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

Appendix Y: South Shore Coastal Drainage Area

Commonwealth of Massachusetts
Executive Office of Energy and Environmental Affairs
Rebecca L. Tepper, Secretary
Massachusetts Department of Environmental Protection
Bonnie Heiple, Commissioner
Bureau of Water Resources
Kathleen M. Baskin, Assistant Commissioner

December 2024

CN 515.1.25

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

Appendix Y: South Shore Coastal Drainage Area

Prepared by:
TMDL Section, Watershed Planning Program
Division of Watershed Management, Bureau of Water Resources
Massachusetts Department of Environmental Protection

December 2024

CN 515.1.25

Suggested Citation
MassDEP. 2024. Final Massachusetts Statewide Total Maximum Daily Load for Pathogen-Impaired Waterbodies. CN 515.1, Massachusetts Department of Environmental Protection, Bureau of Water Resources, Division of Watershed Management, Watershed Planning Program. Worcester, MA.

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.

Contact Information

Watershed Planning Program
Division of Watershed Management, Bureau of Water Resources
Massachusetts Department of Environmental Protection
8 New Bond Street, Worcester, MA 01606
Website: https://www.mass.gov/guides/watershed-planning-program
Email address: dep.wpp@mass.gov

TABLE OF CONTENTS

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 three pathogen-impaired segments in the South Shore Coastal Drainage Area, hereinafter referred to as the South Coastal 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 in 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 three South Coastal segments were calculated with the flow-based equation. Refer to Tables 1-1 and 1-2.

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 South Coastal Watershed Overview section.

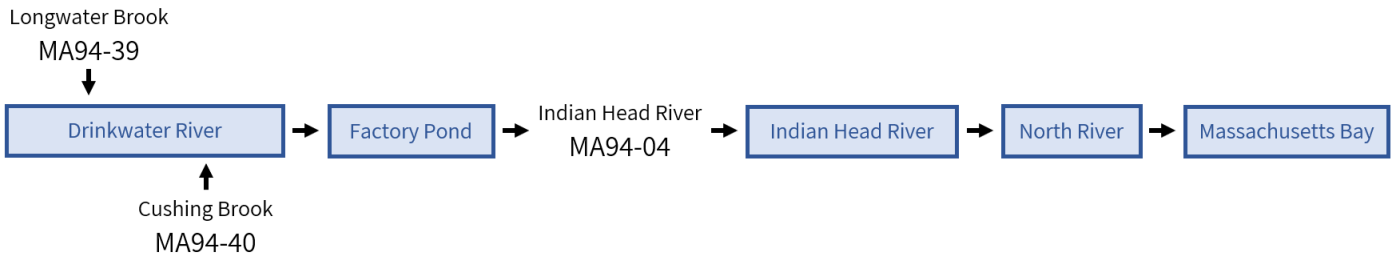


Figure 1-1. Conceptual diagram of water flow through the South Coastal watershed for the three pathogen-impaired segments. Connections between waterbodies are shown with black arrows. Not to scale. Impaired segments are shown with the assessment unit.

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 South Shore 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)					
Indian Head River		R	126	172	27%	WLA (16%)	0.5	4.9	49.0	489.6	4,895.5	48,955.2
MA94-04	B (WW)			(90 day)		LA (84%)	2.6	25.9	259.3	2,593.1	25,931.3	259,312.8
Longwater Brook		R	126	315	60%	WLA (20%)	0.6	6.2	62.3	623.5	6,234.5	62,345.1
MA94-39	B			(90 day)		LA (80%)	2.5	24.6	245.9	2,459.2	24,592.3	245,922.9
Cushing Brook		R	126	474	73%	WLA (19%)	0.6	5.9	58.7	587.0	5,870.0	58,699.6
MA94-40	B			(90 day)		LA (81%)	2.5	25.0	249.6	2,495.7	24,956.8	249,568.4

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 South Shore 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)					
Indian Head River		P	35	NA	-	WLA (16%)	0.1	1.4	13.6	136.0	1,359.9	13,598.7
MA94-04	B (WW)					LA (84%)	0.7	7.2	72.0	720.3	7,203.1	72,031.3
Longwater Brook		P	35	NA	-	WLA (20%)	0.2	1.7	17.3	173.2	1,731.8	17,318.1
MA94-39	B					LA (80%)	0.7	6.8	68.3	683.1	6,831.2	68,311.9
Cushing Brook		P	35	NA	-	WLA (19%)	0.2	1.6	16.3	163.1	1,630.5	16,305.4
MA94-40	B					LA (81%)	0.7	6.9	69.3	693.2	6,932.5	69,324.6

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).*
WW *= Warm Water; waters that meet the warm water fisheries (WWF) definition at 314 CMR 4.02 and are subject to WWF dissolved oxygen and temperature*
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. South Coastal Watershed Overview

The South Coastal Watershed covers an area of approximately 241 square miles (mi^2) in southeastern Massachusetts (Figure 2-1). The largest three subwatersheds are the Cohasset Harbor system, the North and South River systems, and the Plymouth Bay system which includes the Jones and Eel rivers (MassDEP, 2006). There are 167 lakes and ponds in the watershed, of which 14 are designated as Class A Public Water Supplies and Outstanding Resource Waters (MassDEP, 2006). Like many temperate rivers, stream flow in the watershed is on average highest in March and lowest in September, except for several streams in the coastal outwash plain that are groundwater-fed and therefore do not fluctuate dramatically in flow through the year (MassDEP, 2006).

Within the watershed, the North River (including Indian Head River, Drinkwater River, and French Stream in its upper watershed) was designated a state Scenic Protected River by the Massachusetts Department of Environmental Management (now the Department of Conservation and Recreation, MA DCR) in 1978 (MassDEP, 2006). With this designation, the river is managed under the *Scenic and Recreational River Protective Order for the North River* administered by the North River Commission. This order aims to protect natural resources associated with the river by implementing site design standards such as maintaining a 100-foot buffer from the banks of the North River and a 40-foot buffer from the banks of any of its tributaries (MassDEP, 2006).

The South Coastal watershed overlaps a portion of 19 municipalities in Massachusetts. Of these, Duxbury, Hanover, Marshfield, and Scituate are completely contained within the watershed, as well as the majority of Cohasset, Kingston, Norwell, Pembroke, Plymouth and Rockland. 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 Plympton, which has an EPA approved waiver. The networks of drains and pipes in MS4 systems convey polluted runoff from streets and developed areas to waterbodies. 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 sources 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 three Regional Planning Agencies (RPAs) includes the South Coastal 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 in addressing watershed-level issues such as pathogen pollutants and stormwater that cross town boundaries. These South Coastal RPAs include:

- Cape Cod Commission (CCC; CCC, 2022)
- Metropolitan Area Planning Council (MAPC; MAPC, 2021)
- Old Colony Planning Council (OCPC; OCPC, 2022)

The following RPA initiatives and tools utilized in the South Coastal watershed are especially noteworthy:

- Regional stormwater coalitions operate within the RPAs, including CCC's Cape Cod Stormwater Managers Group
- The MAPC utilizes the Integrated Water Management (IWM) approach to coordinate planning across the wastewater, drinking water, and stormwater sectors.
- The MAPC has developed two tools that assist MS4 regulated communities in fulfilling the requirements of the permit. These tools are:

  - Stormwater Utility/Funding Starting Kit (MAPC, 2014)
  - 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).
- The OCPC administers a Community Septic Management Program that assists homeowners in addressing septic system failures.

