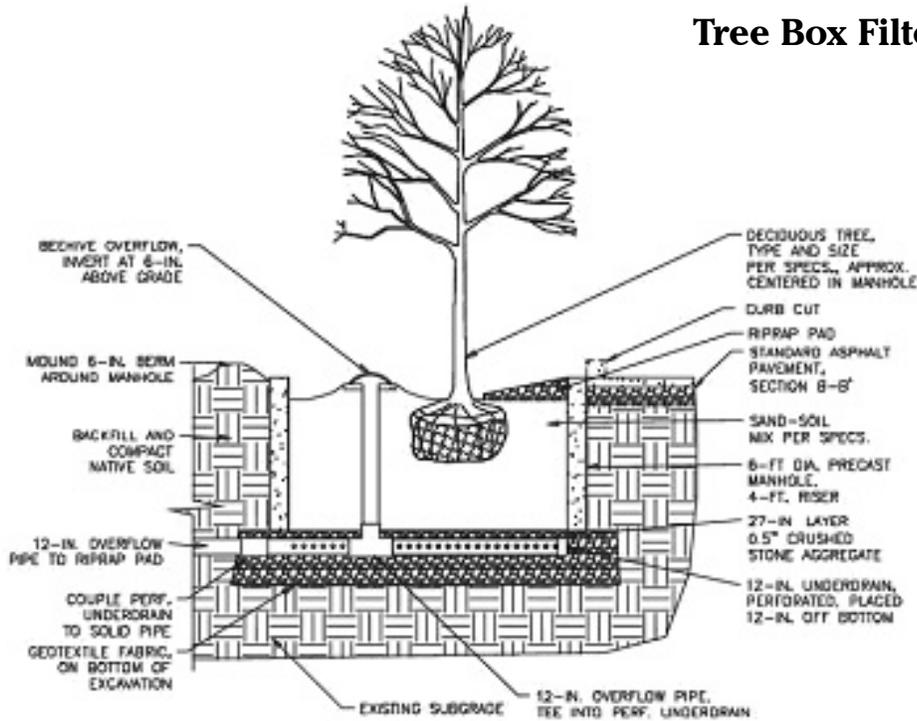
Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	No infiltration credit
4 - TSS Removal	Presumed to remove 80% TSS
5 - Higher Pollutant Loading	May be used as pretreatment device if lined
6 - Discharges to near or to Critical Areas	Not suitable for vernal pools or swimming areas. At other critical areas, may be used as a pretreatment device.
7 - Redevelopment	May be used for retrofit.

Pollutant Removal Efficiencies

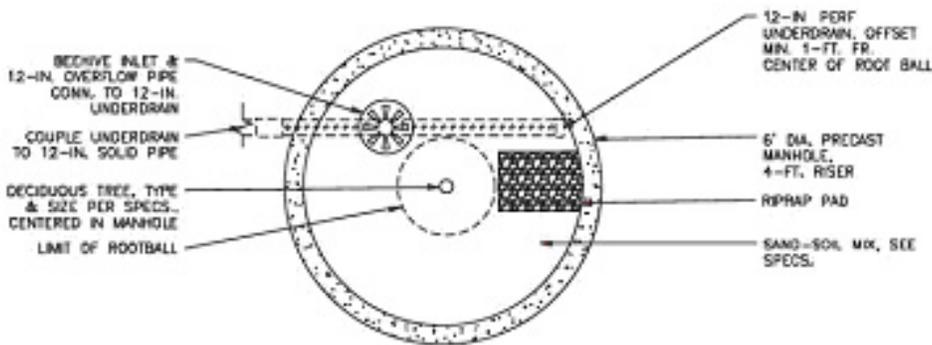
- Total Suspended Solids (TSS)- 80% presumed for regulatory purposes
- Total phosphorus (TP)- Not Reported
- Dissolved Inorganic Nitrogen- Not Reported
- Zinc- Not Reported
- Pathogens (coliform, e. coli)- Not Reported

Tree Box Filter



SECTION

NOT TO SCALE



adapted from the Vermont Stormwater Manual

Maintenance

Activity	Frequency
Check tree	Annually. Expected tree life is 5-10 years.
Rake media surface to maintain permeability	Twice a year
Replace media	When tree is replaced

