Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies

Appendix AA: Cape Cod Coastal Drainage Area

Commonwealth of Massachusetts
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Available Online

https://www.mass.gov/lists/total-maximum-daily-loads-by-watershed

Massachusetts Department of Environmental Protection

The mission of the Massachusetts Department of Environmental Protection (MassDEP) is to protect and enhance the Commonwealth's natural resources – air, water, and land – to provide for the health, safety, and welfare of all people, and to ensure a clean and safe environment for future generations. In carrying out this mission MassDEP commits to address and advance environmental justice and equity for all people of the Commonwealth; provide meaningful, inclusive opportunities for people to participate in agency decisions that affect their lives; and ensure a diverse workforce that reflects the communities we serve.

Watershed Planning Program

The mission of the Watershed Planning Program (WPP) in the Massachusetts Department of Environmental Protection is to protect, enhance, and restore the quality and value of the waters of the Commonwealth. Guided by the federal Clean Water Act, WPP implements this mission statewide through five Sections that each have a different technical focus: (1) Surface Water Quality Standards; (2) Surface Water Quality Monitoring; (3) Data Management and Water Quality Assessment; (4) Total Maximum Daily Load; and (5) Nonpoint Source Management. Together with other MassDEP programs and state environmental agencies, WPP shares in the duty and responsibility to secure the environmental, recreational, and public health benefits of clean water for all people of the Commonwealth.

Acknowledgements

FB Environmental Associates, under contractual agreements with MassDEP, previously prepared two separate documents for the Watershed Planning Program: (1) *Massachusetts TMDL for Pathogen-Impaired Inland Fresh Water Rivers* and (2) *Massachusetts Statewide TMDL for Pathogen-Impaired Coastal Waterbodies*. MassDEP combined these two documents into a single statewide approach encompassing both inland fresh water and coastal impairments to prepare the *Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies*.

Disclaimer

References to trade names, commercial products, manufacturers, or distributors in this report constituted neither endorsement nor recommendations by the Massachusetts Department of Environmental Protection.

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1. Introduction

This appendix to the Massachusetts Statewide Total Maximum Daily Load (TMDL) for Pathogen-Impaired Waterbodies provides additional information to support the determination of the TMDL for the 10 pathogen-impaired segments in the Cape Cod Coastal Drainage Area, hereinafter referred to as the Cape Cod watershed (Figure 1-1). The core document and appendix together complete the TMDL for each of these pathogen-impaired segments.

This appendix includes a description of the watershed and maps to identify the segments of focus for the TMDLs; the impaired uses, and the water classification and qualifiers as designated by the Massachusetts Surface Water Quality Standards (SWQS, 314 CMR 4.00); the water quality standards applicable to the impaired uses; the data supporting the pathogen impairment determination; and a description of the sources of pathogen loading with supporting maps.

This appendix also includes a summary of the allocation of the current indicator bacteria load into two categories: point sources (waste load allocation, WLA) and nonpoint sources (load allocation, LA), based on an analysis of watershed percent impervious cover. This appendix identifies the percent reduction in indicator bacteria pollutant load from current conditions required to meet the TMDL, based on the highest levels of indicator bacteria recorded in the monitoring data, if applicable. The TMDLs for the seven freshwater segments were calculated with the flow-based equation developed to address conditions specific to Cape Cod, the Islands, and the segments on the eastern side of Buzzards Bay (geographically on Cape Cod). The TMDLs for the three estuarine segments were calculated with the load-based equation that addresses these same conditions.

Finally, for each impaired segment, this appendix presents existing local management efforts to reduce pathogen pollutant loading. General recommended next steps for implementation of this TMDL are provided in the Cape Cod Watershed Overview section.

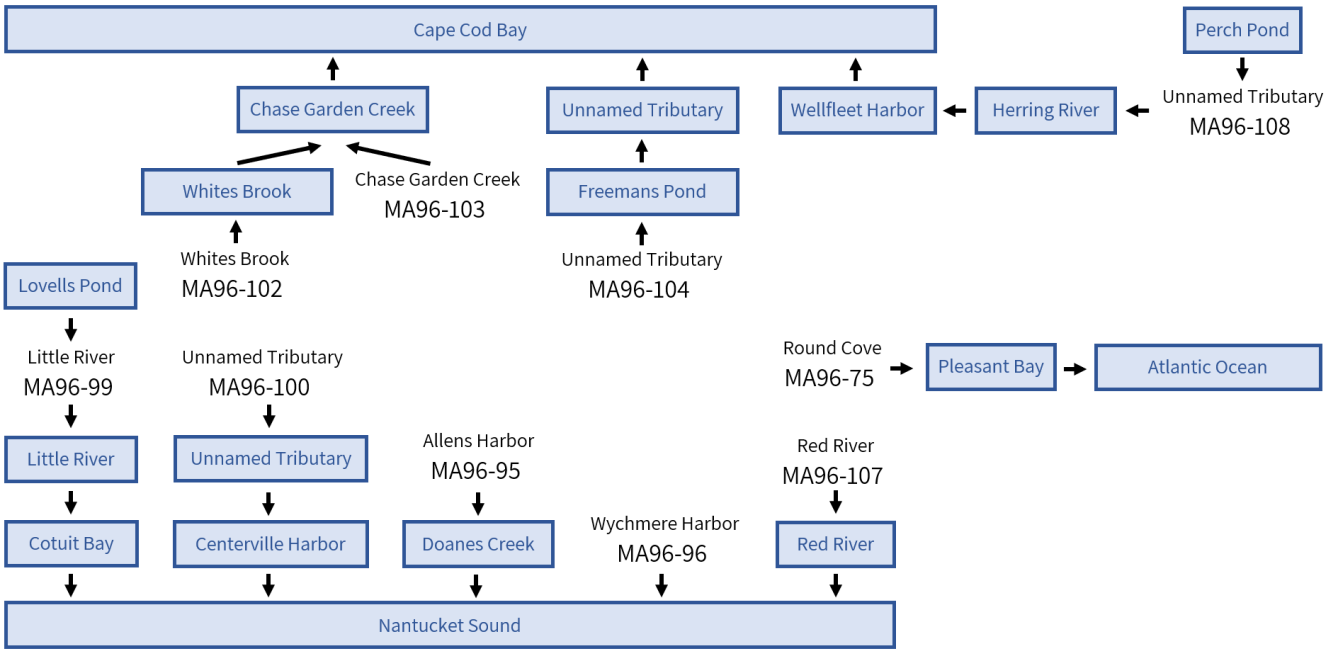


Figure 1-1. Conceptual diagram of water flow through the Cape Cod watershed for the 10 pathogen-impaired segments. Connections between waterbodies are shown with black arrows. Not to scale. Impaired segments are shown with the assessment unit.

Table 1-1. ***E. Coli*** Total Maximum Daily Loads (TMDLs), the percent reductions needed to meet the TMDL target (126 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the flow-based TMDL allocations for pathogen-impaired **freshwater** assessment units in the Cape Cod Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
Little River MA96-99	B	R	126	258 (90 day)	51%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-100	B	R	126	417 (90 day)	70%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Whites Brook MA96-102	B	R	126	439 (90 day)	71%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Chase Garden Creek MA96-103	B	R	126	648 (90 day)	81%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-104	B	R	126	469 (90 day)	73%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Red River MA96-107	B	R	126	621 (90 day)	80%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-108	B (ORW)	R	126	548 (90 day)	77%	WLA (100%)	3.1	30.8	308.3	3,082.7	30,826.8	308,268.0
						LA (0%)	-	-	-	-	-	-

Table 1-2. **Enterococci** Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (35 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the flow-based TMDL allocations for pathogen-impaired **freshwater** assessment units in the Cape Cod Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	*Flow (cfs)* 1	10	100	1,000	10,000	100,000
							Flow-Based Target TMDL (CFU/day*10^9)					
Little River MA96-99	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-100	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Whites Brook MA96-102	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Chase Garden Creek MA96-103	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-104	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Red River MA96-107	B	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-
Unnamed Tributary MA96-108	B (ORW)	P	35	NA	-	WLA (100%)	0.9	8.6	85.6	856.3	8,563.0	85,630.0
						LA (0%)	-	-	-	-	-	-

Table 1-3. Enterococci Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (35 CFU/100ml) based on the Massachusetts Surface Water Quality Standards (SWQS), and the TMDL allocations for pathogen-impaired **marine** assessment units in the Cape Cod Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	Watershed Area (acres)	Impervious Area in 200-foot Buffer (acres)	TMDL (CFU/day*10^9)
Round Cove MA96-75	SA (ORW, SF)	P	35	NA	-	WLA (100%) LA (0%)	332	2.6	0.012 -
Allens Harbor MA96-95	SA (SF)	P	35	NA	-	WLA (100%) LA (0%)	281	9.4	0.042 -
Wychmere Harbor MA96-96	SA (SF)	P	35	NA	-	WLA (100%) LA (0%)	229	8.5	0.038 -

Table 1-4. Fecal Coliform Total Maximum Daily Loads, the percent reductions needed to meet the TMDL target (14 CFU/100ml for Class SA) based on the Massachusetts Surface Water Quality Standards (SWQS), and the TMDL allocations for pathogen-impaired **marine** assessment units in the Cape Cod Coastal Drainage Area

Waterbody & Assessment Unit	Class (Qualifier)	TMDL Type	SWQS-Based TMDL target (CFU/100ml)	Maximum Geomean (CFU/100ml)	Geomean Percent Reduction	TMDL Allocation	Watershed Area (acres)	Impervious Area in 1200-foot Buffer (acres)	TMDL (CFU/day*10^9)
Round Cove MA96-75	SA (ORW, SF)	R	14	NA	-	WLA (100%) LA (0%)	332	2.6	0.005 -
Allens Harbor MA96-95	SA (SF)	R	14	NA	-	WLA (100%) LA (0%)	281	9.4	0.017 -
Wychmere Harbor MA96-96	SA (SF)	R	14	NA	-	WLA (100%) LA (0%)	229	8.5	0.015 -

Class *defined in the Massachusetts Surface Water Quality Standards (SWQS) at 314 CMR 4.02.*
Qualifiers that identify segments with special characteristics are defined at 314 CMR 4.06(1)(d).
ORW *= Outstanding Resource Waters; waters designated for protection under 314 CMR 4.04(2);*
SF *= Shellfishing; waters subject to more stringent regulation by Massachusetts Division of Marine Fisheries (DMF) pursuant to M.G.L. c. 130, § 75*
Pathogen bacteria units are presented in colony-forming units or CFU per 100 milliliter or ml.
TMDL Type *identifies the restorative or protective action approach:*
R *= Restorative TMDL addressing a pathogen impairment identified in the 2018/2020 Integrated List of Waters*
R* *= Restorative TMDL addressing a historic impairment of former indicator bacteria for which no current applicable criteria are available See Section 2.3 of the core document for summary of water quality criteria and designated uses.*
P *= Protective TMDL addressing all applicable uses, regardless of impairment status, for the associated pathogen (refer to the Massachusetts SWQS: 314 CMR 4.00)*
Target TMDL or Total Maximum Daily Load is presented as both SWQS-Based and Flow-Based.
SWQS-Based TMDL Target *is the target concentration applicable to the TMDL pollutant indicator bacteria based on the Surface Water Quality Standards (314 CMR 4.00).*
Flow-Based Target TMD*L is the target concentration (CFU/100mL) multiplied by the standard flow volume (cubic feet per second or cfs). See Section 4.2.2 in core document for full equation and conversion factors.*
Maximum Geomean *is the highest calculated 30- or 90- day rolling geometric mean for TMDL pollutant indicator bacteria associated with the segment.*
Geomean Percent Reduction *is the percent reduction from the highest calculated 30- or 90- day rolling geomean needed to achieve the target concentration. Percent reductions are for planning purposes only.*

2. Cape Cod Watershed Overview

The Cape Cod watershed is a coastal river drainage area that covers 353 square miles (mi^2) in southeastern Massachusetts (Figure 2-1). Cape Cod lacks the characteristic mainstem rivers and associated tributary systems that are common among other watersheds in Massachusetts (MassDEP, 2002), and is instead composed of freshwater streams and few mainstem rivers that flow into numerous coastal embayments on Nantucket Sound, Cape Cod Bay or the Atlantic Ocean. The soil underlying Cape Cod is composed of unconsolidated glacial material such as sand, gravel and boulders, while the beaches were formed from debris released from melting glacial ice (MassDEP, 2002). Despite the small number of freshwater streams, there are numerous lakes and ponds on Cape Cod that were formed by receding glaciers, including many kettle holes. Groundwater is the most important freshwater resource on Cape Cod, and it is naturally low in nutrients and slightly acidic (MassDEP, 2002).

The Cape Cod watershed overlaps a portion of 15 municipalities in Massachusetts, of which 12 are completely contained within the watershed (Barnstable, Brewster, Chatham, Dennis, Eastham, Harwich, Mashpee, Orleans, Provincetown, Truro, Wellfleet, and Yarmouth). The majority of Falmouth and Sandwich and a small portion of Bourne are also within the watershed. See Figure 2-1 for a map showing impaired segments and watershed municipalities.

All municipalities in the watershed operate and maintain municipal separate storm sewer systems (MS4s) in urban areas except for the town of Wellfleet, which has an EPA-approved waiver, and the towns of Provincetown and Truro, which are not subject to MS4 regulations due to their small populations. The networks of drains and pipes in MS4 systems convey polluted runoff from streets and developed areas to waterbodies or to groundwater via infiltration. In addition, these networks are sometimes subject to direct wastewater inflows through illegal cross-connections, leaks from sewer pipes or septic systems, dumping, or other unauthorized wastewater sources, and together these are termed illicit discharges.

EPA and MassDEP jointly issued the General Permits for Stormwater Discharges from MS4s, which became effective on July 1, 2018, with modifications effective on January 6, 2021 (USEPA, 2020). Communities that discharge to pathogen-impaired waterbodies with approved TMDLs are required to implement enhanced best management practices (BMPs) for public education and designate the catchments as Problem Catchments or High Priority under the Illicit Discharge Detection and Elimination (IDDE) Program, in addition to the MS4 requirement to reduce pollutants to the Maximum Extent Practicable (USEPA, 2020).

The geographic range of one Regional Planning Agency (RPA) includes the Cape Cod watershed. RPAs are public organizations advising municipalities, private business groups, and state and federal governments on a range of matters. Their research, coordination and technical assistance are especially valuable on watershed issues such as pathogen pollutants and stormwater that cross town boundaries.

- Cape Cod Commission (CCC; CCC, 2022)

The following RPA initiatives and tools utilized in the Cape Cod watershed are especially noteworthy:

- One regional stormwater coalition operates within the CCC, the Cape Cod Stormwater Managers Group.
- CCC collaborated with MassDEP on a Section 604(b) project (Project #17-04) to create the Cape Cod Stormwater Coalition (CCSWC), a regional stormwater management entity designed to assist Cape Cod municipalities in meeting the requirements under the MS4 General Permit (MassDEP, 2021b).

Beyond these activities, the Massachusetts Statewide Municipal Stormwater Coalition (MSMSC), composed of about 10 stormwater groups around the state, further coordinates with and assists municipalities on pathogen pollutant concerns through their “Think Blue” campaign (Think Blue Massachusetts, 2019).

Additional watershed-scale initiatives are carried out by several organizations, including:

- **Association to Preserve Cape Cod** (APCC), whose mission is “to preserve, protect and enhance the natural resources of Cape Cod” (APCC, 2022).

- **Barnstable Clean Water Coalition** (BCWC), whose mission is "to restore and preserve clean water throughout Barnstable" (BCWC, 2022).
- **Cape Cod Groundwater Guardians** (CCGG), whose mission is "to raise awareness of our unconfined, sole-source aquifer and Cape Cod's community connection through water" (CCGW).
- **Cape Cod Trout Unlimited** (CCTU), whose mission is "coldwater conservation", has undertaken stream restorations on the Cape, including the Childs and Quashnet Rivers (CCTU, 2022).
- **Center for Coastal Studies** (CCS) is dedicated to "understanding, preserving and protecting marine ecosystems and the coastal environment through applied research, education and public policy initiatives" (CCS, 2022).
- **Massachusetts Office of Coastal Zone Management** (CZM) has a Regional office that "serves the coastal communities from Bourne to Provincetown, along with Martha's Vineyard, Nantucket, and the Elizabeth Islands" (CZM, 2022a).
- **State of the Waters: Cape Cod Report** (SOTW) is a multi-year project carried out by the APCC to inform the public about the conditions of waters on Cape Cod (SOTW, 2022).
- **U.S. Department of Agriculture's Natural Resource Conservation Service** (NRCS) began the $30 million Cape Cod Water Resources Restoration Project in 2010. The goal of this project was to "restore 1,500 acres of degraded salt marsh, improve fish access to 4,200 acres of spawning habitat, and improve water quality for 7,300 acres of shellfish beds over 10 years" (NRCS, 2022).

The following actions by identified stakeholders will help reduce pathogen loads to the impaired segments. The list represents a starting point and is not intended to be comprehensive. For a more detailed discussion of pollutant reduction actions, see Section 5, "Implementation" of the Pathogen TMDL core document.

- **Municipalities:** Continue to implement the MS4 permit, which includes specific requirements for waterbodies with an approved Bacteria/Pathogen TMDL, such as prioritization and reporting, enhanced BMPs, IDDE and education (USEPA, 2020).
- **Regional Planning Agencies (RPAs) and municipalities:** Continue and expand collaboration on MS4 and stormwater issues. Cooperatively develop tools and share knowledge to reduce costs, increase innovation, and generate consistent and effective stream restoration efforts at the watershed scale.
    - Two tools developed by the Metropolitan Area Planning Council (MAPC) are potentially valuable in all MS4 communities across the state; municipalities and other RPAs (with permission from MAPC) should consider adapting and/or expanding these tools in their area:
        - Stormwater Utility/Funding Starting Kit (MAPC, 2014); and
        - a GIS toolkit to calculate MS4 outfall catchments, which is a requirement under the MS4 General Permit, created by MAPC and the Neponset River Watershed Association (MAPC, 2018).
- **USDA NRCS and landowners:** Develop comprehensive nutrient management plans for agriculture, reaching farmers through local connections.
- **Parks departments, schools, private landowners, and others** who maintain large, mowed fields with direct connections to surface water should consider maintaining a vegetated buffer along the shoreline. Buffers slow and filter stormwater runoff, provide a visual screen that can discourage large aggregations of waterfowl, and offer many other water quality benefits at low cost.

Sanitary wastes associated with boating activities are a potential source of pathogens to surface waters. Since 2014, all Massachusetts waters are designated as a No-Discharge Zone (NDZ) in which the discharge of boat sewage is prohibited. Many free boat pump-out services are available at various sites along the coast, funded by the Clean Vessel Act. The Massachusetts CZM webpage maintains online maps of these boat pump-out facilities, and the Clean Vessel Act Program offers a *Boaters Pocket Guide to Pumpout Facilities* (CZM, 2022b). Any sewage discharges from boats or boating infrastructure in the waters covered by this TMDL are therefore illicit discharges.

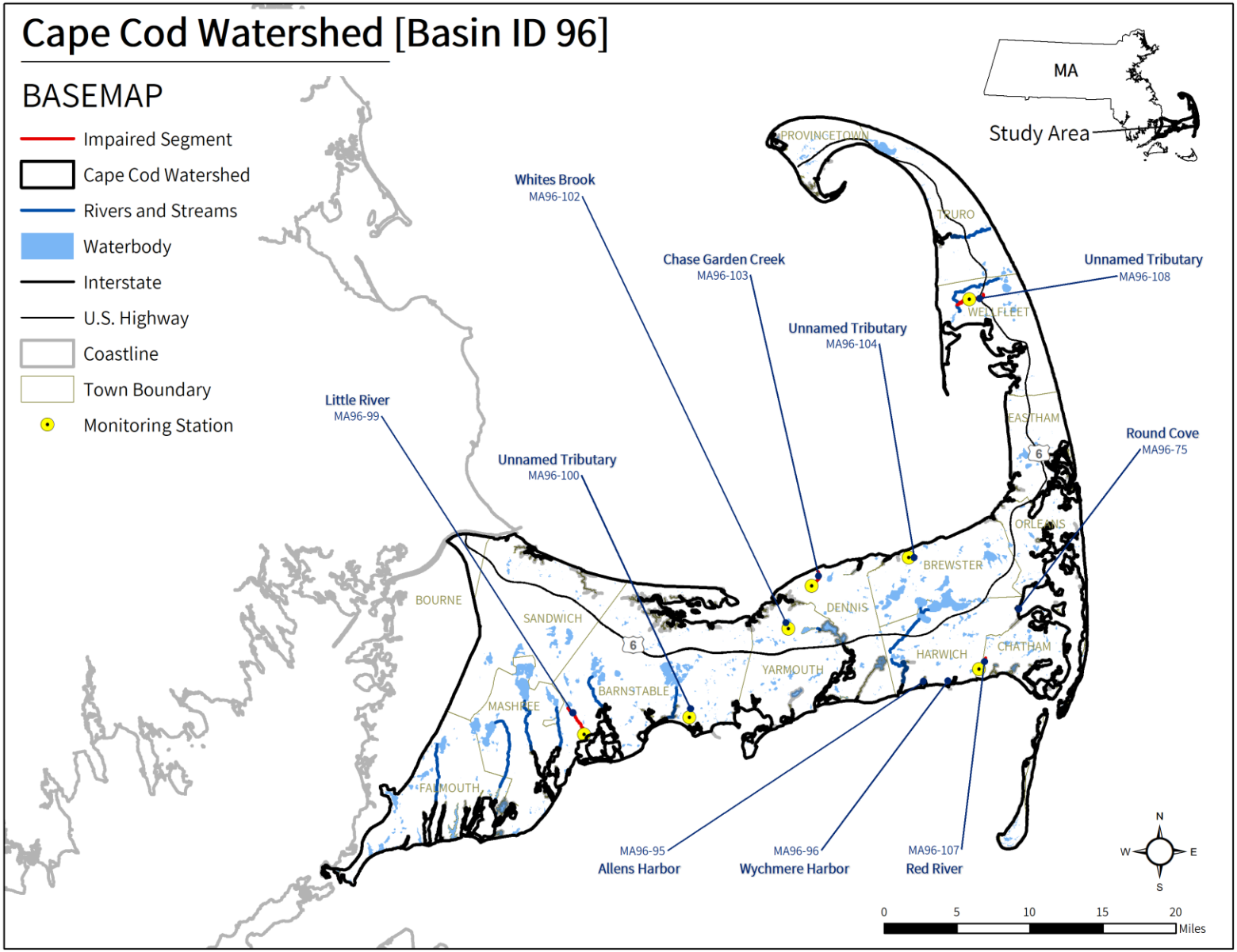


Figure 2-1: Map of all pathogen-impaired segments, water quality monitoring stations, municipal borders, waterbodies, and major roads in the Cape Cod watershed.