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:

- **Billington Sea Association** (BSA) is a non-profit organization "dedicated to working to restore Billington Sea to the natural beauty it once was prior to the 1970s". The BSA monitors water and sediment quality in the Billington Sea and its tributaries; conducts educational projects; and collaborated on mitigation projects to address sources of water quality degradation (Delpapa et al, 2011).
- **Eel River Watershed Association** (ERWA) is a non-profit organization "dedicated to protecting the Eel River and its wildlife" (WAA, 2022).
- **Jones River Watershed Association** (JRWA) is non-profit environmental organization established to "protect, enhance and restore the quality of the natural resources in Southeastern Massachusetts, in particular the Jones River and Cape Cod Bay, for present and future generations, while cultivating effective stewardship of our regional environment through science, advocacy, and education" (JRWA, 2022).
- **North River Commission** (NRC) is tasked with administering the North River Scenic Protective Act, which aims to "protect public and private property, wildlife, fresh and saltwater fisheries, and irreplaceable wild, scenic and recreational river resources" (NRC, 2022).
- **North and South Rivers Watersheds Association** (NSRWA) is a local, non-profit environmental organization that aspires to "educate people about their water, engage people with the outdoors, and lead by example" (NSRWA, 2022).
- **Pembroke Watershed Association** (PWA) is a non-profit organization whose mission is to "educate the public and to restore the ponds of Pembroke for clean and safe recreational use" (PWA, 2022).
- **Six Ponds Improvement Association** (SPIA) is an organization whose purpose is to "education and inform members and the public about environmental issues and other items of special concern to the residents of the Six Ponds area of Plymouth, Massachusetts" (SPIA, 2022).
- **Massachusetts Office of Coastal Zone Management** (CZM) has a South Shore Regional office that "serves the coastal communities from Hingham to Plymouth." (CZM, 2022a).
- **Trout Unlimited (TU)** operates two chapters in the geographic area of the Narragansett Bay watershed in Massachusetts, including the Greater Boston (GBTU) and Southeastern Mass (SEMASS). Their mission is to conserve, protect and restore our country's coldwater fisheries and their watersheds; some of their activities include river cleanups, scientific assessments (e.g., trout habitat, culvert connectivity) and restoration projects (TU, 2022).
- **Watershed Action Alliance of Southeastern Massachusetts** (WAA) works with member organizations to "protect and improve the health of the waterways and watersheds of southeastern Massachusetts" (WAA, 2022). These organizations include many watershed associations in the region. WAA helps these associations by "sharing resources and ideas with member organizations, raising public awareness of watershed issues, and building effective relationships with our state and local decision-makers" (WAA, 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.
- **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 (CZM, 2022b). 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*. Any sewage discharges from boats or boating infrastructure in the waters covered by this TMDL are therefore illicit discharges.

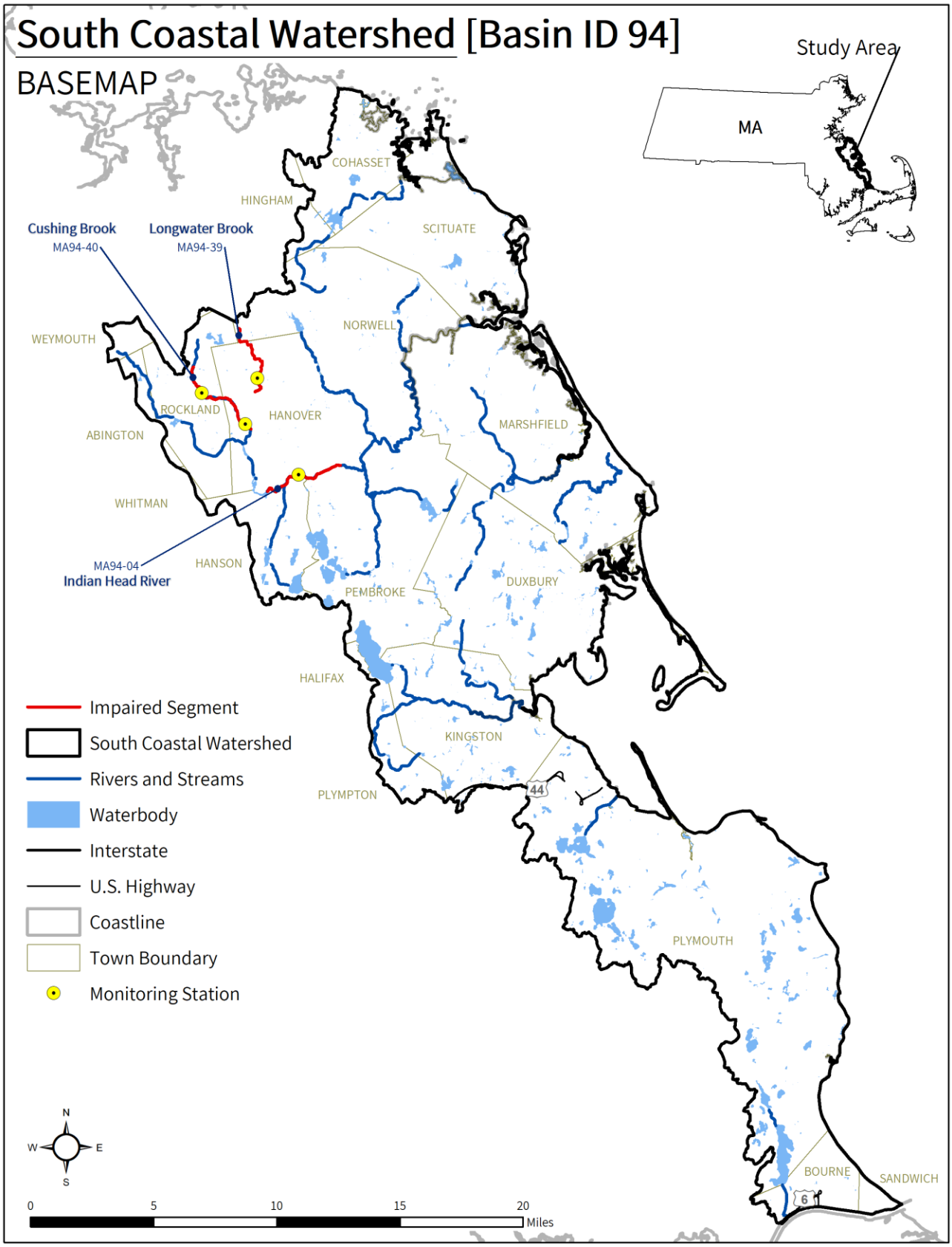


Figure 2-1: Map of all pathogen-impaired segments, water quality monitoring stations, municipal borders, waterbodies, and major roads in the South Coastal watershed.

3. MA94-04 Indian Head River

3.1. Waterbody Overview

Indian Head River segment MA94-04 is 2.8 miles long and begins at the outlet of Factory Pond at the Hanover and Hanson, MA municipal border. The segment flows northeast before ending at the Curtis Crossing Dam (also called Luddams Ford Dam, NATID: MA00428) west of Elm Street at the Hanover and Pembroke, MA municipal border.

Tributaries to the Indian Head River segment MA94-04 include Indian Head Brook, Rocky Run, and a few unnamed streams. Lakes and ponds in the watershed include Trout Pond, Maquan Pond, Wampatuck Pond, Indian Head Pond, Factory Pond, Forge Pond, Studleys Pond, Abington-Rockland Reservoir, Hackett Pond, and a few small unnamed waterbodies. Much of the segment flows through wetland and other natural or forested areas.

Key landmarks in the watershed include the Hanson town center and Hanson Public Library; Indian Head School, Hanson Middle School, North River School, R. Stewart Esten School, South Shore Regional Vocational Technical High School, South Shore Charter Public School, Hanover High School, and Hanover Middle School; Rockland Sanitary Landfill and Rockland Sewer Commission; Fem Hill Cemetery, St. Patrick's Cemetery, and Holy Family Cemetery; the Historic Naval Air Station in Weymouth; Sentas Family Farm and Griffin Dairy Farm; Memorial Field, Arnold Park, Bicentennial Park, and Forge Pond Park; many camps including Camp Wampatuck, Golden Ring Camp, and Camp Kiwanis; Harmon Golf Course and Fitness Center, Rockland Golf Course, and Pembroke Country Club; and many wetland and conservation areas including Little Cedar Swamp, Wampatuck Bogs, Beech Hill Swamp, Wampum Swamp, Peg Swamp, Andruk Bog, Major Reed Park, Hobart Swamp, Shinglemill Brook Swamp, Rockland Town Forest and Conservation Land. From upstream to downstream, segment MA94-04 is crossed by Winter Street (Hanson) and State Street (Hanover).

