Phosphorus Source Identification Report

Town of Scituate, MA

Prepared By: Horsley Witten Group, Inc.

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This report is based on a template prepared by Neponset River Watershed Association as a grant deliverable for the MS4 Municipal Assistance Grant Program.

Scituate Phosphorus Source Identification Report

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1. Background

1.1 The Nutrient Pollution Problem

Nitrogen and phosphorus are naturally occurring plant fertilizers or "nutrients." When land is developed, and storm drain systems are installed, the amount of nitrogen and phosphorous discharged to local streams, ponds and wetlands increases significantly relative to natural stream conditions. In the urban environment, nitrogen and phosphorous come from a variety of sources including organic debris such as fallen leaves, animal and pet waste, lawn and agricultural fertilizers, malfunctioning sewers and septic systems, and atmospheric deposition from car exhaust, among other sources.

Some of these sources also occur in the natural environment. However, in the urban environment the prevalence of paved and impervious areas coupled with the availability of storm drain collection systems allows street runoff containing excess nutrient pollution to be very quickly collected and conveyed to the nearest waterbody, generally with little or no treatment—bypassing the natural processes such as soil filtration and infiltration that would capture and recycle nutrients before they reached waterways in an undeveloped landscape.

As a result, nutrient pollution from polluted stormwater runoff has become a major source of pollution across the country. Nutrient pollution increases undesirable plant and algae growth in waterways, which can be highly toxic to humans and wildlife and reduce oxygen levels in the water. This, in turn, impedes recreation and creates chronic challenges for aquatic life, sometimes leading to fish kills. In freshwater waterways phosphorus is generally the primary pollutant of concern, while nitrogen becomes the primary concern once freshwater rivers flow into saltwater estuaries and bays.

1.2 Regulatory Context

Under the federal and state clean water acts, the Massachusetts Department of Environmental Protection (MassDEP) is charged with establishing water quality standards and determining whether waterways meet these designated standards. MassDEP publishes its Integrated List of Waters, also referred to at the 303d Impaired Waters List, identifying waters that do not meet standards. These waterways are referred to as being "impaired" or "water quality limited" based on one or more causes which may include nitrogen, phosphorus, "nutrient/ eutrophication biological indicators" or in some cases turbidity or transparency.

MassDEP is also charged with preparing waterbody-specific cleanup plans for nutrient pollution known as Total Maximum Daily Loads or TMDLs, though these are yet to be prepared for many impaired waterways.

The Town of Scituate ("the Town") is subject to the requirements of US Environmental Protection Agency's (EPA's) 2016 Massachusetts Small MS4 General Permit. One of the

requirements of this permit is that communities discharging stormwater to waterways that are listed by MassDEP as impaired for phosphorus, or that flow into impaired waterways, and for which a total maximum daily load does not exist, shall prepare a Phosphorus Source Identification Report as detailed in Appendix H of the permit. This report has been developed to satisfy this requirement of the permit.

The phosphorus source identification report must be submitted with the permit year 4 annual report (year ending June 30, 2022 and report due late September 2022). The requirements include (excerpt from EPA 2016 MS4 Permit Appendix H):

1. Calculation of total MS4 area draining to the water quality limited water segments or their tributaries, incorporating updated mapping of the MS4 and catchment delineations produced pursuant to part 2.3.4.6;
2. All screening and monitoring results pursuant to part 2.3.4.7.b., targeting the receiving water segment(s);
3. Impervious area and DCIA for the target catchment;
4. Identification, delineation and prioritization of potential catchments with high phosphorus loading;
5. Identification of potential retrofit opportunities or opportunities for the installation of structural BMPs during redevelopment.

2. MS4 Permit Appendix H Applicability

All of the Town lies within the South Coastal Watershed. Of the 8 main receiving waters identified in the Town's Notice of Intent, two have been identified as specifically impaired for phosphorus: MA94113 Old Oaken Bucket Pond and MA94-33 Musquashcut Pond. Therefore, this report has been prepared in accordance with the guidelines in section II.1.b of Appendix H of the 2016 Massachusetts Small MS4 General Permit (as modified).

The status of receiving waters in Scituate is summarized in **Table 1** below.

Table 1. Receiving Waters for the Town of Scituate's MS4

South Coastal Watershed: Receiving Water	# Outfalls	Impairments
MA94-02 Scituate Harbor	26	Fecal Coliform
MA94-07 Herring River	5	Enterococcus, Fecal Coliform
MA94-09 South River	12	Enterococcus, Fecal Coliform

South Coastal Watershed: Receiving Water	# Outfalls	Impairments
MA94-18 Bound Brook	7	Turbidity
MA94-19 The Gulf	3	Fecal Coliform
MA94-25 First Herring Brook	8	None
MA94113 Old Oaken Bucket Pond	3	Non-native Aquatic Plants, Total Phosphorus
MA94-33 Musquashcut Pond	9	Algae, Chlorophyll-a, Dissolved Oxygen Supersaturation, Fecal Coliform, Total Phosphorus
Other wetlands and tributaries	253	NA
TOTAL:	326	

3. Data Sources and Analytical Methods

Several existing datasets were used to complete this work. **Table 2** below lists the utilized data sets and their origin.

Table 2. Data Sources

Existing Data Set	Origin	Date Published/Updated	Link
2016 Land Cover/Land Use	MassGIS	May 2019	https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use

Existing Data Set	Origin	Date Published/Updated	Link
Soil Survey Geographic (SSURGO) Database for Plymouth County, Massachusetts	USDA	September 2021	Downloaded through Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm). Hydrologic soil groups extracted using Soil Data Viewer Version 6.1 (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053619)
Town Catchments	Town GIS Files	Current as of the publishing of this report	N/A
Massachusetts Land Parcel Database (Metro Boston Region)	MAPC	May 2019	Used to locate SCM opportunities, this shapefile contains the "Parloc_ID" field used to identify parcels. https://datacommon.mapc.org/browser/datasets/360

Impervious area is the portion of the Town that is paved, covered by buildings, or otherwise rendered unable to absorb water naturally due to development. Impervious area for the town was calculated using the MassGIS 2016 Land Cover/Land Use data layer which was published in 2019. This data layer maps impervious and pervious land cover by land use type based on aerial photography and other data sources. This was overlaid with the Town's data layer for outfall catchment areas (the area draining to each town-owned stormwater discharge point) in the target watersheds to estimate total areas and total impervious area discharging to or upstream of phosphorus-impaired waterways, as well as to estimate impervious area for each of the 88 stormwater outfall catchments in these two watersheds (19 in Musquashcut Pond watershed and 69 in the Old Oaken Bucket watershed).