3. MA96-100 Unnamed Tributary

3.1. Waterbody Overview

The unnamed tributary segment MA96-100 is 0.5 miles long and begins at the headwaters south of the intersection of Old Craigville and Old Town roads in Barnstable, MA. The segment flows south to its confluence with the tidal portion of Halls Creek just south of Craigville Beach Road in Barnstable, MA.

There are no tributaries to the unnamed tributary segment MA96-100. There is one small waterbody, Dunns Pond, located in the central portion of the watershed. The majority of the stream flows through wetland areas.

Key landmarks in the watershed include Shaw's grocery store, Hyannis West Elementary School, Barnstable Intermediate School and Barnstable High School. Segment MA96-100 is crossed by only one road, Craigville Beach Road in Barnstable, MA.

The unnamed tributary (MA96-100) drains a total area of 1.0 square mile (mi^2), of which 0.3 mi^2 (28%) are impervious area. A 200-foot buffer around the segment covers an area of 0.041 mi^2, of which 0.003 mi^2 (7%) are impervious area. The watershed is partially served by a public sewer system in Barnstable[1], and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 3-1.

The watershed of unnamed tributary segment MA96-100 is located in a highly-developed part of Massachusetts; more than half of the watershed consists of developed area (52%). The remaining areas consist of forest and natural lands (43%) and wetland areas (5%). There is no agriculture in this watershed. Most of the development is residential, except for the central watershed area

Reduction from Highest Calculated Geomean: 70%

Watershed Area (Acres): 638

Segment Length (Miles): 0.5

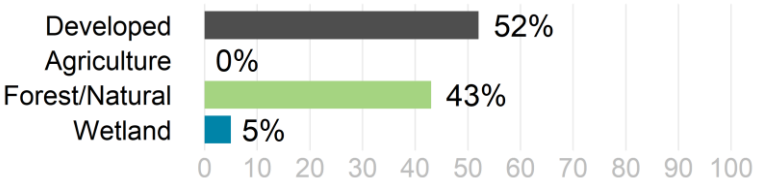
200-foot Buffer Area (Acres): 26

Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 179 (28%)

Impervious Area Within 200-foot Buffer (Acres, %): 2 (7%)

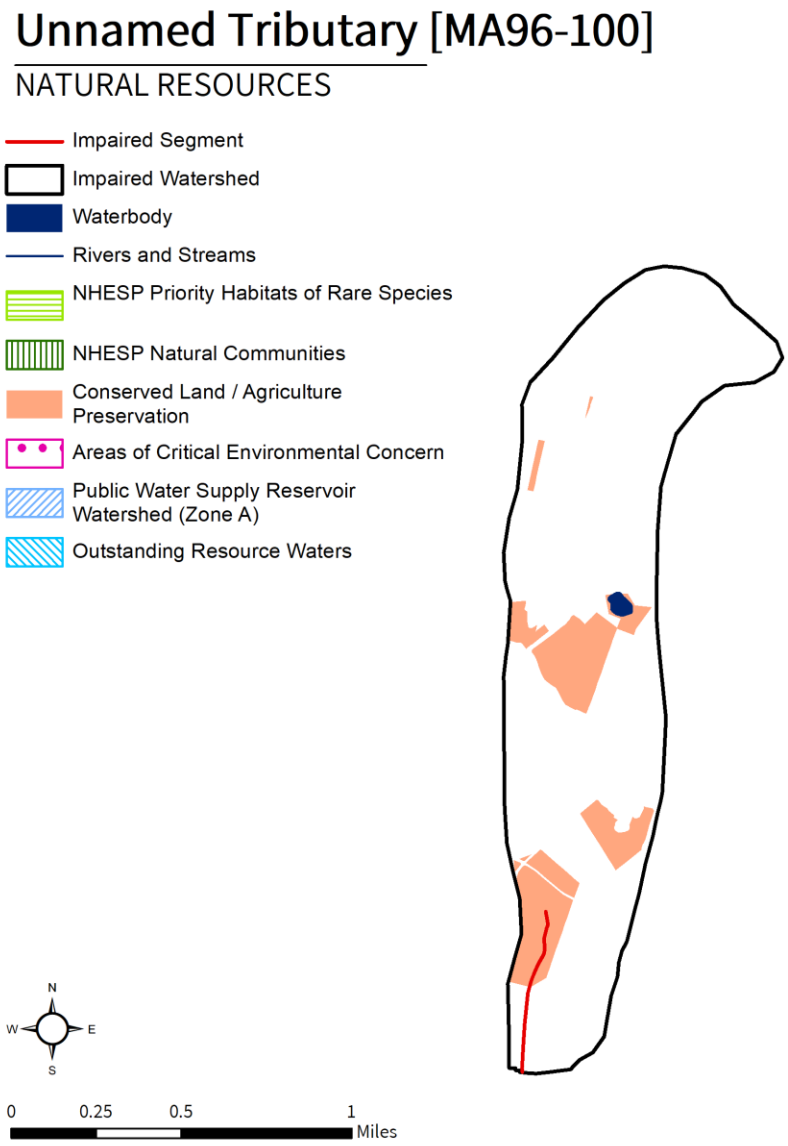


[1] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

which consists of commercial areas and several school campuses.

In the unnamed tributary (MA96-100) watershed, under the Natural Heritage and Endangered Species Program, there are no acres identified within Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 39 acres (6%) of land protected in perpetuity[2], part of 85 acres (13%) of Protected and Recreational Open Space[3]. See Figure 3-1.

[2] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[3] All Protected and Recreational Open Space land is shown on the natural resources map.



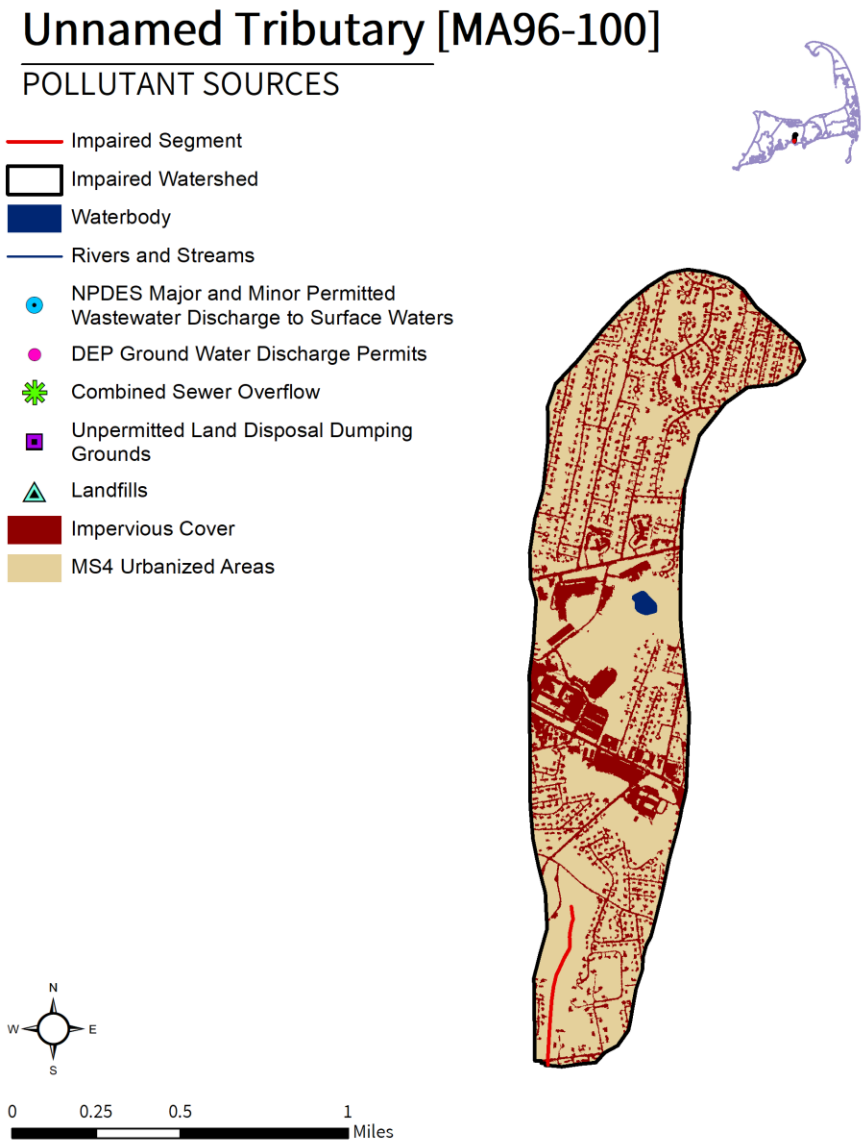


Figure 3-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA96-100. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

3.2. Waterbody Impairment Characterization

The unnamed tributary (MA96-100) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 3-1, 3-2; Figure 3-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1914; data indicated three days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, two exceeded the STV criterion, one during wet weather and one during dry weather.

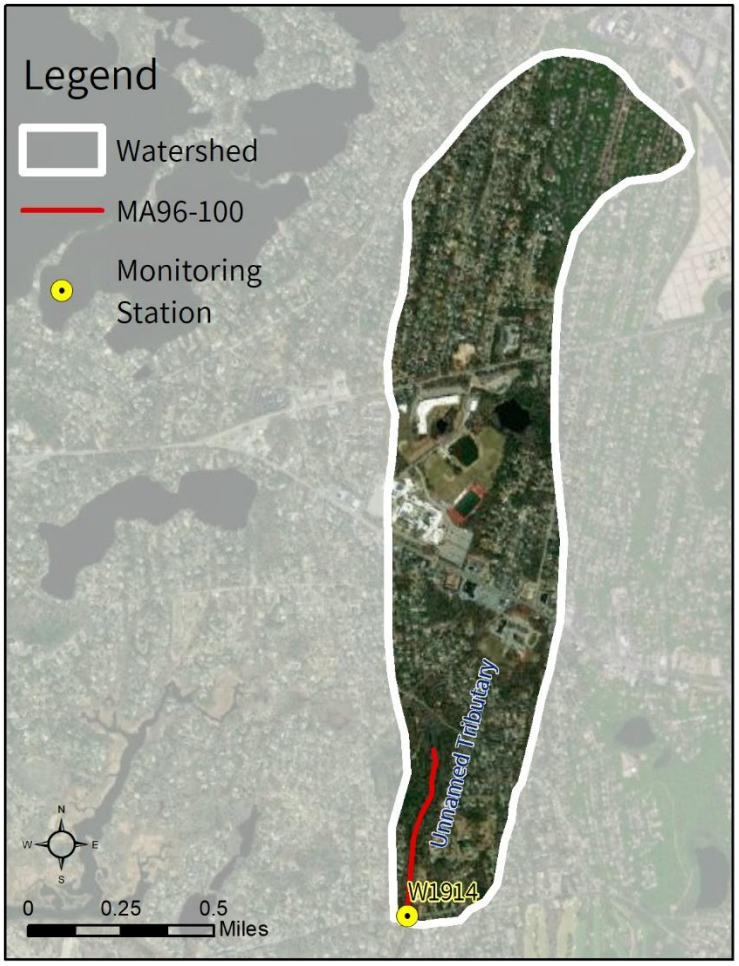


Figure 3-2. Location of monitoring station(s) along the impaired segment.

Table 3-1. Summary of indicator bacteria sampling results by station for the unnamed tributary (MA96-100). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1914	5/19/2009	10/6/2009	6	417	3	2

Table 3-2. Indicator bacteria data by station, indicator, and date for the unnamed tributary (MA96-100). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1914	*E. coli*	5/19/2009	DRY	20	20	
W1914	*E. coli*	6/23/2009	WET	610	110	
W1914	*E. coli*	7/28/2009	DRY	130	117	
W1914	*E. coli*	8/13/2009	DRY	1,900	234	
W1914	*E. coli*	9/1/2009	WET	200	417	
W1914	*E. coli*	10/6/2009	WET	220	323	

3.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for unnamed tributary (MA96-100) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: The watershed is highly developed (52%), and most development consists of residential areas with some commercial areas as well. Within the watershed, 100% of the land area is subject to MS4 permit conditions, 28% is classified as impervious area, and 7% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is likely a substantial a source of pathogens.

Illicit Sewage Discharges: Public sewer service is partially available in the watershed within the town of Barnstable. Sewer-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Land use maps indicate no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: The MA96-100 segment watershed is highly residential, and includes ballfields and sports fields adjacent to the schools in the central watershed. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The wetland areas adjacent to the impaired segment are mostly forested wetlands, meaning they are unlikely to attract waterfowl because they lack open sightlines to water. However, the sports fields located further north into the headwaters may attract waterfowl. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

3.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Barnstable

The majority of Barnstable is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041090), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. According to its 2020 (year two) MS4 annual report, Barnstable has completed an illicit discharge detection and elimination (IDDE) plan, and has updated but not yet adopted post-construction stormwater regulations; it did not specify whether an erosion and sedimentation control (ESC) plan had been developed. MS4 receiving waters impaired by fecal coliform are reported as Hyannis Inner Harbor (MA96-82, 14 outfalls), Centerville River (MA96-04, five outfalls), Maraspin Creek (MA96-06, 11 outfalls), Halls Creek (MA96-93, two outfalls), Snows Creek (MA96-81, one outfall), Bumps River (MA96-02, two outfalls), Barnstable Harbor (MA96-01, one outfall), North Bay (MA96-66, one outfall), Hyannis Harbor (MA96-05, one outfall), and Mill Creek (MA96-37, one outfall).

Barnstable has the following ordinances and bylaws, mostly accessible online via the town website https://town.barnstable.ma.us/ (Town of Barnstable, 2021):

- Wetland protection ordinance
- Stormwater Utility: None found
- Pet Waste: None found

Barnstable has a Local Comprehensive Plan, first published in 2010, and updated in 2020. This plan includes a section on natural resources, with objectives aimed at conserving existing water resources. Within this section there is a sub-section about stormwater and goals to prevent stormwater runoff. These goals include reducing bacteria from animal waste and adopting a sewer-neutral policy. Additionally, Barnstable has an Open Space and Recreation Plan, published in 2018, which includes a more extensive inventory of water resources within the town. All of these documents are available through the town's website, https://town.barnstable.ma.us/ (Town of Barnstable, 2021).

4. MA96-102 Whites Brook

4.1. Waterbody Overview

Whites Brook segment MA96-102 is 0.3 miles long and begins in the channelized wetland south of Main St/Route 6A in Yarmouth, MA. The segment flows generally north before becoming tidal north of Route 6A in Yarmouth, MA.

There are no tributaries to Whites Brook segment MA96-102. Lakes and ponds in the watershed include Greenaugh Pond, Perch Pond, and Elishas Pond. Much of the tributary flows through wetland areas.

Key landmarks in the watershed include the northern tip of Bayberry Hills Golf course, located in the southernmost part of the watershed, as well as Camp Greenough and Fred Thacher Church Street Playground. Segment MA96-102 is crossed only by Main St/Route 6A in Yarmouth.

Whites Brook (MA96-102) drains a total area of 1.2 square miles (mi^2), of which 0.2 mi^2 (15%) are impervious area. A 200-foot buffer around the segment covers an area of 0.027 mi^2, of which 0.002 mi^2 (7%) are impervious area. The watershed is not currently served by a public sewer system[4], and 54% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 4-1.

The Whites Brook segment MA96-102 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (60%) and 15% is wetland. Developed area, composing 25% of the watershed, consists primarily of residential areas with some commercial development along Route 6A. There is no agricultural land in the watershed.

Reduction from Highest Calculated Geomean: 71

Watershed Area (Acres): 733

Segment Length (Miles): 0.3

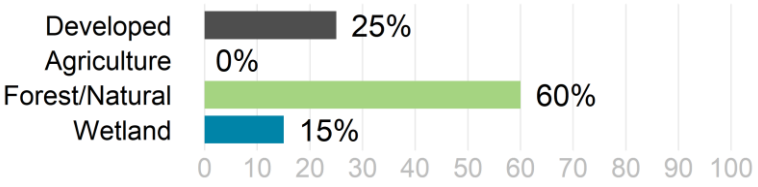
200-foot Buffer Area (Acres): 18

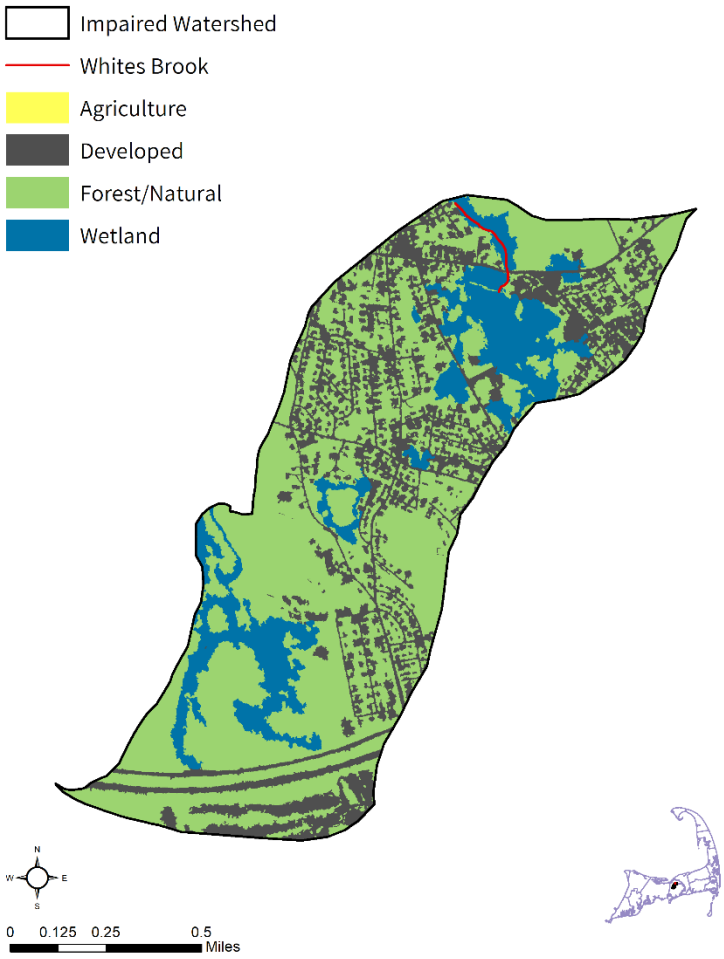
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 108 (15%)

Impervious Area Within 200-foot Buffer (Acres, %): 1 (7%)

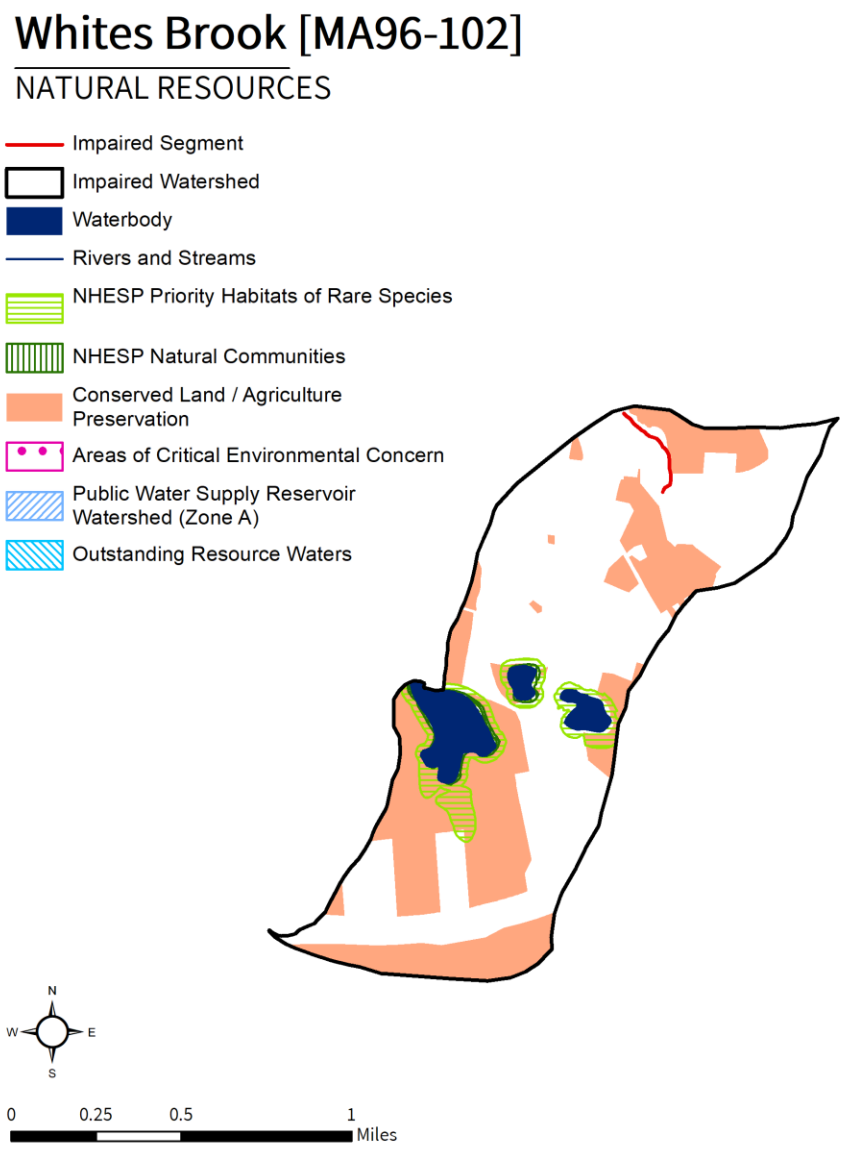




[4] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

In the Whites Brook (MA96-102) watershed, under the Natural Heritage and Endangered Species Program, there are 73 acres (10%) of Priority Habitats of Rare Species, and 10 acres (1%) of Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 124 acres (17%) of land protected in perpetuity[5], part of 256 acres (35%) of Protected and Recreational Open Space[6]. See Figure 4-1.

[5] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[6] All Protected and Recreational Open Space land is shown on the natural resources map.