Reduction from Highest Calculated Geomean: 27%

Watershed Area (Acres): 19,489

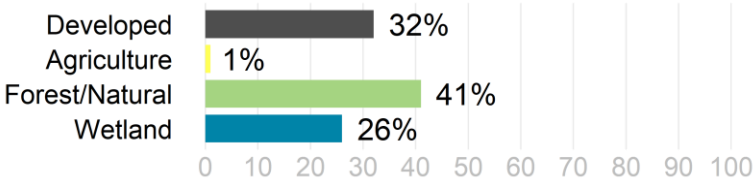
Segment Length (Miles): 2.8

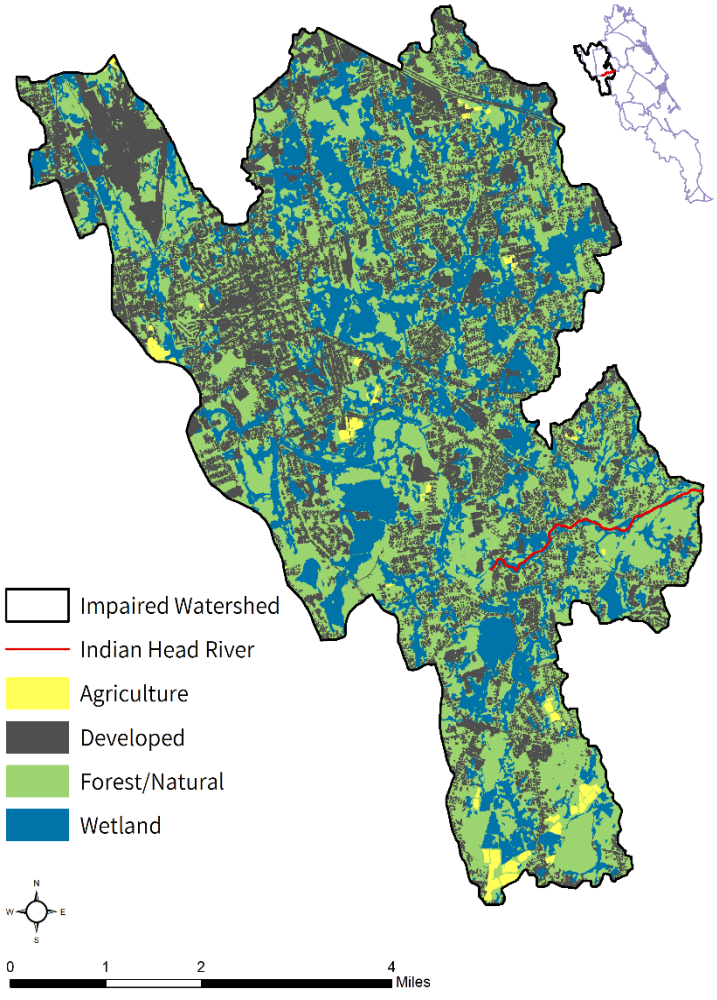
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B (Warm Water)

Impervious Area (Acres, %): 3,095 (16%)

DCIA Area (Acres, %): 1,891 (10%)





Indian Head River (MA94-04) drains a total area of 30.4 square miles (mi^2), of which 4.8 mi^2 (16%) are impervious and 3.0 mi^2 (10%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Abington, Hanover,

Hingham, Norwell, Pembroke, Rockland, and Weymouth[1]; and 100% of the total land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There is one NPDES permit on file governing municipal wastewater treatment plant discharges (Rockland WWTP), and it is not within the immediate drainage area to the impaired segment. There are two MassDEP discharge-to-groundwater permits for on-site wastewater discharge within the watershed (one within the immediate drainage area, Table 3-1). There are no combined sewer overflows (CSOs) within the watershed. There are two landfills and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 3-1.

The Indian Head River segment MA94-04 watershed is located in a moderately-developed part of Massachusetts. A little under half of the watershed consists of forest and natural lands (41%) and 26% consists of wetland areas. There is a small amount of agriculture (1%) that mostly consists of cranberry bogs located within the Indian Head Brook subwatershed. Development accounts for roughly a third (32%) of total land use and is composed mostly of residential neighborhoods, with a larger amount of commercial and industrial development in the northern part of the watershed.

In the Indian Head River (MA84-04) watershed, there are 717 acres (4%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities, as designated by the Natural Heritage and Endangered Species Program. There are 235 acres (1%) under Public Water Supply protection, none within designated Areas of Critical Environmental Concern, and 663 acres (3%) of Outstanding Resource Waters. Overall, there are 2,008 acres (10%) of land protected in perpetuity[2], part of 2,817 acres (14%) of Protected and Recreational Open Space[3]. See Figure 3-1.

Table 3-1. Groundwater discharge permits in the segment watershed. Only permits unique to this segment watershed are shown. 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)
791-1	STONEBRIDGE COMMONS CONDOMINIUM	HANSON	Sanitary Discharge	22,650

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

[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.

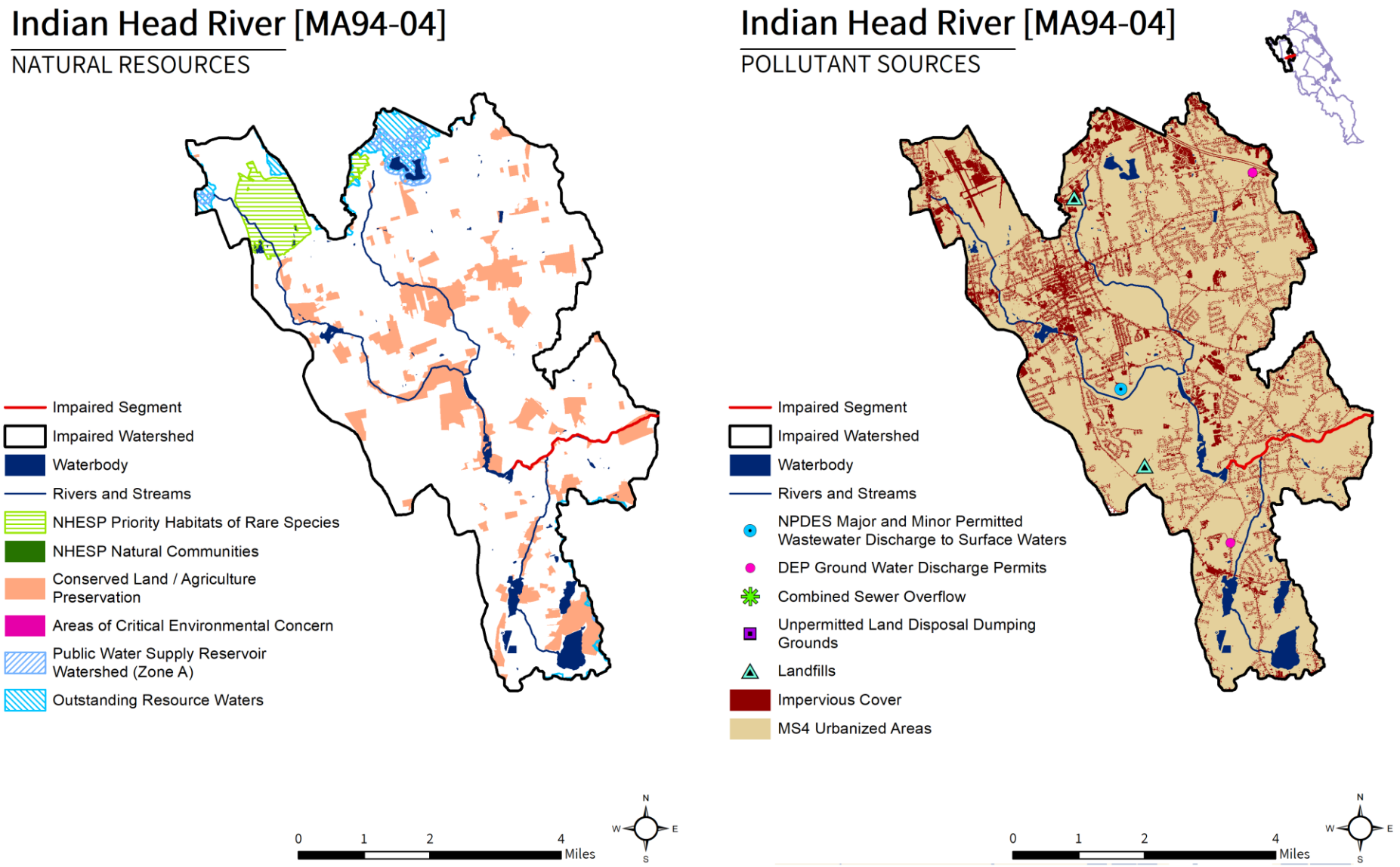


Figure 3-1. Natural resources and potential pollution sources draining to the Indian Head River segment MA94-04. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

3.2. Waterbody Impairment Characterization

The Indian Head River (MA94-04) is a Class B, Warm Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station listed below (refer to Tables 3-2, 3-3; 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 Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2006, five samples were collected at W1528; 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 five samples, none exceeded the STV criterion.