Directly connected impervious area (DCIA), also referred to as "effective impervious cover," is the amount of impervious area that is directly connected to the storm drain system. Most land in the Town was developed before the creation of modern requirements to capture, clean, slow down, and recharge stormwater runoff using stormwater control measures (SCMs). However, many new development and redevelopment projects constructed in recent years have required the installation or upgrade of SCMs, such that today some properties have no SCMs, some have

SCMs that meet some modern standards, and some have SCMs that are fully compliant with modern standards. Because site-specific information about the existence of specific SCMs is not currently available at the parcel level, an estimate of DCIA or effective impervious cover is used to approximate the average level of SCMs installed across the watershed. Estimating DCIA can yield a more specific pollutant loading estimate for a given area. DCIA was estimated based on land use categories following EPA guidance.

To estimate the pollutant loads for phosphorus in each catchment, estimated pollutant loading rates for different combinations of land use type, land cover type, and soil type were applied in accordance with guidance in the EPA 2016 MS4 Permit. The individual loading rates for these unique subsections were summed based on catchment, which produced an overall estimated catchment pollutant loading rate.

For a more detailed description of the analytical methods used for this project, please refer to **Appendix E:** Scituate Phosphorus Source Identification Report - Methods.

4. Total Area Draining to Phosphorus-Impaired Waterbodies

The total area of the Town is approximately 10,753 acres, all in the South Coastal Watershed. As mentioned above, only two waterbodies in the Town are impaired for phosphorus: MA94113 Old Oaken Bucket Pond (~3,200-acre watershed) and MA94-33 Musquashcut Pond (~470-acre watershed). These are the two target watersheds for this report.

5. Impervious Area and Directly Connected Impervious Area

Table A-1 in **Appendix A** of this report provides impervious area and estimates of DCIA for all storm drain outfall catchments in the Town within the catchments draining to the two waterbodies impaired for phosphorus. **Table 3** below shows the same information for the ten catchments with the most impervious area over both target watersheds. The catchments are labeled using the Town's identifier for the outfall to which they drain. The table is sorted in descending order of total impervious area. It is important to note that most of this impervious area is not owned or maintained by the Town, but by private parties or other public agencies.

Table 3. Total Impervious Area and DCIA for the Ten Most Impervious Catchments for Impaired Waterbodies

Watershed	Catchment ID	Impervious Area (Acres)	Percent Impervious	DCIA Area (Acres)	Percent DCIA
OOBP	49-000-006	25.48	44.57 %	5.58	9.77 %
MP	15-000-002	16.27	20.40 %	1.97	2.48 %
OOBP	70-000-010	13.12	56.43 %	2.72	11.69 %
MP	15-000-001	11.45	42.21 %	2.19	8.06 %
OOBP	21-000-006	10.59	15.65 %	1.13	1.67 %

Watershed	Catchment ID	Impervious Area (Acres)	Percent Impervious	DCIA Area (Acres)	Percent DCIA
MP	07-000-002	8.47	39.69 %	1.45	6.80 %
OOBP	52-000-005	7.69	23.89 %	1.15	3.57 %
OOBP	70-000-004	7.67	81.25 %	3.78	40.03 %
OOBP	50-000-008	6.71	26.00 %	0.97	3.77 %
OOBP	70-000-013	6.55	15.41 %	0.55	1.29 %

6. Estimated Phosphorus Loading from Catchments

Using the methods described in **Appendix E**, estimates of phosphorus loading potential were created for each of the Town's storm drain outfall catchments within the target watersheds (88 in total). **Table B-1** in **Appendix B** of this report shows calculated phosphorus loading estimates for each analyzed catchment, and **Table 4** below shows the catchments with the highest estimated phosphorus in the target watersheds.

Table 4. Estimated Phosphorus Loading for High Priority Catchments

Ranking	Watershed	CatchmentID	Estimated Phosphorus Load (lbs/year)
1	MP	15-000-002	41.76
2	OOBP	49-000-006	40.52
3	OOBP	21-000-006	30.67
4	OOBP	70-000-010	23.56
5	MP	15-000-001	21.24
6	OOBP	52-000-005	18.41
7	OOBP	70-000-013	15.77
8	OOBP	48-000-003	15.69
9	OOBP	49-000-003	15.60
10	OOBP	50-000-008	15.24
11	OOBP	WC-042	15.20
12	MP	07-000-002	14.96
13	OOBP	70-000-004	13.44
14	OOBP	33-000-004	13.18
15	OOBP	70-000-007	13.17
16	OOBP	57-000-002	12.23
17	OOBP	47-000-001	11.49
18	OOBP	47-000-003	11.08
19	OOBP	62-000-007	10.97

Note these are estimated loadings based on soil type, land use and estimated DCIA (e.g., typical level of SCMs in town). Actual loading may vary considerably from site to site depending on what SCMs are actually present, and regional studies such as the Charles River Phosphorus

TMDL have indicated that the default DCIA assumptions used by EPA are somewhat optimistic, such that actual loading rates may be higher. However, these estimates provide a valuable guide to help identify those areas in the Town that should be the highest priorities for interventions to begin reducing pollutant loading.

7. Outfall Screening Monitoring Results

Outfall screening data for the MS4 outfalls discharging to the phosphorus-impaired receiving waters is currently being compiled and will be included in **Appendix D** of this report when available.

8. Catchment Prioritization

To help inform future retrofits for phosphorus reductions, the catchments in each watershed were prioritized. Since no outfall screening data are currently available to improve projections, this report is prioritizing the catchments based solely on the phosphorus loading estimates, in the order shown in **Table B-1**. In addition, **Figure 1** shows the target watershed catchments by prioritization. "High Priority" catchments were those with pollutant loading potential of 10lbs/year and higher. When outfall screening data become available, the list of catchments should be re-examined and the "High Priority" list should be updated based on these real-world data.

