

# Phosphorus Source Identification Report

MS4 Permit Compliance



**Town of Tewksbury, MA**

Department of Public Works

999 Whipple Road

Tewksbury, MA 01876

June 30, 2022

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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

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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 16<sup>th</sup> 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)

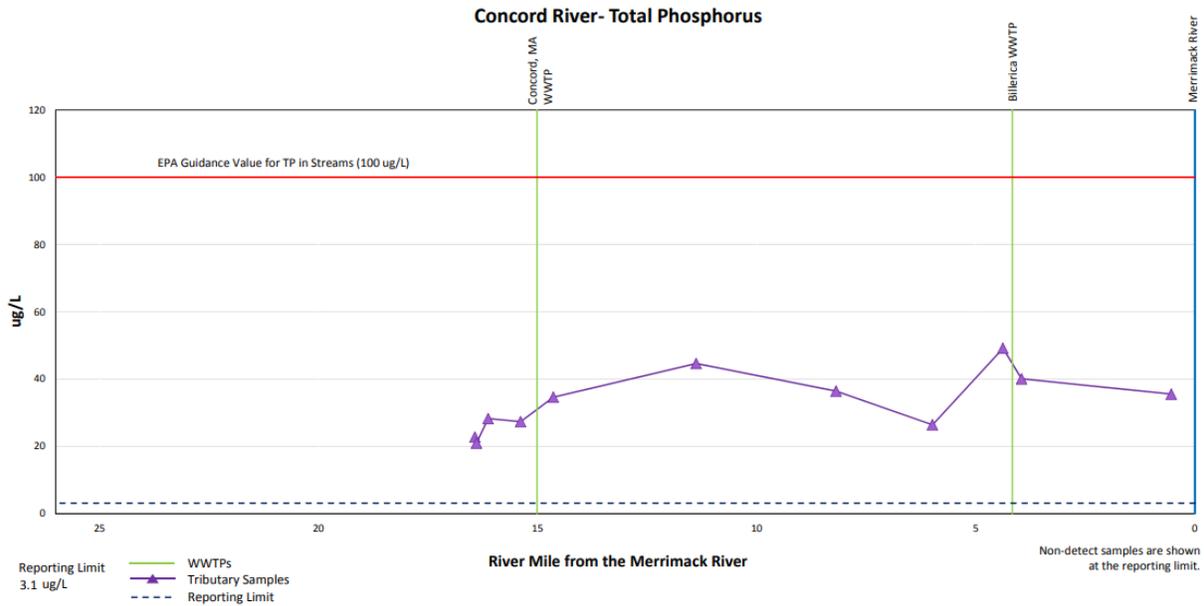
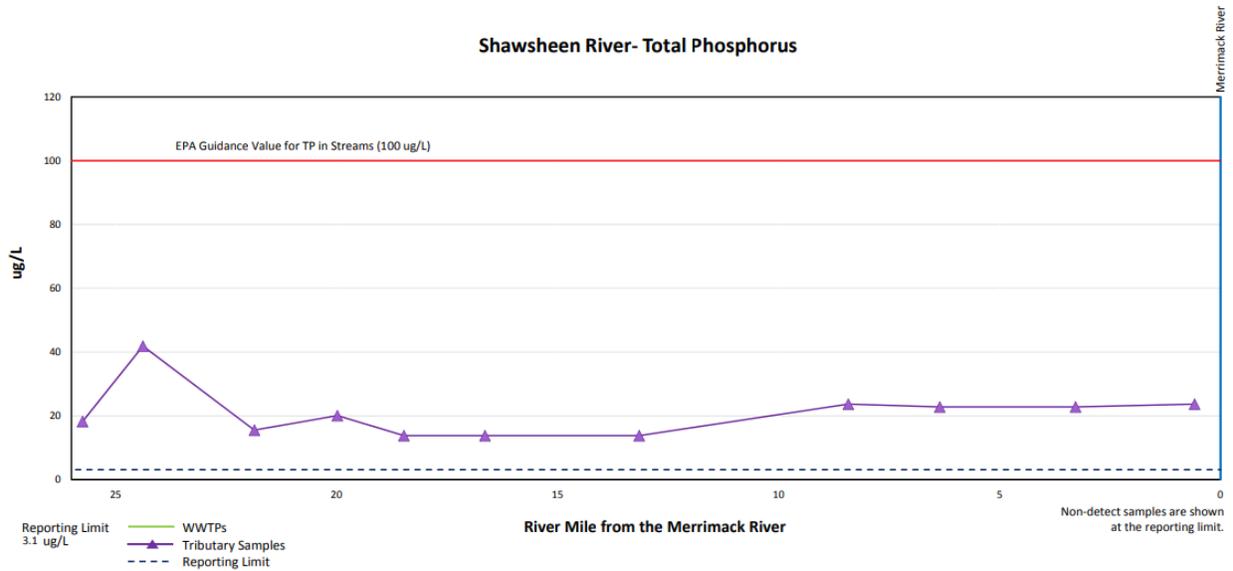


Figure 2: Shawsheen River Total Phosphorus Dry Weather Sampling Results (Source: CDM Smith, 2017)



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.

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### 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*<sup>1</sup> 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*<sup>2</sup>. 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 area<sup>3</sup>

\*\*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	$DCIA\% = 0.4(IA\%)^{1.2}$

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

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

<sup>3</sup> 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>

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

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 Tewksbury<sup>4</sup>.

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<sup>4</sup> 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*

*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.