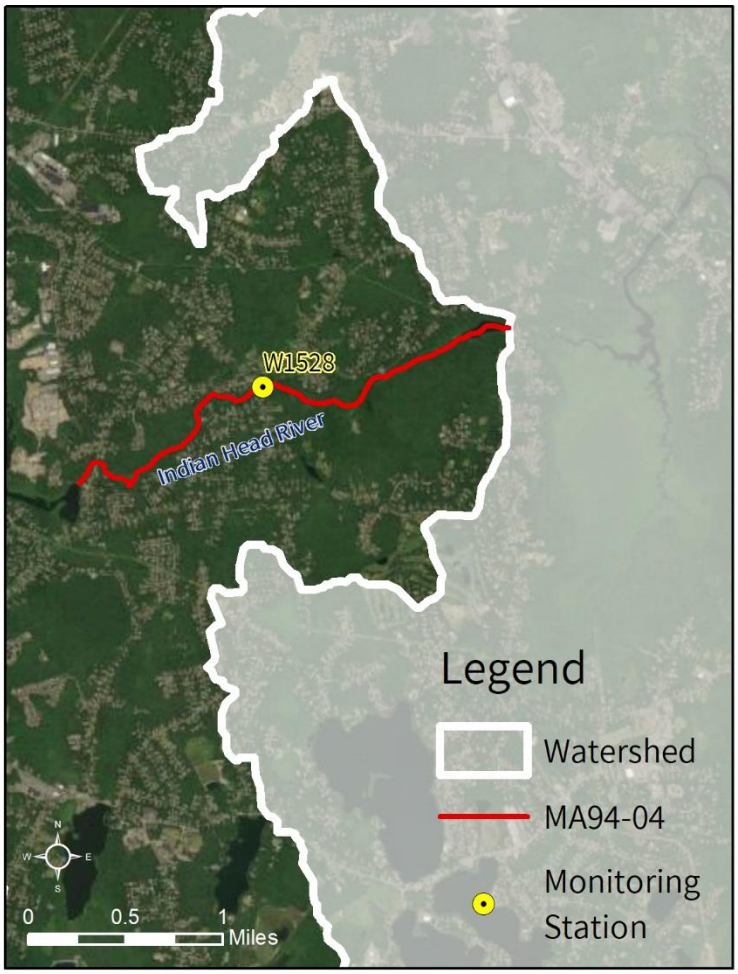


Figure 3-2. Location of monitoring station(s) along the impaired segment.

Table 3-2. Summary of indicator bacteria sampling results by station for the Indian Head River (MA94-04). 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 site 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
W1528	6/20/2006	10/11/2006	5	172	4	0

Table 3-3. Indicator bacteria data by station, indicator, and date for the Indian Head River (MA94-04). 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) for *E. coli* indicator bacteria; 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)
W1528	*E. coli*	6/20/2006	DRY	80	80	
W1528	*E. coli*	7/6/2006	DRY	250	141	
W1528	*E. coli*	8/2/2006	DRY	200	159	
W1528	*E. coli*	9/6/2006	DRY	220	172	
W1528	*E. coli*	10/11/2006	DRY	75	149	
W1528	Fecal Coliform	6/20/2006	DRY	150		
W1528	Fecal Coliform	7/6/2006	DRY	310		
W1528	Fecal Coliform	8/2/2006	DRY	340		
W1528	Fecal Coliform	9/6/2006	DRY	230		
W1528	Fecal Coliform	10/11/2006	DRY	150		

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 direct wildlife and domesticated animal waste (including pets).

Indicator bacteria data (*E. coli*) for Indian Head River (MA94-04) were below the single sample criterion (all samples were collected under dry weather conditions), however, the rolling geometric mean criterion was exceeded, and no wet weather data were available. Elevated results during dry weather suggest that baseflow sources, such as leaking pipes, illegal cross connections, other illicit discharges, and failing septic systems, are likely to be major sources of pathogens. Additional sampling under wet conditions would likely help identify other pollutant sources, if present.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is a moderate amount of development in the watershed (32%), consisting of residential areas as well as industrial and commercial development. The entire land area is subject to MS4 permit conditions, 16% is classified as impervious area, and 10% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within Abington, Hingham, Norwell, Pembroke, Rockland, and Weymouth. Sewer-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and 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 development in the watershed utilizes on-site systems for wastewater treatment. Additionally, there are two MassDEP permits for on-site wastewater discharges to

groundwater. In addition to these permitted point sources, 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. This agricultural land is comprised predominately of a horse farm, cranberry bogs, and other pasture/hay fields. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are a few residential neighborhoods near the Indian Head River segment MA94-04. 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 fields and wetland areas are located 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.

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 Hanover

All of Hanover is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041036), 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. Hanover completed an illicit discharge detection and elimination (IDDE) plan in 2014, but has not completed an erosion and sedimentation control (ESC) plan or the required post-construction stormwater regulations. According to the NOI, pathogen-impaired MS4 receiving waters include four impaired by fecal coliform. There are 11 stormwater outfalls into Drinkwater River (MA94-21), five outfalls into Forge Pond (listed on NOI as MA94037, though currently part of MA94-21), two outfalls into Iron Mine Brook (MA94-24, though listed as attaining primary and secondary contact recreation in the 2018/20 Integrated List), one outfall to North River (MA94-05) and three outfalls into Third Herring Brook (MA94-27, also not identified as pathogen-impaired in the 2018/20 Integrated List).

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

- Wetland protection bylaw;
- Stormwater regulation bylaw ;
- Stormwater Utility: None found; and
- Pet Waste: None found.

Hanover has a 2018 Master Plan, in which the town's natural environment and its importance is a major theme. In the open space and recreation section, water resources are identified, and specific river impairments are mentioned (p. 104). The environmental challenges section identifies many issues related to stormwater management (p. 103). Hanover does not have a public sewer system, and all wastewater treatment is provided by on-site septic systems (p. 104). The town has an Open Space and Recreation Plan from 2018 that includes a more targeted and in-depth environmental inventory and analysis (Town of Hanover, 2021).

As part of a recent MassDEP 604b grant (Project #21-02), the Town of Hanover is partnering with the North and South Rivers Watershed Association (NSWRA) and the Massachusetts Bays National Estuary Partnership (MassBays) to conduct an iterative bacteria sampling program to determine sources of high bacteria counts, provide outreach to the community about water quality impairments, and to determine impairment solutions. Iterative sampling will be conducted on five tributaries to the North River, including Longwater Brook, Cushing Brook, French Stream, Drinkwater River, and Indian Head. Sampling sites will differ depending on previous

results but will generally bracket high counts both upstream and downstream and will be conducted three times per month from April through September. Valid data will be submitted to the MassDEP external data portal. NSWRA will work with community groups (high school environmental clubs and scout troops) to enlist sampling volunteers and will provide sampling results to the public via town board meetings, an electronic newsletter, and social media outlets.

Town of Hanson

The majority of Hanson is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041037), 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. Hanson completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations, all in 2014. Hanson does not report any outfalls to impaired waterbodies on its NOI.

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

- Wetland protection bylaw;
- Stormwater regulation bylaw and stormwater utility fees; and
- Pet Waste: None found.

Hanson has a 2008 Master Plan that includes a recreation, land-use, and natural resources section. This section specifically recognizes the importance of stream-based green corridors (V-10). The Master Plan states the town is unsewered (II-22). Hanson also has a 2009 Open Space and Recreation Plan, although this plan is not current because it was only meant to inform planning until 2014 (Town of Hanson, 2021).

Town of Pembroke

All of Pembroke is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041054), 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 2013, Pembroke completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. According to the NOI, fecal coliform-impaired MS4 receiving waters include three stormwater outfalls into the North River (MA94-05).

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

- Stormwater control bylaw and utility fee;
- Wetland protection bylaw; and
- Pet Waste: None found.

No Master Plan was found for Pembroke online, but there is an Open Space and Recreation Plan from 2019. This plan contains inventories and analyses of water resources, including the North River mentioned above; there is no mention of surface water quality impairments (Town of Pembroke, 2021).

Town of Rockland

All of Rockland is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041058), 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. Rockland completed an illicit discharge detection and elimination (IDDE) plan in 2003, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2004. According to the NOI, fecal coliform-impaired MS4 receiving waters include 23 stormwater outfalls into French Stream (MA94-03) and four outfalls into Studleys Pond (MA94151).

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

- Stormwater management bylaw;
- Wetland protection bylaw;
- Animal waste control bylaw; and
- Stormwater Utility: None found.