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

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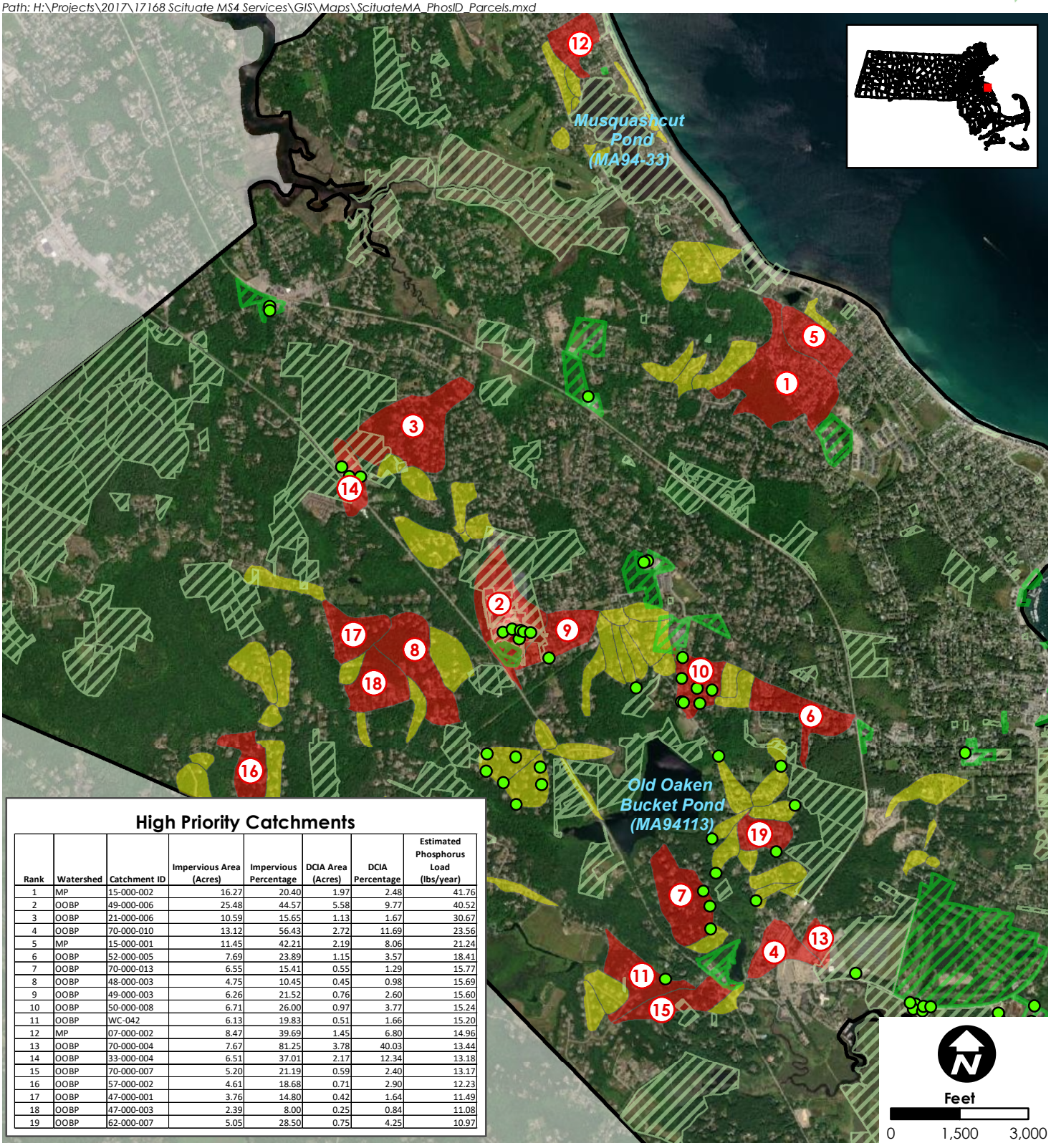

High Priority Catchments

Rank	Watershed	Catchment ID	Impervious Area (Acres)	Impervious Percentage	DCIA Area (Acres)	DCIA Percentage	Estimated Phosphorus Load (lbs/year)
1	MP	15-000-002	16.27	20.40	1.97	2.48	41.76
2	OOBP	49-000-006	25.48	44.57	5.58	9.77	40.52
3	OOBP	21-000-006	10.59	15.65	1.13	1.67	30.67
4	OOBP	70-000-010	13.12	56.43	2.72	11.69	23.56
5	MP	15-000-001	11.45	42.21	2.19	8.06	21.24
6	OOBP	52-000-005	7.69	23.89	1.15	3.57	18.41
7	OOBP	70-000-013	6.55	15.41	0.55	1.29	15.77
8	OOBP	48-000-003	4.75	10.45	0.45	0.98	15.69
9	OOBP	49-000-003	6.26	21.52	0.76	2.60	15.60
10	OOBP	50-000-008	6.71	26.00	0.97	3.77	15.24
11	OOBP	WC-042	6.13	19.83	0.51	1.66	15.20
12	MP	07-000-002	8.47	39.69	1.45	6.80	14.96
13	OOBP	70-000-004	7.67	81.25	3.78	40.03	13.44
14	OOBP	33-000-004	6.51	37.01	2.17	12.34	13.18
15	OOBP	70-000-007	5.20	21.19	0.59	2.40	13.17
16	OOBP	57-000-002	4.61	18.68	0.71	2.90	12.23
17	OOBP	47-000-001	3.76	14.80	0.42	1.64	11.49
18	OOBP	47-000-003	2.39	8.00	0.25	0.84	11.08
19	OOBP	62-000-007	5.05	28.50	0.75	4.25	10.97

Date: 5/27/2022
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

BMPs

Scituate Owned Parcels
- Not considered for Retrofit
- Considered for Retrofit

Scituate

Catchment Prioritization for Phosphorus Impaired Receiving Waters
- Low Priority
- High Priority

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Figure 1
Top Priority Catchment Areas based on Phosphorus Loading Musquashcut Pond and Old Oaken Bucket Pond.

9. Potential Retrofit Opportunities

First, potential parcels in the target watersheds were identified by selecting all parcels owned by the Town of Scituate. Then, undeveloped parcels and recently constructed or retrofitted parcels (e.g., Scituate High School and Scituate Public Safety Complex) were removed from the list to focus on those properties with existing impervious cover that could be reduced and/or retrofit with SCMs. This list of parcels was cross-referenced with the phosphorus-loading catchment prioritization. The parcels located partially or wholly in the high priority catchments are listed in **Table 6** below, with the full list included in **Appendix C**.

Table 6. Town-owned Parcels in High Priority Catchments to Prioritize for Stormwater Retrofits

TP Ranking	WS	Catchment ID	Municipal Property	Address	Parcel ID(s)	Notes
2	OOBP	49-000-006	Scituate Town Hall	600 C J CUSHING WAY	37_5_4_0	Also intersects with Catchment 49-000-03
15	OOBP	70-000-007	Old Oaken Bucket Water Treatment Plant	262-276 C J CUSHING WAY	48_1_10_A	Also intersects with Catchment 99-999-006-P

This information will be used as a ranking criterion for SCM retrofit opportunities as a part of the upcoming Town-wide retrofit inventory. Other ranking criteria will include estimated pollutant loading reductions, cost, various implementation limitations, and additional benefits of proposed SCMs identified in the field. All rights-of-way, particularly in the high phosphorus-loading catchments, should be considered for retrofits in addition to individual parcels. In addition, as Town-owned parcels are evaluated, the Town should begin considering privately-owned parcels in the watershed, as well.

These results provide a valuable starting point for the next phase of requirements in Appendix H of the 2016 MS4 Permit (as modified) which are due by the end of permit year 5 (6/30/2023), which include:

- "Evaluate all permittee-owned properties identified as presenting retrofit opportunities",
- "Provide a listing of planned structural BMPs and a plan and schedule for implementation", and
- "Any structural BMPs installed…by the permittee…shall be tracked and the permittee shall estimate the phosphorus removal by the BMP."

APPENDIX A:
Impervious/DCIA Summary by Catchment

Appendix A: Scituate Phosphorus Source Identification Report - Impervious/DCIA Summary by Catchment

This document lists the calculated impervious area and estimated DCIA for each catchment within the Musquashcut Pond and Old Oaken Bucket Pond watersheds in Scituate, ranked by most impervious area in acres to least.