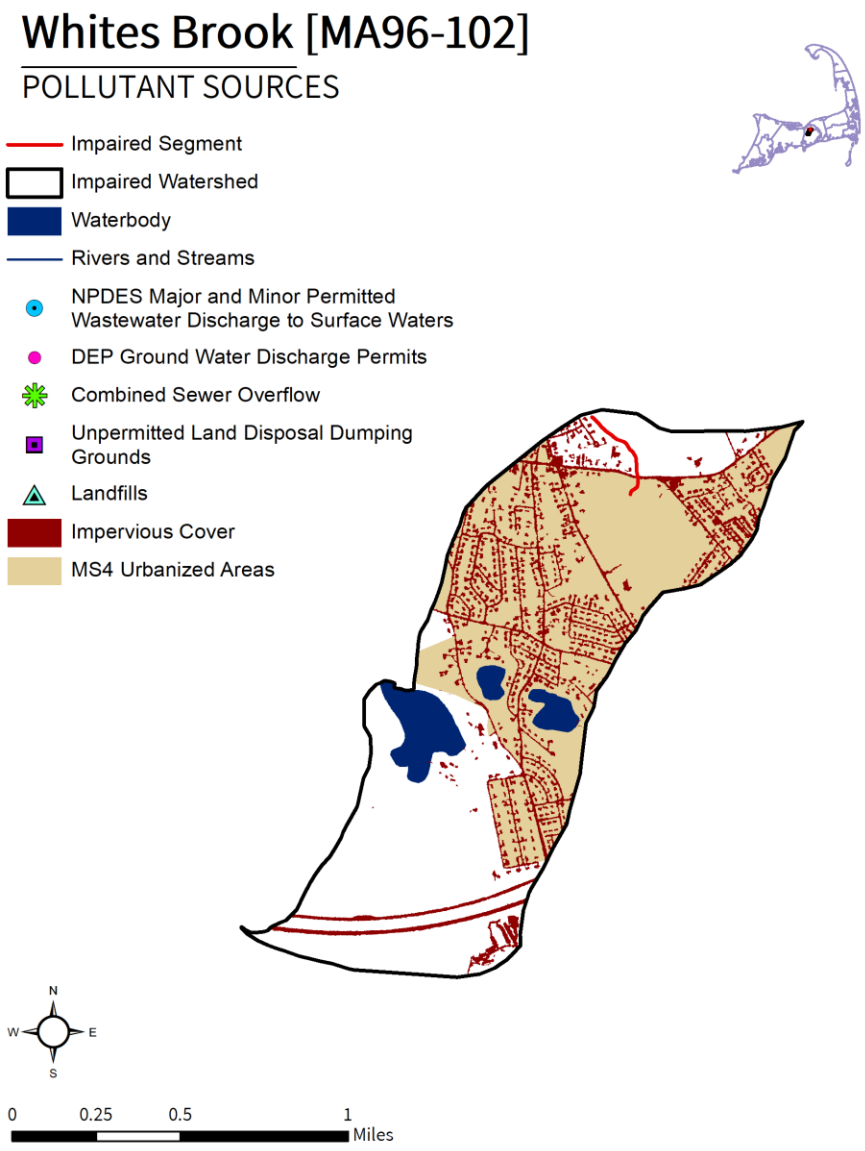


Figure 4-1. Natural resources and potential pollution sources draining to the Whites Brook segment MA96-102. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

4.2. Waterbody Impairment Characterization

Whites Brook (MA96-102) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 4-1, 4-2; Figure 4-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli.* The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1924; data indicated four days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, two exceeded the STV criterion, one during wet weather and one during dry weather.

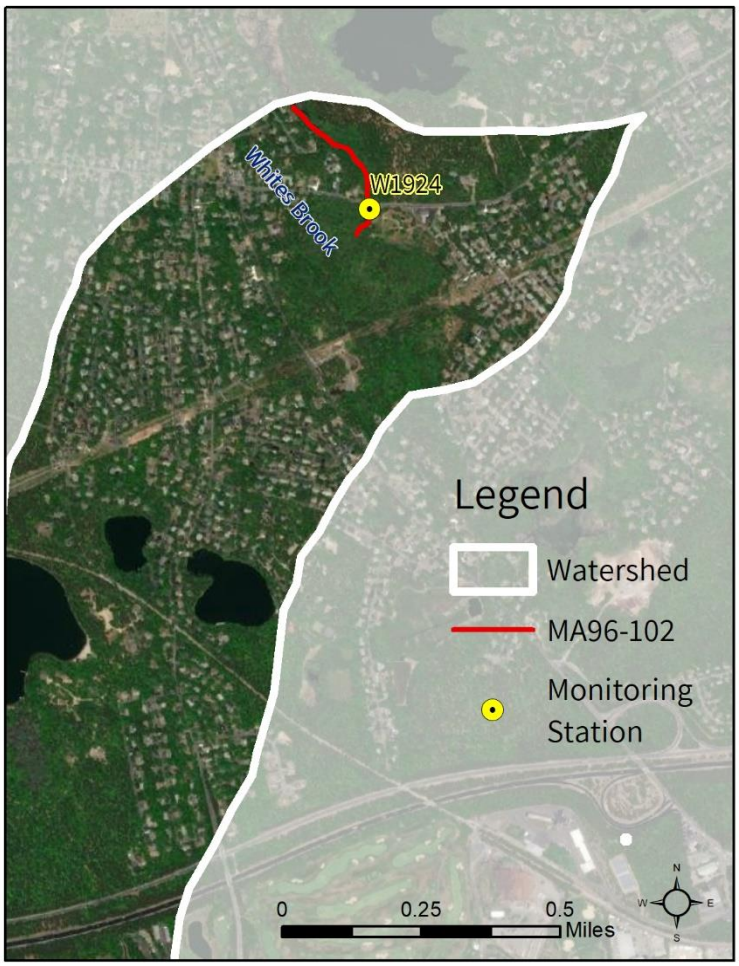


Figure 4-2. Location of monitoring station(s) along the impaired segment.

Table 4-1. Summary of indicator bacteria sampling results by station for Whites Brook (MA96-102). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1924	5/19/2009	10/6/2009	6	439	4	2

Table 4-2. Indicator bacteria data by station, indicator, and date for Whites Brook (MA96-102). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1924	*E. coli*	5/19/2009	DRY	10*	10	
W1924	*E. coli*	6/23/2009	WET	2,200	148	
W1924	*E. coli*	7/28/2009	DRY	70	115	
W1924	*E. coli*	8/13/2009	DRY	1,100	203	
W1924	*E. coli*	9/1/2009	WET	220	439	
W1924	*E. coli*	10/6/2009	WET	170	232	

* Value below the Method Detection Limit (MDL) of 10 CFU/100mL; the MDL is reported and used to calculate the geometric means for *E. coli*.

4.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Whites Brook (MA96-102) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (25%), most of which consists of residential areas with some commercial zones as well. Within the watershed, 54% of the land area is subject to MS4 permit conditions, 15% is classified as impervious area, and 7% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is not currently available in the watershed within the town of Yarmouth. As a result, sewerage-related risks to water quality are not a likely source of pathogens.

On-Site Wastewater Disposal Systems: All of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: According to land use maps, there is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhoods and a park near the Whites Brook segment MA96-102. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: The wetland areas adjacent to the impaired segment are mostly forested wetlands, meaning they are unlikely to attract waterfowl due to lack of open sightlines to water. However, there are some large mowed areas (mostly residential). Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

4.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Yarmouth

The majority of Yarmouth is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041176), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2009, Yarmouth completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the town's NOI, fecal coliform-impaired MS4 receiving waters include eight stormwater outfalls into the Bass River (MA96-12), one outfall into Chase Garden Creek (MA96-35), two outfalls into Hyannis Inner Harbor (MA96-82), one outfall into Lewis Bay (MA96-36), one outfall into Mill Creek (MA96-80), one additional outfall into Mill Creek (MA96-37), and one outfall into Parker's River (MA96-38).

Yarmouth has the following ordinances and bylaws, mostly accessible online via the town website https://www.yarmouth.ma.us/ (Town of Yarmouth, 2021):

- Stormwater control bylaws
- Wetland protection bylaws
- Pet waste control bylaw
- Stormwater Utility: None found

Yarmouth has a Local Comprehensive Plan originally developed in 2001 and updated in 2015. This plan has a section about water resources within the town and how to properly plan for the conservation and continued use of these resources, including limiting stormwater run-off and nonpoint source pollutants. Yarmouth does not have a municipal sewage system. The town also has a 2015 Open Space and Recreation Plan, which features an updated inventory and analysis of water resources within the town, and sections on stormwater and wastewater impacts (Town of Yarmouth, 2021).

5. MA96-103 Chase Garden Creek

5.1. Waterbody Overview

Chase Garden Creek segment MA96-103 is 1.2 miles long and begins south of Roads End and west of Jericho Road in Dennis, MA. The segment flows generally south, south before ending at New Boston Road in Dennis, MA.

There is one unnamed tributary to Chase Garden Creek entering from the eastern side of the watershed near Hope Lane. There is one small unnamed pond in the watershed, near the junction of Elm Street with Main Street/Route 6A. Much of the river flows through wetland areas.

Key landmarks in the watershed include the Cape Cod Museum of Art, part of the Dennis Village Cemetery, the Cape Playhouse Theater, and the 1736 Josiah Dennis Manse Museum. From upstream to downstream, segment MA96-103 is crossed by an unnamed road once, Scarsdale Road three times, Whig Street twice, Hope Lane, Nobscussett Road, Beach Street, and New Boston Road at the segment end, all in Dennis, MA.

Chase Garden Creek (MA96-103) drains a total area of 0.6 square miles (mi^2), of which 0.1 mi^2 (18%) are impervious area. A 200-foot buffer around the segment covers an area of 0.096 mi^2, of which 0.008 mi^2 (8%) are impervious area. The watershed is not currently served by public sewer[7], and 67% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 5-1.

The Chase Garden Creek segment MA96-103 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (59%) and 9% consists of wetland areas. The remainder of the watershed is covered by development (31%) and agricultural activity (1%). Most of the development consists of residential

Reduction from Highest Calculated Geomean: 81%

Watershed Area (Acres): 392

Segment Length (Miles): 1.2

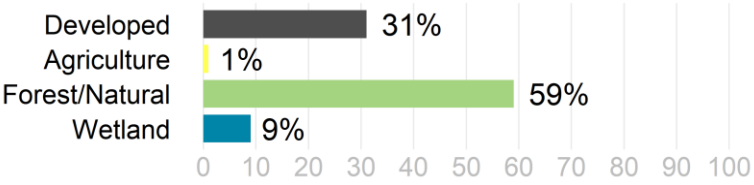
200-foot Buffer Area (Acres): 61

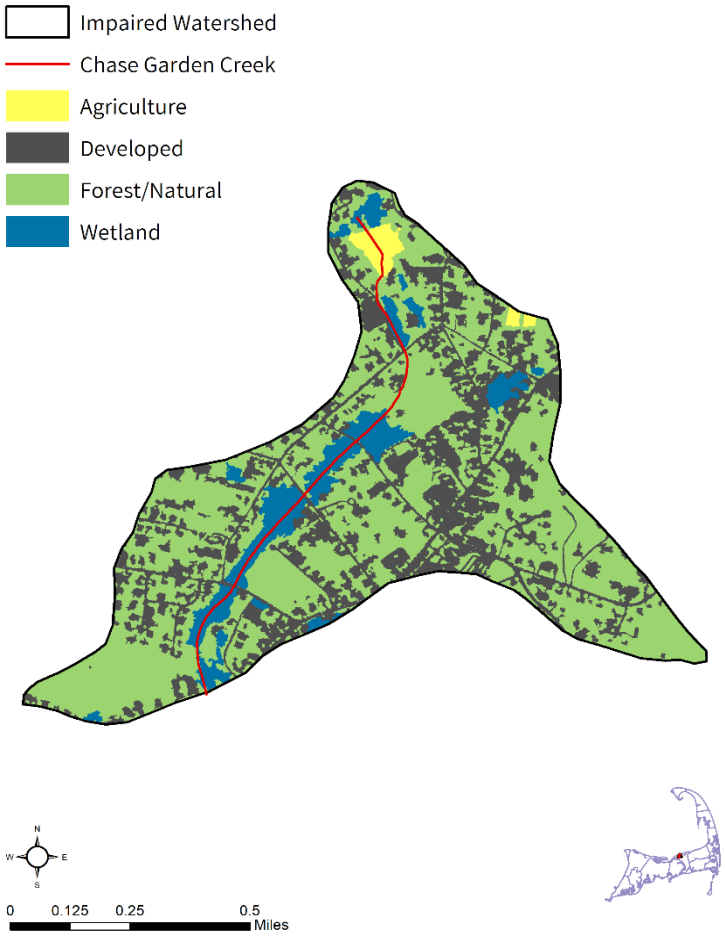
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 71 (18%)

Impervious Area Within 200-foot Buffer (Acres, %): 5 (8%)



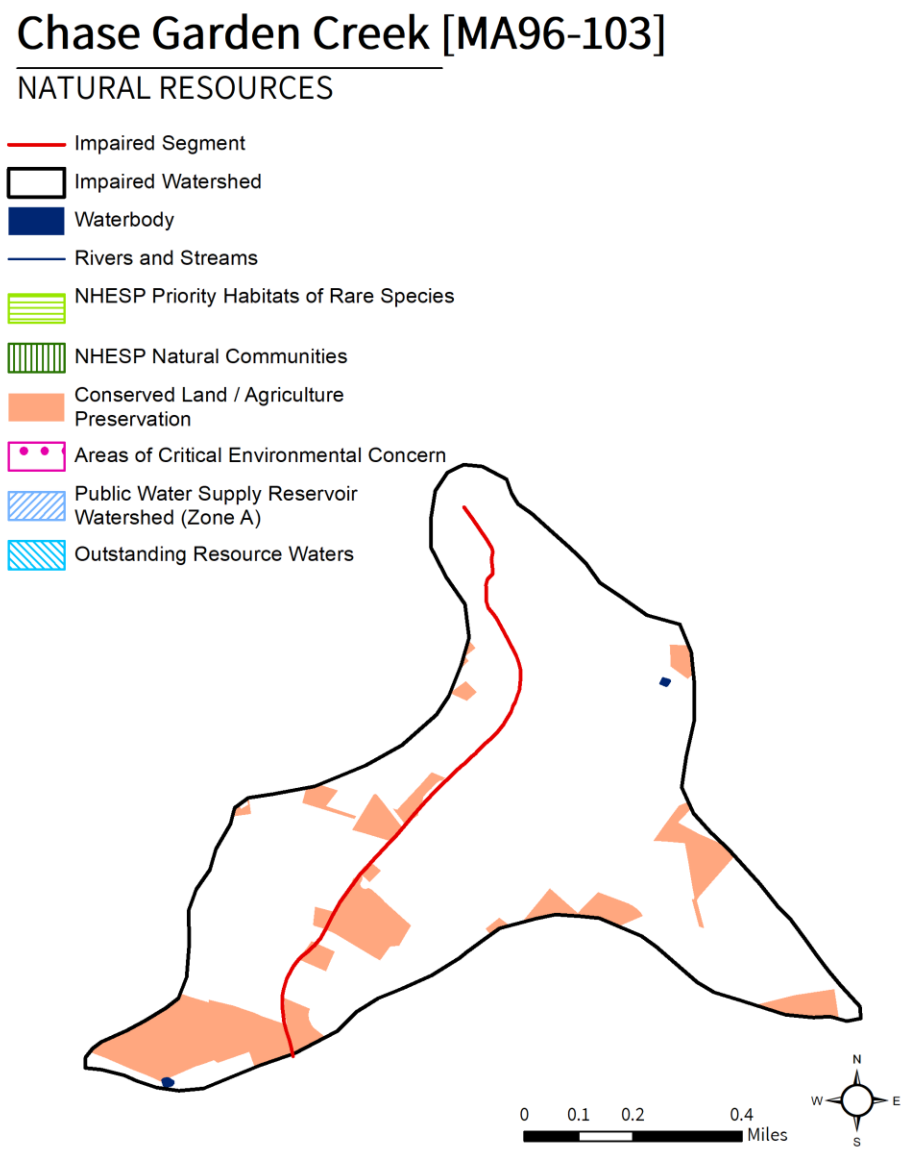


[7] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

areas with some commercial development along Route 6A/Main Street. The agricultural activity consists of cranberry bogs located directly along the impaired segment in the northern portion of the watershed and small pasture/hay fields at the northeastern edge of the watershed.

In the Chase Garden Creek (MA96-103) watershed, under the Natural Heritage and Endangered Species Program, there are no acres identified within Priority Habitats of Rare Species or Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 48 acres (12%) of land protected in perpetuity[8], part of 56 acres (14%) of Protected and Recreational Open Space[9]. See Figure 5-1.

[8] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[9] All Protected and Recreational Open Space land is shown on the natural resources map.



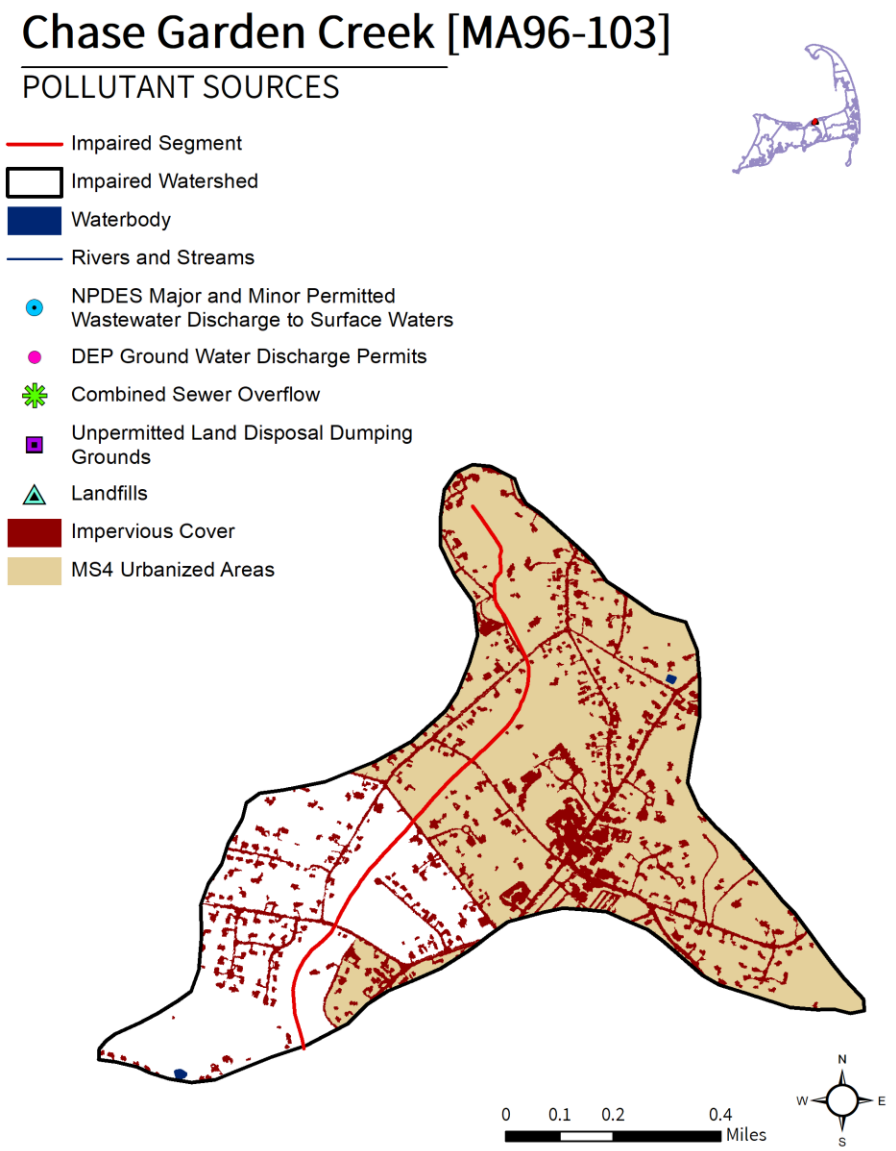


Figure 5-1. Natural resources and potential pollution sources draining to the Chase Garden Creek segment MA96-103. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

5.2. Waterbody Impairment Characterization

Chase Garden Creek (MA96-103) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 5-1, 5-2; Figure 5-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli.* The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1923; data indicated six days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, two exceeded the STV criterion, one during wet weather and one during dry weather.

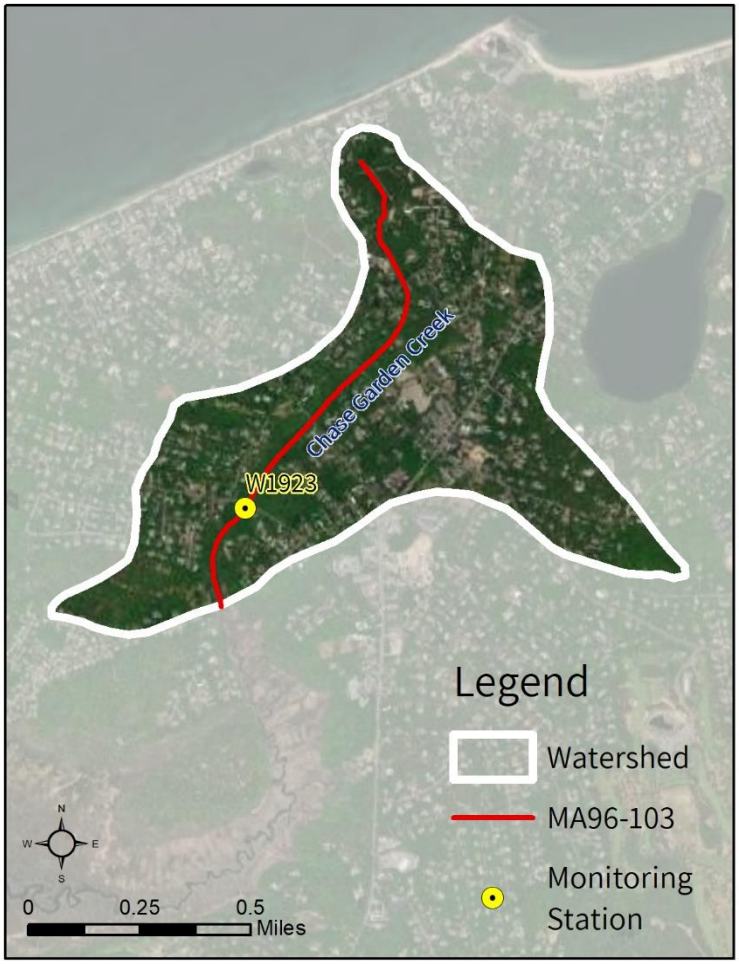


Figure 5-2. Location of monitoring station(s) along the impaired segment.