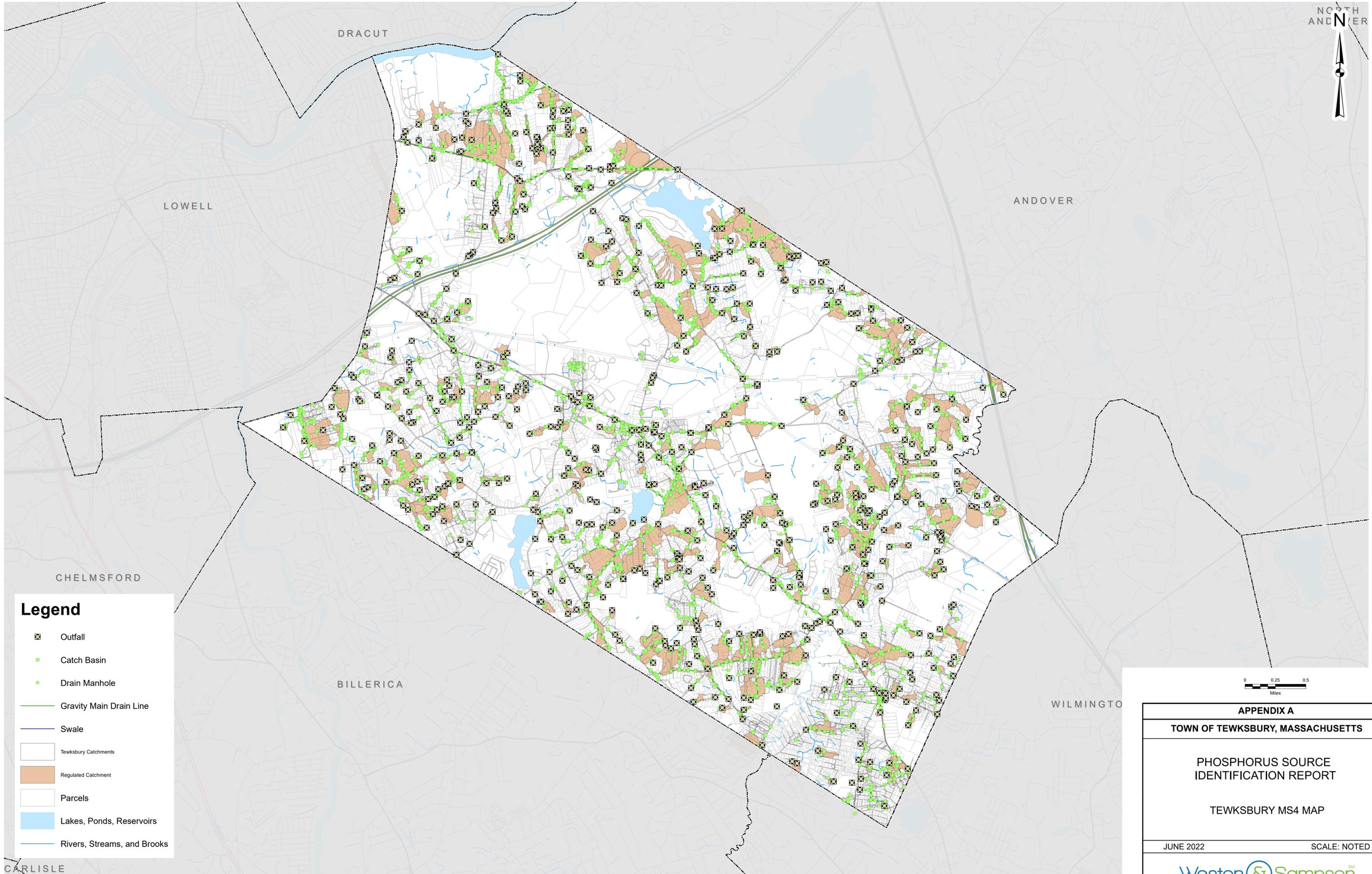
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APPENDIX A

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

0 0.25 0.5  
Miles

**APPENDIX A**  
**TOWN OF TEWKSBURY, MASSACHUSETTS**  
**PHOSPHORUS SOURCE IDENTIFICATION REPORT**  
**TEWKSBURY MS4 MAP**

JUNE 2022 SCALE: NOTED

**Weston & Sampson**<sup>SM</sup>

**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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

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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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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

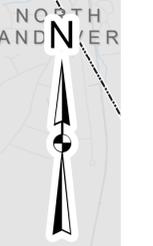
**Town of Tewksbury, MA Phosphorus Source Identification Report**

**Appendix B - Impervious Area and DCIA Statistics for All Catchments**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>IA (Acres)</b>	<b>Percent Connectivity</b>	<b>Percent DCIA</b>	<b>Percent IA</b>
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

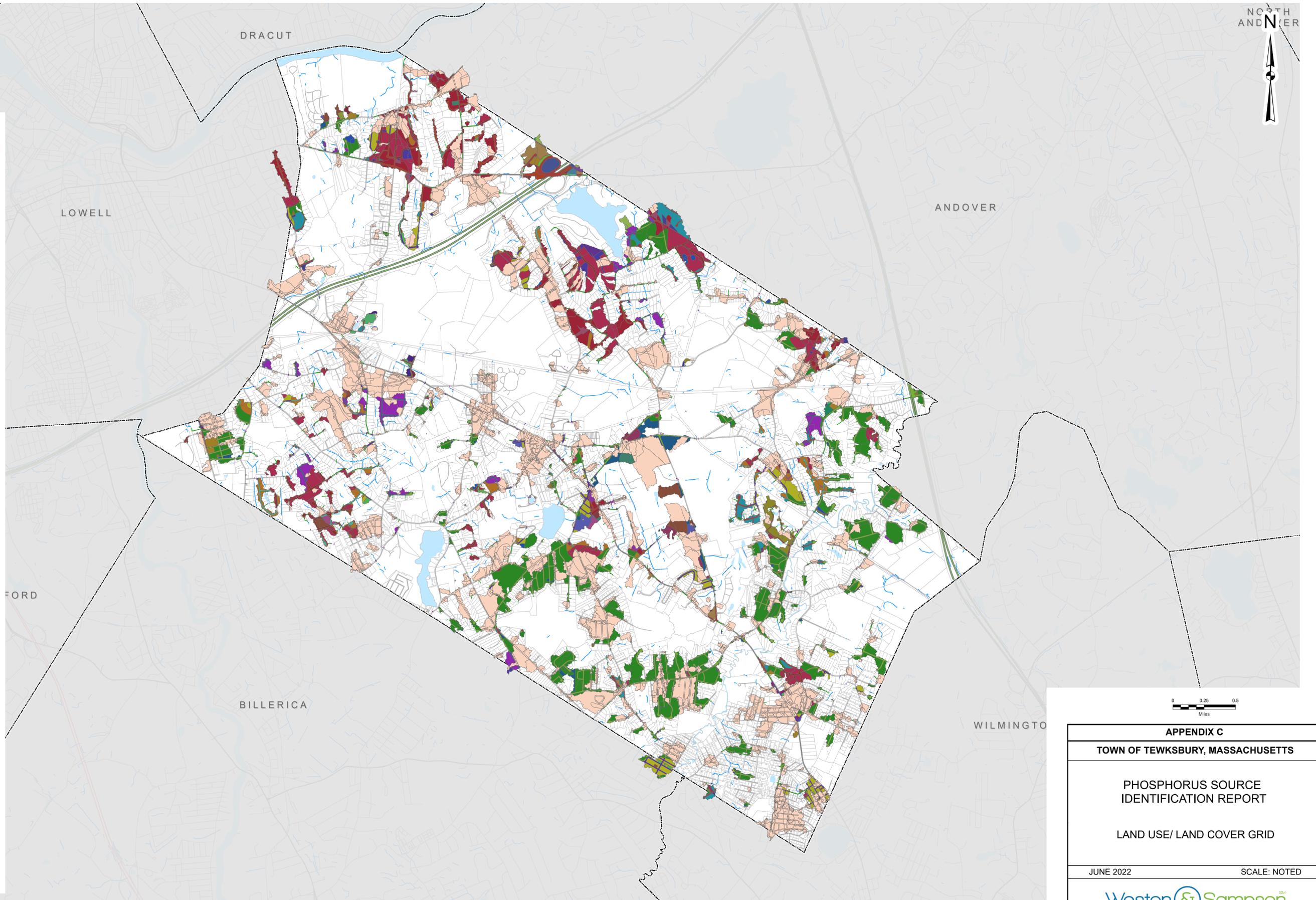
**APPENDIX C**

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



<b>APPENDIX C</b>	
<b>TOWN OF TEWKSBURY, MASSACHUSETTS</b>	
<b>PHOSPHORUS SOURCE IDENTIFICATION REPORT</b>	
<b>LAND USE/ LAND COVER GRID</b>	
JUNE 2022	SCALE: NOTED
	