Table A-1. Impervious area and estimates of DCIA for all outfall catchments in the Town within the Musquashcut Pond and Old Oaken Bucket Pond Watersheds.

Watershed	Catchment ID	Impervious Area (Acres)	Percent Impervious	DCIA Area (Acres)	Percent DCIA
OOBP	49-000-006	25.48	44.57	5.58	9.77
MP	15-000-002	16.27	20.40	1.97	2.48
OOBP	70-000-010	13.12	56.43	2.72	11.69
MP	15-000-001	11.45	42.21	2.19	8.06
OOBP	21-000-006	10.59	15.65	1.13	1.67
MP	07-000-002	8.47	39.69	1.45	6.80
OOBP	52-000-005	7.69	23.89	1.15	3.57
OOBP	70-000-004	7.67	81.25	3.78	40.03
OOBP	50-000-008	6.71	26.00	0.97	3.77
OOBP	70-000-013	6.55	15.41	0.55	1.29
OOBP	33-000-004	6.51	37.01	2.17	12.34
OOBP	49-000-003	6.26	21.52	0.76	2.60
OOBP	WC-042	6.13	19.83	0.51	1.66
OOBP	70-000-007	5.20	21.19	0.59	2.40
OOBP	62-000-007	5.05	28.50	0.75	4.25
OOBP	48-000-003	4.75	10.45	0.45	0.98
OOBP	57-000-002	4.61	18.68	0.71	2.90
OOBP	47-000-001	3.76	14.80	0.42	1.64
MP	24-000-002	3.75	25.95	0.78	5.43
MP	15-000-003	3.74	24.32	0.59	3.86
MP	14-000-002	3.70	34.00	1.41	13.00
OOBP	64-000-003	3.49	20.82	0.54	3.24
OOBP	57-000-003	3.33	22.53	0.45	3.04
OOBP	50-000-003	3.28	20.85	0.53	3.35
OOBP	61-000-002	3.23	30.84	0.69	6.60
OOBP	WC-043	3.09	25.65	0.45	3.78
OOBP	59-000-001	3.05	18.47	0.51	3.07
OOBP	70-000-001	2.98	28.23	0.62	5.89
MP	23-000-006	2.91	33.39	0.47	5.35
OOBP	32-000-004	2.88	21.71	0.46	3.48
MP	07-000-003	2.87	33.67	0.48	5.60
OOBP	60-000-001	2.79	15.80	0.40	2.29

Watershed	Catchment ID	Impervious Area (Acres)	Percent Impervious	DCIA Area (Acres)	Percent DCIA
OOBP	34-000-003	2.71	12.67	0.27	1.26
OOBP	61-000-003	2.58	26.42	0.87	8.94
OOBP	68-000-003	2.51	30.19	0.54	6.46
MP	08-000-001	2.42	78.54	0.79	25.57
OOBP	46-000-001	2.40	14.04	0.28	1.63
OOBP	47-000-003	2.39	8.00	0.25	0.84
OOBP	68-000-010	2.38	31.85	0.38	5.15
OOBP	50-000-006	2.16	32.69	0.46	6.92
OOBP	62-000-009	2.09	26.99	0.30	3.84
OOBP	99-999-007-P	2.09	21.77	0.28	2.93
MP	15-000-006	2.02	44.70	0.42	9.36
OOBP	WC-031	1.94	21.47	0.26	2.88
OOBP	50-000-002	1.87	25.54	0.27	3.75
OOBP	51-000-002	1.85	22.38	0.41	4.93
OOBP	51-000-004	1.68	29.43	0.33	5.80
OOBP	58-000-004	1.67	23.89	0.27	3.91
OOBP	46-000-004	1.63	16.21	0.23	2.33
MP	15-000-004	1.58	32.03	0.30	6.05
OOBP	34-000-002	1.58	24.66	0.27	4.21
OOBP	60-000-002	1.58	28.17	0.55	9.78
OOBP	50-000-005	1.56	15.11	0.27	2.65
OOBP	50-000-001	1.56	40.91	0.48	12.60
MP	23-000-007	1.51	22.16	0.27	3.91
OOBP	70-000-017	1.48	18.78	0.27	3.38
OOBP	59-000-002	1.46	20.03	0.30	4.14
OOBP	49-000-001	1.44	17.05	0.23	2.70
OOBP	99-999-006-P	1.42	26.98	0.36	6.78
OOBP	71-000-007	1.34	32.52	0.25	6.14
OOBP	48-000-009	1.33	6.67	0.10	0.52
OOBP	99-999-003-P	1.22	13.93	0.16	1.85
OOBP	70-000-015	1.15	31.49	0.33	8.97
OOBP	49-000-008	1.12	22.25	0.37	7.28
OOBP	20-000-007	1.10	21.56	0.19	3.71
MP	08-000-002	1.08	83.68	0.52	40.32
OOBP	50-000-007	1.06	24.65	0.30	6.87
MP	07-000-006	1.06	30.86	0.32	9.35
OOBP	62-000-005	1.03	22.73	0.18	4.00
OOBP	70-000-002	0.98	26.49	0.17	4.73
MP	07-000-004	0.97	28.00	0.35	10.03
OOBP	58-000-002	0.95	26.29	0.22	5.97
OOBP	46-000-006	0.93	23.07	0.22	5.51
OOBP	47-000-005	0.88	16.85	0.13	2.47
OOBP	64-000-002	0.82	45.97	0.27	15.16

Watershed	Catchment ID	Impervious Area (Acres)	Percent Impervious	DCIA Area (Acres)	Percent DCIA
MP	07-000-007	0.82	36.19	0.19	8.47
OOBP	70-000-012	0.76	11.73	0.09	1.42
MP	08-000-003	0.72	82.86	0.44	50.95
OOBP	56-000-004	0.62	19.54	0.16	4.98
OOBP	56-000-001	0.62	5.52	0.06	0.49
MP	07-000-008	0.57	43.75	0.24	18.36
OOBP	64-000-001	0.53	37.17	0.16	11.32
OOBP	62-000-004	0.43	9.13	0.06	1.33
OOBP	70-000-016	0.40	17.70	0.11	4.77
OOBP	50-000-004	0.37	5.66	0.04	0.66
OOBP	70-000-011	0.26	28.32	0.09	9.37
MP	07-000-005	0.26	28.00	0.08	9.18
OOBP	WC-030	0.08	9.29	0.02	2.04

APPENDIX B:
Estimated Phosphorus Loading Summary by Catchment

Appendix B: Scituate Phosphorus Source Identification Report - Estimated Phosphorus Loading Summary by Catchment

This document lists the estimated Phosphorus Loading Summary for each catchment within the Musquashcut Pond and Old Oaken Bucket Pond watersheds in Scituate, ordered by most estimated phosphorus loads to least.