Table 5-1. Summary of indicator bacteria sampling results by station for Chase Garden Creek (MA96-103). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1923	5/19/2009	10/6/2009	6	648	6	2

Table 5-2. Indicator bacteria data by station, indicator, and date for Chase Garden Creek (MA96-103). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1923	*E. coli*	5/19/2009	DRY	350	350	
W1923	*E. coli*	6/23/2009	WET	1,200	648	
W1923	*E. coli*	7/28/2009	DRY	120	369	
W1923	*E. coli*	8/13/2009	DRY	1,500	524	
W1923	*E. coli*	9/1/2009	WET	210	461	
W1923	*E. coli*	10/6/2009	WET	81	235	

5.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Chase Garden Creek (MA96-103) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a fairly large amount of development in the watershed (31%), most of which consists of residential areas with some commercial development as well. Within the watershed, 67% of the land area is subject to MS4 permit conditions, 18% is classified as impervious area, and 8% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is not currently available in the watershed within the town of Dennis. As a result, sewerage-related risks to water quality are not likely source of pathogens.

On-Site Wastewater Disposal Systems: All of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a relatively small portion (1%) of the total land use, however, a cranberry bog is located directly adjacent to a northern stretch of the segment.

Pet Waste: There are many residential neighborhoods in the Chase Garden Creek segment MA96-103 watershed, as well as a cemetery and dog park near the southern reaches of the segment and some conserved

lands directly adjacent to the segment. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment in the southern portion of the watershed, as well as several large agricultural fields in the northern portion of the watershed. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

5.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Dennis

The majority of Dennis is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041103), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 90% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Dennis completed an illicit discharge detection and elimination (IDDE) plan in 2019, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2009. According to the NOI, Dennis has five waterbodies impaired by fecal coliform: Bass River (MA96-12, four outfalls), Swan Pond River (MA96-14, two outfalls), Sesuit Creek (MA96-13, one outfall), Chase Garden Creek (MA96-35, one outfall), and Quivett Creek (MA96-09, one outfall).

Dennis has the following ordinances and bylaws, mostly accessible online via the town website https://www.town.dennis.ma.us/ (Town of Dennis, 2021):

- Wetland protection bylaw
- Stormwater and stormwater utility fee bylaw
- Pet waste removal bylaw

Dennis has a dated Comprehensive Plan (2002) with sections on natural resources and their protection. There is a specific section about water resources (pg. 38), which states that the municipal water supply provides drinking water to the entire town (pg. 38). This section also includes an analysis of future water usage (pg. 40), and stormwater concerns (pg. 60). Dennis also has an Open Space and Recreation Plan (2020) which describes water-based resources in the town (pg. 28) and identifies mitigating untreated stormwater runoff as a goal (pg. 83) (Town of Dennis, 2021).

6. MA96-104 Unnamed Tributary

6.1. Waterbody Overview

The unnamed tributary segment MA96-104 is 0.6 miles long and begins at the outlet of a channelized wetland south of Lower Road in Brewster, MA. The segment flows west before its outlet to Freemans Pond in Brewster, MA.

There are a few unnamed tributaries to segment MA96-104. Lakes and ponds within the watershed consist of Schoolhouse Pond and several small unnamed waterbodies. Much of the segment flows through wetland areas.

Key landmarks in the watershed include the Brewster Fire Department, Shady Knoll Campground, and the Sweetwater Forest Cape Cod Family Campground. From upstream to downstream, segment MA96-104 is crossed by Fiddlers Lane, Brier Lane, and Lower Road, all in Brewster, MA.

The unnamed tributary (MA96-104) drains a total area of 1.5 square miles (mi^2), of which 0.2 mi^2 (11%) are impervious area. A 200-foot buffer around the segment covers an area of 0.049 mi^2, of which 0.004 mi^2 (8%) are impervious area. The watershed is not served by public sewer systems[10], and 75% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, two MassDEP discharge-to-groundwater permits for on-site wastewater discharge, and no combined sewer overflows (CSOs) within the watershed (Tables 6-1). There are also no landfills or unpermitted land disposal dumping grounds. See Figure 6-1.

The unnamed tributary segment MA96-104 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed is forest and natural lands (66%) and 14% consists of wetland areas. The remainder of the watershed is primarily covered by development (20%), and there is very little agricultural activity (<1%). Most of the development consists of residential areas with

Reduction from Highest Calculated Geomean: 73%

Watershed Area (Acres): 976

Segment Length (Miles): 0.6

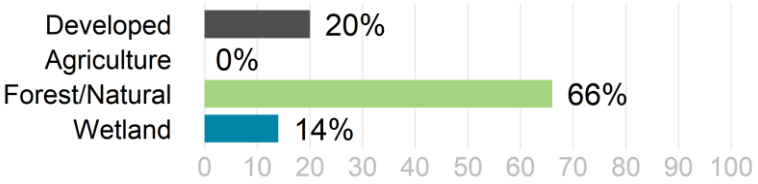
200-foot Buffer Area (Acres): 31

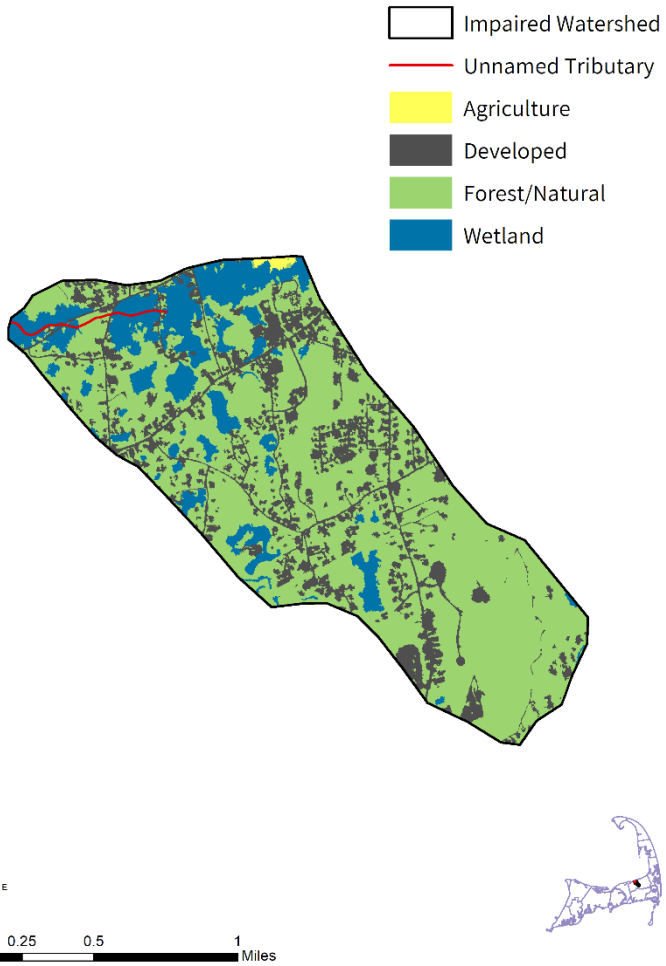
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 103 (11%)

Impervious Area Within 200-foot Buffer (Acres, %): 2 (8%)





[10] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

some commercial activity along Route 6A. Agriculture consists of the Brewster Community Garden in the northeast tip of the watershed.

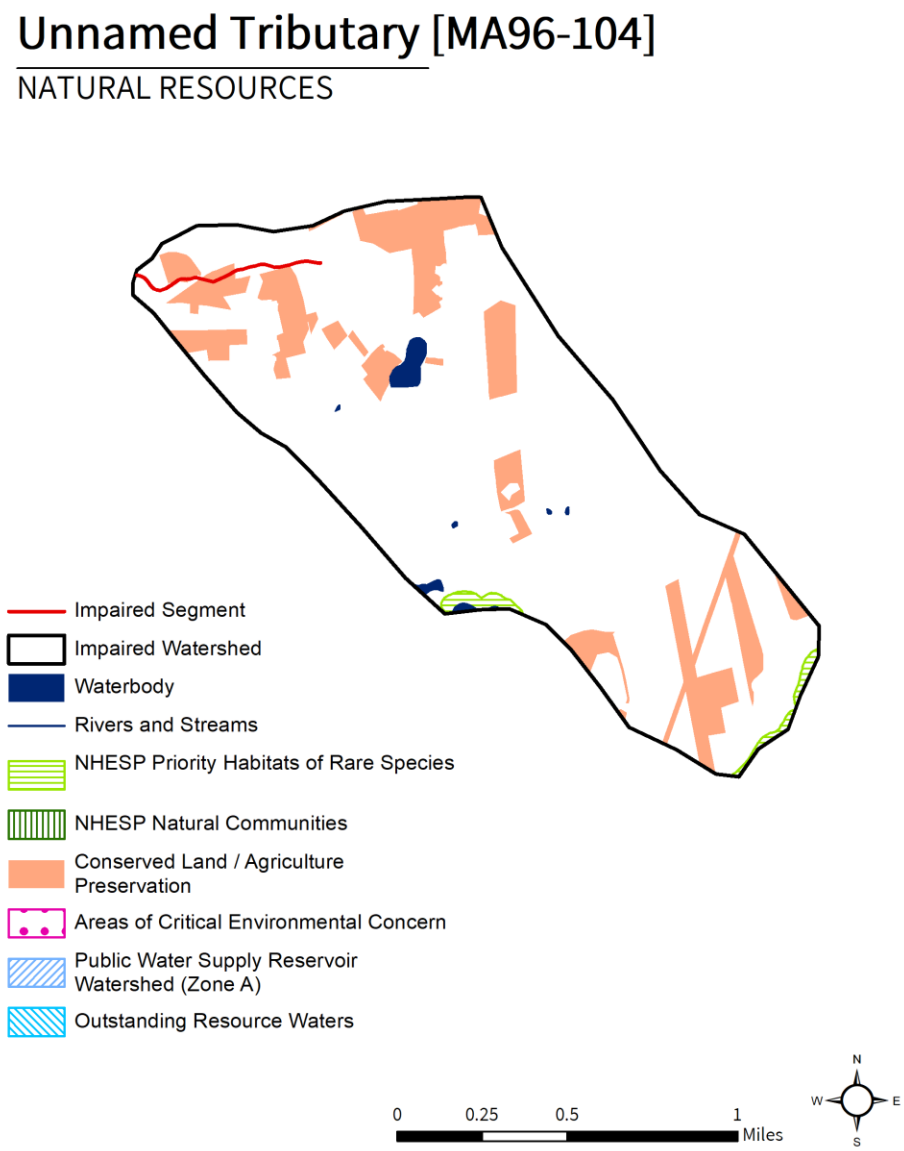
In the unnamed tributary (MA96-104) watershed, under the Natural Heritage and Endangered Species Program, there are 11 acres (1%) of Priority Habitats of Rare Species and none as Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 156 acres (16%) of land protected in perpetuity[11], part of 166 acres (17%) of Protected and Recreational Open Space[12]. See Figure 6-1.

Table 6-1. Groundwater discharge permits in the segment watershed. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
599-3	BREWSTER MANOR	BREWSTER	Sanitary Discharge	32,000
951-0	MAPLEWOOD AT BREWSTER	BREWSTER	Sanitary Discharge	19,800

[11] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.

[12] All Protected and Recreational Open Space land is shown on the natural resources map.



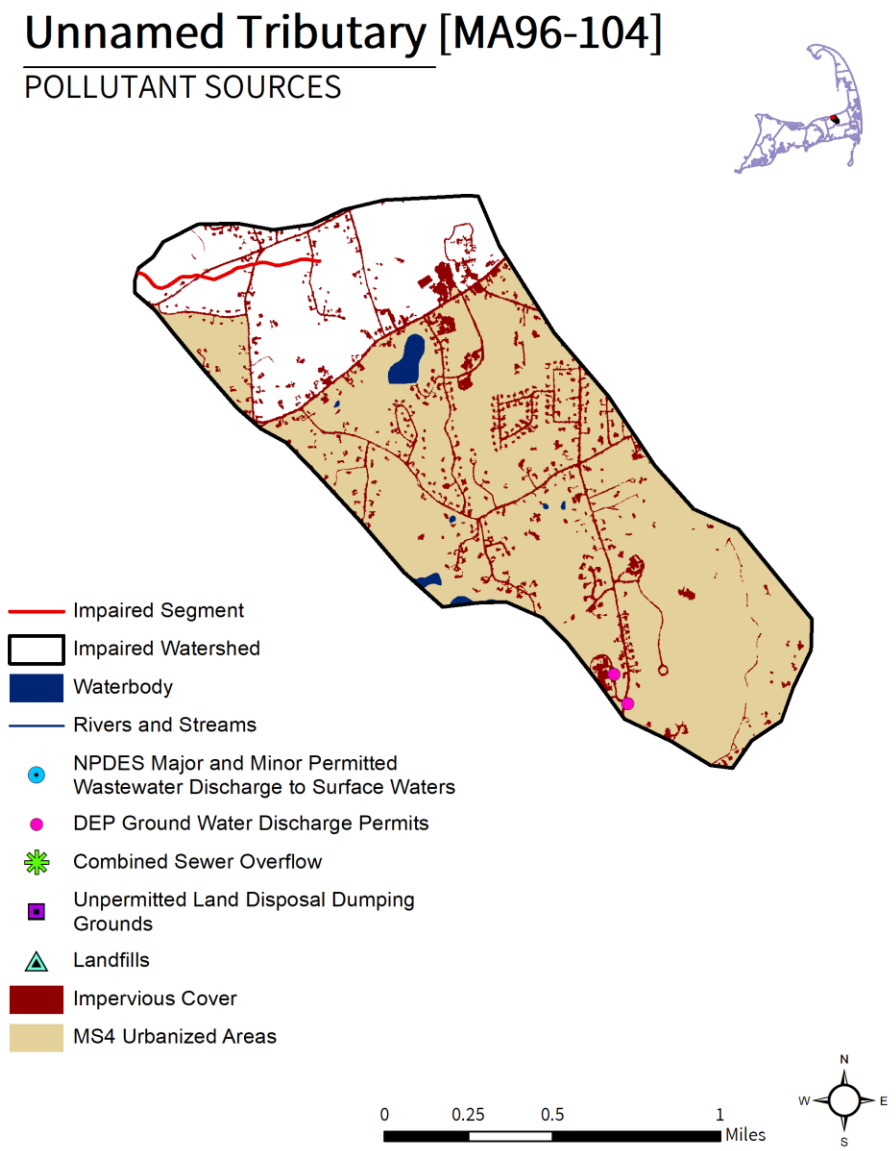


Figure 6-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA96-104. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

6.2. Waterbody Impairment Characterization

The unnamed tributary (MA96-104) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 6-2, 6-3; Figure 6-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1921; data indicated five days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, three exceeded the STV criterion, two during wet weather and one during dry weather.

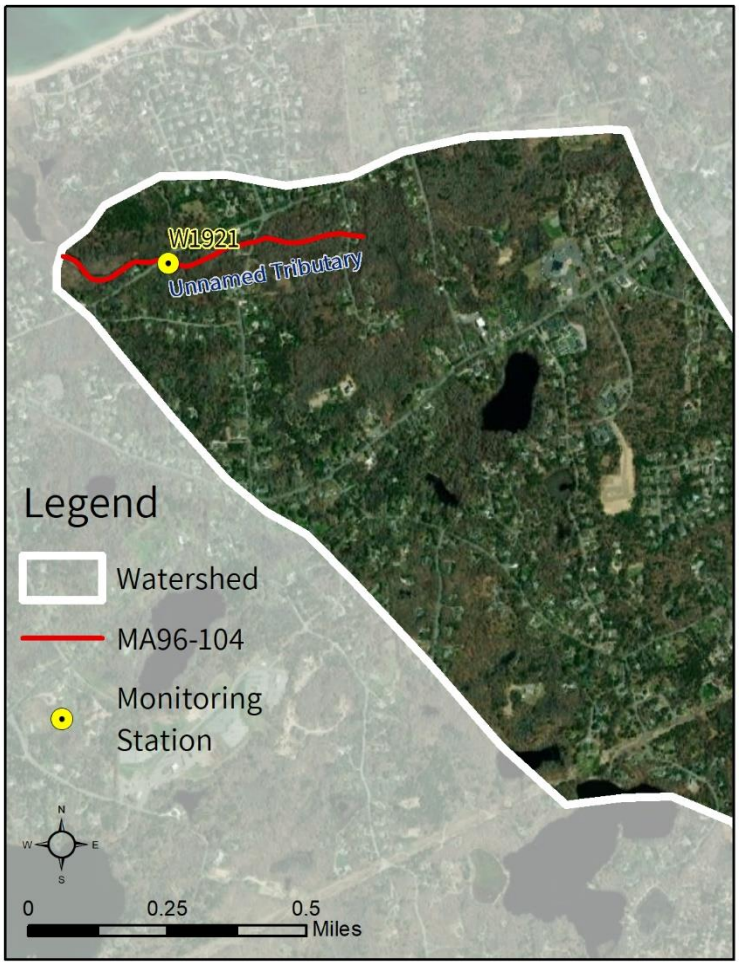


Figure 6-2. Location of monitoring station(s) along the impaired segment.

Table 6-2. Summary of indicator bacteria sampling results by station for the unnamed tributary (MA96-104). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1921	5/19/2009	10/6/2009	6	469	5	3

Table 6-3. Indicator bacteria data by station, indicator, and date for the unnamed tributary (MA96-104). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1921	*E. coli*	5/19/2009	DRY	40	40	
W1921	*E. coli*	6/23/2009	WET	420	130	
W1921	*E. coli*	7/28/2009	DRY	240	159	
W1921	*E. coli*	8/13/2009	DRY	1,000	252	
W1921	*E. coli*	9/1/2009	WET	480	469	
W1921	*E. coli*	10/6/2009	WET	280	424	

6.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for unnamed tributary (MA96-104) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (20%), most of which consists of residential areas with some commercial activity as well. Within the watershed, 75% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 8% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is not currently available in the watershed within the town of Brewster. As a result, sewerage-related risks to water quality are not likely source of pathogens.

On-Site Wastewater Disposal Systems: All of the development in the watershed utilizes on-site systems for wastewater treatment. There are also two MassDEP permits for on-site wastewater discharges to groundwater. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a very small portion (<1%) of the total land use, represented entirely by the small Brewster Community Garden, located in the northeast corner of the watershed. It is unlikely agriculture is a source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhoods and conservation land with trails near the unnamed tributary segment MA96-104, as well as several campgrounds within the watershed. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment in the downstream reaches of the segment, as well as a few large mowed areas in the watershed. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

6.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Brewster

The majority of Brewster is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041096), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Brewster completed an illicit discharge detection and elimination (IDDE) plan in 2011 but has not completed an erosion and sedimentation control (ESC) plan, or the required post-construction stormwater regulations. According to the town's NOI none of the receiving waters within the MS4 area are impaired; however, the NOI did not identify the Brewster waterbodies known to be pathogen-impaired with TMDLs, including Quivett Creek (MA96-09) and Namskaket Creek (MA96-27) (MassDEP, 2009).

Brewster has the following ordinances and bylaws, mostly accessible online via the town website https://www.brewster-ma.gov/ (Town of Brewster, 2021):

- Wetland protection ordinance
- Stormwater ordinance
- Pet Waste: None found

Brewster's Master Plan was created in 1970, and the town is forming a committee to develop a Master Plan update in late 2021. The 1970 plan includes a section about land sustainability and recreational opportunities, but no other mention of natural resources or the environment is made. The town has a 2020 Open Space and Recreation Plan, which includes an inventory of water resources outlining specific water bodies and swimming beaches (Town of Brewster, 2021).

7. MA96-107 Red River

7.1. Waterbody Overview

Red River segment MA96-107 is 0.9 miles long and begins at its headwaters west of Mayflower Drive, Chatham, MA. The segment flows southwest along the Chatham-Harwich town border to South Chatham Road (Harwich)/Deep Hole Road (Chatham).

There are no tributaries to Red River segment MA96-107. Lakes and ponds in the watershed include Bucks Pond and a few other unnamed waterbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include Bucks Pond Beach, Hawks Nest State Park, T.W. Nickerson Landscape/Gravel Operation, and South Chatham Cemetery. From upstream to downstream, segment MA96-107 is crossed by an unnamed road (Chatham), Main Street/Route 28 (Chatham), Shirley Drive (Chatham), and South Chatham Road (Harwich)/Deep Hole Road (Chatham) on the Harwich/Chatham town line.

Red River (MA96-107) drains a total area of 1.8 square miles (mi^2), of which 0.3 mi^2 (14%) are impervious area. A 200-foot buffer around the segment covers an area of 0.075 mi^2, of which 0.007 mi^2 (9%) are impervious area. The watershed may be partially served by a public sewer system in Chatham, but not in Harwich[13]; and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 7-1.