Rockland has a Master Plan from 2020, which includes a section that inventories the town's water resources. This plan also has a Sustainability and Clean Energy section (p. 83). TDMLs and impaired waterbodies are identified in the water resources section (p. 44). The town has a public sewer system managed by the Rockland Sewer Commission (p. 60). Freshwater beaches are identified. Additionally, Rockland has a 2018 Open Space and Recreation Plan which contains more detail on beaches and other natural resources (Town of Rockland, 2021).

4. MA94-39 Longwater Brook

4.1. Waterbody Overview

The Longwater Brook segment MA94-39 is 2.8 miles long and begins at its headwaters south of Pilgrims Highway/MA-3 in Norwell, MA. The segment flows south before ending at the confluence with Drinkwater River in Hanover, MA.

Tributaries to the Longwater Brook segment MA94-39 include Shinglemill Brook and a few unnamed tributaries. Lakes and ponds in the watershed include Hacketts Pond, Shinglemill Pond, and a few small unnamed underbodies. Much of the river flows through wetland areas.

Key landmarks in the watershed include The Learning Ladder PreSchool, Hanover High School, Hanover Middle School, Cedar Elementary School, and South Shore Charter Public School; and many wetland and conservation areas including Shinglemill Brook Swamp, Pine Island Swamp, and Rinear Property conservation area. From upstream to downstream, segment MA94-39 is crossed by Philip Drive (Norwell), American Elm Avenue (Hanover), Cedarwood Road (Hanover), Brookwood Road (Hanover), Webster Street/MA-123 (Hanover), Bates Way (Hanover).

Longwater Brook (MA94-39) drains a total area of 3.0 square miles (mi^2), of which 0.6 mi^2 (20%) are impervious and 0.4 mi^2 (13%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Norwell [4]; 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, one MassDEP discharge-to-groundwater permit for on-site wastewater discharge (Table 4-1), and no combined sewer overflows (CSOs) within the watershed. There are no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 4-1.

The Longwater Brook segment MA94-39 watershed is located in a moderately-developed part of Massachusetts. Roughly three quarters of

Reduction from Highest Calculated Geomean: 60%

Watershed Area (Acres): 1,905

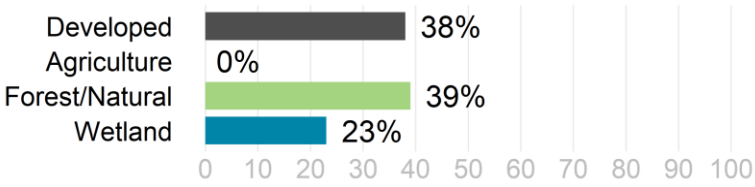
Segment Length (Miles): 2.8

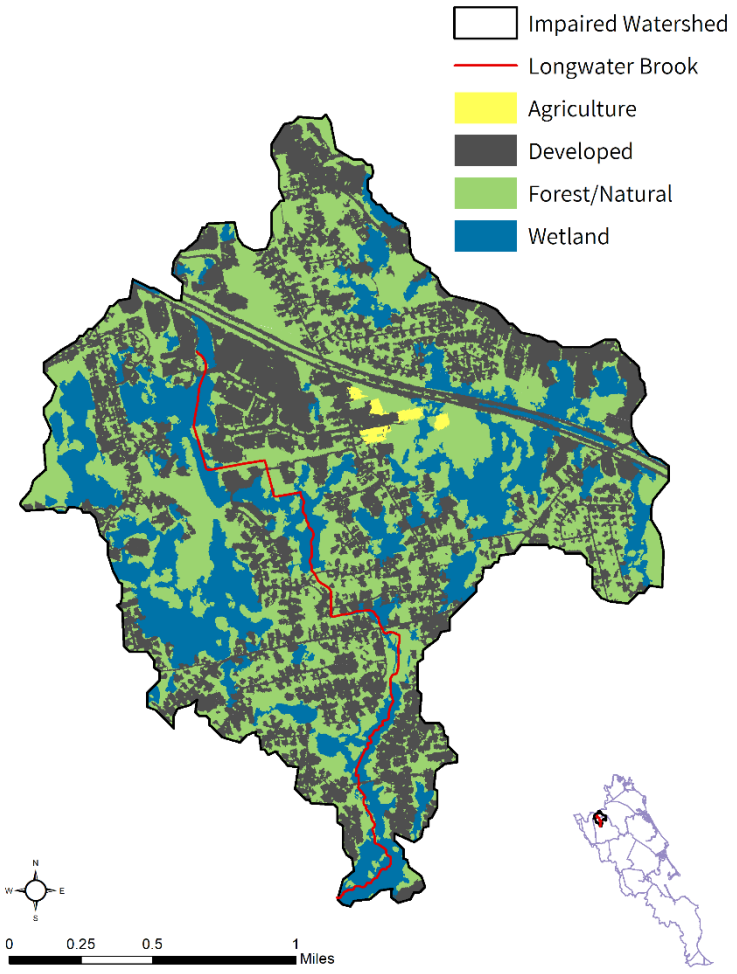
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 385 (20%)

DCIA Area (Acres, %): 250 (13%)





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

the watershed consists of forest and natural lands (39%) or wetland areas (23%). There is a small amount of agriculture (<1%), most of which is pasture/hay fields and some cultivated fields. The remainder is developed (38%), consisting mostly of residential neighborhoods with some commercial and industrial development within close proximity to Pilgrims Highway/MA-3 in the headwaters.

In the Longwater Brook (MA94-39) watershed, there are no Priority Habitats of Rare Species or Priority Natural Vegetation Communities, as designated by the Natural Heritage and Endangered Species Program. There are 27 acres (1%) under Public Water Supply protection, none within designated Areas of Critical Environmental Concern, and 23 acres (1%) of Outstanding Resource Waters. Overall, there are 110 acres (6%) of land protected in perpetuity[5], part of 143 acres (8%) of Protected and Recreational Open Space[6]. See Figure 4-1.

Table 4-1. Groundwater discharge permits in the segment watershed. Only permits unique to this segment watershed are shown. 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)
961-0	WEBSTER VILLAGE	HANOVER	Sanitary Discharge	14,300

[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.