Table B-1. Calculated phosphorus loading estimates for all catchments in the Town within the Musquashcut Pond and Old Oaken Bucket Pond Watersheds.

Ranking	Watershed	CatchmentID	Estimated Phosphorus Load (lbs/year)
1	MP	15-000-002	41.76
2	OOBP	49-000-006	40.52
3	OOBP	21-000-006	30.67
4	OOBP	70-000-010	23.56
5	MP	15-000-001	21.24
6	OOBP	52-000-005	18.41
7	OOBP	70-000-013	15.77
8	OOBP	48-000-003	15.69
9	OOBP	49-000-003	15.60
10	OOBP	50-000-008	15.24
11	OOBP	WC-042	15.20
12	MP	07-000-002	14.96
13	OOBP	70-000-004	13.44
14	OOBP	33-000-004	13.18
15	OOBP	70-000-007	13.17
16	OOBP	57-000-002	12.23
17	OOBP	47-000-001	11.49
18	OOBP	47-000-003	11.08
19	OOBP	62-000-007	10.97
20	MP	15-000-003	8.85
21	MP	24-000-002	8.57
22	MP	14-000-002	8.50
23	OOBP	64-000-003	8.40
24	OOBP	50-000-003	7.88
25	OOBP	WC-043	7.66
26	OOBP	46-000-001	7.55
27	OOBP	32-000-004	7.41
28	OOBP	70-000-001	7.08
29	OOBP	61-000-002	6.96
30	OOBP	61-000-003	6.83

Ranking	Watershed	CatchmentID	Estimated Phosphorus Load (lbs/year)
31	OOBP	57-000-003	6.24
32	OOBP	48-000-009	6.05
33	OOBP	34-000-003	6.00
34	MP	07-000-003	5.83
35	MP	23-000-006	5.33
36	OOBP	59-000-001	5.24
37	OOBP	99-999-007-P	5.21
38	OOBP	68-000-010	4.82
39	OOBP	60-000-001	4.72
40	OOBP	62-000-009	4.70
41	OOBP	WC-031	4.59
42	OOBP	51-000-002	4.52
43	OOBP	50-000-005	4.47
44	OOBP	50-000-006	4.34
45	OOBP	50-000-002	4.18
46	OOBP	70-000-017	4.16
47	OOBP	46-000-004	4.15
48	OOBP	68-000-003	4.06
49	OOBP	49-000-001	3.95
50	OOBP	58-000-004	3.83
51	MP	08-000-001	3.78
52	MP	15-000-006	3.68
53	OOBP	51-000-004	3.62
54	MP	23-000-007	3.60
55	MP	15-000-004	3.46
56	OOBP	34-000-002	3.34
57	OOBP	56-000-001	3.20
58	OOBP	60-000-002	3.05
59	OOBP	59-000-002	3.05
60	OOBP	99-999-006-P	2.97
61	MP	07-000-004	2.83
62	OOBP	50-000-001	2.82
63	OOBP	70-000-012	2.81
64	OOBP	99-999-003-P	2.66
65	OOBP	71-000-007	2.65
66	OOBP	70-000-015	2.61
67	OOBP	62-000-005	2.50
68	OOBP	20-000-007	2.49
69	OOBP	46-000-006	2.46
70	OOBP	50-000-007	2.45
71	MP	07-000-006	2.37
72	OOBP	47-000-005	2.27
73	OOBP	70-000-002	2.23

Ranking	Watershed	CatchmentID	Estimated Phosphorus Load (lbs/year)
74	OOBP	50-000-004	2.17
75	OOBP	62-000-004	2.11
76	OOBP	58-000-002	1.97
77	MP	07-000-007	1.71
78	OOBP	49-000-008	1.68
79	MP	08-000-002	1.60
80	OOBP	56-000-004	1.48
81	OOBP	64-000-002	1.37
82	OOBP	70-000-016	1.34
83	MP	07-000-008	1.09
84	MP	08-000-003	1.07
85	OOBP	64-000-001	0.95
86	OOBP	70-000-011	0.68
87	MP	07-000-005	0.63
88	OOBP	WC-030	0.34

APPENDIX C:
Town-Owned Parcels Sorted by Phosphorus Priority Ranking

Appendix C: Scituate Phosphorus Source Identification Report - Town-Owned Parcels Sorted by Phosphorus Priority Ranking

This document lists the Town-owned properties within the Musquashcut Pond and Old Oaken Bucket Pond Watersheds sorted by the calculated catchment phosphorus priority ranking. If a property is located within more than one catchment, it is listed under the highest ranked catchment, with a note about the other catchment(s). If the property includes more than one parcel, all parcels are listed, and the property is shown under the highest ranked catchment of any of the relevant parcels. A few properties are not located within a catchment to an outfall; these are listed at the end of the table with not applicable (NA) in the first two columns.

Table C-1. Town-owned parcels within the Musquashcut Pond and Old Oaken Bucket Pond Watersheds to be considered for stormwater retrofits, ranked by calculated catchment estimated phosphorus load.

TP Ranking	WS	Catchment ID	Municipal Property	Address	Parcel ID(s)	Area (Acres)	Impervious Area (Acres)	Percent Impervious	Notes
2	OOBP	49-000-006	Scituate Town Hall	600 C J CUSHING WAY	37_5_4_0	3.69	0.88	23.94	Also intersects with Catchment 49-000-03
15	OOBP	70-000-007	Old Oaken Bucket Water Treatment Plant	262-276 C J CUSHING WAY	48_1_10_A	2.71	1.12	41.51	Also intersects with Catchment 99-999-006-P
24	OOBP	50-000-003	Recreation Department	327-333 FIRST PARISH RD	38_12_0_B	10.98	4.21	38.38	Also intersects with Catchments 50-000-002, 50-000-007, 50-000-008
45	OOBP	50-000-002	Scituate Library	0 BRANCH ST	38_1_16_B	11.06	0.09	0.85	
				85 BRANCH ST	38_1_16_A	4.86	0.70	14.49	
NA	OOBP	NA	Greenbush Field	0 C J CUSHING WAY	48_1_10_0	6.66	0.71	10.62	
NA	OOBP	NA	Scituate Fire Department	147 FIRST PARISH RD	49_1_39_A	2.07	0.82	39.55	
NA	OOBP	NA	Widow's Walk Golf Course	250 DRIFTWAY	59_1_1_0	139.04	3.96	2.85	
NA	MP	NA	Closed Fire Station	9 MITCHELL AV	15_3_A_0	0.17	0.11	64.74	

APPENDIX D:
Town Outfall Screening Data (Discharging to Phosphorus-impaired Receiving Waters and Their Tributaries)

<PENDING FINAL DATA COLLECTION>

APPENDIX E:
Scituate Phosphorus Source Identification Report - Methods

Appendix E: Scituate Phosphorus Source Identification Report - Methods[1]