**APPENDIX D**

Pollutant Loading Analysis Results

**Town of Tewksbury Phosphorus Source Identification Report**

**Appendix D - Pollutant Loading Analysis Results**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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

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**Appendix D - Pollutant Loading Analysis Results**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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

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<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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

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<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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

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<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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

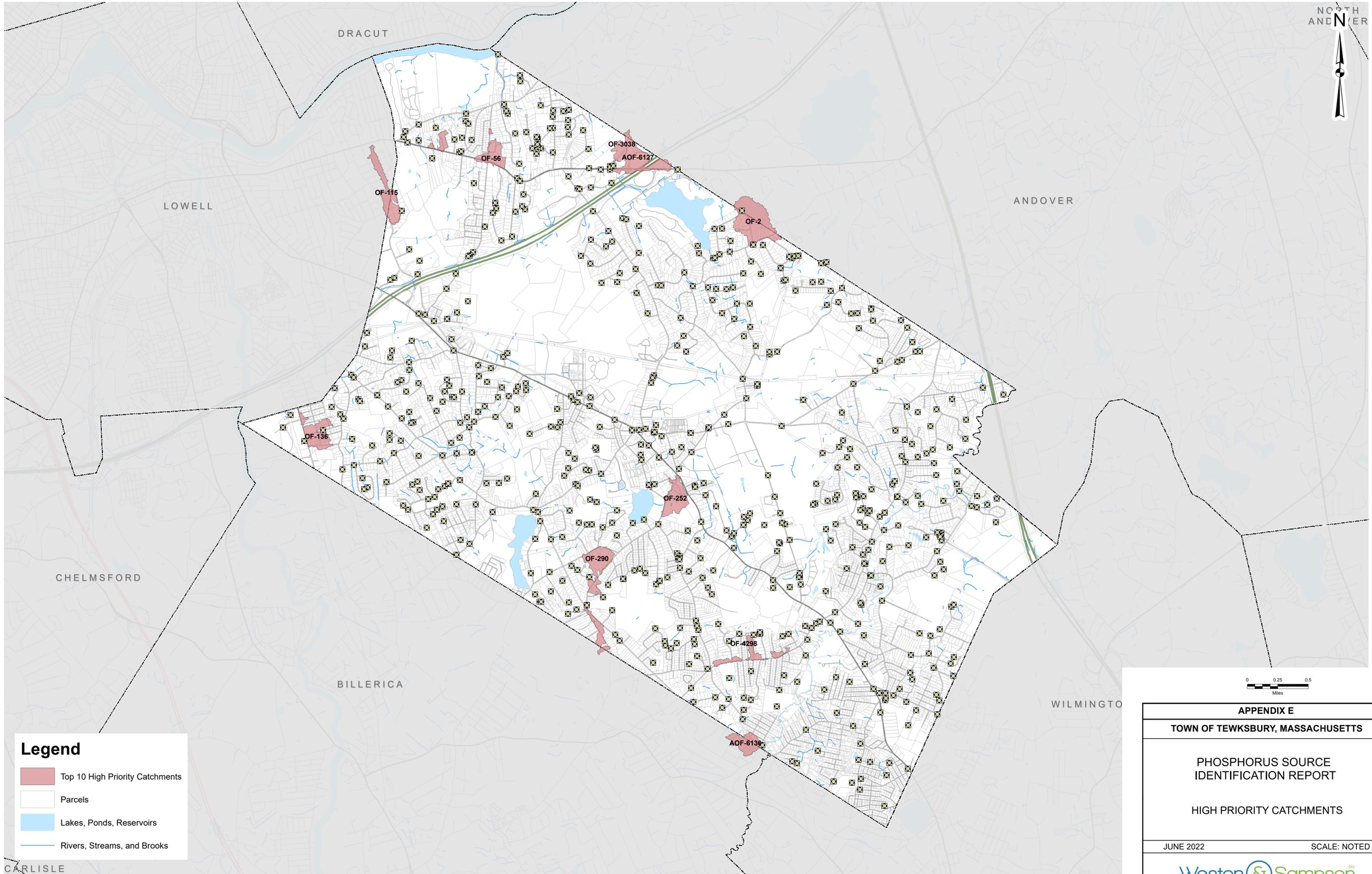
**Town of Tewksbury Phosphorus Source Identification Report**

**Appendix D - Pollutant Loading Analysis Results**

<b>Catchment</b>	<b>Regulated Status</b>	<b>Catchment Size (Ac)</b>	<b>DCIA (Acres)</b>	<b>Phosphorus Loading (lb/yr)</b>	<b>Relative Phosphorus Loading (lb/yr/ac)</b>
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



**Legend**

- Top 10 High Priority Catchments
- Parcels
- Lakes, Ponds, Reservoirs
- Rivers, Streams, and Brooks