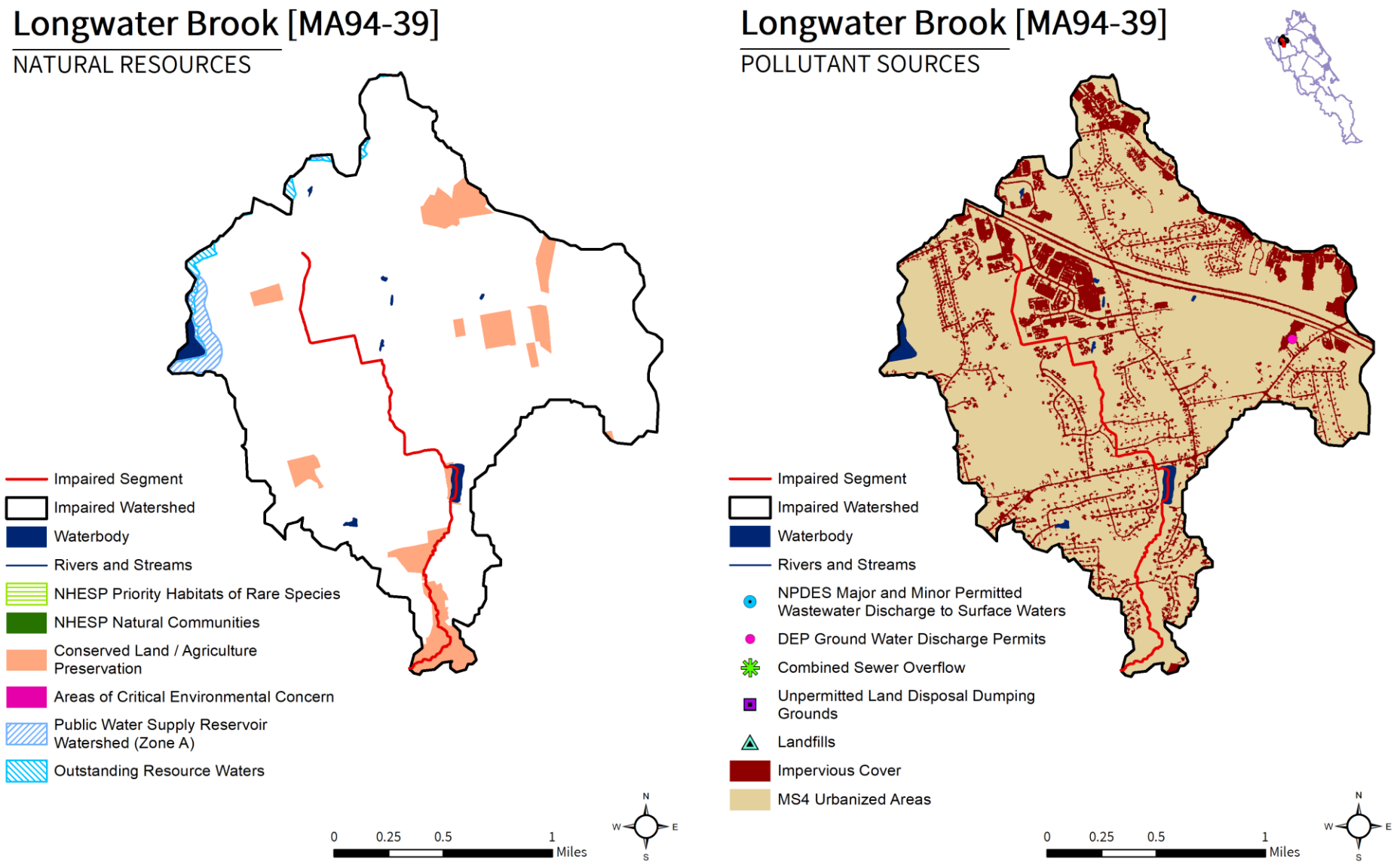


Figure 4-1. Natural resources and potential pollution sources draining to the Longwater Brook segment MA94-39. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

4.2. Waterbody Impairment Characterization

Longwater Brook (MA94-39) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station listed below (refer to Tables 4-2, 4-3; 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 Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2006, five samples were collected at W1529 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 five samples, two exceeded the STV criterion, one during wet weather and one during dry weather.

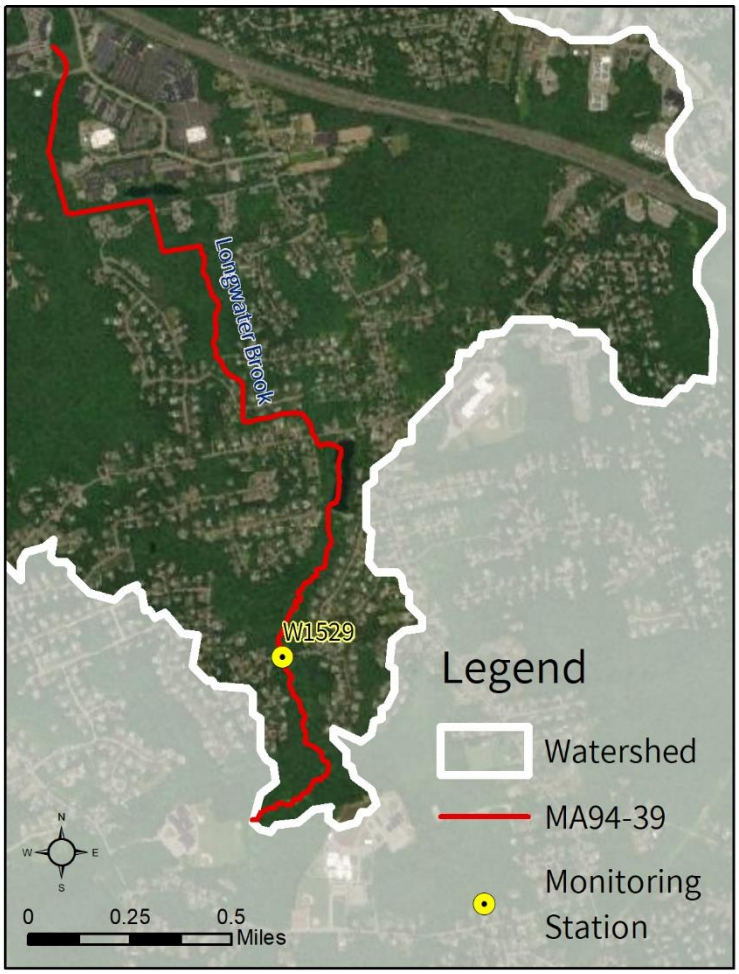


Figure 4-2. Location of monitoring station(s) along the impaired segment.

Table 4-2. Summary of indicator bacteria sampling results by station for Longwater Brook (MA94-39). 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 site 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
W1529	5/9/2006	8/23/2006	5	315	3	2

Table 4-3. Indicator bacteria data by station, indicator, and date for Longwater Brook (MA94-39). 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) for *E. coli* indicator bacteria; 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)
W1529	*E. coli*	5/9/2006	WET	33	33	
W1529	*E. coli*	6/6/2006	DRY	178	77	
W1529	*E. coli*	6/26/2006	WET	411	134	
W1529	*E. coli*	7/11/2006	DRY	488	185	
W1529	*E. coli*	8/23/2006	DRY	276	315	

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 direct wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Longwater Brook (MA94-39) 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 baseflow 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 (38%), though it is concentrated around the segment. Development consists of residential areas as well as industrial and commercial development. The entire land area is subject to MS4 permit conditions, 20% is classified as impervious area, and 13% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within Norwell. Sewer-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and 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. Additionally, there is one MassDEP permit for on-site wastewater discharge to groundwater. In addition to these permitted point sources, 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. This agricultural land is comprised of pasture/hay fields and cultivated fields. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are residential neighborhoods and conservation lands along most of the Longwater Brook segment MA94-39. 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 a few open fields and wetland areas 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.

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 Hanover. See Section 3.4

Town of Norwell

The majority of Norwell is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041052), 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. Norwell completed an illicit discharge detection and elimination (IDDE) plan in 2014, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2012. According to the NOI, fecal coliform-impaired MS4 receiving waters include seven stormwater outfalls into North River (MA94-05) and two outfalls into Third Herring Brook (MA94-27, though not listed as pathogen-impaired in the 2018/20 Integrated List).

Norwell has the following ordinances and bylaws, mostly accessible online via the town website at https://www.townofnorwell.net/ (Town of Norwell, 2021):

- Stormwater control bylaw and utility fee;
- Norwell does not have any supplementary regulations beyond the MassDEP regulations for wetland protection; and
- Pet Waste: None found.

Norwell has a Master Plan from 2005, which includes a section dedicated to the town's natural resources and their protection. Increasing stormwater protection is an action item in the plan (Town of Norwell, 2021).

5. MA94-40 Cushing Brook

5.1. Waterbody Overview

The Cushing Brook segment MA94-40 is 3.1 miles long and begins at its headwaters east of Pleasant Street in Rockland, MA. The segment flows south before ending at the confluence with Drinkwater River in Hanover, MA.

Tributaries to the Cushing Brook segment MA94-40 include Ben Mann Brook and a few unnamed streams. Lakes and ponds in the watershed include a portion of the Abington-Rockland Reservoir and a few small unnamed waterbodies. The segment flows through wetlands, forested, and other natural areas.

Key landmarks in the watershed include industrial parks off Commerce Road and Reservoir Park Drive in Rockland; Mt. Pleasant Cemetery; South Shore Disc Golf; as well as Hingham Street Conservation Land, Hobart Swamp, Rinear Property conservation area, and John Smith Lane Conservation Land. Segment MA94-40 is crossed by John Smith Lane (Rockland), Liberty Lane (Rockland), Webster Street (Rockland), East Water Street/MA-123 (Rockland), Pleasant Street (Hanover), and Hanover Street/MA-139 (Hanover).

Cushing Brook (MA94-40) drains a total area of 4.1 square miles (mi^2), of which 0.8 mi^2 (19%) are impervious and 0.5 mi^2 (13%) are directly connected impervious area (DCIA). The watershed is partially served by a public sewer system in Rockland[7], and the entire land area is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (USEPA, 2020). There is one additional NPDES permit on file governing the point source discharge of pollutants to surface waters, however, this permit is for a water treatment facility which is not a likely source of pathogens to Cushing Brook. There are no MassDEP discharge-to-groundwater permits for on-site wastewater discharge or combined sewer overflows (CSO) within the watershed. There is one landfill and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 5-1.