The Red River segment MA96-107 watershed is located in a moderately-developed part of Massachusetts. More than two-thirds of the watershed is forest and natural lands (70%) and 5% is wetland areas. The remainder of the watershed is covered by development (25%);

Reduction from Highest Calculated Geomean: 80%

Watershed Area (Acres): 1,169

Segment Length (Miles): 0.9

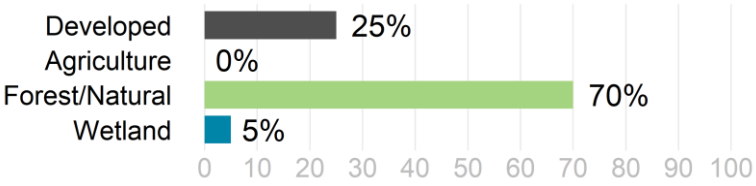
200-foot Buffer Area (Acres): 48

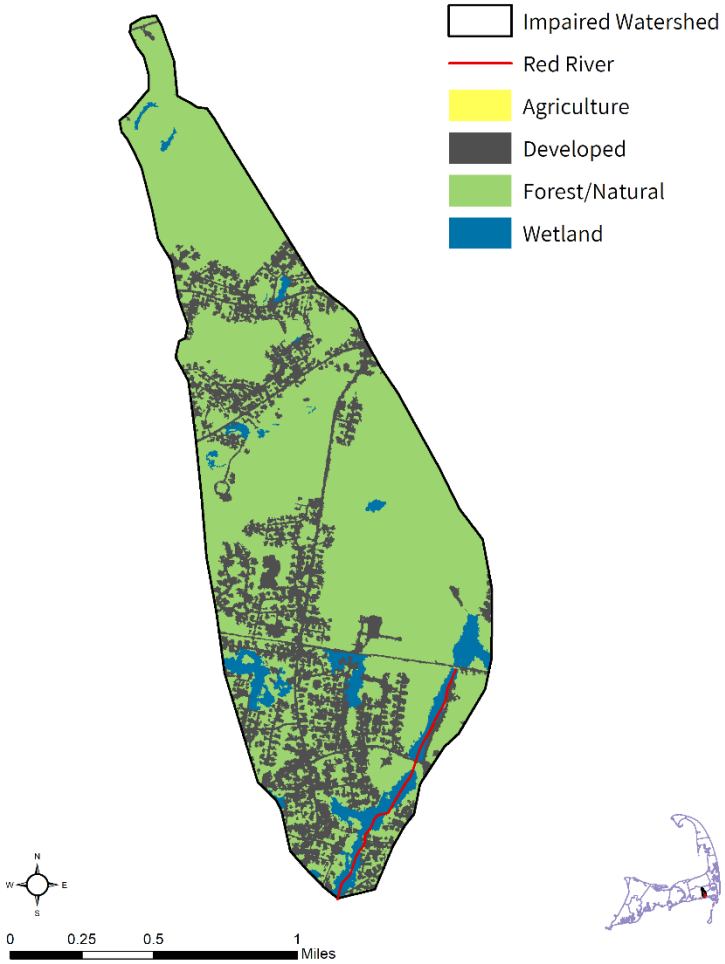
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 165 (14%)

Impervious Area Within 200-foot Buffer (Acres, %): 4 (9%)



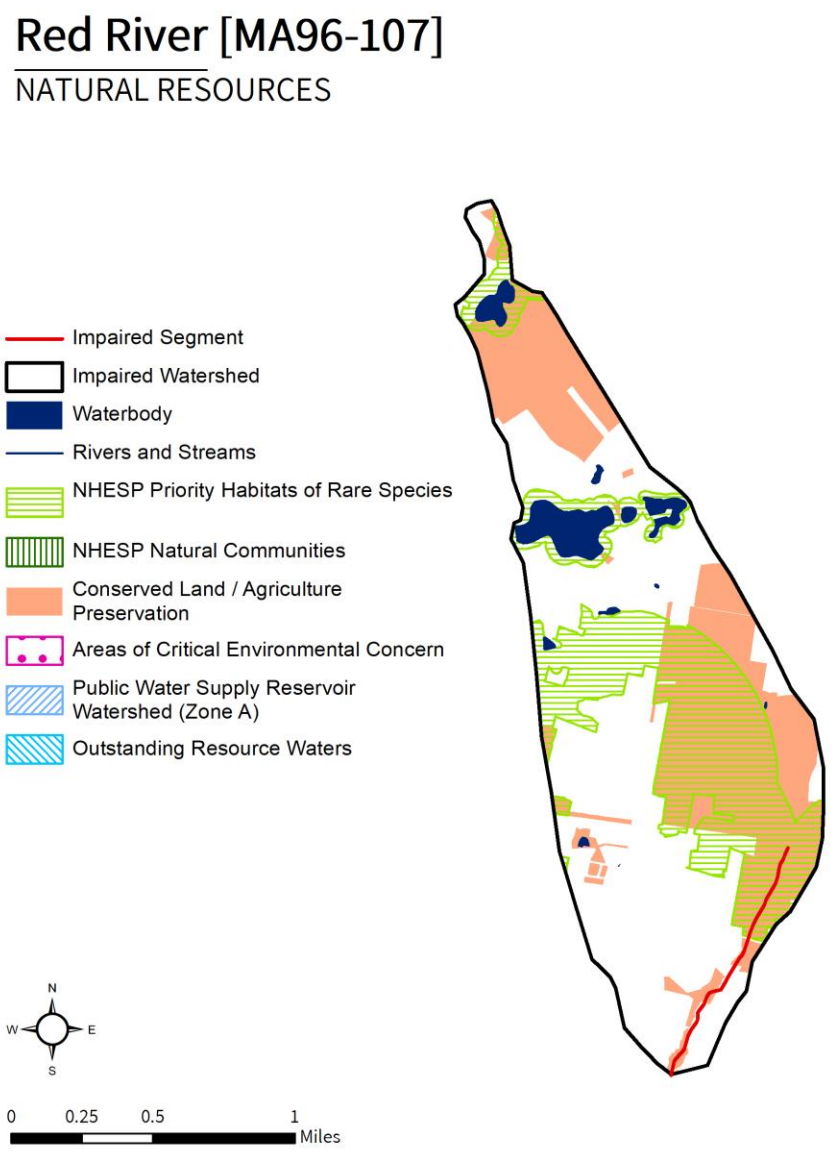


[13] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

there is no agricultural activity. Most of the development consists of residential areas with some industrial and commercial areas.

In the Red River (MA96-107) watershed, under the Natural Heritage and Endangered Species Program, there are 410 acres (35%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 443 acres (38%) of land protected in perpetuity[14], part of 446 acres (38%) of Protected and Recreational Open Space[15]. See Figure 7-1.

[14] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[15] All Protected and Recreational Open Space land is shown on the natural resources map.



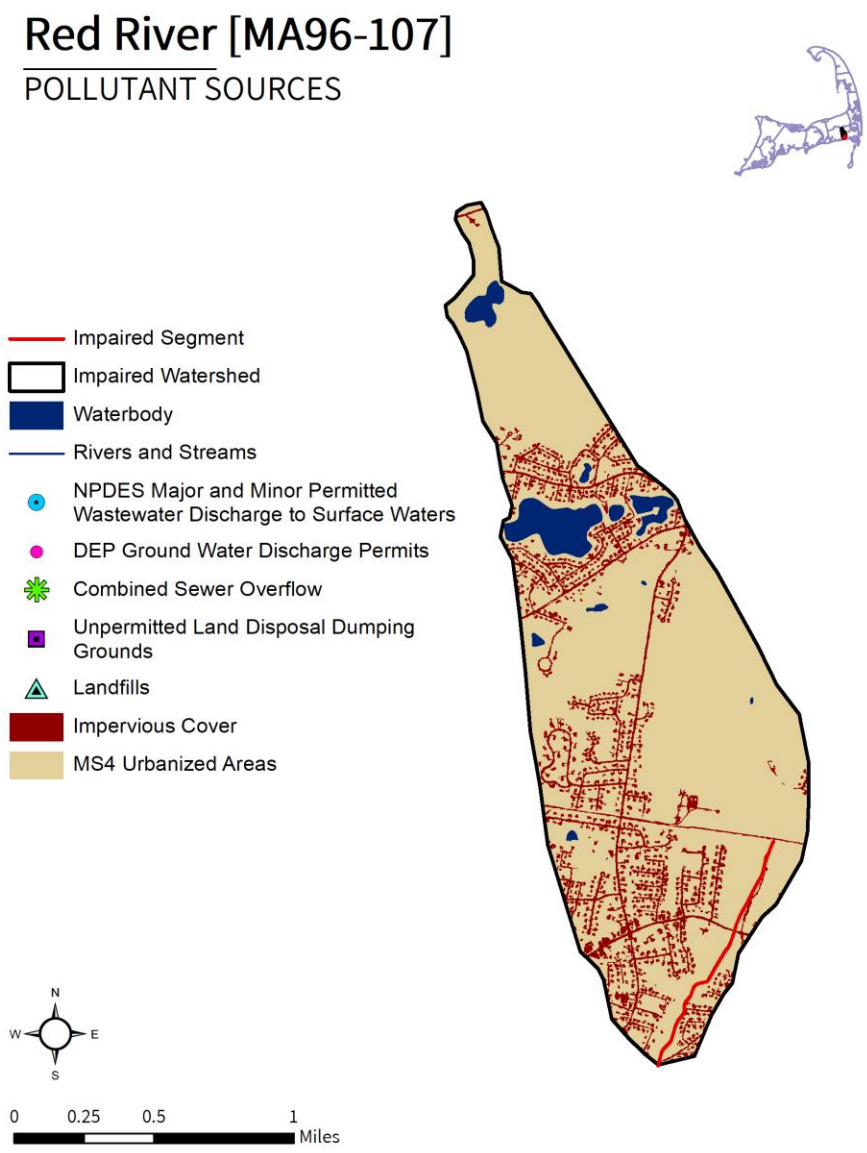


Figure 7-1. Natural resources and potential pollution sources draining to the Red River segment MA96-107. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

7.2. Waterbody Impairment Characterization

The Red River (MA96-107) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 7-1, 7-2; Figure 7-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1918; data indicated five days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, three exceeded the STV criterion, two during wet weather and one during dry weather.

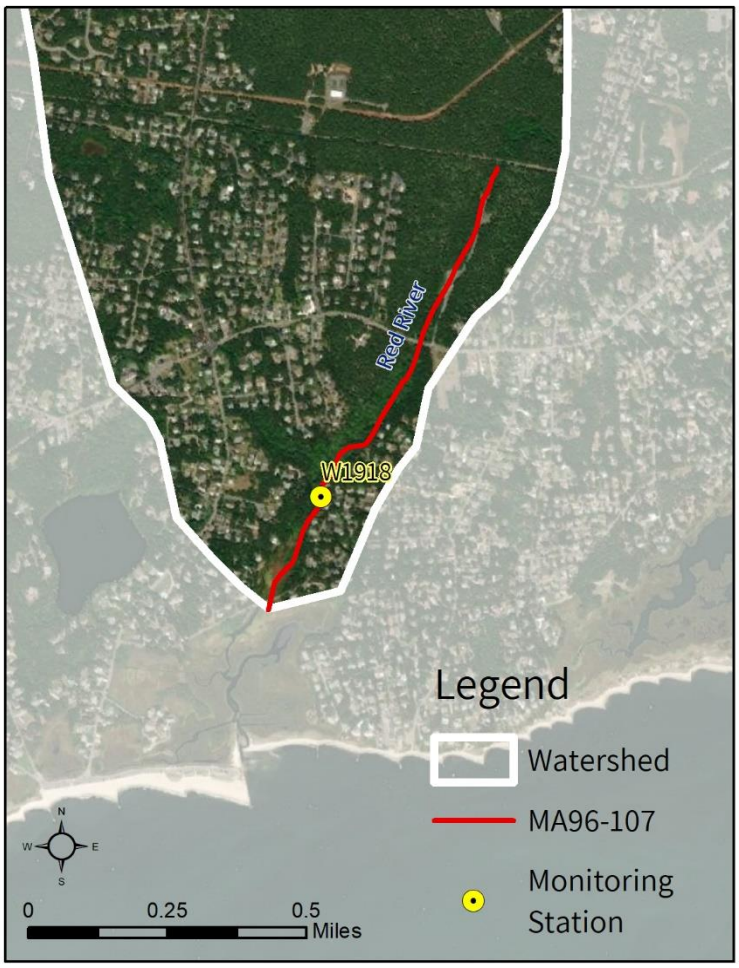


Figure 7-2. Location of monitoring station(s) along the impaired segment.

Table 7-1. Summary of indicator bacteria sampling results by station for the Red River (MA96-107). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1918	5/19/2009	10/6/2009	6	621	5	3

Table 7-2. Indicator bacteria data by station, indicator, and date for the Red River (MA96-107). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1918	*E. coli*	5/19/2009	DRY	10	10	
W1918	*E. coli*	6/23/2009	WET	5,300	230	
W1918	*E. coli*	7/28/2009	DRY	40	128	
W1918	*E. coli*	8/13/2009	DRY	1,600	241	
W1918	*E. coli*	9/1/2009	WET	380	599	
W1918	*E. coli*	10/6/2009	WET	6,100	621	

7.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Red River (MA96-107) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a fairly large amount of development in the watershed (25%), most of which consists of residential areas with some industrial and commercial development as well. 100% of the land area is subject to MS4 permit conditions, 14% is classified as impervious area, and 9% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the town of Chatham, but is not available in the town of Harwich. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Most of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: There is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhoods and parks near the Red River segment MA96-107. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: Several large open emergent wetland areas are directly adjacent to the impaired segment in the southern reaches of the segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

7.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Chatham

The majority of Chatham is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041101), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. It does not appear that Chatham has created an illicit discharge detection and elimination (IDDE) plan, but they adopted an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations, both in 2004. According to the town's NOI, pathogen-impaired MS4 receiving waters include four stormwater outfalls into Frost Fish Creek (MA96-49), one outfall into Mill Creek (MA96-31, likely mislabeled in the NOI, Mill Creek in Chatham is MA96-41), three outfalls into Mill Pond (MA96-52), two outfalls into Muddy Creek (MA96-51), two outfalls into Oyster Pond (MA96-45), one outfall into Oyster Pond River (MA96-46), four outfalls into Ryder Cove (MA96-50), and one outfall into Stage Harbor (MA96-11), all impaired by fecal coliform. There is one stormwater outfall into Cockle Cove Creek (MA96-79), impaired by both fecal coliform and enterococcus.

Chatham has the following ordinances and bylaws, mostly accessible online via the town website https://www.chatham-ma.gov/ (Town of Chatham, 2021):

- Wetland protection bylaw
- Stormwater and stormwater utility bylaw
- Pet Waste: None found

Chatham has a draft 2003 Comprehensive Plan posted to the municipal website which set the goals of amending the zoning bylaws and other regulations to require stormwater management for new developments, to implement additional BMPs, and to minimize impervious surfaces, among other stormwater related goals. No Open Space and Recreation Plan was found online for Chatham (Town of Chatham, 2021).

Town of Harwich

The majority of Harwich is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041120), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Harwich completed an erosion and sedimentation control (ESC) plan in 2010, and an illicit discharge detection and elimination (IDDE) plan and post-construction stormwater regulations in 2018. According to the NOI, the MS4 system includes four stormwater outfalls into the Herring River (MA96-22) and three outfalls into Saquatucket Harbor (MA96-23), both of which are impaired by fecal coliform.

Harwich has the following ordinances and bylaws, mostly accessible online via the town website https://www.harwich-ma.gov/ (Town of Harwich, 2021):

- Wetland protection bylaw
- Stormwater Regulations and Utility: None found
- Pet Waste: None found

The town of Harwich has a 2011 Local Comprehensive Plan which clearly outlines several objectives related to the environment, including more effective management of conserved lands (pg. 17). Another goal identified in this plan is to increase the general aquifer protection, and stormwater regulation is specifically mentioned as a means to achieve this (pg. F-2). The Master Plan refers to the 2010 Open Space and Recreation Plan (OSRP) for more in-depth information on the environment. The OSRP specifically identifies natural areas in need of protection and an open spaced inventory within Harwich (Town of Harwich, 2021).

8. MA96-108 Unnamed Tributary

8.1. Waterbody Overview

The unnamed tributary segment MA96-108 is 2.0 miles long and begins at the outlet of Perch Pond in Wellfleet, MA. The segment flows south, then west before ending at its confluence with Herring River in Wellfleet (the area within the Cape Cod National Seashore is designated as an ORW).

Tributaries to unnamed tributary segment MA96-108 include numerous unnamed streams. Lakes and ponds in the watershed consist of Perch Pond and a few unnamed waterbodies. Nearly all of the segment flows through wetland areas.

Key landmarks in the watershed include Oakdale Cemetery and Lawrence R. Gardinier Square. From upstream to downstream, segment MA96-108 is crossed by Grant Army of the Republic Highway/Route 6 and Pole Dike Road, all in Wellfleet.

The unnamed tributary watershed (MA96-108) drains a total area of 2.0 square miles (mi^2), of which 0.2 mi^2 (10%) are impervious area. A 200-foot buffer around the segment covers an area of 0.149 mi^2, of which 0.003 mi^2 (2%) are impervious area. The watershed is not currently served by a public sewer system[16], and none of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 8-1.

The watershed for segment MA96-108 is located in a moderately-developed part of Massachusetts. Slightly more than half of the watershed consists of forest and natural lands (54%) and 29% consists of wetland areas. The remainder of the watershed is covered by development (17%) as there is no agricultural activity (0%). Most of the development consists of residential areas with some industrial and commercial buildings in the

Reduction from Highest Calculated Geomean: 77%

Watershed Area (Acres): 1,256

Segment Length (Miles): 2.0

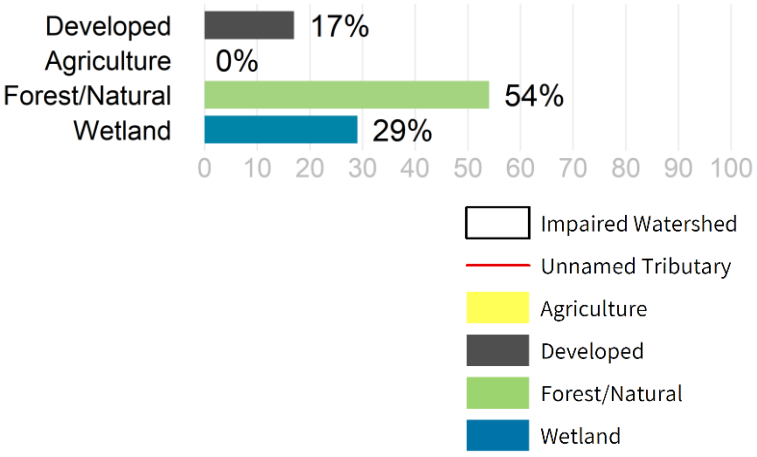
200-foot Buffer Area (Acres): 95

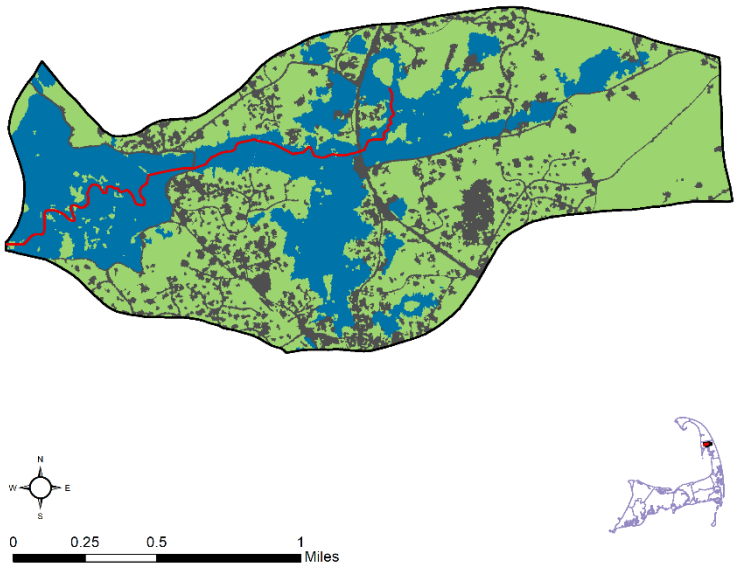
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Outstanding Resource Water)

Impervious Area (Acres, %): 120 (10%)

Impervious Area Within 200-foot Buffer (Acres, %): 2 (2%)



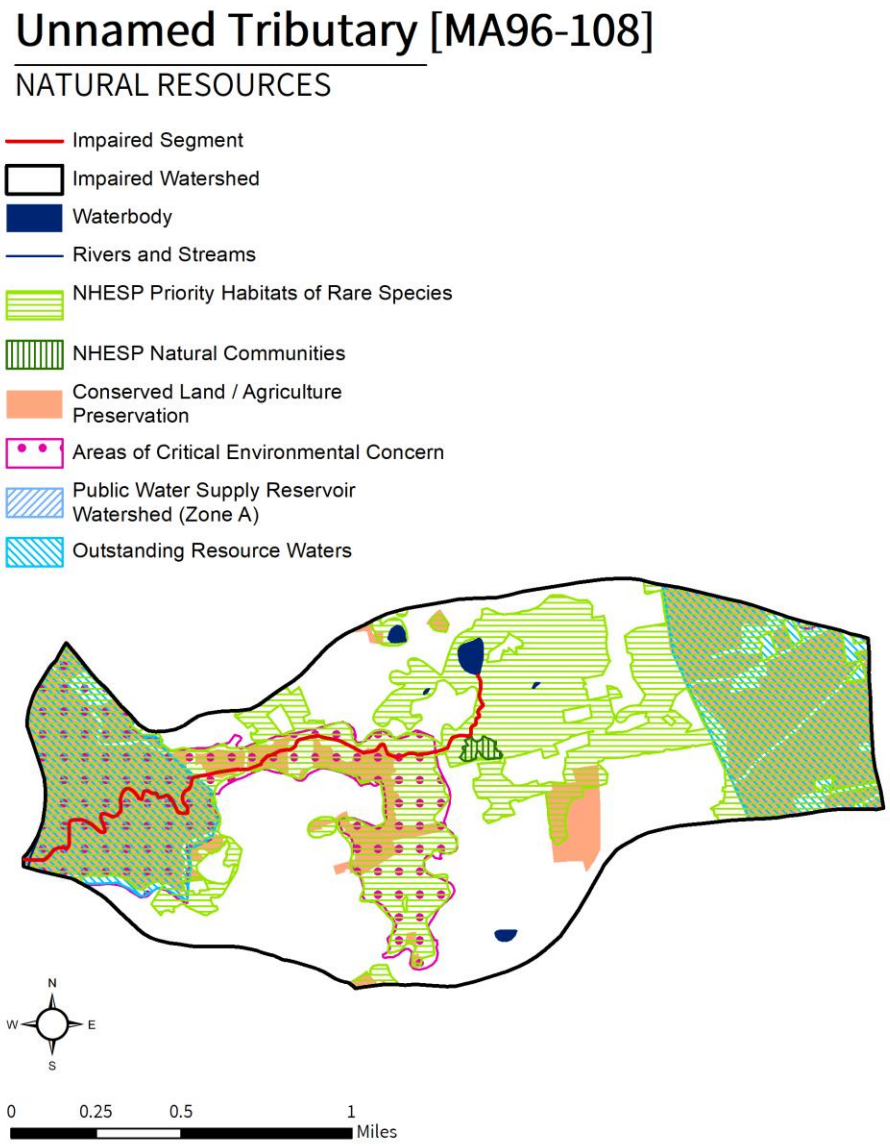


[16] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

southern area of the watershed closer to the Wellfleet town center.

In the unnamed tributary (MA96-108) watershed, under the Natural Heritage and Endangered Species Program, there are 696 acres (55%) of Priority Habitats of Rare Species and four acres (<1%) of Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, 292 acres (23%) within the Wellfleet Harbor Area of Critical Environmental Concern, and 355 acres (28%) of Outstanding Resource Waters. Overall, there are 363 acres (29%) of land protected in perpetuity[17], part of 387 acres (31%) of Protected and Recreational Open Space[18]. See Figure 8-1.

[17] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[18] All Protected and Recreational Open Space land is shown on the natural resources map.