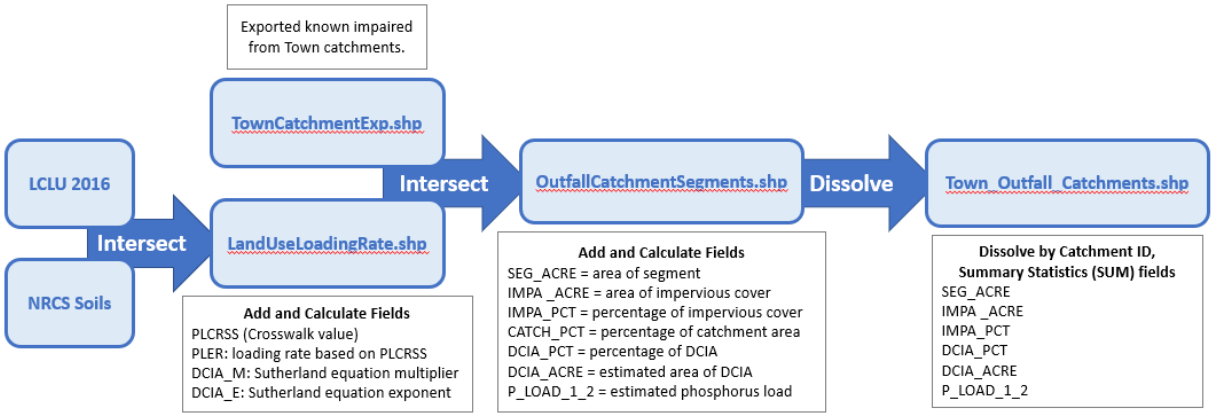
Introduction

This document explains the methods followed to produce the information in the Scituate Phosphorus Source Identification Report. All actions described were performed using ArcMap 10.6.1. The analysis used three existing shapefiles, described in **Table 1** below.

Table 1. Shapefiles Used in Analysis

Existing Data Set	Origin	Date Published/ Updated	Link
2016 Land Cover/Land Use	MassGIS	May 2019	https://docs.digital.mass.gov/dataset/massgis-data-2016-land-coverland-use
Soil Survey Geographic (SSURGO) Database for Plymouth County, Massachusetts	USDA	September 2021	Downloaded through Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm). Hydrologic soil groups extracted using Soil Data Viewer Version 6.1 (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053619)
Town Catchments	Town GIS, created by Woodard and Curran for IDDE Prioritization	12/03/18	N/A

Figure 1. Diagram of Methodology



[1] Methods described here are based on guidance within the EPA MS4 Permit for MA, but refined and elaborated by staff from Neponset River Watershed Association and Pioneer Valley Planning Commission in consultation with MassDEP, and EPA (NPRWA and PVPC, 2021), as well as by Horsley Witten Group when specific to the Town of Scituate.

Step 1: Creation of Base Shapefile

First a 2016 land cover/land use crosswalk was developed to determine phosphorus loading rates, by expanding on the 2005 land use crosswalk in the MS4. This crosswalk method compares general land use to land cover and assigns a P load crosswalk value based on the predominant condition. General land use determined the crosswalk value where the predefined crosswalk category expressed an accurate depiction of land use activity, e.g., Agriculture to "Ag" or Commercial to "Com_Ind". Land cover was used to determine the P load crosswalk value when the general land use predefined crosswalk category did not accurately depict land use activity, e.g., Tax Exempt, ROW, Open Land, Recreation, Unknown –are all better represented by using the land cover value to determine crosswalk values as opposed to the predefined land use crosswalk value of "Com_Ind".

Table 2a. MassGIS 2016 Land Use Phosphorus Load Crosswalk

COVERNAME	USEGENNAME	PLCRSS
Pervious	Agriculture	Ag
Impervious	Agriculture	Ag
Water	Agriculture	Water
Pervious	Commercial	Com_Ind
Impervious	Commercial	Com_Ind
Water	Commercial	Water
Pervious	Forest	For
Impervious	Forest	For
Water	Forest	Water
Pervious	Industrial	Com_Ind
Impervious	Industrial	Com_Ind
Water	Industrial	Water
Bare Land	Mixed use, other	Open
Cultivated	Mixed use, other	Ag
Deciduous Forest	Mixed use, other	For
Developed Open Space	Mixed use, other	Open
Evergreen Forest	Mixed use, other	For
Grassland	Mixed use, other	Open
Impervious	Mixed use, other	Open
Palustrine Aquatic Bed	Mixed use, other	For
Palustrine Emergent Wetland	Mixed use, other	For
Palustrine Forested Wetland	Mixed use, other	For
Palustrine Scrub/Shrub	Mixed use, other	For
Pasture/Hay	Mixed use, other	Ag
Scrub/Shrub	Mixed use, other	For
Water	Mixed use, other	Water
Pervious	Mixed use, primarily commercial	Com_Ind
Impervious	Mixed use, primarily commercial	Com_Ind
Water	Mixed use, primarily commercial	Water
Pervious	Mixed use, primarily residential	LDR
Impervious	Mixed use, primarily residential	LDR
Water	Mixed use, primarily residential	Water

COVERNAME	USEGENNAME	PLCRSS
Bare Land	Open land	Open
Cultivated	Open land	Ag
Deciduous Forest	Open land	For
Developed Open Space	Open land	Open
Estuarine Emergent Wetland	Open land	Water
Evergreen Forest	Open land	For
Grassland	Open land	Open
Impervious	Open land	Open
Palustrine Aquatic Bed	Open land	For
Palustrine Emergent Wetland	Open land	For
Palustrine Forested Wetland	Open land	For
Palustrine Scrub/Shrub	Open land	For
Pasture/Hay	Open land	Ag
Scrub/Shrub	Open land	For
Water	Open land	Water
Bare Land	Recreation	Open
Cultivated	Recreation	Ag
Deciduous Forest	Recreation	For
Developed Open Space	Recreation	Open
Estuarine Emergent Wetland	Recreation	Water
Evergreen Forest	Recreation	For
Grassland	Recreation	Open
Impervious	Recreation	Open
Palustrine Aquatic Bed	Recreation	For
Palustrine Emergent Wetland	Recreation	For
Palustrine Forested Wetland	Recreation	For
Palustrine Scrub/Shrub	Recreation	For
Pasture/Hay	Recreation	Ag
Scrub/Shrub	Recreation	For
Water	Recreation	Water
Pervious	Residential - multi-family	MFR_HDR
Impervious	Residential - multi-family	MFR_HDR
Water	Residential - multi-family	Water
Pervious	Residential - other	MDR
Impervious	Residential - other	MDR
Water	Residential - other	Water
Pervious	Residential - single family	LDR
Impervious	Residential - single family	LDR
Water	Residential - single family	Water
Bare Land	Right-of-way	Open
Cultivated	Right-of-way	Ag
Deciduous Forest	Right-of-way	For
Developed Open Space	Right-of-way	Open
Estuarine Emergent Wetland	Right-of-way	Water
Evergreen Forest	Right-of-way	For