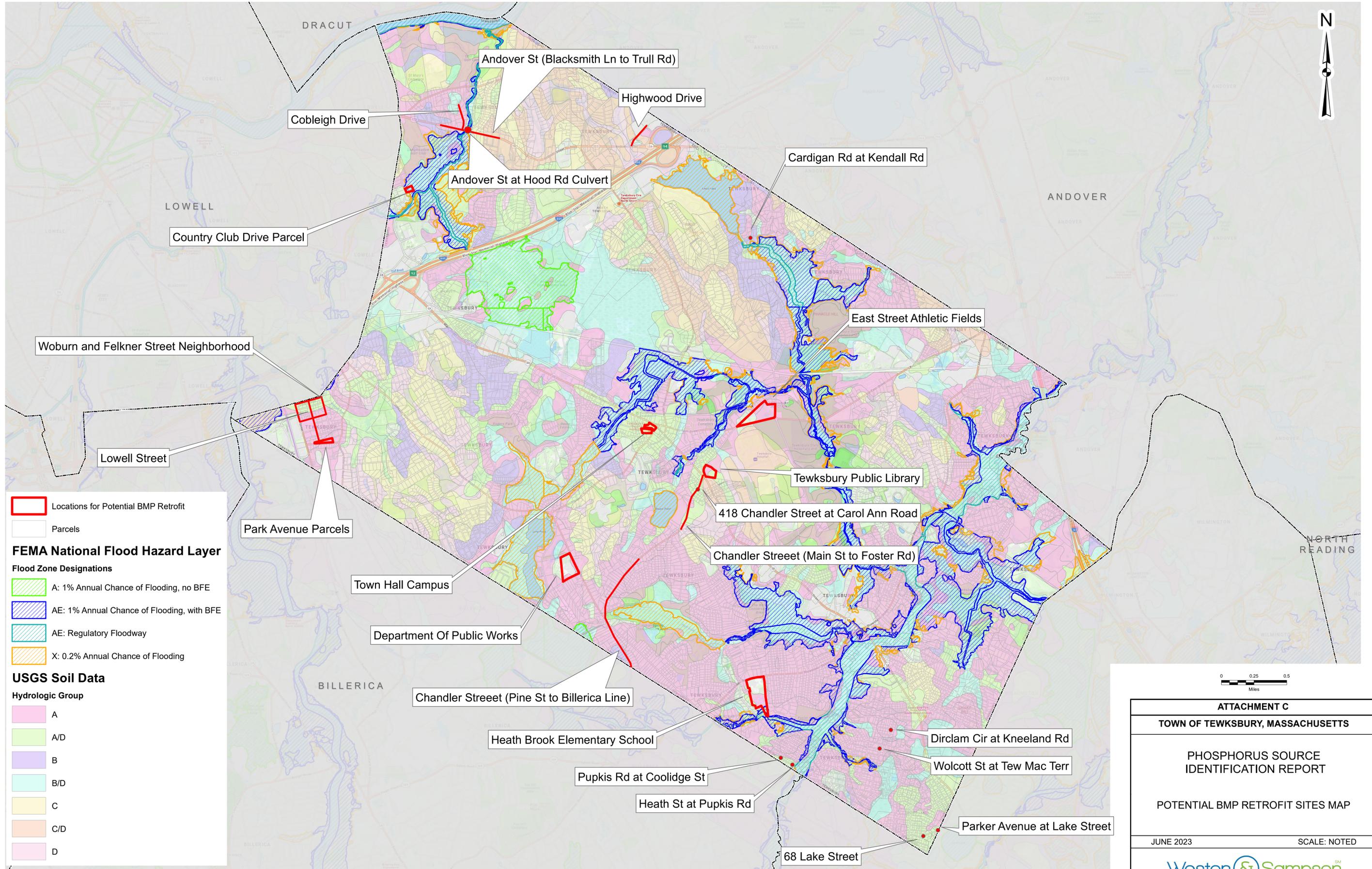
Attachment B
BMP Assessment Matrix

Town of Tewksbury, MA
Phosphorus Source Identification Report - Retrofit Project Ranking

Project Name and Location	Criteria	MS4 Catchment Ranking in PSIR	Location: Parcel or ROW	If Parcel: Total lot size	If parcel: pervious space available	If ROW: Next Scheduled Improvement	If ROW: Existing green space in buffer strip	Within National FEMA flood hazard layer or Town-identified flooding location	Within 300' of sensitive ecological receptors, wetlands areas, or source water protection areas	Dominant Hydrologic Soil Group	Depth to Groundwater	Anticipated BMP Design & Construction Cost	Anticipated Maintenance Cost/ Required Level of Effort	Roadwork or Infrastructure Improvements Planned in Area	Project Score	Proposed BMPs
	Weight															
Hillcrest Road at Chandler Street		8	5			5	5	15	0	10	5	10	10	15	88	Deep sump catch basin with adjoining dry well or infiltration trench
Parker Avenue at Lake Street		0	5			5	10	15	5	10	0	10	10	15	85	Deep sump catch basin with adjoining dry well or infiltration trench
Woburn Street and Felkner Street Neighborhood		7	5			5	10	15	5	10	0	6	6	15	84	Curb bump-out, infiltration trench
Andover Street at Hood Road Culvert		3	5			5	10	15	5	5	0	6	6	15	75	Curb bump-out, infiltration trench
Dirclam Circle at Kneeland Road		0	5			5	10	0	5	10	5	10	10	15	75	Deep sump catch basin with adjoining dry well or infiltration trench
Wolcott Street at Tew Mac Terrace		0	5			5	10	0	0	10	5	10	10	15	70	Deep sump catch basin with adjoining dry well or infiltration trench
Lowell Street		7	5			3	10	15	5	10	5	6	2	0	68	Permeable pavement and/or curb bump-outs, leaching catch basins
Country Club Drive		6	10	2	4			15	5	5	5	6	10	0	68	Tree filter pit, infiltration trench
Heath Street at Pupkis Road		2	5			5	5	0	5	10	0	10	10	15	67	Deep sump catch basin with adjoining dry well or infiltration trench
68 Lake Street		0	5			5	10	0	0	10	0	10	10	15	65	Deep sump catch basin with adjoining dry well or infiltration trench
Park Avenue Parcels (across from 7 and 15 Park Avenue)		7	10	2	4			15	5	10	5	2	2	0	62	Bioretention Area
Chandler Street (from Pine Street to Billerica line)		4	5			5	10	0	5	10	5	6	10	0	60	Tree filter pit, infiltration trench
Heath Brook Elementary School (199 Shawsheen Street)		1	10	4	6			15	5	10	5	2	2	0	60	Bioretention area
Cardigan Road at Kendall Road		9	5			3	10	0	5	10	5	6	6	0	59	Curb bump-out, infiltration trench
Tewksbury Department of Public Works (999 Whipple Road)		0	10	4	6			0	5	10	5	2	2	15	59	Infiltration chambers, infiltration basins and hydrodynamic separators
Chandler Street (from Main Street to Foster Road)		8	5			3	5	0	0	10	5	6	10	0	52	Tree filter pit, infiltration trench
Town Hall Campus (1009 Main Street & 11 Town Hall Avenue)		0	10	2	6			15	0	5	0	6	6	0	50	Bioretention areas, tree trenches
Tewksbury Public Library (300 Chandler Street)		0	10	2	6			0	5	10	5	6	6	0	50	Detention basin, small rain gardens
Highwood Drive		5	5			3	5	0	5	5	5	6	10	0	49	Tree filter pit, infiltration trench
Cobleigh Drive		3	5			3	10	0	5	10	0	6	6	0	48	Curb bump-out, infiltration trench
Shawsheen Street (from Foster Road to Darlene Circle)		1	5			3	5	0	0	10	5	6	10	0	45	Tree filter pit, infiltration trench
East Street Athletic Fields (90 Chandler Street)		0	10	4	6			0	5	10	5	2	2	0	44	Bioretention area, permeable paving
Andover Street (Blacksmith Lane to Trull Road)		3	5			3	5	0	5	5	0	6	10	0	42	Tree filter pit, infiltration trench
Pupkis Road at Coolidge Street		2	5			3	10	0	0	10	0	6	6	0	42	Curb bump-out, infiltration trench

*Highlighted cells filled in based on known project information, capital improvement plan and information on Town website, flagged for Town input

Attachment C
Map of Retrofit Sites



Legend

- Locations for Potential BMP Retrofit
- Parcels

FEMA National Flood Hazard Layer

Flood Zone Designations

- A: 1% Annual Chance of Flooding, no BFE
- AE: 1% Annual Chance of Flooding, with BFE
- AE: Regulatory Floodway
- X: 0.2% Annual Chance of Flooding