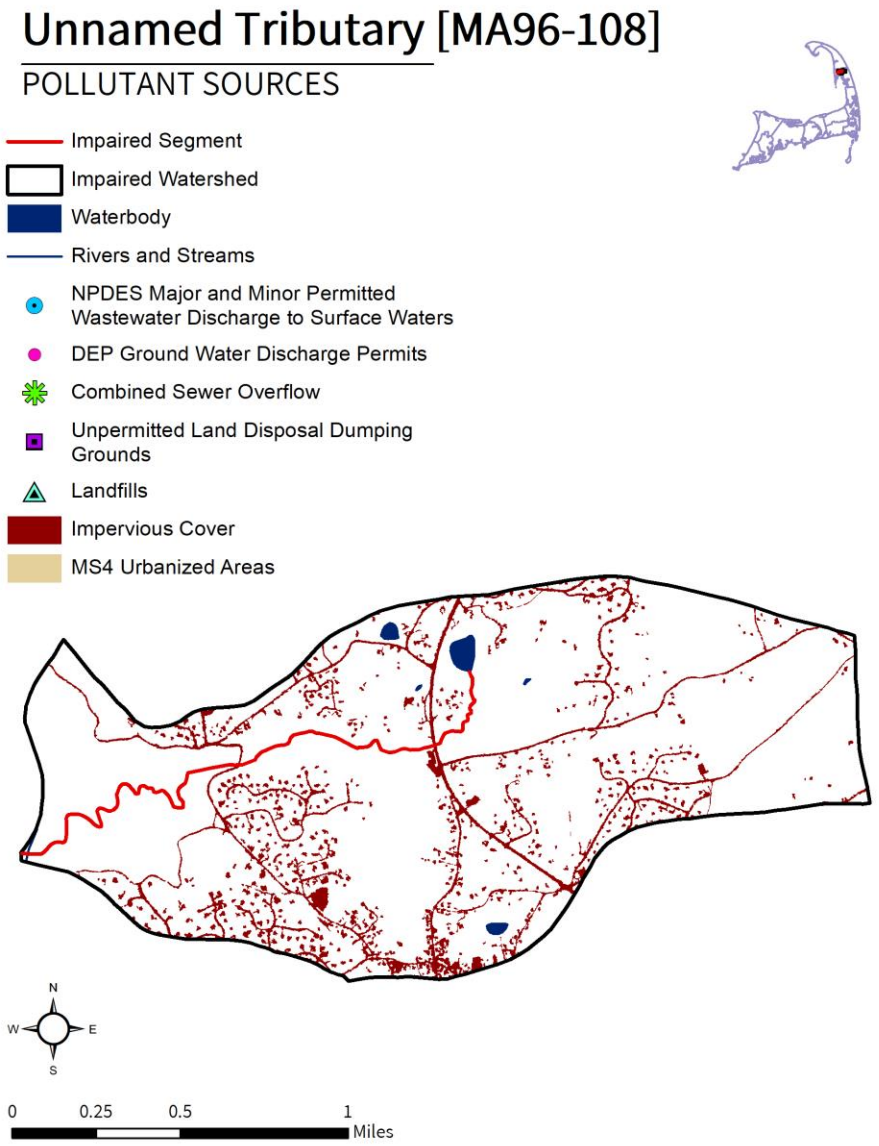


Figure 8-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA96-108. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

8.2. Waterbody Impairment Characterization

The unnamed tributary (MA96-108) is a Class B, Outstanding Resource Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations listed below (refer to Tables 8-1, 8-2; Figure 8-2) using the indicator bacteria *E. coli*. Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli.* The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1917; data indicated five days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, three exceeded the STV criterion, two during wet weather and one during dry weather.

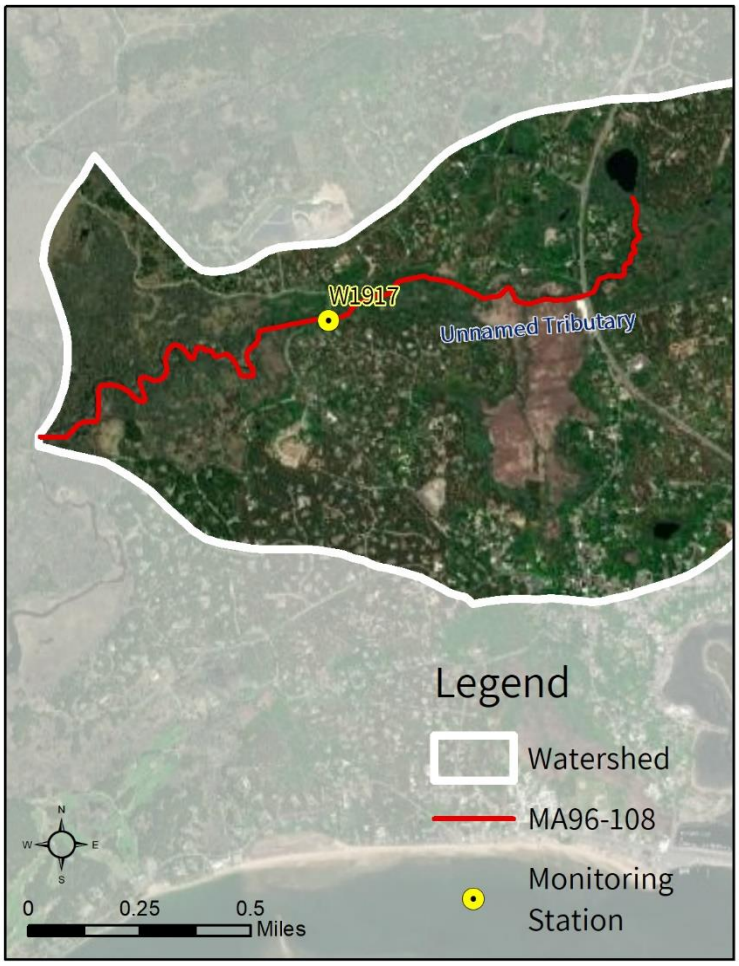


Figure 8-2. Location of monitoring station(s) along the impaired segment.

Table 8-1. Summary of indicator bacteria sampling results by station for the unnamed tributary (MA96-108). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1917	5/19/2009	10/6/2009	6	548	5	3

Table 8-2. Indicator bacteria data by station, indicator, and date for the unnamed tributary (MA96-108). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1917	*E. coli*	5/19/2009	DRY	80	80	
W1917	*E. coli*	6/23/2009	WET	430	185	
W1917	*E. coli*	7/28/2009	DRY	390	238	
W1917	*E. coli*	8/13/2009	DRY	800	322	
W1917	*E. coli*	9/1/2009	WET	670	548	
W1917	*E. coli*	10/6/2009	WET	230	468	

8.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for the unnamed tributary segment (MA96-108) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (17%), most of which consists of residential areas with some industrial and commercial activity as well. Within the watershed, none of the land area is subject to MS4 permit conditions, 10% is classified as impervious area, and 2% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is not currently available in the watershed within the town of Wellfleet. As a result, sewerage-related risks to water quality are not a likely source of pathogens.

On-Site Wastewater Disposal Systems: All of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Land use maps show no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhood parks near the unnamed tributary segment MA96-108. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: There are multiple large open wetland areas that are directly adjacent to the impaired segment, including near the tributary outlet into the Herring River in Duck Harbor. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

8.4. Existing Local Managements

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Wellfleet

Wellfleet has an EPA-approved MS4 waiver, dated June 13, 2016, since the town has a population of less than 1,000 within its urbanized area.

Wellfleet has the following ordinances and bylaws, mostly accessible online via the town website https://www.wellfleet-ma.gov/ (Town of Wellfleet, 2022):

- Wetland protection bylaw
- Stormwater bylaw
- Pet Waste Control bylaw
- Stormwater Utility: None found

Wellfleet has a 2008 Local Comprehensive Plan that features a Natural Resources section that identifies stormwater as the main source of contamination to Wellfleet Harbor. Protecting water resources is the main focus of this section; specific strategies include upgrading the town's storm and wastewater treatment processes, monitoring tidal restrictions to develop restoration options, educating the public on the values of high water quality, and conducting a nutrient study to identify current and future threats to town waters (Town of Wellfleet, 2022).

9. MA96-75 Round Cove

9.1. Waterbody Overview

The Round Cove segment MA96-75 is 0.02 square miles (mi^2) in area and begins east of Route 28 in Harwich, MA. The segment is tidally influenced, but generally flows south before its outlet to Pleasant Bay in Harwich, MA.

There are no tributaries to the Round Cove segment MA96-75, and one unnamed pond in the watershed. Much of the segment is surrounded by wetland area.

Key landmarks are the Wesquassett Resort adjacent to Round Cove and the south reaches of the Cape Cod National Golf Club in Harwich, MA. The segment is not crossed by any roads, pedestrian bridges, etc.

The Round Cove segment (MA96-75) drains a total area of 0.5 mi^2, of which 0.1 mi^2 (16%) is impervious area. A 200-foot buffer around the segment covers an area of 0.033 mi^2, of which 0.004 mi^2 (12%) are impervious area. The watershed may be served by a public sewer system in Harwich[19], and 74% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are also no landfills or unpermitted land disposal dumping grounds. See Figure 9-1.

The Round Cove segment MA96-75 watershed is located in a moderately-developed part of Massachusetts. Forest and natural areas cover two-thirds of the land area (66%) and wetlands cover 4%. Development covers less than one-third of the land area (30%); there is no agricultural activity. Development is composed primarily of residential areas, with the exception of a commercial resort directly north of the segment.

In the Round Cove segment (MA96-75) watershed, under the Natural Heritage and Endangered Species Program, there are three

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 332

Segment Area (mi^2): 0.02

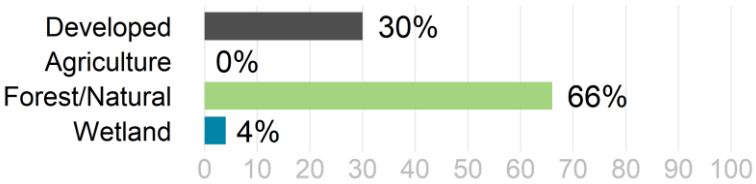
200-foot Buffer Area (Acres): 21

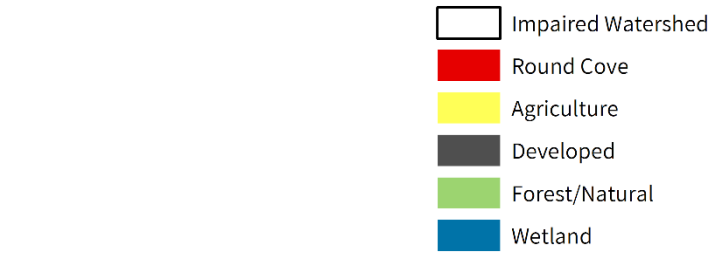
Impairment(s): Fecal Coliform (Shellfish)

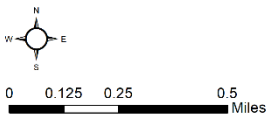
Class (Qualifier): SA (Shellfishing, Outstanding Resource Water)

Impervious Area (Acres, %): 55 (16%)

Impervious Area Within 200-foot Buffer (Acres, %): 3 (12%)



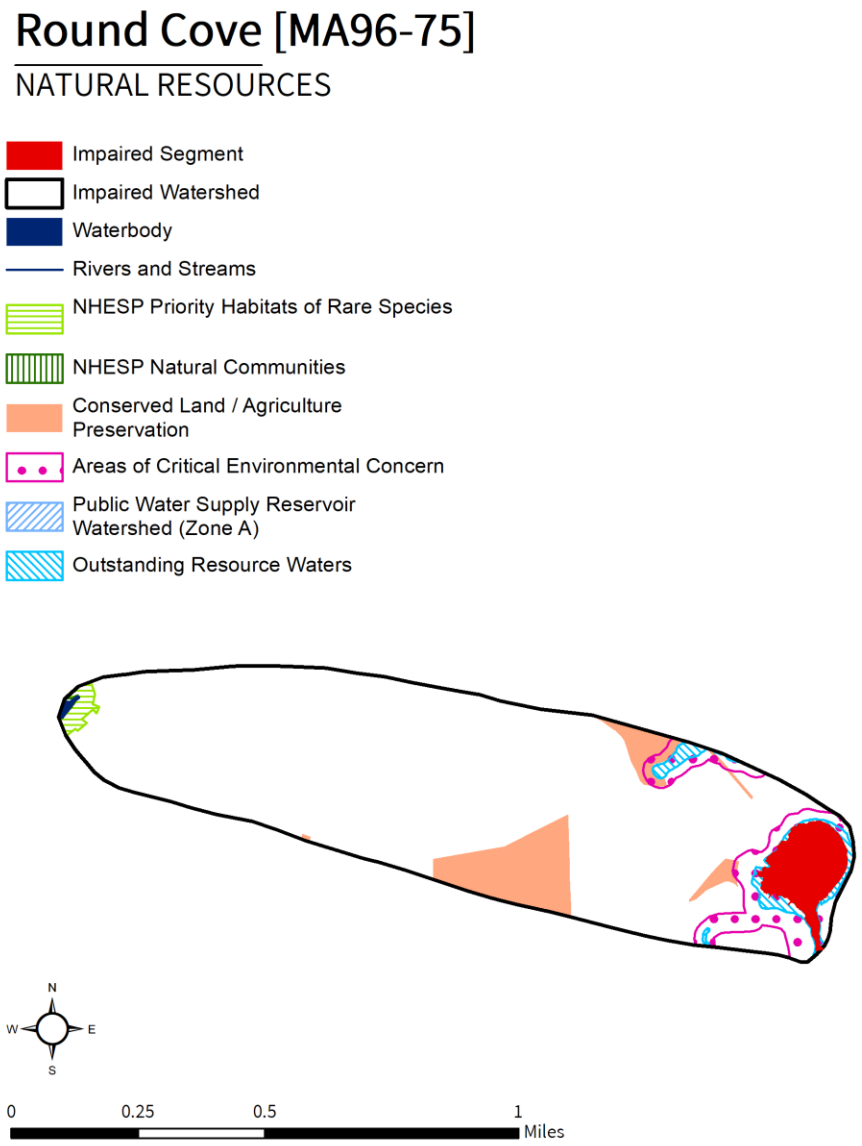




[19] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

acres (1%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no areas under Public Water Supply protection, 38 acres (12%) within the Pleasant Bay Area of Critical Environmental Concern, and 19 acres (6%) of Outstanding Resource Waters. Overall, there are 22 acres (6%) of land protected in perpetuity[20], part of 27 acres (8%) of Protected and Recreational Open Space[21]. See Figure 9-1.

[20] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[21] All Protected and Recreational Open Space land is shown on the natural resources map.



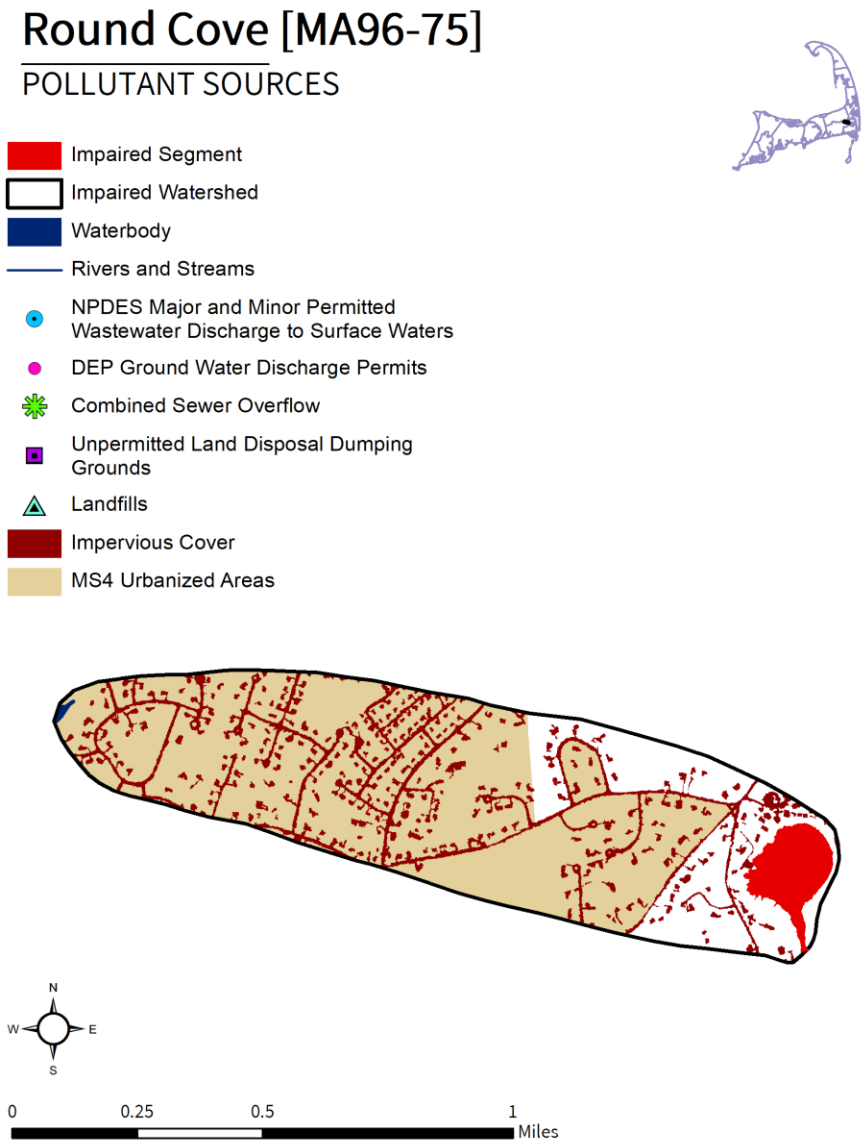


Figure 9-1. Natural resources and potential pollution sources draining to the Round Cove segment MA96-75. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

9.2. Waterbody Impairment Characterization

Round Cove (MA96-75) is a Class SA tidal estuary, Outstanding Resource Water, with a Shellfishing qualifier (MassDEP, 2021a).

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at a shellfish growing area that covers 0.02 mi^2 (94% of the segment area; refer to Figure 9-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries (Table 9-1).

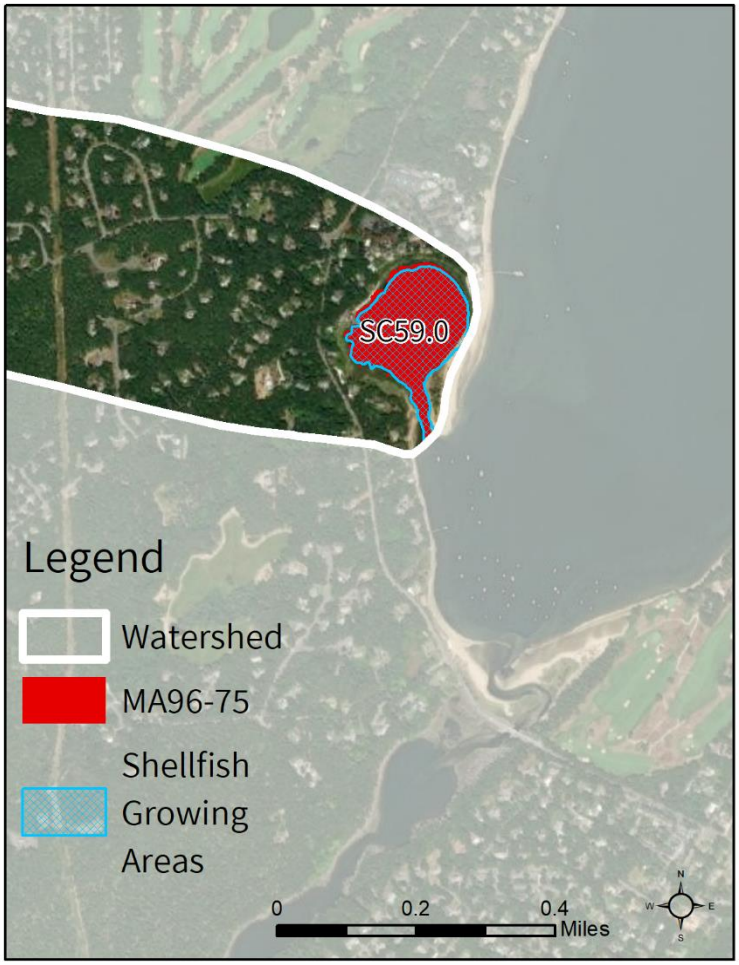


Figure 9-2. Location of shellfish growing area associated with the impaired segment.

Table 9-1. Summary of MA DFG Division of Marine Fisheries classification data from January 2014 for a shellfish growing area in the Round Cove segment MA96-75. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
SC59.0	Round Cove	Conditionally Approved	0.0210	94%

9.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (30%), most of which consists of residential areas with minimal commercial development. 74% of the land area is subject to MS4 permit conditions, 16% is classified as impervious area, and 12% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the town of Harwich. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities or discharged directly into the water when the vessel is more than three miles offshore, outside of the designated No Discharge Zone (NDZ). Negligent boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There is one vessel sewage pump-out facility directly adjacent to Round Cove segment MA96-75: Round Cove Harbormaster (Harwich). Although pump-out facilities provide boaters with a means of disposing of onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Land use maps show no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhoods and parks near the Round Cove segment MA96-75, including directly adjacent to the segment. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas, including tidal wetlands, are directly adjacent to the impaired segment. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

9.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Harwich. See Section 7.4

10. MA96-95 Allens Harbor

10.1. Waterbody Overview

The Allens Harbor segment MA96-95 is 0.02 square miles (mi^2) in area and begins south of Lower County Road in Harwich, MA. The segment is tidally influenced, ending at Doanes Creek, also in Harwich.

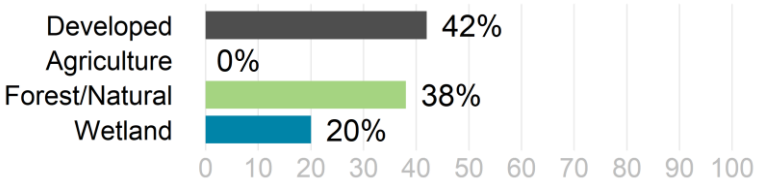
There are no tributaries to the Allens Harbor segment MA96-95. Lakes and ponds in the watershed include a few small unnamed waterbodies. Much of the segment is surrounded by wetland areas.