COVERNAME	USEGENNAME	PLCRSS
Grassland	Right-of-way	Open
Impervious	Right-of-way	HWY
Palustrine Aquatic Bed	Right-of-way	For
Palustrine Emergent Wetland	Right-of-way	For
Palustrine Forested Wetland	Right-of-way	For
Palustrine Scrub/Shrub	Right-of-way	For
Pasture/Hay	Right-of-way	Ag
Scrub/Shrub	Right-of-way	For
Water	Right-of-way	Water
Bare Land	Tax exempt	Open
Cultivated	Tax exempt	Ag
Deciduous Forest	Tax exempt	For
Developed Open Space	Tax exempt	Open
Estuarine Emergent Wetland	Tax exempt	Water
Evergreen Forest	Tax exempt	For
Grassland	Tax exempt	Open
Impervious	Tax exempt	HWY
Palustrine Aquatic Bed	Tax exempt	For
Palustrine Emergent Wetland	Tax exempt	For
Palustrine Forested Wetland	Tax exempt	For
Palustrine Scrub/Shrub	Tax exempt	For
Pasture/Hay	Tax exempt	Ag
Scrub/Shrub	Tax exempt	For
Water	Tax exempt	Water
Bare Land	Unknown	Open
Cultivated	Unknown	Ag
Deciduous Forest	Unknown	For
Developed Open Space	Unknown	For
Estuarine Emergent Wetland	Unknown	Water
Evergreen Forest	Unknown	For
Grassland	Unknown	Open
Impervious	Unknown	HWY
Palustrine Aquatic Bed	Unknown	For
Palustrine Emergent Wetland	Unknown	For
Palustrine Forested Wetland	Unknown	For
Palustrine Scrub/Shrub	Unknown	For
Pasture/Hay	Unknown	Ag
Scrub/Shrub	Unknown	For
Water	Unknown	Water
Bare Land	Water	Open
Cultivated	Water	Ag
Deciduous Forest	Water	For
Developed Open Space	Water	For
Estuarine Emergent Wetland	Water	Water
Evergreen Forest	Water	For

COVERNAME	USEGENNAME	PLCRSS
Grassland	Water	Open
Impervious	Water	Open
Palustrine Aquatic Bed	Water	For
Palustrine Emergent Wetland	Water	For
Palustrine Forested Wetland	Water	For
Palustrine Scrub/Shrub	Water	For
Pasture/Hay	Water	Ag
Scrub/Shrub	Water	Open
Water	Water	Water

To support the analysis, a base shapefile containing pertinent information for land cover, land use, and soil types in the area of interest was created. This was completed by performing a "intersect" operation with two input shapefiles shown in **Table 1** above: the 2016 Land Cover/Land Use shapefile and a shapefile containing the SSURGO soil hydrologic groups. For dual hydrologic groups not accounted for in *Table 1-2 in Attachment 1 of Appendix F of the 2016 Massachusetts Small MS4 General Permit guidance document* (i.e., A/D, B/D), the values for hydrologic group D were used. Each record in the shapefile represents areas with specific land cover, land use, and soil types.

Several fields were then added to the resulting "Land Use Loading Rate" (MS4_NSI_NPL_210614) shapefile to support later steps of this analysis. **Table 2b** below lists the added field and provides a brief description of the data that was added.

Table 2b. Summary of Fields Added to "LandUseLoadingRate" Shapefile

Added Field	Description
PLCRSS	The phosphorus loading category to which a record was assigned. See *Table 1-2 in Attachment 1 of Appendix F of the 2016 Massachusetts Small MS4 General Permit* for a full listing of loading categories and rates.
PLER	The numerical phosphorus loading rate assigned to a record. The value originates from *Table 1-2 in Attachment 1 of Appendix F of the 2016 Massachusetts Small MS4 General Permit*
DCIA_M	The multiplier from the applicable Sutherland equation to estimate directly connected impervious area for a record. Note that entry is <Null> for all non-impervious records. For more detailed information about how these values were assigned, see the "DCIA Calculation" section below.
DCIA_E	The exponent from the applicable Sutherland equation to estimate directly connected impervious area for a record. Note that entry is <Null> for all non-impervious records. For more detailed information about how these values were assigned, see the "DCIA Calculation" section below.

Step 2: Preparation of Catchment Shapefile and Intersect with Base Shapefile

To prepare the catchment shapefile for later analysis, a field entitled "CatchAreaAcre" was added to the attribute table. The "calculate geometry" function was used to populate this field for each record, measuring the total area of each catchment in acres. The catchment areas were selected if they were in a phosphorus impaired watershed (Musquashcut Pond and Old Oaken Bucket Pond), and then exported to a separate shapefile (swCatchmentExp.shp) as a base for the analysis. A catchment area was considered "in" the Musquashcut Pond watershed if it discharged to the pond or one of its tributaries or upgradient wetlands. A catchment area was considered "in" the Old Oaken Bucket Pond if its discharge point was within the mapped zones (A, B, or C) as a surface water source of drinking water per MassGIS.

Once the additional field was added, the "Intersect" tool was run with two input datasets: "Land use Loading Rate" (described in the last section) and the Town's Catchment shapefile. The resulting shapefile was entitled "Scituate Catchment Segments."

This resulting shapefile limits the information contained in the broader "Land Use Loading Rate" to just what specifically occurs in each of the Town's catchments, allowing further catchment-level analysis of several criteria.

Step 3: Summarized Analysis

New fields were added to the recently created shapefile. **Table 3** below lists the new fields, the description of the data they contain and shows the operations involved in calculating the applicable data. Further details about each calculation can be found in the individual sections below.

Table 3. New Fields Added to "Scituate Catchment Segments" Shapefile

New Field	Description	Units	Function Used to Calculate	Calculation Method
SEG_ACRE	The area of a record.	Acres	Calculate Geometry	Calculate the area in acres.
IMPA _ACRE	The area of impervious surfaces occupied by a record.	Acres	Calculate Geometry	Query only records with "Impervious" entry for CoverName, then calculate the area in acres. After removing the query, all non-impervious records will have a "0" listed for this field.
IMPA_PCT	The amount of impervious area in a record.	% total catchment area	Field Calculator	([IMPA_ACRE]/[CatchAreaAcres])*10 0
CATCH_PCT	The percentage of the catchment represented by a record.	% total catchment area	Field Calculator	([SEG_ACRE]/[CatchAreaAcres])*100
DCIA_PCT	An estimate of directly connected impervious area represented by a record	% total catchment area	Field Calculator	([IMPA_PCT]^[DCIA_E])*[DCIA_M]

New Field	Description	Units	Function Used to Calculate	Calculation Method
DCIA_ACRE	An estimate the amount of directly connected impervious area associated with a	Acres	Field Calculator	([DCIA_PCT]/100)*[CatchAreaAcres]
P_LOAD_1_2	The estimated phosphorus load from a record	Lbs/Year	Field Calculator	[SEG_ACRE]*[PLER]

**PercentOfCatch was only used as a "check" field and is not described further in this document.*

Step 4: Impervious Calculation

The "Scituate Catchment Segments" shapefile contains polygons of areas within each catchment with like land cover, land use, and soil type. To begin, the "Scituate Catchment Segments" was queried so that only polygons with an entry of "Impervious" for the "CoverName" field were shown. Then, the Calculate Geometry tool was used on those queried records to display the area of each impervious polygon in acres. These results were eventually summed for overall catchment totals of impervious area as described in the "Step 7: Final Preparation of Deliverable Shapefile" section below.