USGS Soil Data

Hydrologic Group

- A
- A/D
- B
- B/D
- C
- C/D
- D



ATTACHMENT C

TOWN OF TEWKSBURY, MASSACHUSETTS

PHOSPHORUS SOURCE IDENTIFICATION REPORT

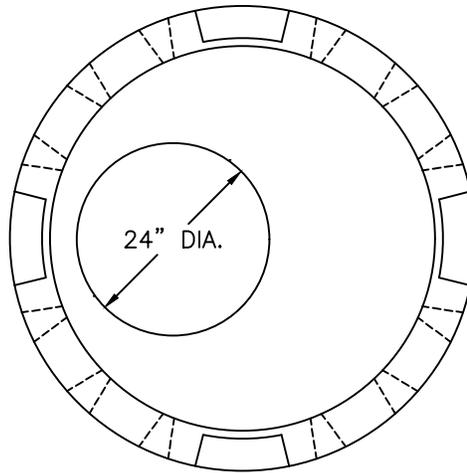
POTENTIAL BMP RETROFIT SITES MAP

JUNE 2023 SCALE: NOTED

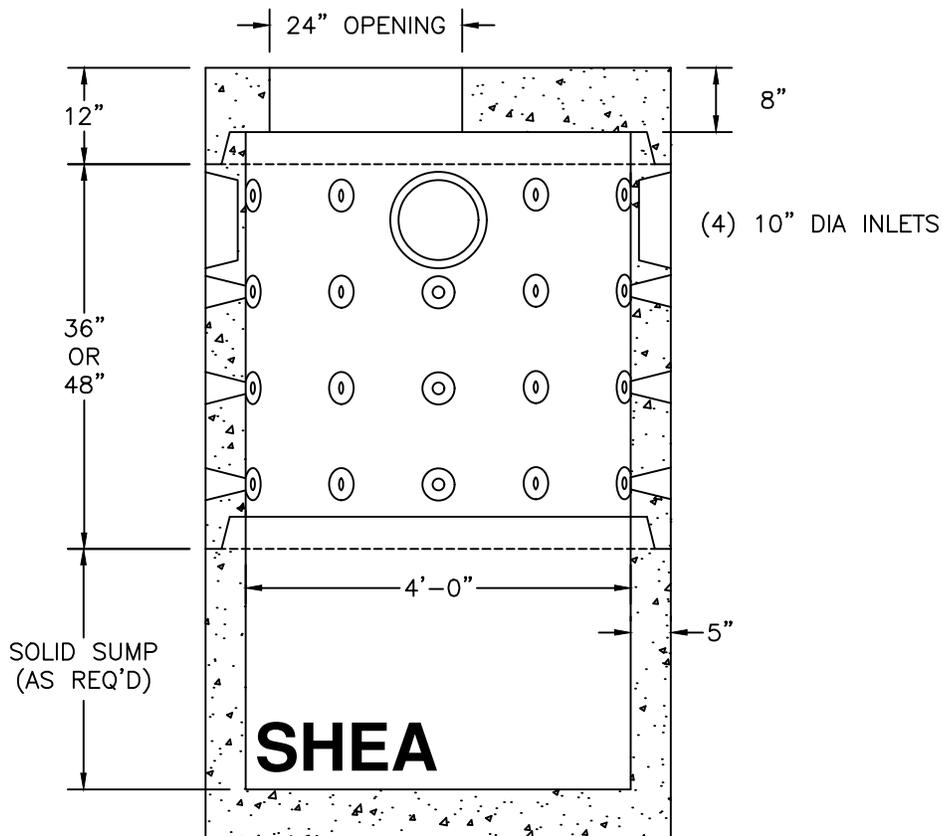


Attachment D

Working Design Drawings and Conceptual Designs



PLAN VIEW



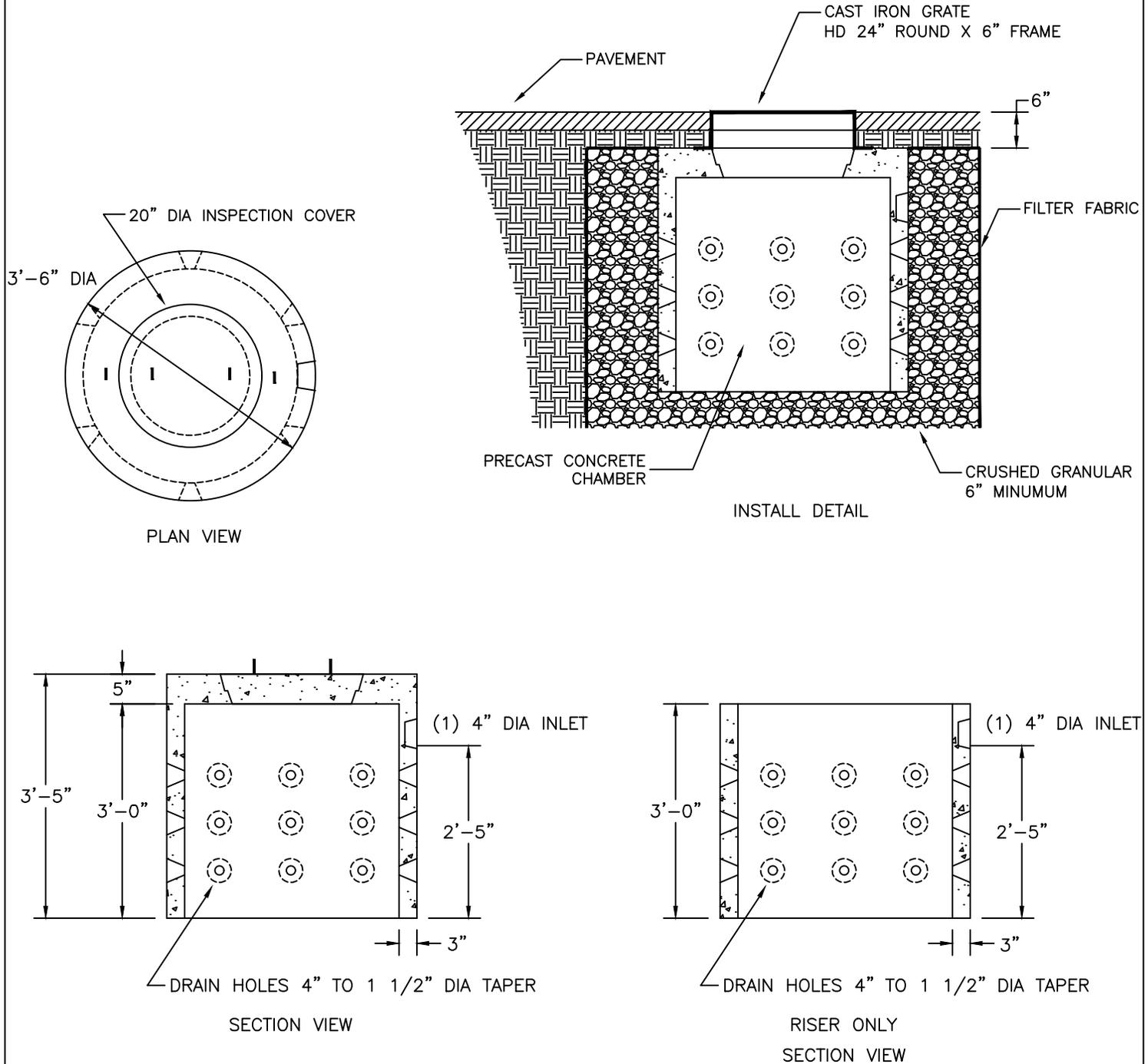
SECTION VIEW

NOTES:

1. CONCRETE: 4,000 PSI MINIMUM AFTER 28 DAYS.
2. DESIGNED FOR AASHTO HS-20 LOADING, 1 TO 5 FEET COVER.
3. OPTIONAL ECCENTRIC CONES AVAILABLE.
4. VOLUME: 94 GALLONS/VF.
5. ADDITIONAL SECTIONS CAN BE ADDED TO INCREASE HEIGHT.