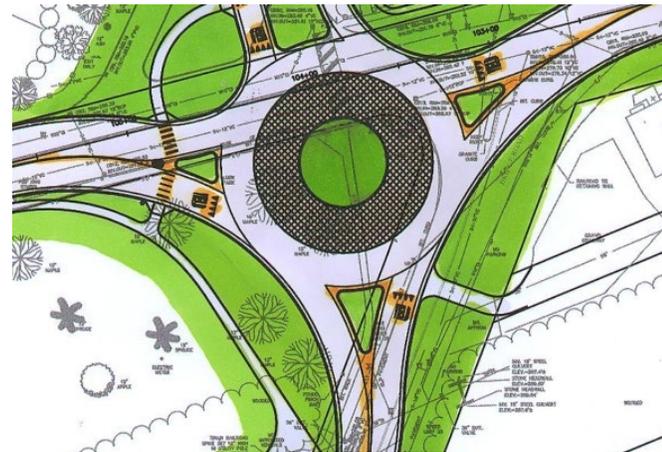
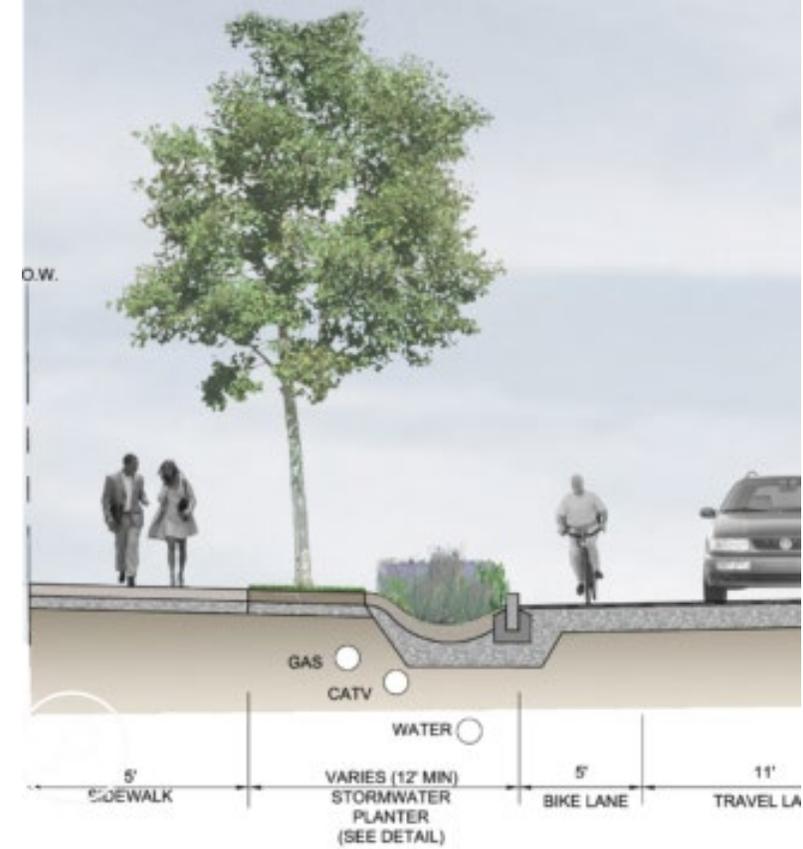
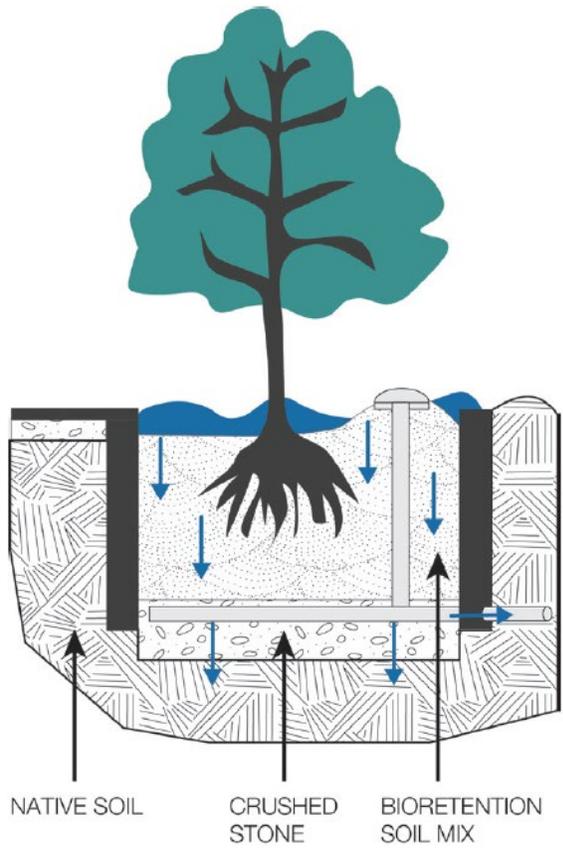
**APPENDIX E**  
**TOWN OF TEWKSBURY, MASSACHUSETTS**  
  