Reduction from Highest Calculated Geomean: 73%

Watershed Area (Acres): 2,612

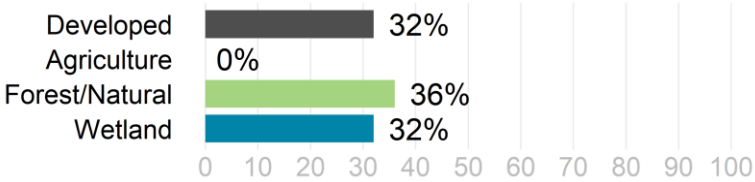
Segment Length (Miles): 3.1

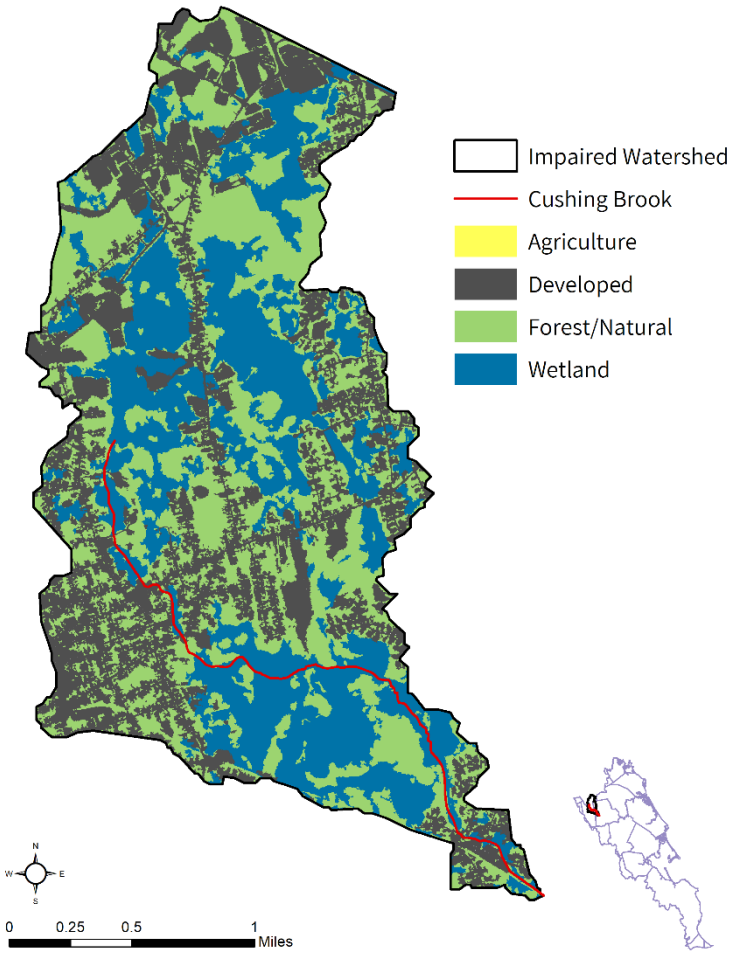
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 497 (19%)

DCIA Area (Acres, %): 348 (13%)





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

The Cushing Brook segment MA94-40 watershed is located in a moderately-developed part of Massachusetts. More than half of the watershed consists of forest and natural lands (36%) or wetland areas (32%). The remainder of the watershed consists of developed areas (32%). Most of the development consists of residential areas with some commercial buildings located near major roads in the watershed. There are no agricultural areas in the watershed.

In the Cushing Brook (MA94-40) watershed, under the Natural Heritage and Endangered Species Program, there are 56 acres (2%) of Priority Habitats of Rare Species and no acres (0%) of Priority Natural Vegetation Communities. There are also 181 acres (7%) under Public Water Supply protection, no acres within designated Areas of Critical Environmental Concern, and 476 acres (18%) of Outstanding Resource Waters. Overall, there are 364 acres (14%) of land protected in perpetuity[8], part of 380 acres (15%) 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.

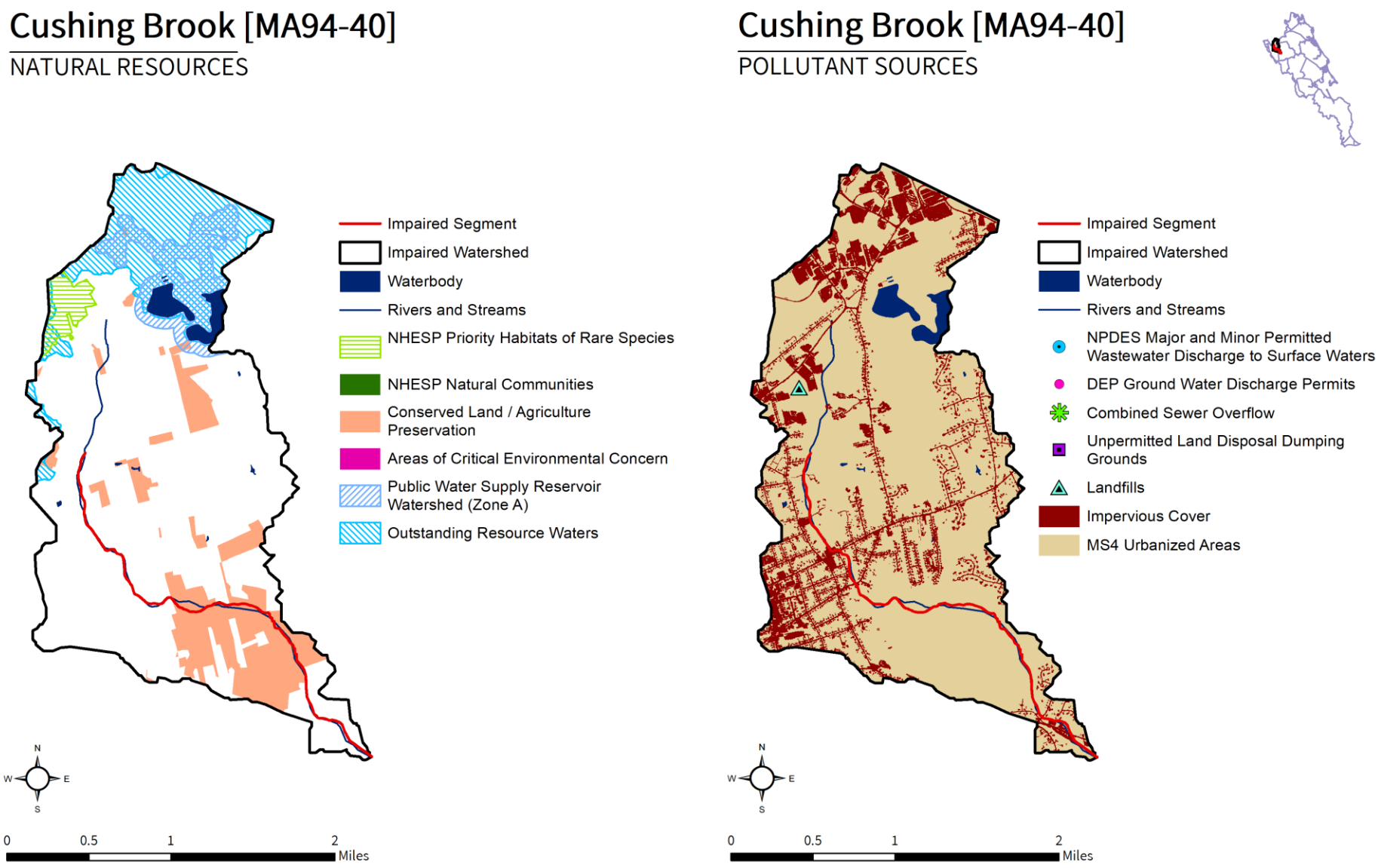


Figure 5-1. Natural resources and potential pollution sources draining to the Cushing Brook segment MA94-40. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

5.2. Waterbody Impairment Characterization

Cushing Brook (MA94-40) is a Class B Water (MassDEP, 2021a).

The Primary Contact Recreation use was assessed for attainment of SWQS at the station 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 Statistical Threshold Value (STV) criterion of 410 CFU/100 mL for *E. coli.* The geomean and STV criteria for the impaired segment apply to data on a year-round, 90-day rolling basis.

- In 2006, five samples were collected at W1525; 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 five samples, one exceeded the STV criterion during dry weather.
- In 2006, five samples were collected at W1523, resulting in two days when the 90-day rolling geomean exceeded the criterion. Since there were no stations and years with more than 10 samples, the STV criterion was applied to single sample results. Out of five samples, two exceeded the STV criterion during dry weather.