SHEA PRODUCT ID: 36LCS4ID/48LCS4ID	PREPARED FOR:	FILE NAME: cb48lch5w.dwg	
WEIGHT (LBS): 2,055#/2,740#	DRAWN BY: ARO	DATE: 03/01/2018	
773 Salem Street-Wilmington, MA 153 Cranberry Hwy-Rochester, MA 87 Haverhill Road-Amesbury, MA 160 Old Turnpike Rd-Nottingham, NH			

MINI-DRY WELL
160 GALLONS



NOTES:

1. CONCRETE: 4,000 PSI MINIMUM AFTER 28 DAYS.
2. DESIGNED FOR AASHTO HS-20 LOADING, 1 TO 5 FT COVER.
3. CAPACITY INCREASES IN INCREMENTS OF 160 GALLONS FOR EVERY 3' SECTION ADDED.
4. BOTTOM PLATES AVAILABLE.

ITEM NO.	DESCRIPTION	WEIGHT
MDWH	3' SECTION W/COVER (ONE PIECE)	1,404#
MDWHNC	3' SECTION NO COVER	1,048#

SHEA PRODUCT ID: SEE TABLE

PREPARED FOR:

FILE NAME: dwcmini.dwg

WEIGHT (LBS): SEE TABLE

DRAWN BY: ARO

DATE: 03/01/2018

PAGE: F1



VOLUME 1

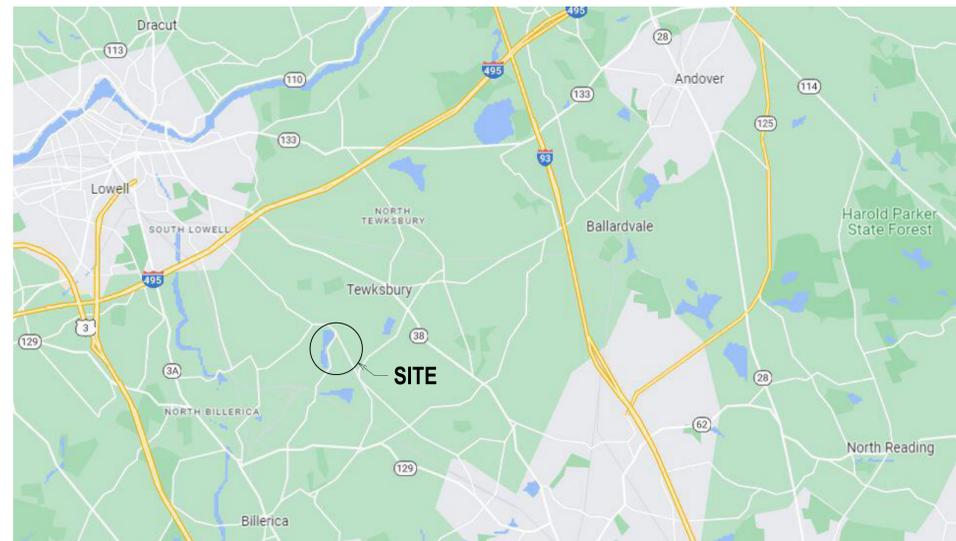
TOWN OF TEWKSBURY, MA

NEW DEPARTMENT OF PUBLIC WORKS & SCHOOL MAINTENANCE FACILITY
 999 WHIPPLE ROAD TEWKSBURY, MA 01876

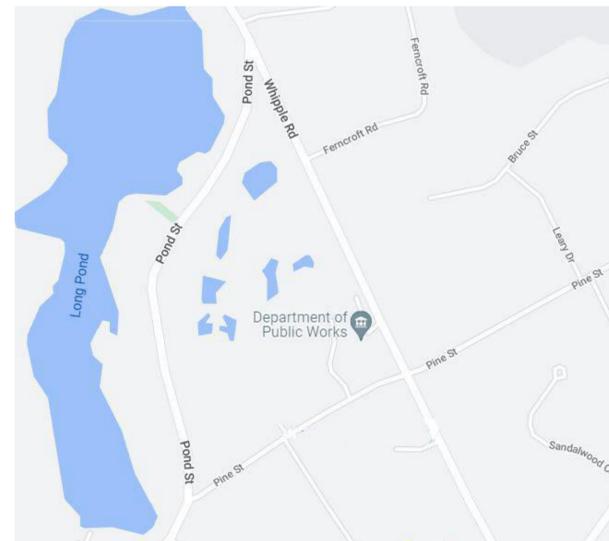


Weston & Sampson

Weston & Sampson Engineers, Inc.
 100 Foxborough Boulevard, Suite 250
 Foxborough, MA 02035
 978.532.1900 800.SAMPSON
 www.westonandsampson.com