**PHOSPHORUS SOURCE IDENTIFICATION REPORT**  
  
**HIGH PRIORITY CATCHMENTS**

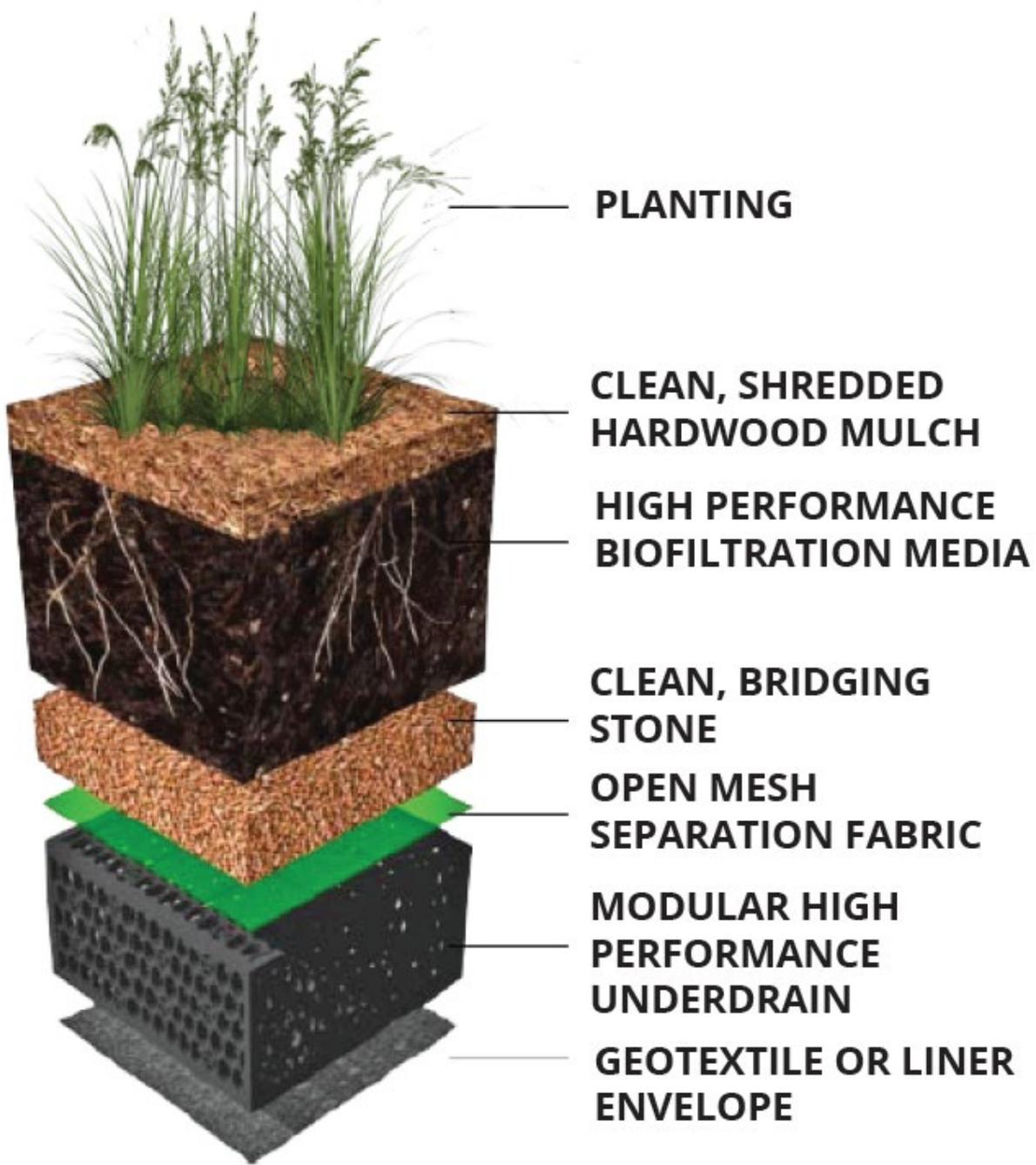
JUNE 2022 SCALE: NOTED



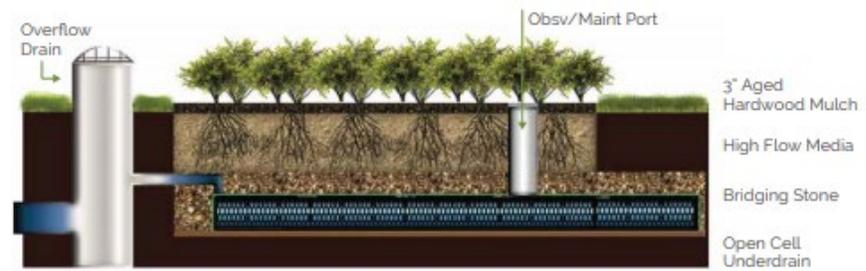
**APPENDIX F**

BMP Retrofit Cut Sheets and Examples

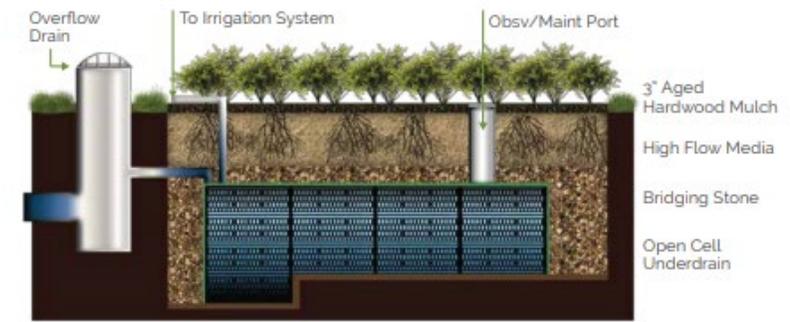




Expanded Detention



Expanded Infiltration



Rainwater Harvesting



## Bioretention Areas & Rain Gardens



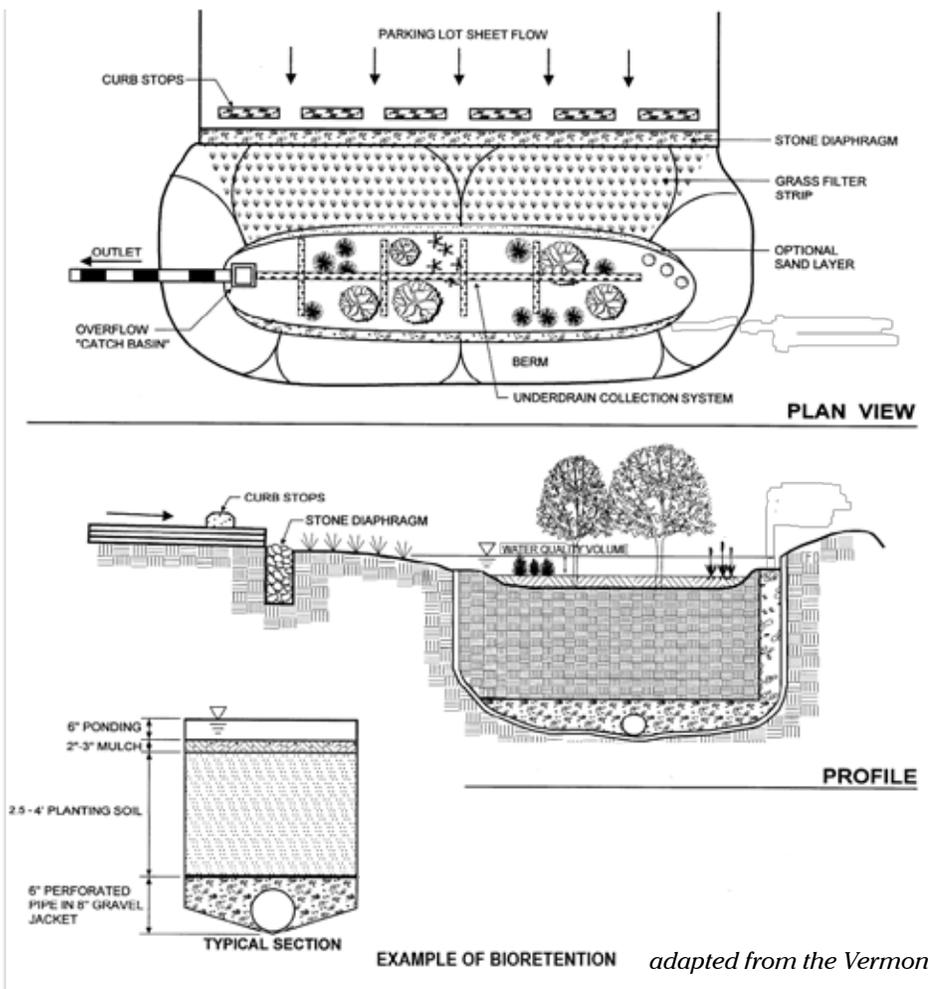
**Description:** Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch 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
<b>2 - Peak Flow</b>	N/A
<b>3 - Recharge</b>	An exfiltrating bioretention area provides groundwater recharge.
<b>4 - TSS Removal</b>	90% TSS removal credit with adequate pretreatment
<b>5 - Higher Pollutant Loading</b>	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.
<b>6 - Discharges near or to Critical Areas</b>	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
<b>7 - Redevelopment</b>	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:**