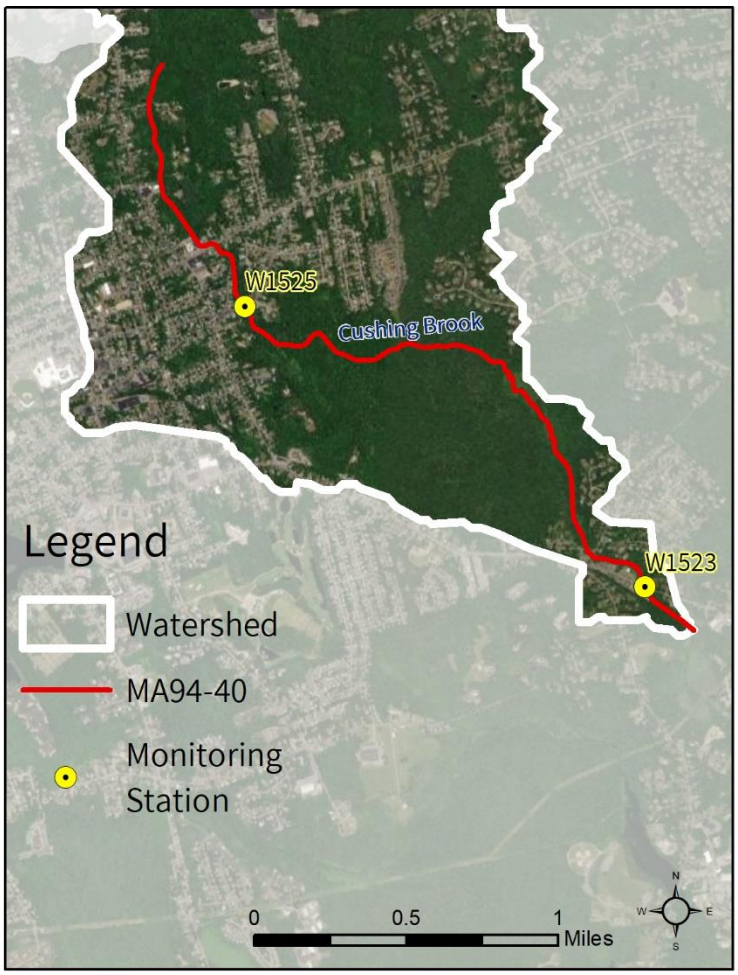


Figure 5-2. Location of monitoring station(s) along the impaired segment.

Table 5-1. Summary of indicator bacteria sampling results by station for Cushing Brook (MA94-40). 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 site 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
W1525	5/9/2006	8/23/2006	5	393	4	1
W1523	5/9/2006	8/23/2006	5	474	2	2

Table 5-2. Indicator bacteria data by station, indicator, and date for Cushing Brook (MA94-40). 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) for *E. coli* indicator bacteria; 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)
W1525	*E. coli*	5/9/2006	WET	72	72	
W1525	*E. coli*	6/6/2006	WET⁺	291	145	
W1525	*E. coli*	6/26/2006	WET	387	201	
W1525	*E. coli*	7/11/2006	DRY	345	230	
W1525	*E. coli*	8/23/2006	DRY‡	613	393	
W1523	*E. coli*	5/9/2006	WET	16	16	
W1523	*E. coli*	6/6/2006	WET⁺	147	48	
W1523	*E. coli*	6/26/2006	WET	291	88	
W1523	*E. coli*	7/11/2006	DRY	2,420*	202	
W1523	*E. coli*	8/23/2006	DRY‡	488	474	

* Value above the Method Detection Limit (MDL) of 2,419.6 CFU/100mL; the MDL is reported and used to calculate the geometric means for *E. coli*.

⁺ Note: manually changed from "DRY" to "WET" classification because data collected at multiple nearby precipitation gages indicate that this is more representative of true conditions at the site.

‡Note: although conditions on this date are within the "dry" weather classification, precipitation data collected at numerous gages in the vicinity recorded 1+ inches of precipitation fell on August 20-21, 2006.

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 direct wildlife and domesticated animal waste (including pets).

Indicator bacteria data for Cushing Brook (MA94-40) 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 baseflow 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 (32%), most of which consists of residential areas, with some commercial development as well. The entire land area is subject to MS4 permit conditions, 19% is classified as impervious area, and 13% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service is available in the watershed within the Massachusetts town of Rockland. Sewer-related risks to water quality include leaking infrastructure (pipes, pump stations, etc.) and

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.

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: Conservation lands and some residential neighborhoods are adjacent to the Cushing Brook segment MA94-40. 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 open wetlands 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.

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 5-1.

Town of Hanover. See Section 3.4

Town of Rockland. See Section 3.4

6. References

CCC. (2022). Cape Cod Commission. Retrieved from home page: https://capecodcommission.org/

CZM. (2022a). Massachusetts Office of Coastal Zone Management. Retrieved from South Shore Region page: https://www.mass.gov/locations/czm-south-shore-region

CZM. (2022b). Boat Pumpout Facilities. Retrieved from: https://www.mass.gov/service-details/boat-pumpout-facilities

Delpapa, C. et al (2011). *Plymouth Pond and River Monitoring Program. Quality Assurance Project Plan 2011-2013.* The Town of Plymouth Environmental Management Division, Billington Sea Association, Herring Ponds Watershed Association, and the Six Ponds Improvement Association. Plymouth, MA. Available at: https://www.theherringpondswatershed.org/wp-content/uploads/2020/03/PlymouthPondandRiverMonitoringProgram.pdf

JRWA. (2022). Jones River Watershed Association. Retrieved from home page: https://jonesriver.org/

MAPC. (2014). Metropolitan Area Planning Council. Retrieved from Stormwater Financing/Utility Starter Kit: https://www.mapc.org/resource-library/stormwater-financing-utility-starter-kit/

MAPC. (2018). Metropolitan Area Planning Council. Retrieved from MS4 Outfall Catchment Calculator: https://www.mapc.org/resource-library/ms4-outfall-catchment-calculator/

MAPC. (2021). Metropolitan Area Planning Council. Retrieved from home page: https://www.mapc.org/

MassDEP. (2021a). *314 CMR 4.00: Massachusetts Surface Water Quality Standards.* Massachusetts Department of Environmental Protection, Boston, MA. Available at: https://www.mass.gov/doc/314-cmr-400/download

MassDEP. (2021b). Water Utility Resilience Program. Retrieved from home page: https://www.mass.gov/guides/water-utility-resilience-program

MassDEP. (2022). *Massachusetts Integrated List of Waters for the Clean Water Act 2018/2020 Reporting Cycle.* CN 505.1. Massachusetts Department of Environmental Protection, Bureau of Water Resources, Division of Watershed Management, Watershed Planning Program. Worcester, MA. Available at https://www.mass.gov/doc/final-massachusetts-integrated-list-of-waters-for-the-clean-water-act-20182020-reporting-cycle/download

MassDEP. (2006). *South Shore Coastal Watersheds: 2001 Water Quality Assessment Report*. CN 93.0. Massachusetts Department of Environmental Protection. Division of Watershed Management. Worcester, MA. March 2006. Available at: https://www.mass.gov/doc/south-shore-coastal-watersheds-2001-water-quality-assessment-report-introduction/download

NRC. (2022). North River Commission. Retrieved from home page: http://www.northrivercommission.net/

NSRWA. (2022). North and South Rivers Watershed Association. Retrieved from home page: https://www.nsrwa.org/

OCPC. (2022). Old Colony Planning Council. Retrieved from home page: http://www.ocpcrpa.org/

PWA. (2022). Pembroke Watershed Association. Retrieved from home page: https://pembrokewatershed.com/about-us

SPIA. (2022). Six Ponds Improvement Association. Retrieved from home page: https://sixponds.org/

Think Blue Massachusetts (2019). Retrieved from About Think Blue Massachusetts: https://www.thinkbluemassachusetts.org/about-us

Town of Hanover. (2021). Retrieved from Town of Hanover home page: https://www.hanover-ma.gov/

Town of Hanson. (2021). Retrieved from Town of Hanson home page: https://www.hanson-ma.gov/

Town of Norwell. (2021). Retrieved from Town of Norwell home page: https://www.townofnorwell.net/

Town of Pembroke. (2021). Retrieved from Town of Pembroke home page: https://www.pembroke-ma.gov/

Town of Rockland. (2021). Retrieved from Town of Rockland home page: https://rockland-ma.gov/

TU. (2022). Trout Unlimited. Retrieved from Trout Unlimited Chapter Location page: https://www.tu.org/find-your-chapter/

USEPA. (2020). General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts, United States Environmental Protection Agency. Region 1. National Pollutant Discharge Elimination System (NPDES). Issued April 4, 2016. Modified December 7, 2020. Available at: https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/final-2016-ma-sms4-gp-mod.pdf

WAA. (2022). Watershed Action Alliance of Southeastern Massachusetts. Retrieved from home page: https://watershedaction.org/