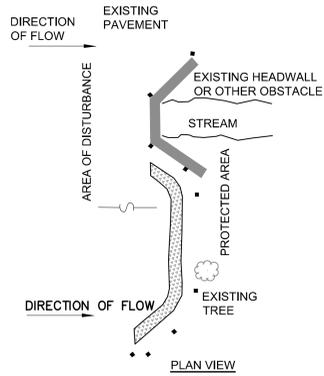
LOCATION MAP



VICINITY MAP

Issue Date: **JUNE 23, 2023**

Issued For: **BID SET**

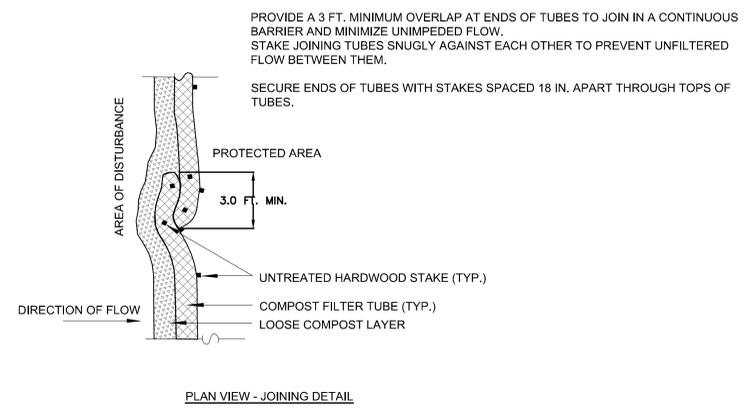
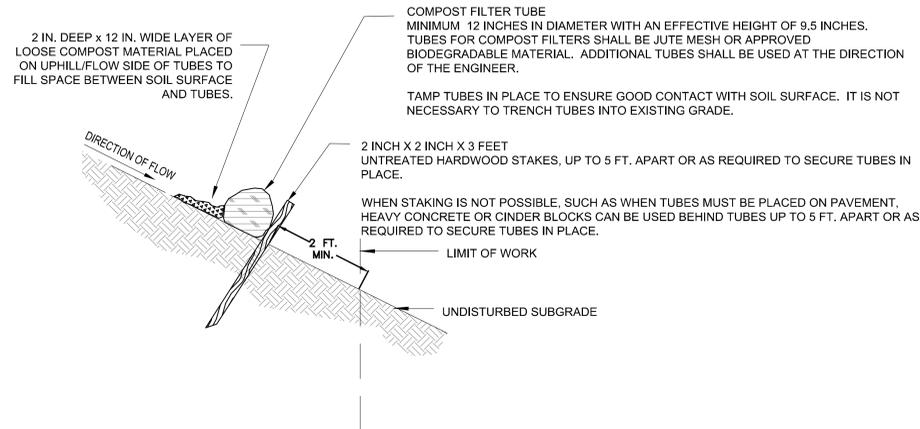


GENERAL NOTES:

1. PROVIDE A MINIMUM TUBE DIAMETER OF 12 INCHES FOR SLOPES UP TO 50 FEET IN LENGTH WITH A SLOPE RATIO OF 3H:1V OR STEEPER. LONGER SLOPES OF 3H:1V MAY REQUIRE LARGER TUBE DIAMETER OR ADDITIONAL COURSING OF FILTER TUBES TO CREATE A FILTER BERM. REFER TO MANUFACTURER'S RECOMMENDATIONS FOR SITUATIONS WITH LONGER OR STEEPER SLOPES.
2. INSTALL TUBES ALONG CONTOURS AND PERPENDICULAR TO CONCENTRATED FLOW.
3. DO NOT INSTALL IN PERENNIAL, EPHEMERAL OR INTERMITTENT STREAMS.
4. CONFIGURE TUBES AROUND EXISTING SITE FEATURES TO MINIMIZE SITE DISTURBANCE AND MAXIMIZE CAPTURE AREA OF STORMWATER RUN-OFF.
5. MULCH MATERIAL FOR THE FILTER TUBES SHALL BE WEED-FREE STRAW, WOOD EXCELSIOR, COMPOST, OR WOOD CHIPS, OR COIR. STRAW SHALL BE WEED FREE AND DERIVED FROM THRESHING OF GRAIN CROP.

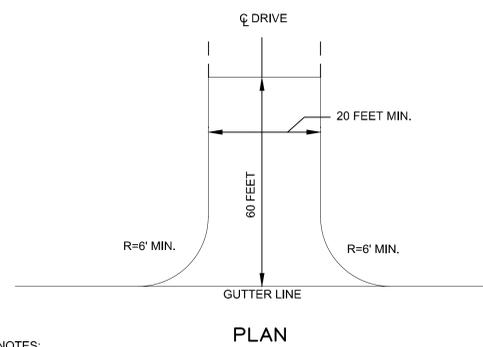
PLACING TUBES AGAINST THE UPHILL SIDE OF WELL-ANCHORED, STATIONARY FEATURES SUCH AS EXISTING TREES CAN PROVIDE ADDITIONAL BRACING.

CURVE ENDS UPHILL TO PREVENT DIVERSION OF UNFILTERED RUN-OFF.



1 EROSION CONTROL MEASURE: SINGLE COMPOST FILTER TUBE DETAIL

SCALE: N.T.S.

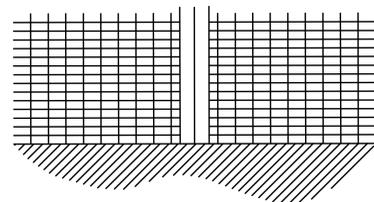


NOTES:

1. AT LEAST ONE CONSTRUCTION ENTRANCE SHALL BE PLACED AT EACH ENTRANCE TO THE SITE, THROUGHOUT CONSTRUCTION ACTIVITIES.
2. THE LOCATION OF THE CONSTRUCTION ENTRANCE(S) SHALL BE APPROVED BY THE OWNER PRIOR TO PLACEMENT.
3. CONSTRUCTION ENTRANCE(S) SHALL CONSIST OF 2" CRUSHED STONE PLACED AT A DEPTH OF A MINIMUM 8 INCHES PLACED OVER GEOTEXTILE FABRIC.
4. CONTRACTOR IS RESPONSIBLE FOR DAILY INSPECTION AND ALL NECESSARY MAINTENANCE OF ALL ENTRANCES.
5. CONTRACTOR IS RESPONSIBLE FOR REMOVAL OF SEDIMENTS OR ANY OTHER MATERIALS TRACKED ONTO THE STREET, AS WELL MAINTENANCE OF EROSION CONTROL MEASURES.

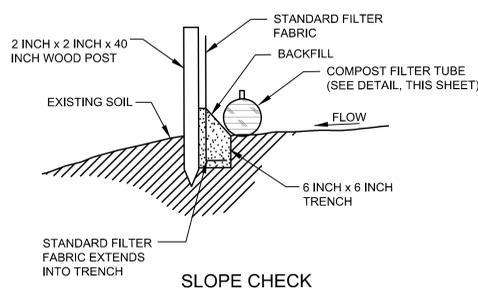
2 STABILIZED TEMPORARY CONSTRUCTION ENTRANCE

SCALE: N.T.S.



WHEN JOINING TWO OR MORE SILTATION FENCES TIE THE TWO END POSTS TOGETHER WITH NYLON CORD.