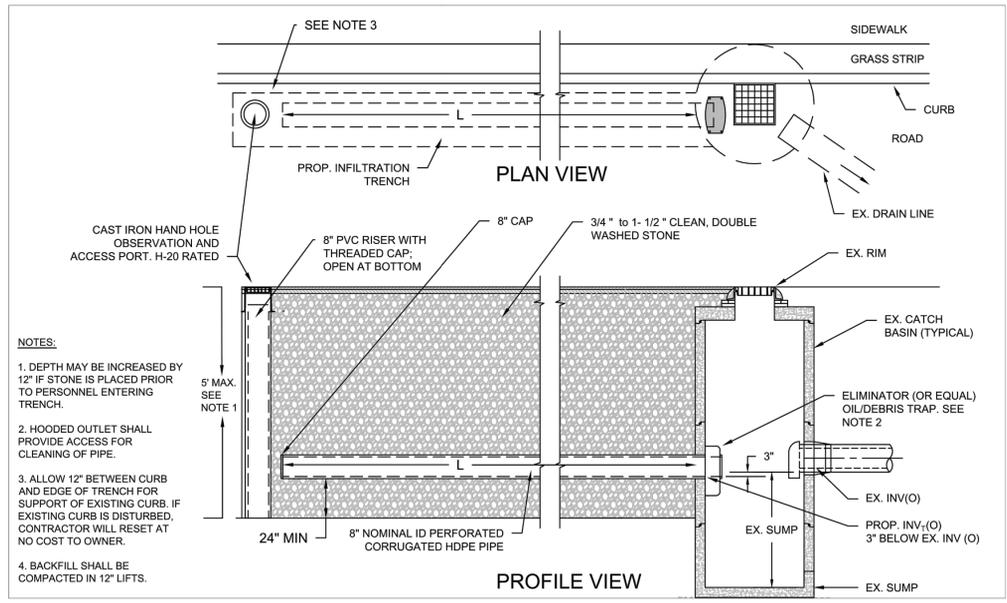
- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- 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

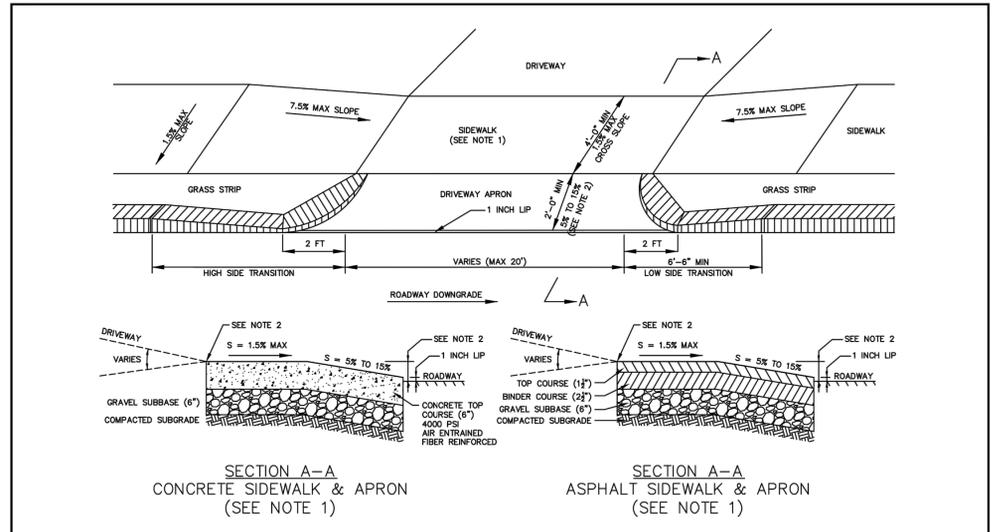
**Maintenance**

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



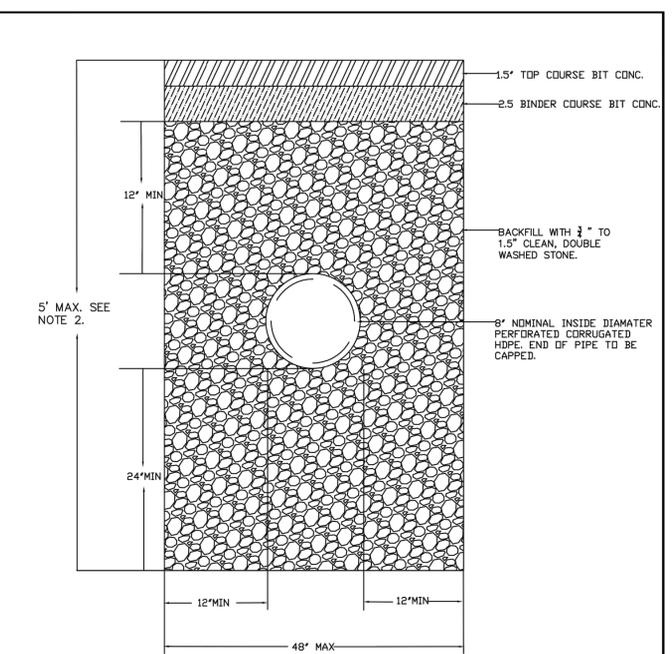
- NOTES:**
1. DEPTH MAY BE INCREASED BY 12" IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING TRENCH.
  2. HOODED OUTLET SHALL PROVIDE ACCESS FOR CLEANING OF PIPE.
  3. ALLOW 12" BETWEEN CURB AND EDGE OF TRENCH FOR SUPPORT OF EXISTING CURB. IF EXISTING CURB IS DISTURBED, CONTRACTOR WILL RESET AT NO COST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

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



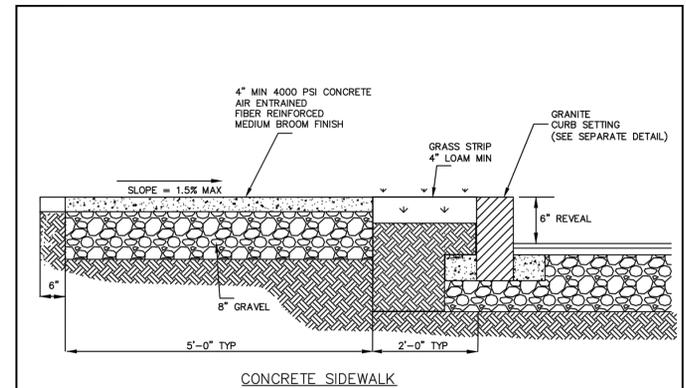
- NOTES:**
1. MATCH DRIVEWAY APRON MATERIALS WITH EXISTING SIDEWALK MATERIAL
  2. DOWNWARD SLOPING DRIVEWAYS REQUIRE A SIDEWALK HEIGHT AT LEAST 3" ABOVE THE ROADWAY