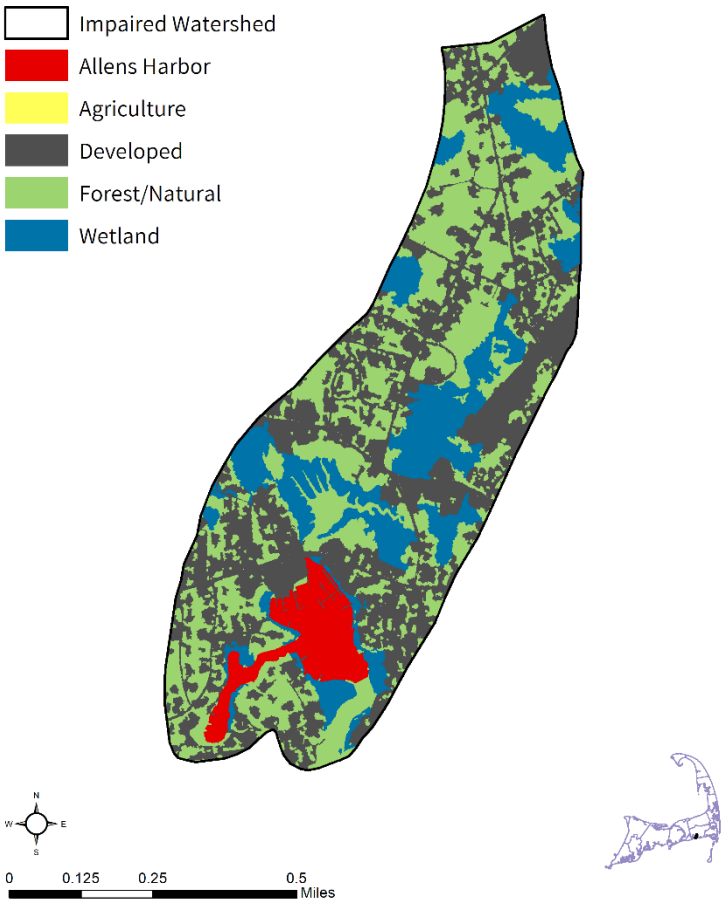
Key landmarks in the watershed include the Allens Harbor Yacht Club and Allens Harbor Marina, part of the Harwich Port Golf Club, and part of Mt. Pleasant Cemetery. Allens Harbor segment MA96-95 is not crossed by any roads, pedestrian bridges, etc.

The Allens Harbor segment (MA96-95) drains a total area of 0.4 mi^2, of which 0.1 mi^2 (24%) are impervious area. A 200-foot buffer around the segment covers an area of 0.050 mi^2, of which 0.015 mi^2 (29%) are impervious area. The watershed may be served by a public sewer system in Harwich[22], and the entire land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, one MassDEP discharge-to-groundwater permit for on-site wastewater discharge, and no combined sewer overflows (CSOs) within the watershed (Table 10-1). There are also no landfills or unpermitted land disposal dumping grounds. See Figure 10-1.

The Allens Harbor segment MA96-95 watershed is located in a fairly highly-developed part of Massachusetts. Roughly equal parts of the watershed are covered by developed area (42%) as forest and natural areas (38%); the remaining is covered by wetland (20%). There are no agricultural areas. Wetlands are located throughout the watershed, including adjacent to the impaired segment. Development consists of primarily residential areas, as well as some

Reduction from Highest Calculated Geomean: NA
Watershed Area (Acres): 279
Segment Area (mi^2): 0.03
200-foot Buffer Area (Acres): 32
Impairment(s): Fecal Coliform (Shellfish)
Class (Qualifier): SA (Shellfishing)
Impervious Area (Acres, %): 66 (24%)
Impervious Area Within 200-foot Buffer (Acres, %): 9 (29%)





[22] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

industrial uses (marinas) directly adjacent to and within the segment, and some commercial uses along Route 28.

In the Allens Harbor segment (MA96-95) watershed, under the Natural Heritage and Endangered Species Program, there are five acres (2%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are five acres (2%) of land protected in perpetuity[23], part of 23 acres (8%) of Protected and Recreational Open Space[24]. See Figure 10-1.

Table 10-1. Groundwater discharge permits in the segment watershed. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
613-1	HARWICH LAUNDRY & CLEANERS	HARWICH	Laundromat	14,400

[23] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[24] All Protected and Recreational Open Space land is shown on the natural resources map.

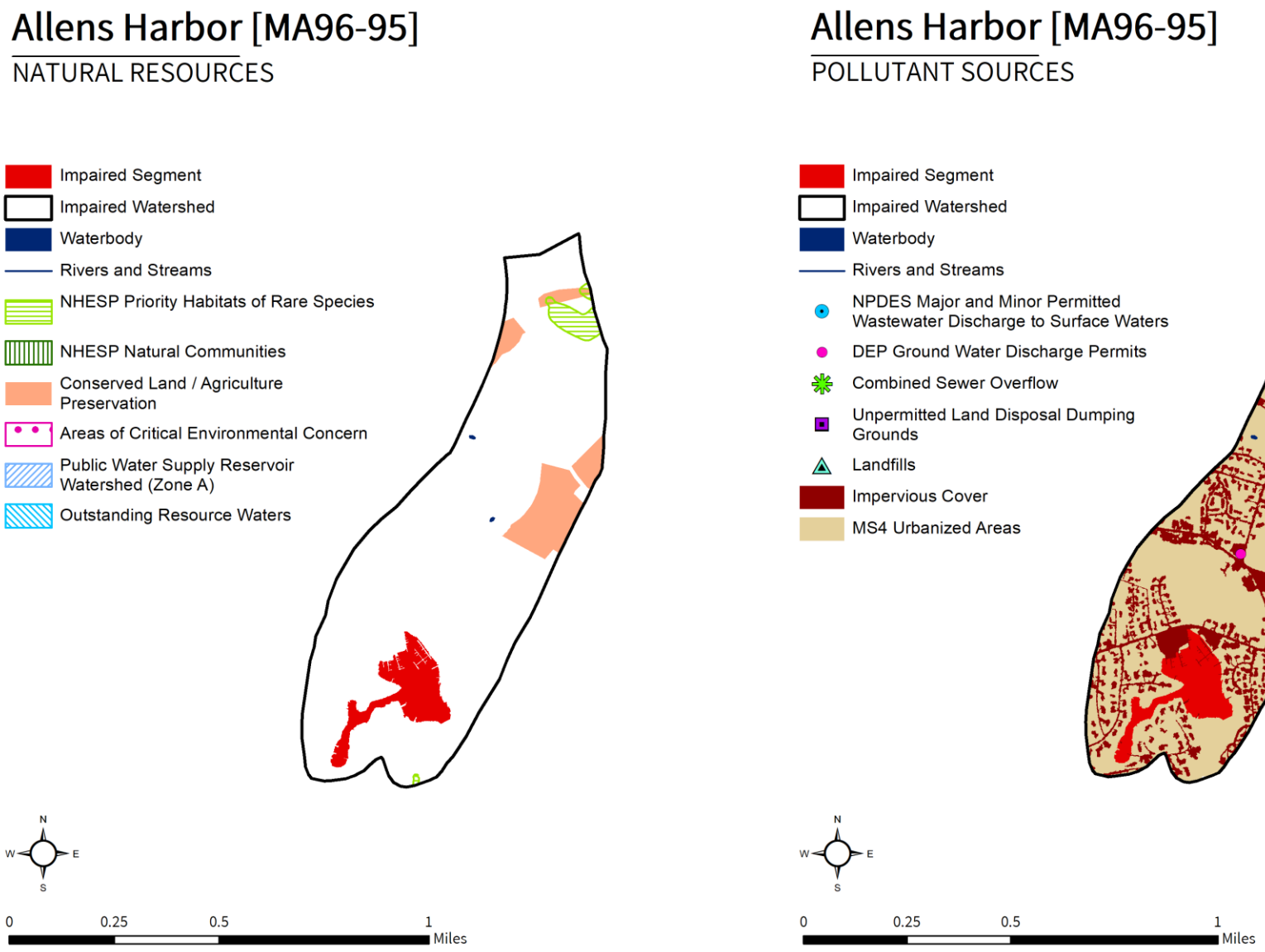


Figure 10-1. Natural resources and potential pollution sources draining to the Allens Harbor segment MA96-95. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

10.2. Waterbody Impairment Characterization

Allens Harbor (MA96-95) is a Class SA tidal estuary, with a Shellfishing qualifier (MassDEP, 2021a).

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at two shellfish growing areas that cover 0.03 mi^2 (99% of the segment area; refer to Figure 10-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries (Table 10-2).

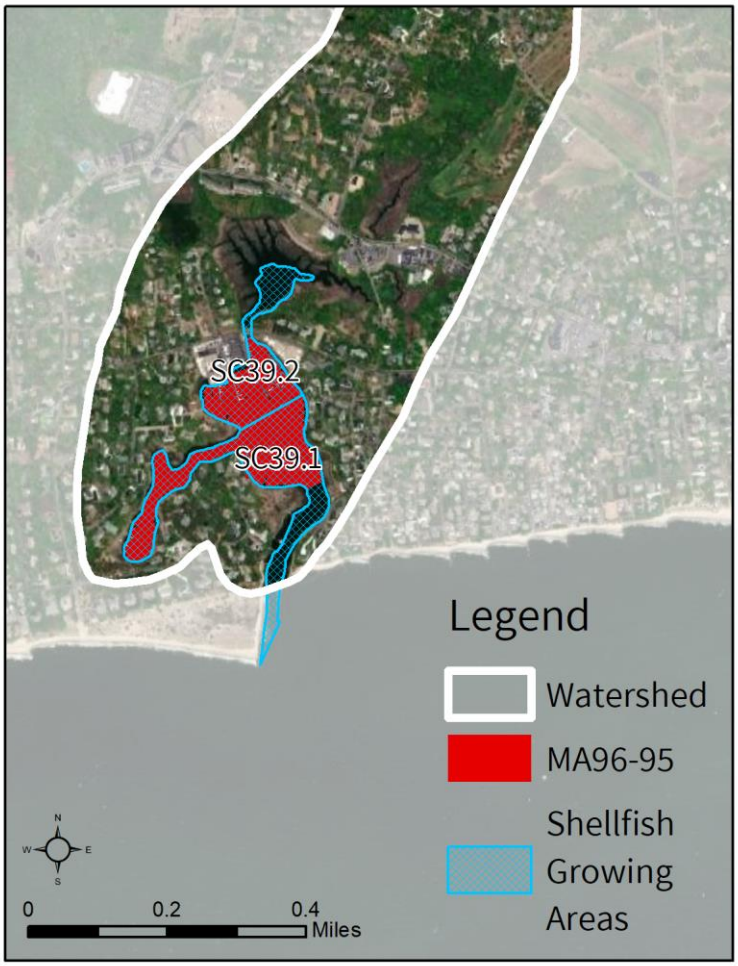


Figure 10-2. Location of shellfish growing areas associated with the impaired segment.

Table 10-2. Summary of MA DFG Division of Marine Fisheries classification data from January 2014 for two shellfish growing areas in the Allens Harbor segment MA96-95. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
SC39.1	Allens Harbor	Conditionally Approved	0.0169	65%
SC39.2	Allens Harbor	Prohibited	0.0087	34%

10.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a large amount of development in the watershed (42%), most of which consists of residential areas with some industrial and commercial development as well. Within the watershed, the entire land area is subject to MS4 permit conditions, 24% is classified as impervious area, and 29% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is likely a substantial source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the town of Harwich. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site systems for wastewater treatment. There is one MassDEP permit for an on-site wastewater discharge to groundwater. In addition to this permitted point source, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities or discharged directly into the water when the vessel is more than three miles offshore, outside of the designated No Discharge Zone (NDZ). Negligent boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to Allens Harbor segment MA96-95. Although pump-out facilities provide boaters with a means of disposing of onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: There is no agricultural activity in the watershed. As a result, stormwater runoff from agricultural land is not a likely source of pathogens to the impaired segment.

Pet Waste: There are many residential neighborhoods and parks near the Allens Harbor segment MA96-95. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open wetland areas are directly adjacent to the impaired segment, including emergent wetlands north of Lower County Road. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

10.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Harwich. See Section 7.4

11. MA96-96 Wychmere Harbor

11.1. Waterbody Overview

The Wychmere Harbor segment MA96-96 is 0.02 square miles (mi^2) in area and begins south of Route 28, Harwich, MA. The segment is tidally influenced and ends at the outlet to Nantucket Sound, Harwich.

There are no tributaries to the Wychmere Harbor segment MA96-96, and there are no lakes or ponds in the watershed.

Key landmarks in the watershed include Harwich Port Boat Yard, Larson Park, and Robert F. Smith Cold Brook Preserve. The segment is not crossed by any roads, pedestrian bridges, etc.

The Wychmere Harbor segment (MA96-96) drains a total area of 0.17 mi^2, of which 0.05 mi^2 (31%) are impervious area. A 200-foot buffer around the segment covers an area of 0.037 mi^2, of which 0.013 mi^2 (36%) are impervious area. The watershed may be partially served by a public sewer system in Harwich[25], and 100% of the land area in Massachusetts is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, one MassDEP discharge-to-groundwater permit for on-site wastewater discharge, and no combined sewer overflows (CSOs) within the watershed (Table 11-1). There are also no landfills or unpermitted land disposal dumping grounds. See Figure 11-1.

The Wychmere Harbor segment MA96-96 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed (53%) consists of development composed of residential areas and commercial buildings along Route 28 and around Wychmere Harbor. Most of the remaining watershed consists of forest and natural lands (38%) and wetland areas (2%). Agricultural land covers a moderate portion of the watershed (7%) and consists of a single cranberry bog in the upper watershed.

In the Wychmere Harbor segment (MA96-96) watershed, under the Natural Heritage and

Reduction from Highest Calculated Geomean: NA

Watershed Area (Acres): 107

Segment Area (mi^2): 0.02

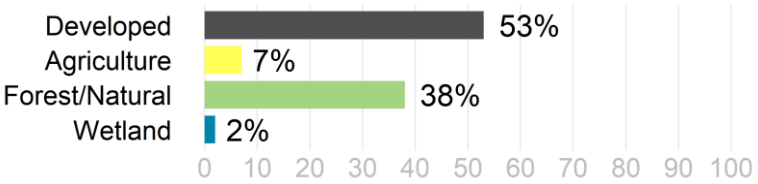
200-foot Buffer Area (Acres): 24

Impairment(s): Fecal Coliform (Shellfish)

Class (Qualifier): SA (Shellfishing)

Impervious Area (Acres, %): 33 (31%)

Impervious Area Within 200-foot Buffer (Acres, %): 8 (36%)



[25] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

Endangered Species Program, there is one acre (1%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. There are three acres (3%) of land protected in perpetuity[26], part of four acres (4%) of Protected and Recreational Open Space[27]. See Figure 11-1.

Table 11-1. Groundwater discharge permits in the segment watershed. PERR = permit number plus renewal number. TYPE = type of groundwater discharge. FLOW = permitted effluent in gallons per day (gpd).

PERR	NAME	TOWN	TYPE	FLOW (GPD)
324-5	SNOW INN	HARWICH	Sanitary Discharge	80,000

[26] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[27] All Protected and Recreational Open Space land is shown on the natural resources map.

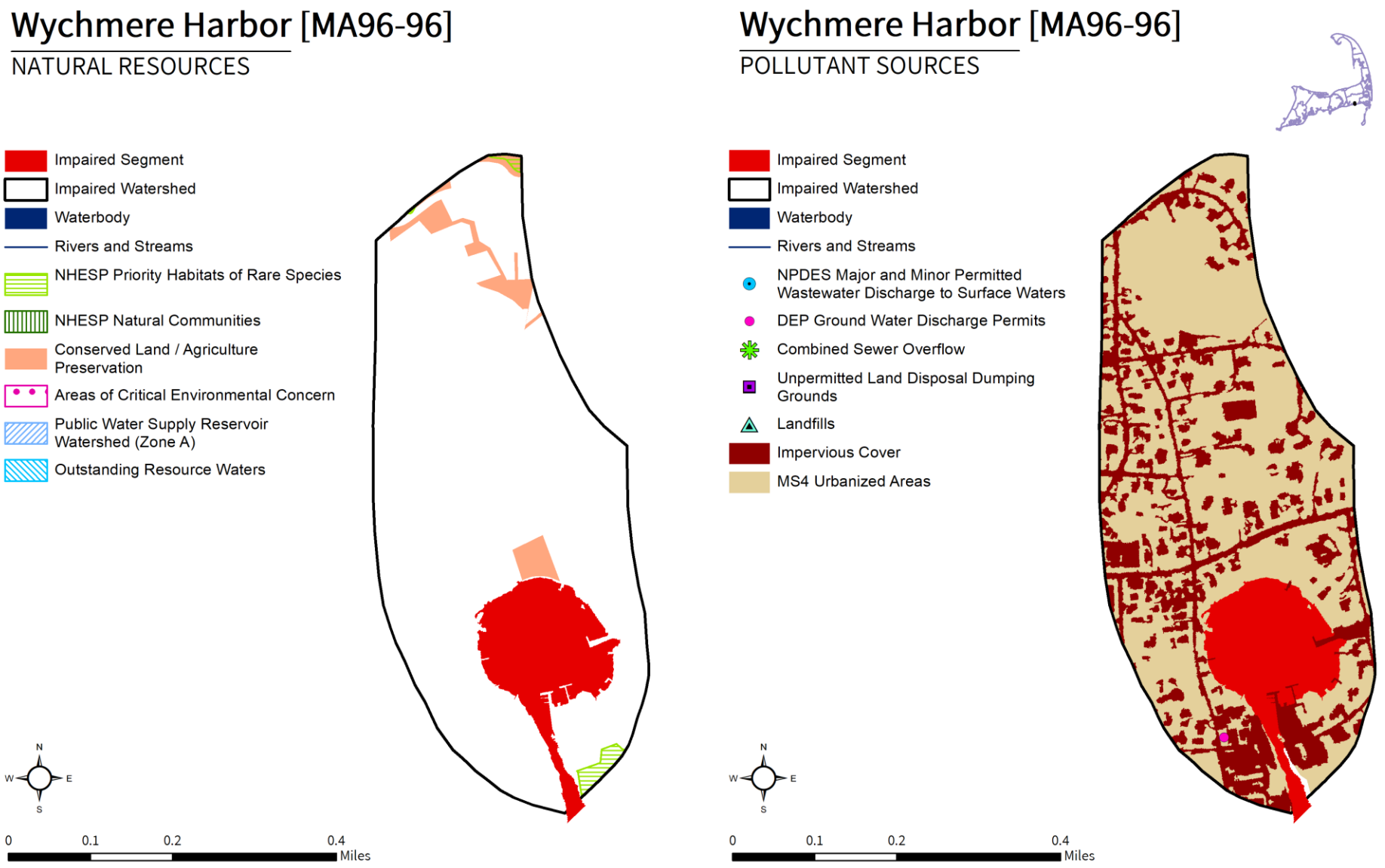


Figure 11-1. Natural resources and potential pollution sources draining to the Wychmere Harbor segment MA96-96. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

11.2. Waterbody Impairment Characterization

Wychmere Harbor (MA96-96) is a Class SA tidal estuary, with a Shellfishing qualifier (MassDEP, 2021a).

The Shellfish Harvesting use was assessed for attainment of SWQS using fecal coliform indicator bacteria at two shellfish growing areas that cover 0.02 mi^2 (97% of the segment area; refer to Figure 11-2). MassDEP assessed the Shellfish Harvesting use as not supporting since the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries (Table 11-2).

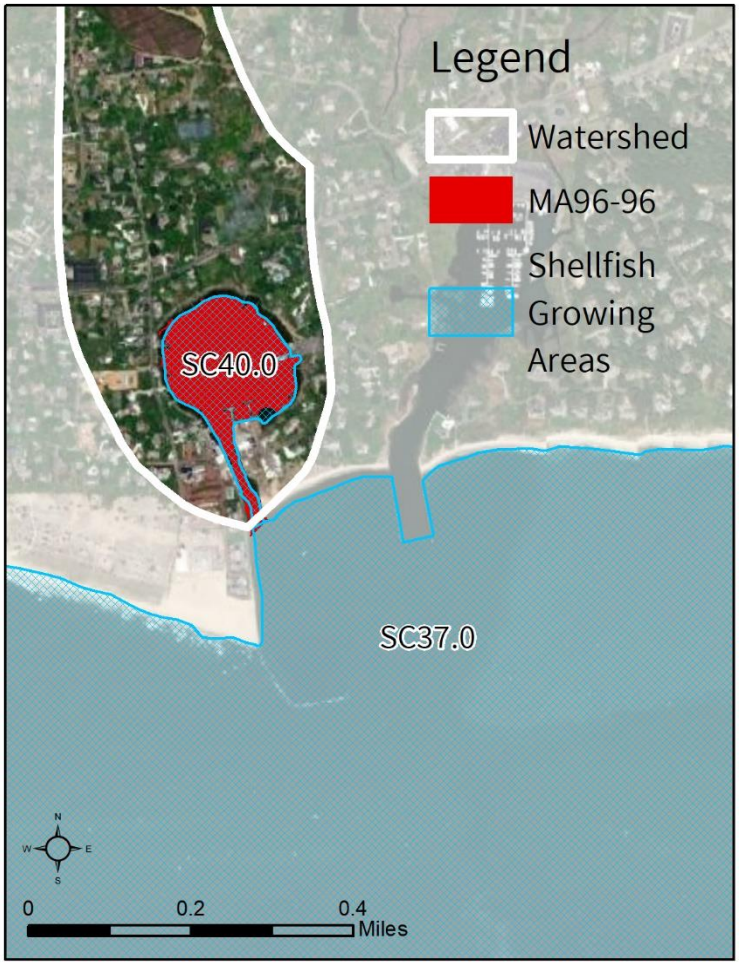


Figure 11-2. Location of shellfish growing areas associated with the impaired segment.

Table 11-2. Summary of MA DFG Division of Marine Fisheries classification data from January 2014 for two shellfish growing areas in the Wychmere Harbor segment MA96-96. Percentage indicates the relative area within the segment covered by each shellfish growing area. Shellfish Harvesting is classified as not supporting if the growing area normalized to the segment area is less than 100% approved for shellfishing by the Massachusetts Division of Marine Fisheries.

Name	Area Description	Class	Area (mi^2)	Percentage
SC37.0	Harwich South Coastal	Approved	0.0001	<1%
SC40.0	Wychmere Harbor	Conditionally Approved	0.0210	97%

11.3. Potential Pathogen Sources

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a large amount of development in the watershed (53%), most of which consists of residential areas with some commercial development as well. The entire land area is subject to MS4 permit conditions, 31% is classified as impervious area, and 36% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within the town of Harwich, MA. Sewerage-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and sanitary sewer overflows (SSOs), which may be caused by undersized infrastructure, blockages, or excessive infiltration of groundwater or rainwater into pipes, exceeding system capacity. Illicit connections of wastewater to stormwater conveyances are also a potential source.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site systems for wastewater treatment. There is one MassDEP permit for an on-site wastewater discharge to groundwater. In addition to this permitted point source, it is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Illicit Boat Discharges: The segment is navigable by marine vessels. Vessels with onboard toilets are required to have a marine sanitation device (MSD) to treat or store wastewater. MSDs that treat wastewater may be improperly maintained or malfunctioning and therefore could discharge untreated sewage to coastal waterbodies. For MSDs that store wastewater, this sewage can either be pumped out at shore-based pump-out facilities or discharged directly into the water when the vessel is more than three miles offshore, outside of the designated No Discharge Zone (NDZ). Negligent boaters who ignore these laws and discharge untreated sewage to coastal waterbodies may be a source of pathogen pollution.