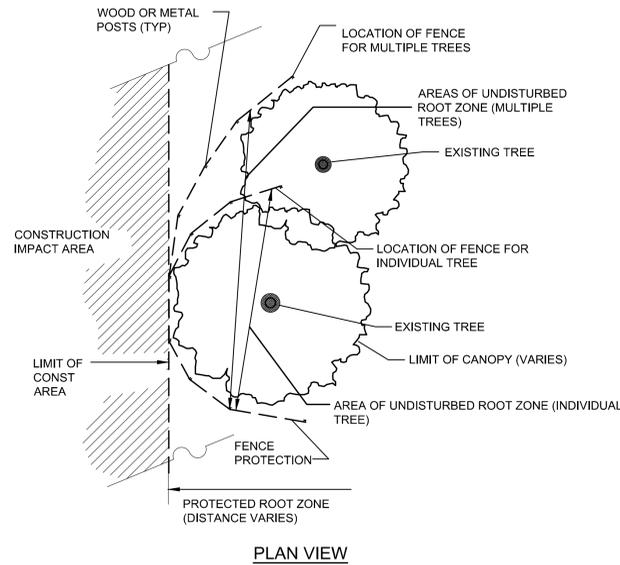
DITCH CHECK



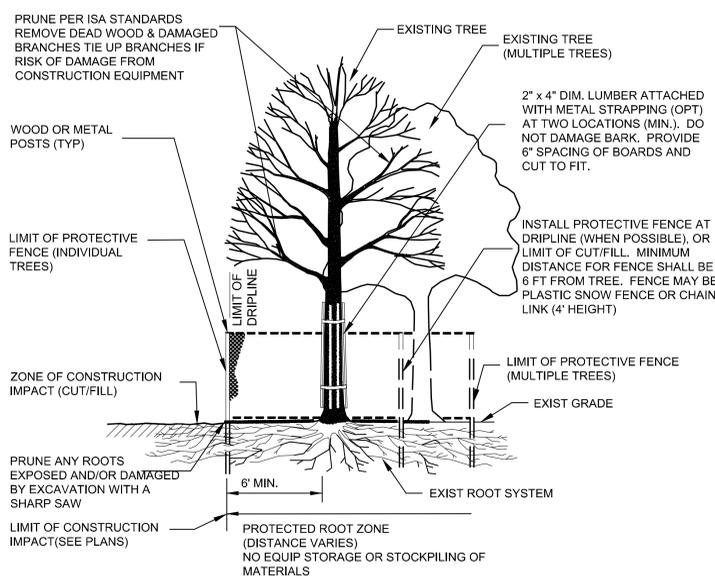
SLOPE CHECK

4 SILT FENCE- EROSION CONTROL

SCALE: N.T.S.



PLAN VIEW



5 EXISTING TREE PROTECTION

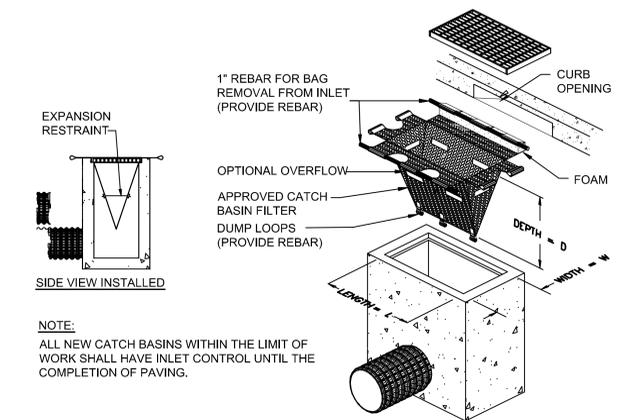
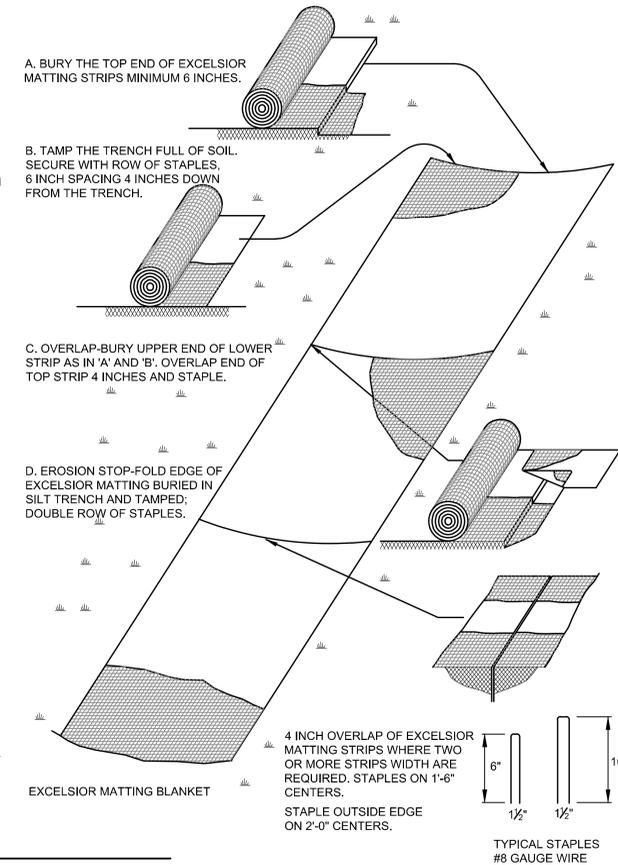
SCALE: N.T.S.

1. EROSION CONTROL MEASURES SHALL BE INCORPORATED IN THE SEQUENCE OF CONSTRUCTION TO PREVENT SEDIMENT LADEN WATER FROM LEAVING THE SITE.
2. AREAS SUBJECT TO EROSION SHALL BE MINIMIZED IN TERMS OF TIME AND AREA.
3. IN GENERAL, WORK REQUIRING EROSION CONTROL INCLUDES EXCAVATIONS, FILLS, DRAINAGE, SWALES AND DITCHES, ROUGH AND FINISH GRADING, AND STOCKPILING OF EARTH.
4. DO NOT DISTURB VEGETATION AND TOPSOIL BEYOND THE PROPOSED LIMIT OF SILT FENCE ACTIVITIES.
5. TEMPORARY SILT CONTROLS SHALL BE PLACED AS SHOWN ON THE PLAN, PERMANENTLY STABILIZE EACH COMPLETED SEGMENT OF CONSTRUCTION.
6. THE CONTRACTOR SHALL REMOVE TEMPORARY SILT CONTROLS AND ALL ACCUMULATED SILT AND DEBRIS AFTER COMPLETION OF CONSTRUCTION OPERATIONS.
7. SILT CONTROLS SHALL BE IN PLACE AT ALL TIMES DURING CONSTRUCTION.
8. THE CONTRACTOR SHALL REMOVE AND LEGALLY DISPOSE OF ALL SILT AND DEBRIS FROM EACH DRAINAGE STRUCTURE UPON COMPLETION OF THE PROJECT.
9. OBJECTS AND/OR AREAS DAMAGED BY THE CONTRACTOR'S OPERATIONS SHALL BE RESTORED TO THEIR ORIGINAL CONDITION.
10. ALL DISTURBED AREAS SHALL BE RESTORED TO SATISFACTORY COMPLETION OF ALL WORK SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.
11. SILT CONTROLS SHALL BE REMOVED UPON THE SATISFACTORY COMPLETION OF ALL WORK SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.
12. SITE PERIMETER SHALL HAVE COMPOST FILTER TUBES INSTALLED AS SHOWN ON C102.

3 EROSION CONTROL BLANKET

SCALE: N.T.S.

NOTE:
JUTE NETTING TO BE USED ON ALL SLOPES GREATER THAN 4H:1V AS INDICATED ON SITE LAYOUT AND MATERIAL PLANS.