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



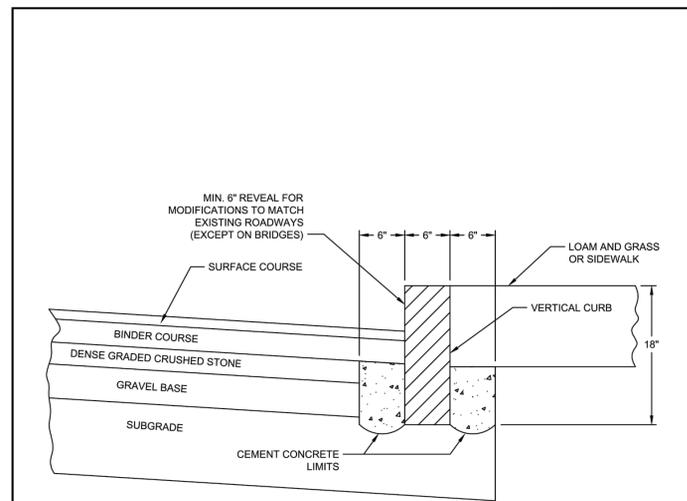
- NOTES:**
1. ALL BACKFILL SHALL BE COMPACTED IN 12 INCH LIFTS.
  2. DEPTH MAY BE INCREASED BY 1 FOOT IF STONE IS PLACED PRIOR TO PERSONNEL ENTERING THE TRENCH.
  3. MEASURES SHALL BE TAKEN TO PREVENT MIGRATION OF FINES INTO BACKFILL.
  4. PIPE SPECS BASED OFF HD100EC PIPE MANUFACTURED BY LANE ENTERPRISES.

	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.

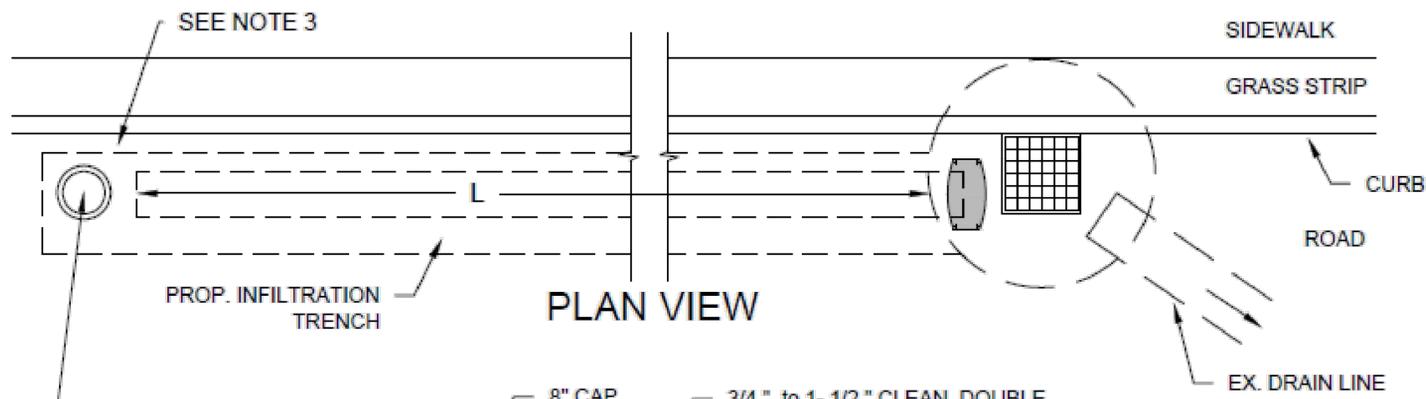
No.	Revision/Issue	Date

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

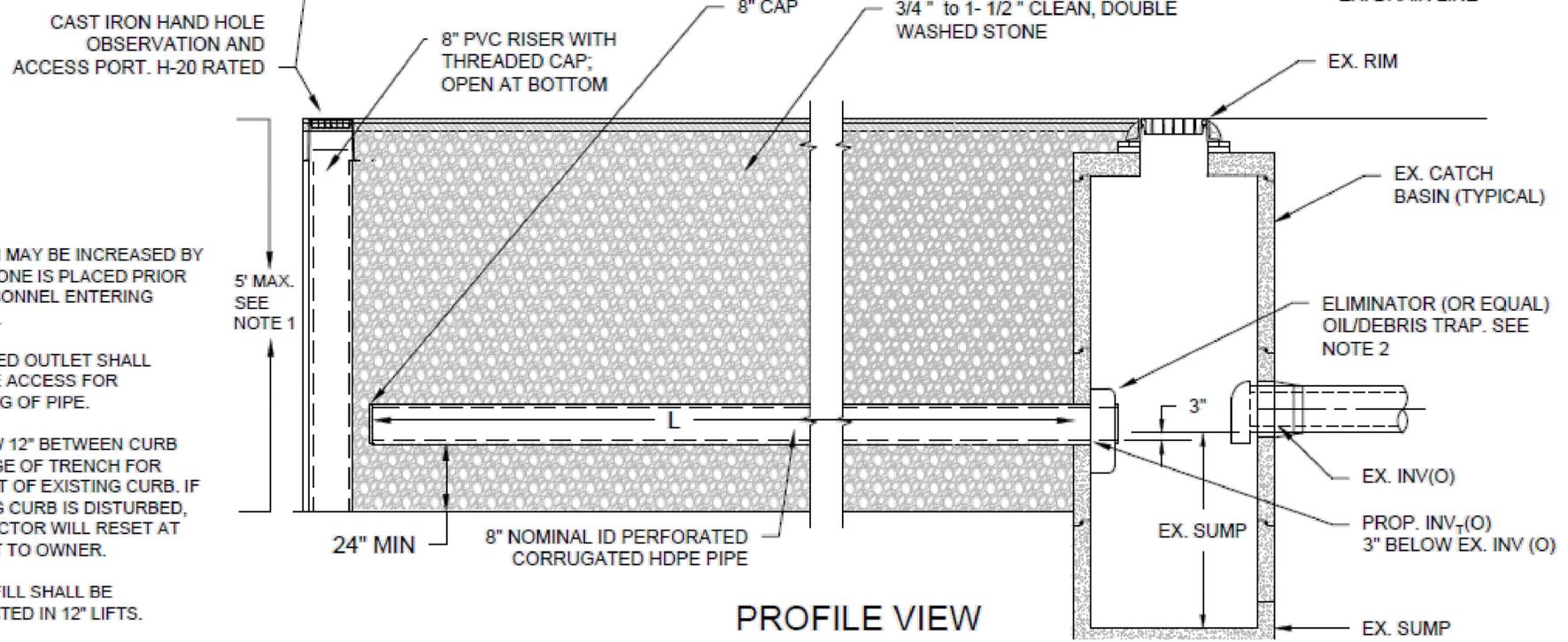
**2021 GREEN INFRASTRUCTURE IMPROVEMENTS PROJECT**