To further illustrate impervious cover statistics and for use in DCIA calculation, the impervious cover in each polygon was also calculated as a percentage of each catchment. For this measurement, the Field Calculator tool was used on the "IMPA_PCT" field to divide the impervious area of each polygon ("IMPA_ACRE") by the total catchment size ("CatchAreaAcres"), created when preparing the catchment shapefile). This figure was then multiplied by 100 to obtain a percent.

Step 5: DCIA Calculation

DCIA estimates were based on the Sutherland equations within the EPA guidance document entitled "Estimating Change in Impervious Area (IA) and Directly Connected Impervious Areas (DCIA) for Massachusetts Small MS4 Permit" (Revised April 2014). **Table 4** below shows the relation between various land uses in the watershed, the chosen "connectedness" category, and the associated Sutherland equation used in the DCIA estimate. Note that these estimates only occurred on polygons that contained an "Impervious" entry in the CoverName field, as DCIA only exists where impervious area exists.

Table 4. "Connectedness" Category and Sutherland DCIA Equation Assignments for All Land Uses. NOTE: DCIA and IA are both percentages.

USEGENNAME	"Connectedness" Category	Sutherland Equation
Agriculture	Mostly Disconnected	$DCIA=0.01(IA)^2$
Commercial	Average	$DCIA=0.1(IA)^{1.5}$
Forest	Mostly Disconnected	$DCIA=0.01(IA)^2$
Industrial	Average	$DCIA=0.1(IA)^{1.5}$
Mixed use, other	Average	$DCIA=0.1(IA)^{1.5}$

USEGENNAME	"Connectedness" Category	Sutherland Equation
Mixed use, primarily commercial	Average	$DCIA=0.1(IA)^{1.5}$
Mixed use, primarily residential	Average	$DCIA=0.1(IA)^{1.5}$
Open land	Average	$DCIA=0.1(IA)^{1.5}$
Recreation	Average	$DCIA=0.1(IA)^{1.5}$
Residential - multi-family	Highly Connected	$DCIA=0.4(IA)^{1.2}$
Residential - other	Average	$DCIA=0.1(IA)^{1.5}$
Residential - single family	Average	$DCIA=0.1(IA)^{1.5}$
Right-of-way	Average	$DCIA=0.1(IA)^{1.5}$
Tax exempt	Average	$DCIA=0.1(IA)^{1.5}$
Unknown	Average	$DCIA=0.1(IA)^{1.5}$
Water	Average	$DCIA=0.1(IA)^{1.5}$

In these equations, the percentage of impervious cover for a given area is used to determine the percentage of DCIA in the same area. Thus, DCIA percent was calculated in the "DCIA_PCT" field using Field Calculator. In this calculation, the impervious percentage represented by the polygon ("IMPA_PCT") was raised to the power shown in the appropriate equation (already entered in the "DCIA_E" field when preparing the base shapefile) and multiplied by the factor shown (already entered in the "DCIA_M" field when preparing the base shapefile). Essentially, the Field Calculator equation was "DCIA_PCT" = ("IMPA_PCT" ^ "DCIA_E") * "DCIA_M". These results were eventually summed for overall catchment totals of impervious area as described in the "Step 7: Final Preparation of Deliverable Shapefile" section below.

Finally, the estimated acreage of DCIA for each polygon was calculated in the "DCIA_ACRE" field using Field Calculator. In this calculation, "DCIA_PCT" was divided by 100 and multiplied by the overall catchment size ("CatchAreaAcre").

Step 6: Phosphorus Load Calculation

Phosphorus loads were calculated for each record in the Scituate Catchment Segments shapefile by multiplying the area of each polygon ("AreaAcre") by the phosphorus loading rate assigned to the record's specific land cover/land use/soil type combination (the "PLER" field, which was entered during the creation of the base shapefile). The Field Calculator tool was used to complete this calculation in the "P_LOAD" field. As the name suggests, the units for the loading rates are pounds/acre/year. These results are eventually summed for overall catchment totals of impervious area as described in the "Step 7: Final Preparation of Deliverable Shapefile" section below.

For reference, the phosphorus loading category into which each record is assigned is recorded in the "PLCRSS" field, which stands for Phosphorus Load Crosswalk. The entries in this field correspond to the land uses and phosphorus load export rates shown in *Table 1-2 of Attachment 1 to Appendix F of the 2016 Massachusetts Small MS4 General Permit*. An abbreviated crosswalk is shown in **Table 5** below.

Table 5. Crosswalk Linking Land Use and Land Cover to the Phosphorus Source Categories Shown in Table 1-2 of Attachment 1 to Appendix F of the 2016 Massachusetts Small MS4 General Permit

USEGENNAME	Phosphorus Source Category
Agriculture	Agriculture (Ag)
Commercial	Commercial/Industrial (Com-Ind)
Forest	Forest (For)
Industrial	Commercial/Industrial (Com- Ind)
Mixed use, other	Varied based on land cover
Mixed use, primarily commercial	Commercial/Industrial (Com- Ind)
Mixed use, primarily residential	Medium-Density Residential (MDR)
Open land	Open Land (Open)
Recreation	Open Land (Open)
Residential - multi-family	Multi-Family and High- Density Residential (MFR- HDR)
Residential - other	Medium-Density Residential (MDR)
Residential - single family	Medium-Density Residential (MDR)
Right-of-way	Varied based on land cover
Tax exempt	Varied based on land cover
Unknown	Varied based on land cover
Water	Varied based on land cover

Step 7: Final Preparation of Deliverable Shapefile

Once all calculations were made as described above, the "OutfallCatchmentSegments" shapefile was condensed using the Dissolve tool. The "Dissolve_Field" was defined as the field containing catchment identifiers and the following fields were defined as "Statistics Fields" with a "Statistic Type" of "Sum": "SEG_ACRE," "IMPA_ACRE," "IMPA_PCT," "DCIA_ACRE," "DCIA_PCT," and "P_LOAD."

The resulting layer was named "Scituate_Outfall_Catchments" and was provided with all other deliverables from this project. This shapefile displays the Town's catchments and contains totals of each catchment's area, impervious area, estimated DCIA, impervious percentage, estimated DCIA percentage, and estimated phosphorus load.