6 INLET SEDIMENT CONTROL

SCALE: N.T.S.



Consultants:

Revisions:

No.	Date	Description

COA:

Seal:



Issued For:

BID SET

Scale:

Date: JUNE 23, 2023

Drawn By: CTK

Reviewed By: TJC

Approved By: JIP

W&S Project No.: ENG20-0263

W&S File No.:

Drawing Title:

DETAILS I

Sheet Number:

C500

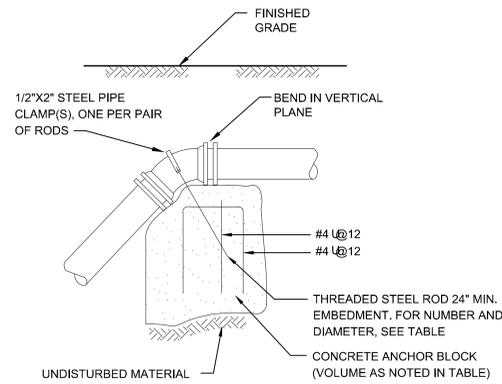


TABLE OF DIMENSIONS FOR ANCHOR BLOCKS		NO. AND SIZE OF THREADED RODS	
BEND SIZE	Volume	NO.	DIAM.
6"-22.5"	0.6 C.Y.	2	1/2"
6"-45"	1.0 C.Y.	2	1/2"
8"-22.5"	1.0 C.Y.	2	1/2"
8"-45"	1.8 C.Y.	2	3/4"
12"-22.5"	2.5 C.Y.	2	3/4"
12"-45"	4.0 C.Y.	4	3/4"

1 ANCHOR BLOCK DETAIL
SCALE: N.T.S.

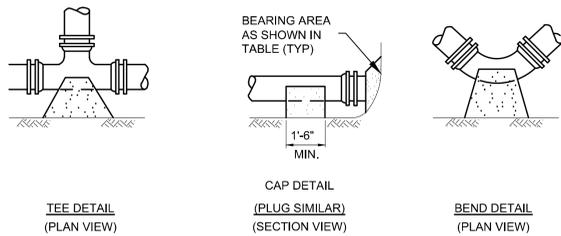
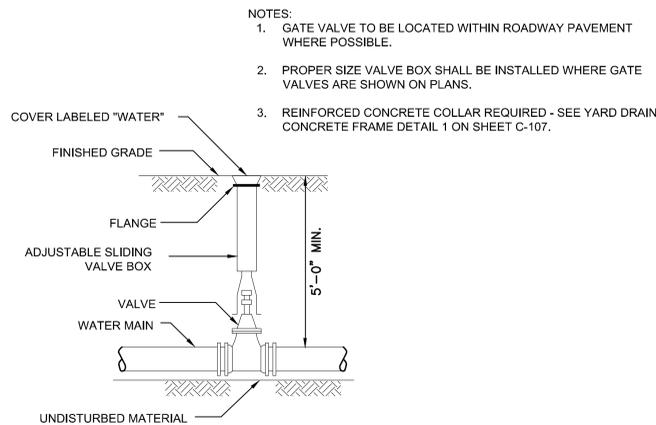


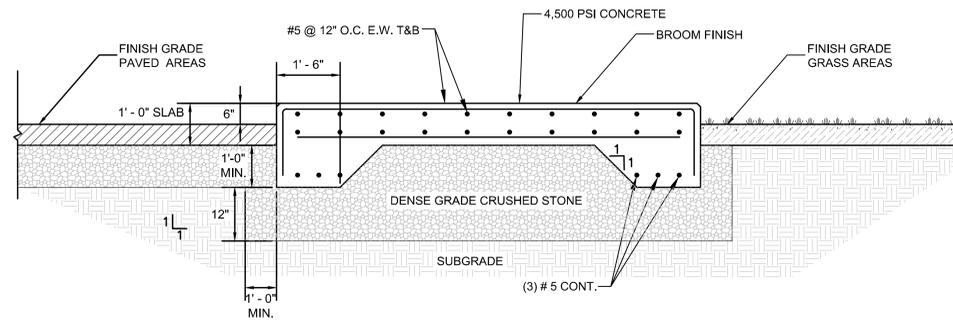
TABLE OF CONCRETE THRUST RESTRAINT MINIMUM BEARING AREAS IN SQUARE FEET AGAINST UNDISTURBED MATERIAL FOR WATER MAIN FITTINGS				
SIZE OF MAIN	90° BENDS, TEES, CAPS AND PLUGS	45° BENDS AND WYES	22-1/2" BENDS	11-1/4" BENDS
6", 8"	5	4	2	2
10", 12"	12	9	5	2
16"	20	15	8	4
20"	36	24	13	7

- NOTES:
1. CONCRETE THRUST RESTRAINT SHALL ONLY BE USED WHERE OTHER MEANS OF RESTRAINT ARE NOT FEASIBLE.
2. CONTRACTOR SHALL USE CARE TO AVOID PLACEMENT OF CONCRETE ON THE FITTING JOINTS.

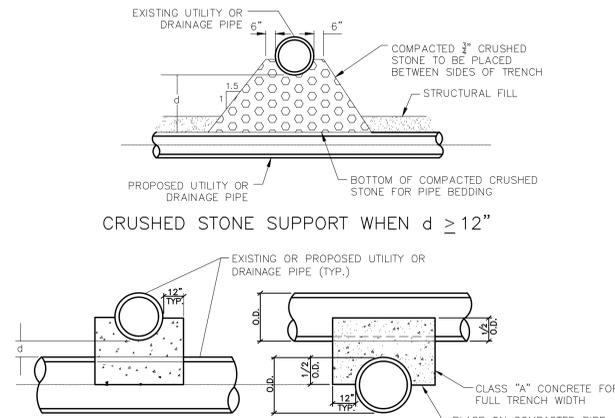
3 CONCRETE THRUST RESTRAINT FOR FITTINGS
SCALE: N.T.S.



6 VALVE AND BOX DETAIL
SCALE: N.T.S.



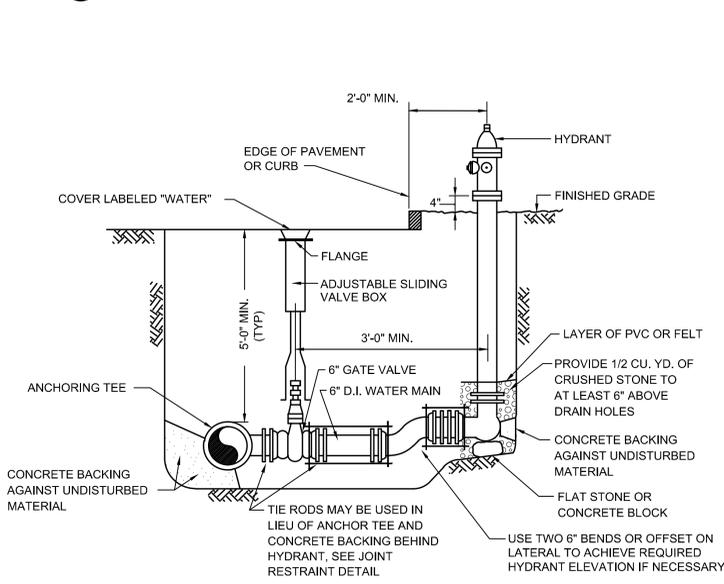
2 TYPICAL EQUIPMENT PAD DETAIL
SCALE: N.T.S.