**ARLINGTON CONSTRUCTION DETAILS**

Dr:	S:	13
WCC		
NTS		
FEBRUARY 2021		

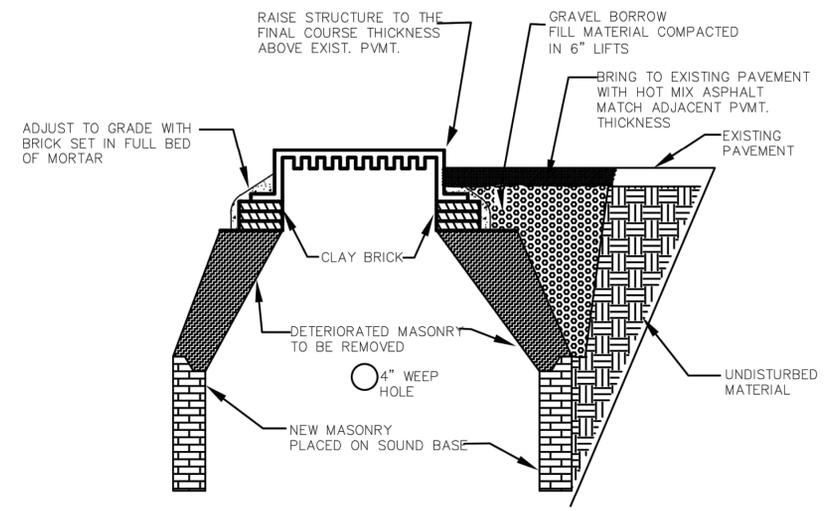


PLAN VIEW

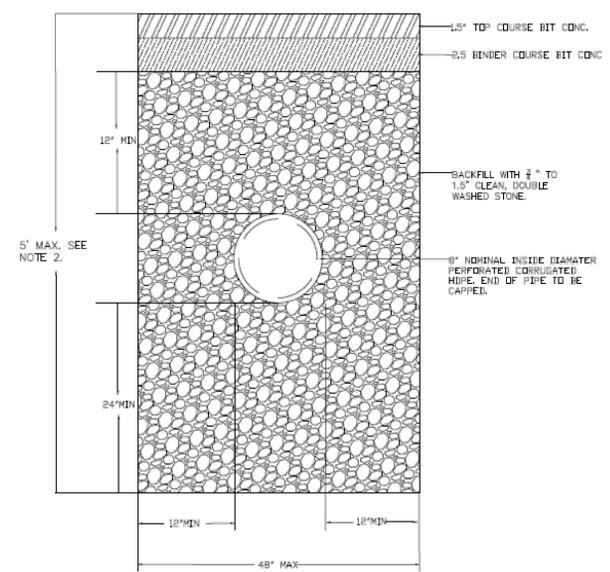


PROFILE VIEW

- 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.



TYPICAL REBUILD OF DRAINAGE/SEWER STRUCTURE



- 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.

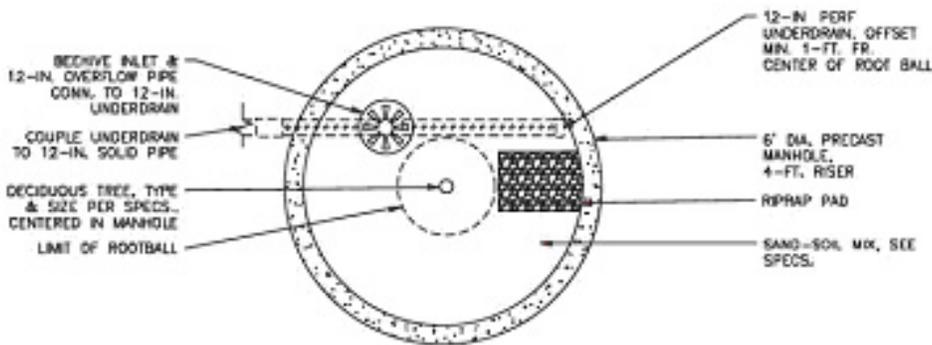
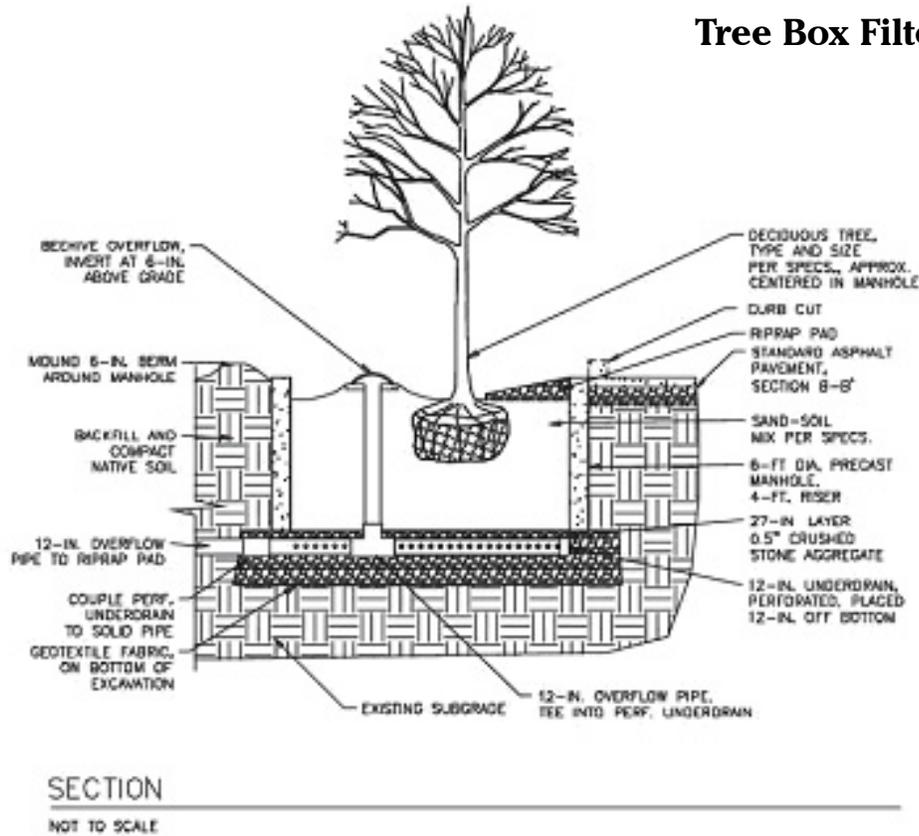
**Ability to meet specific standards**

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



*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