Vessel Pump-Out Facilities: There are no vessel sewage pump-out facilities directly adjacent to Wychmere Harbor segment MA96-96. Although pump-out facilities provide boaters with a means of disposing of onboard sewage without discharging it into coastal waters, these facilities are generally associated with high boating activity. Pump-out facilities which malfunction or leak also represent a potential pathogen source. As a result, waterbodies adjacent to pump-out facilities are likely at high risk of illicit boat (and facility) discharges.

Agriculture: Agricultural activities in the watershed account for a minor portion (7%) of the total land use. Pasture/hay and cultivated fields are located in the central area of the watershed. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are many residential neighborhoods and parks near the Wychmere Harbor segment MA96-96, including Larson Park bordering the Harbor. Conservation lands, parks, and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few open wetland areas are directly adjacent to the impaired segment around Wychmere Harbor. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

11.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see the map in Figure 2-1.

Town of Harwich. See Section 7.4

12. MA96-99 Little River

12.1. Waterbody Overview

Little River segment MA96-99 is 1.8 miles long and begins at it the outlet of Lovells Pond in Barnstable, MA. The segment flows southeast before ending at its confluence with the tidal portion of the river, south of Old Post Road, Barnstable, MA.

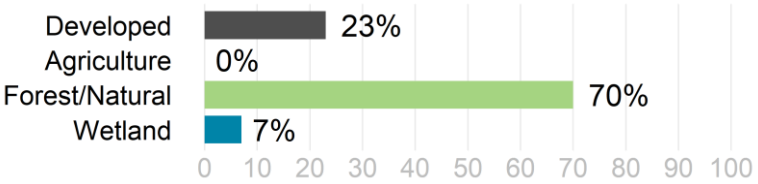
Tributaries to Little River segment MA96-99 include a few unnamed streams. Lakes and ponds in the watershed include Lovells Pond and several small, unnamed waterbodies. Some of the river flows through wetland areas.

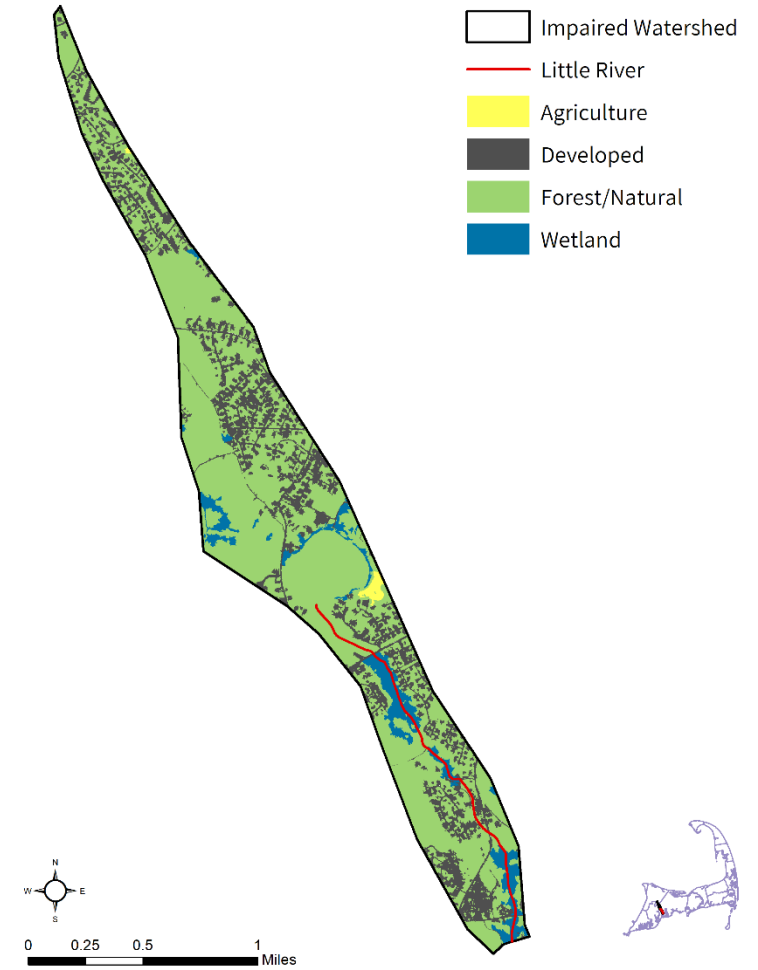
Key landmarks in the watershed include Mosswood Cemetery, Cape Traditions Tree & Landscaping, and part of Holly Ridge Golf Club. From upstream to downstream, segment MA96-99 is crossed by Falmouth Road/Route 28, Sampsons Mill Road, Captain Samadrus Road, Captain Isaiahs Road, Putnam Avenue, and Old Post Road, all in Barnstable, MA.

Little River (MA96-99) drains a total area of 1.5 square miles (mi2), of which 0.2 mi^2 (11%) are impervious area. A 200-foot buffer around the segment covers an area of 0.143 mi^2, of which 0.009 mi^2 (6%) are impervious area. The watershed is not served by a public sewer system in Barnstable[28], and 93% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There are no NPDES permits on file governing point source discharges of pollutants to surface waters, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds. See Figure 12-1.

The Little River segment MA96-99 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (70%) and 7% consists of wetland areas. The remainder is primarily covered by development (23%) with little agricultural activity (<1%). The developed areas consist primarily of clustered areas of residential

Reduction from Highest Calculated Geomean: 51%
Watershed Area (Acres): 940
Segment Length (Miles): 1.8
200-foot Buffer Area (Acres): 91
Impairment(s): *E. coli* (Primary Contact Recreation)
Class (Qualifier): B
Impervious Area (Acres, %): 103 (11%)
Impervious Area Within 200-foot Buffer (Acres, %): 6 (6%)



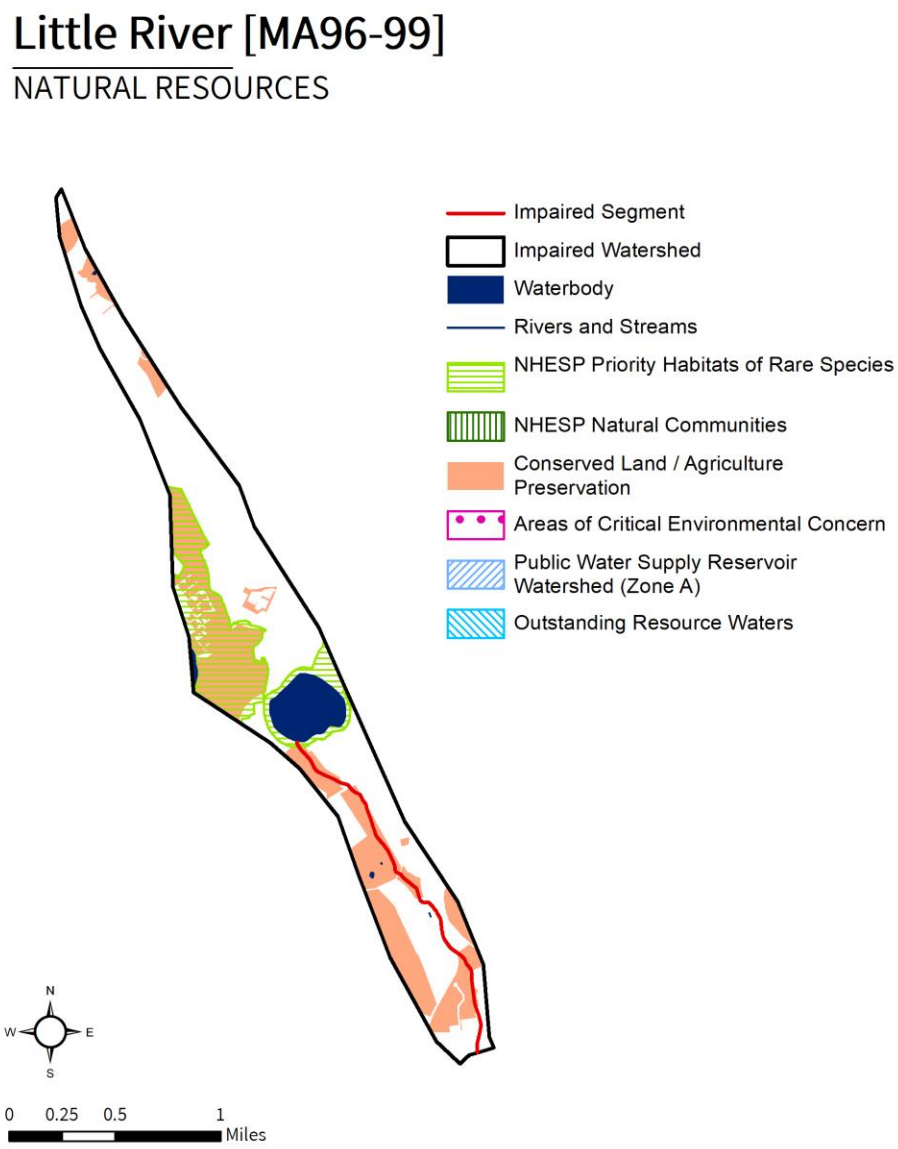


[28] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service area, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021c), MS4 reports, and local knowledge.

homes, with some commercial and industrial zones as well. The minimal area of agriculture, located east of Lovells Pond, consists of a cranberry bog.

In the Little River segment (MA96-99) watershed, under the Natural Heritage and Endangered Species Program, there are 225 acres (24%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 260 acres (28%) of land protected in perpetuity[29], part of 307 acres (33%) of Protected and Recreational Open Space[30]. See Figure 12-1.

[29] Land protected in perpetuity includes conservation restrictions, agricultural preservation, private deed restrictions, wetland restrictions, aquifer protection, historic preservation, etc. Refer to Mass GIS metadata for the Protected and Recreational Open Space data layer.
[30] All Protected and Recreational Open Space land is shown on the natural resources map.



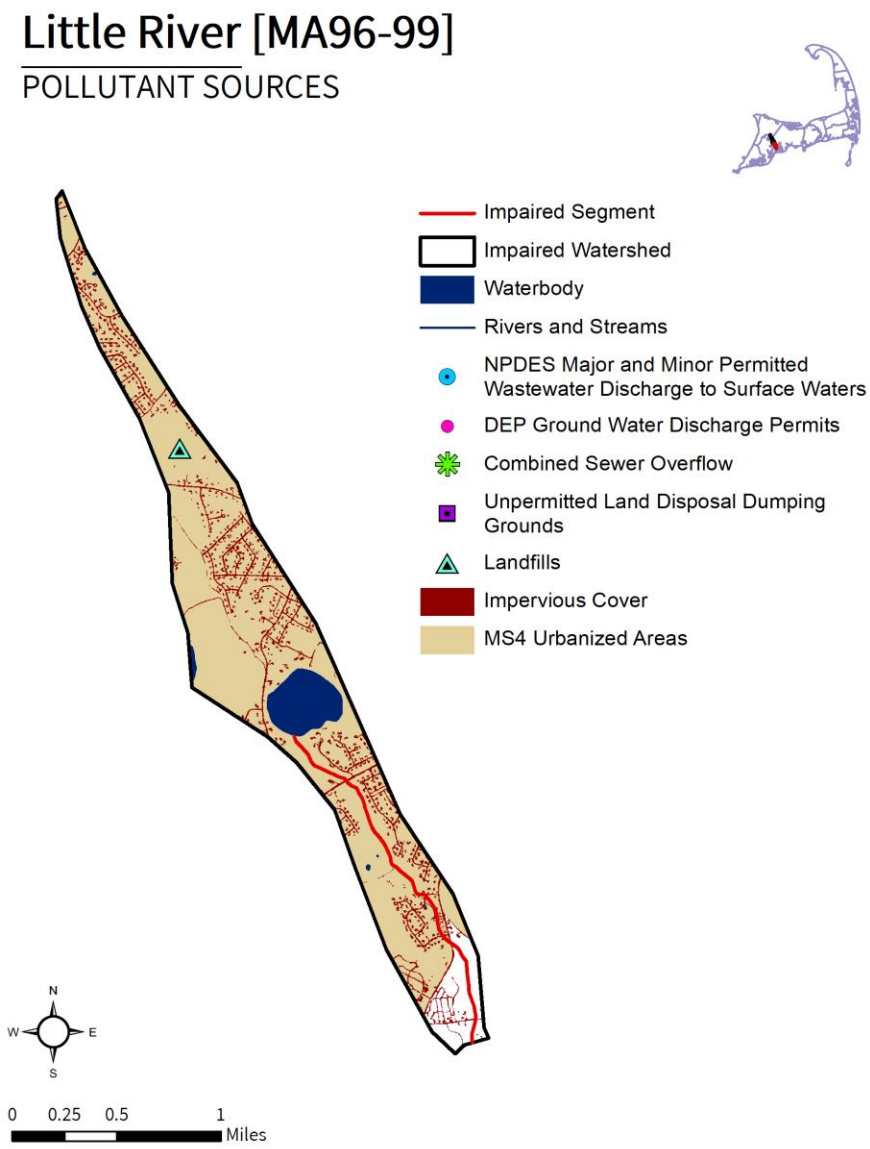


Figure 12-1. Natural resources and potential pollution sources draining to the Little River segment MA96-99. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

12.2. Waterbody Impairment Characterization

The Little River (MA96-99) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the stations identified below (refer to Tables 12-1, 12-2; Figure 12-2). Data were evaluated against the SWQS geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria and the STV criterion of 410 CFU/100 mL for *E. coli*. The geomean STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2009, six samples were collected at W1913; data indicated three days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the Statistical Threshold Value (STV) criterion was applied to single sample results. Out of six samples, one exceeded the STV criterion during dry weather.

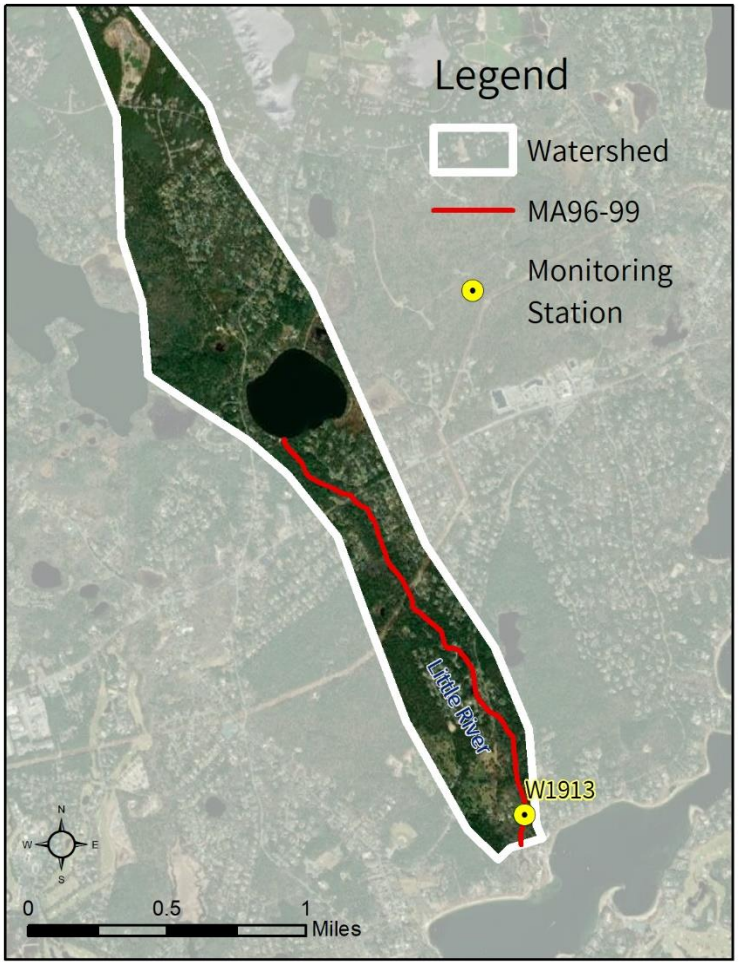


Figure 12-2. Location of monitoring station(s) along the impaired segment.

Table 12-1. Summary of indicator bacteria sampling results by station for the Little River (MA96-99). The maximum 90-day rolling geometric mean (geomean), the number of days exceeding the geomean criterion of 126 CFU/100 mL for *E. coli* indicator bacteria, and the number of single samples exceeding the STV criterion of 410 CFU/100 mL for *E. coli* indicator bacteria are shown. The STV criterion is applied to the single sample results if less than 10 samples were collected within a calendar year at a site. The highest maximum 90-day rolling geomean of the sites is used to calculate the percent load reduction required to meet SWQS.

Unique Station ID	First Sample	Last Sample	Count	Maximum 90-Day Rolling Geomean (CFU/100mL)	Number Geomean Exceedances	Number STV Exceedances
W1913	5/19/2009	10/6/2009	6	258	3	1

Table 12-2. Indicator bacteria data by station, indicator, and date for the Little River (MA96-99). Each sample date was designated as representing wet or dry weather conditions with wet weather defined as more than 0.5 inches of precipitation in the previous 72 hours. Red text in the Results column highlights criteria exceedances of 410 CFU/100 mL (applied to single-sample "Result" since there were no more than 10 samples in a year to calculate the STV); and red text in the Geomean column highlights exceedances of the 126 CFU/100 mL criterion (applied to rolling 90-day geomean) for *E. coli* indicator bacteria.

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1913	*E. coli*	5/19/2009	DRY	40	40	
W1913	*E. coli*	6/23/2009	WET	200	89	
W1913	*E. coli*	7/28/2009	DRY	190	115	
W1913	*E. coli*	8/13/2009	DRY	900	192	
W1913	*E. coli*	9/1/2009	WET	130	258	
W1913	*E. coli*	10/6/2009	WET	28	158	

12.3. Potential Pathogen Sources

Comparing data collected during wet weather versus dry weather conditions provides an indication of the types of sources present, information that can be used to focus pollutant reduction activities. Pathogen levels (as estimated by indicator bacteria) are usually higher in wet weather conditions as storm sewer systems overflow and/or stormwater runoff carries fecal matter that has accumulated on the landscape to surface waters via overland flow and stormwater conduits. Wet weather sources include wildlife and domesticated animal waste (including pets), urban stormwater runoff (including MS4 areas), CSOs, and sanitary sewer overflows (SSOs). In other cases, dry weather pathogen and associated indicator bacteria concentrations can be high when there is a constant flow of pollutants during dry weather, which then becomes diluted during periods of precipitation. Dry weather sources include leaking sewer pipes, illicit connections of sanitary sewers to storm drains, failing septic systems, recreational use (such as swimmers), and wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Little River (MA96-99) were elevated during both wet and dry weather. Elevated results during wet weather are consistent with urban stormwater, pet waste, and wildlife pathogen sources, as are certain types of septic system malfunctions, such as rainwater infiltration or saturated disposal fields which overflow during precipitation. Elevated results during dry weather suggest that ongoing sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be the major sources of pathogens.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (23%), most of which consists of residential areas with some industrial and commercial development as well. Within the watershed, 93% of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 6% of the land area within a 200-foot buffer of the segment is classified as impervious area. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is not available in the watershed within the town of Barnstable. As a result, sewerage-related risks to water quality are not a likely source of pathogens.

On-Site Wastewater Disposal Systems: Some of the development in the watershed utilizes on-site systems for wastewater treatment. It is likely that some septic systems are not properly maintained and are discharging untreated effluent to groundwater.

Agriculture: Agricultural activities in the watershed account for a very small portion (<1%) of the total land use. One small area of cranberry bogs is located next to Lovells Pond.

Pet Waste: There are many residential neighborhoods near the Little River segment MA96-99, as well as conservation lands directly adjacent to Little River, such as the Little River Sanctuary. Conservation lands, parks,

and ballfields popular for dog-walking, especially where paths or residential neighborhoods are adjacent to rivers, ponds, or wetlands, represent possible sources of pathogens.

Wildlife Waste: A few large open areas are directly adjacent to the impaired segment, including wetlands and fields. Large mowed areas, fields, or wetlands with a clear sightline to a waterbody may attract large congregations of waterfowl, resulting in elevated indicator bacteria counts in the water.

12.4. Existing Local Management

This section identifies the major municipalities immediately surrounding the impaired segment and its contributing watershed. For a complete view of upstream municipalities and waterbodies, see Figure 2-1.

Town of Barnstable. See Section 3.4

A CZM Coastal Pollutant Remediation (CPR) grant was awarded in 2020 to the Town of Barnstable who constructed stormwater infrastructure to treat nitrogen and bacteria at two priority sites in the Three Bays watershed. Goals are to restore coastal habitat and improve water quality for swimming and shellfishing (CZM, 2023).

Town of Sandwich

The majority of Sandwich is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041155), and the town has an EPA-approved Notice of Intent (NOI). The town has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. Sandwich completed an illicit discharge detection and elimination (IDDE) plan in 1991, an erosion and sedimentation control (ESC) plan in 1999, and post-construction stormwater regulations in 2004. According to the town's NOI, fecal coliform-impaired MS4 receiving waters include 18 stormwater outfalls into Mill Creek, 13 outfalls into Scorton Creek, five outfalls into Dock Creek, one outfall into Old Harbor Creek, five outfalls into Springhill Creek, and an unspecified number of outfalls into the Cape Cod Canal (no Assessment Unit provided).

Sandwich has the following ordinances and bylaws, mostly accessible online via the town website https://www.sandwichmass.org/ (Town of Sandwich, 2021):

- Wetland protection bylaw
- Animal waste control bylaw
- Stormwater Control Bylaw and Utility: None Found

Sandwich has a 2009 Local Comprehensive Plan, which includes environmental inventories and a section focused on sustainability planning in the town. The plan identifies waterbodies with discharge issues and prioritizes reducing stormwater runoff. *E. coli* impairments are noted in reference to shellfishing closures in Scorton Creek (pg. 2-16). The town does not have any form of public sewer infrastructure, and residents rely solely on on-site septic systems. Sandwich also has a 1999 Open Space and Recreation Plan (Town of Sandwich, 2021).

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