4 TYPICAL UTILITY SUPPORTS
SCALE: N.T.S.

- NOTES:
1. d = DISTANCE BETWEEN UTILITY AND DRAINAGE PIPES.
2. SUPPORTS SHALL BE INSTALLED WHERE SPECIFIED ON THE PLANS AND WHERE DIRECTED BY THE ENGINEER.
3. CRUSHED STONE SUPPORTS SHALL BE INCLUDED IN THE COST OF THE PROPOSED UTILITY OR DRAINAGE PIPE AND CONCRETE PIPE CRADLES SHALL BE PAID FOR AS "FIELD CONCRETE."

7 HYDRANT AND VALVE DETAIL
SCALE: N.T.S.

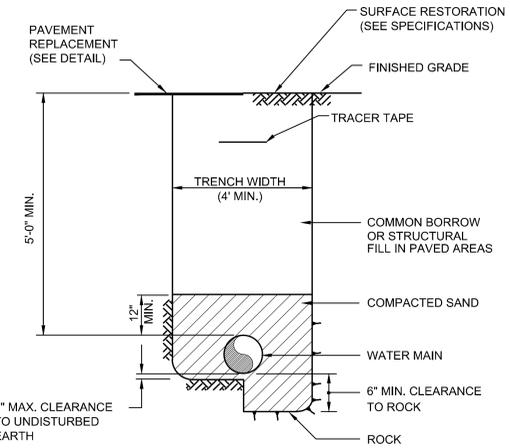


7 HYDRANT AND VALVE DETAIL
SCALE: N.T.S.

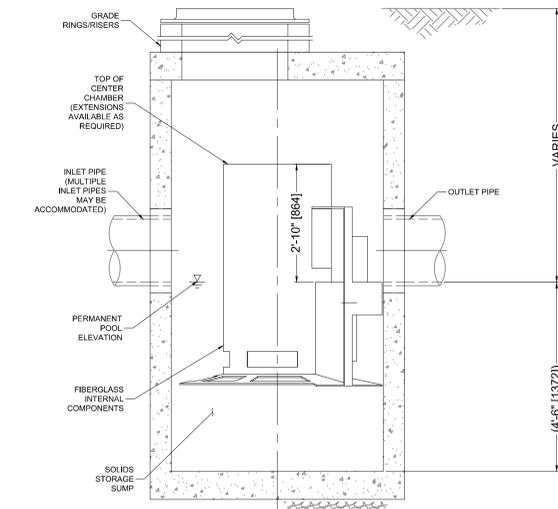
- NOTES:
1. HYDRANT GATE VALVE TO BE LOCATED WITHIN ROADWAY PAVEMENT WHERE POSSIBLE.
2. WHERE HYDRANT IS WITHIN 30-FEET OF TEE, ALL JOINTS BETWEEN HYDRANT AND TEE SHALL BE RESTRAINED. WHERE HYDRANT IS GREATER THAN 30-FEET FROM THE TEE, ALL JOINTS WITHIN 30-FEET OF THE HYDRANT SHALL BE RESTRAINED.

NOTES:

- GENERAL CONTRACTOR IS RESPONSIBLE FOR CONSTRUCTION OF ALL CONCRETE PADS.
- SEE LAYOUT AND GRADING PLANS FOR FINISH GRADE
- COORDINATE WITH ALL CONTRACTORS AND ADJUST PAD LOCATIONS AND DIMENSIONS IN FIELD
- SLABS 8" OR LESS IN THICKNESS SHALL HAVE ONE LAYER OF REINFORCING PLACED IN THE TOP ONE THIRD OF THE SLAB.
- THE EXACT SIZE, SHAPE AND LOCATION OF EQUIPMENT (HOUSEKEEPING) PAD(S) SHALL BE DETERMINED BY THE CONTRACTOR AFTER APPROVAL OF SHOP DRAWINGS FOR EQUIPMENT. ANCHOR BOLTS, WHERE REQUIRED, SHALL BE SIZED AND LOCATED ACCORDING TO THE MANUFACTURER'S REQUIREMENTS.
- CONTRACTOR SHALL PROVIDE CAULK WITH POLYSULFIDE SEALANT AND PREFORMED JOINT FILLER WHERE EQUIPMENT PADS ADJOIN THE BUILDING.
- EQUIPMENT PAD DETAIL SHALL BE USE FOR, BUT NOT LIMITED TO, THE ELECTRICAL TRANSFORMER PAD, EMERGENCY GENERATOR PAD, PROPANE TANK PAD AND KNOCKDOWN PAD.
- CONTRACTOR SHALL COORDINATE WITH THE ELECTRICAL CONTRACTOR FOR CONDUIT PENETRATIONS IN EQUIPMENT PADS



5 WATER MAIN TRENCH DETAIL
SCALE: N.T.S.



8 WATER QUALITY STRUCTURE (WQS)
SCALE: N.T.S.

- NOTES:
1. WATER QUALITY STRUCTURES SHALL BE CONTECH OR APPROVED EQUAL:
• WQS-A2 MODEL CDS2025-5
• WQS-E1 MODEL CDS1515-3
• WQS-B1 MODEL CDS1515-3
• WQS-D1 MODEL CDS2015-4
2. WATER QUALITY STRUCTURE SHALL BE DESIGNED TO RESIST BUOYANCY. ASSUMING GROUNDWATER IS AT GRADE, MANUFACTURER SHALL PROVIDE BUOYANCY CALCULATIONS, STAMPED BY A MASSACHUSETTS P.E.
4. WQS FRAME AND COVERS SHALL BE H-20 WHEEL LOAD RATED.
5. PROVIDE COLLAR AT BOTTOM OF STRUCTURE FOR ANT-BUOYANCY IF NEEDED.

Consultants:

No.	Date	Description

Revisions:

No.	Date	Description

COA:

Scale:

Seal:

Issued For:
BID SET

Scale:

Date: JUNE 23, 2023
 Drawn By: CTK
 Reviewed By: TJC
 Approved By: JIP
 WQS Project No.: ENG20-0263
 WQS File No.:

Drawing Title:
DETAILS IV

Sheet Number:
C503

