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

Appendix X: North Shore Coastal Drainage Area

Commonwealth of Massachusetts
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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

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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 four pathogen-impaired segments in the North Shore Coastal Drainage Area, hereinafter referred to as the North 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 four North 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 North Coastal Watershed Overview section.

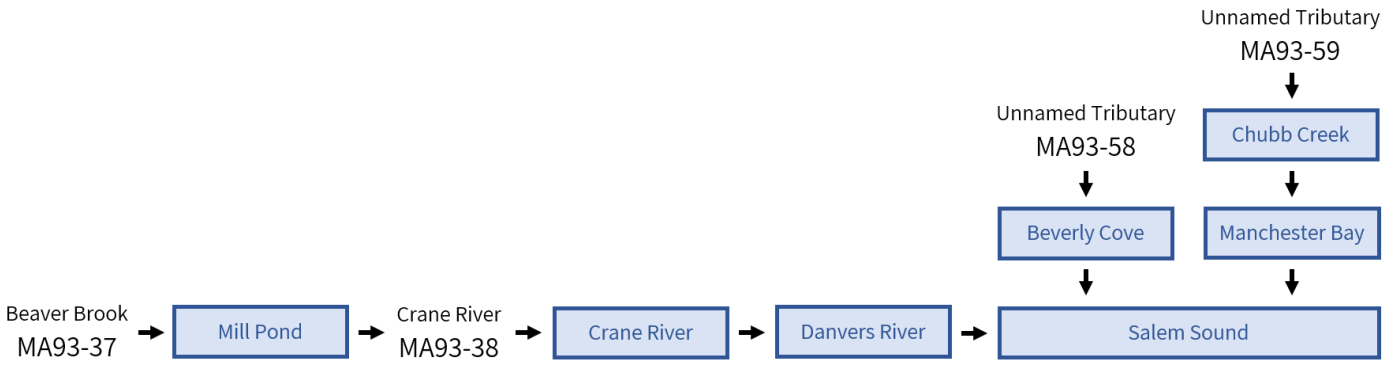


Figure 1-1. Conceptual diagram of water flow through the North Coastal watershed for the four pathogen-impaired segments. Connections between waterbodies are shown with black arrows. Not to scale. Impaired segments are shown with the assessment unit.

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 North 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)					
Beaver Brook MA93-37	B	R	126	1,893 (90 day)	93%	WLA (26%)	0.8	8.1	81.0	810.3	8,103.3	81,032.7
						LA (74%)	2.3	22.7	227.2	2,272.4	22,723.5	227,235.3
Crane River MA93-38	B	R	126	1,301 (90 day)	90%	WLA (30%)	0.9	9.3	93.2	932.2	9,321.5	93,215.3
						LA (70%)	2.2	21.5	215.1	2,150.5	21,505.3	215,052.7
Unnamed Tributary MA93-58	B	R	126	359 (90 day)	65%	WLA (11%)	0.3	3.3	33.0	330.1	3,301.3	33,012.5
						LA (89%)	2.8	27.5	275.3	2,752.6	27,525.6	275,255.5
Unnamed Tributary MA93-59	B	R	126	1,078 (90 day)	88%	WLA (9%)	0.3	2.8	27.9	279.0	2,790.1	27,901.0
						LA (91%)	2.8	28.0	280.4	2,803.7	28,036.7	280,367.0

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 North 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)					
Beaver Brook MA93-37	B	P	35	NA	-	WLA (26%)	0.2	2.3	22.5	225.1	2,250.9	22,509.1
						LA (74%)	0.6	6.3	63.1	631.2	6,312.1	63,120.9
Crane River MA93-38	B	P	35	NA	-	WLA (30%)	0.3	2.6	25.9	258.9	2,589.3	25,893.1
						LA (70%)	0.6	6.0	59.7	597.4	5,973.7	59,736.9
Unnamed Tributary MA93-58	B	P	35	939 (90 day)	96%	WLA (11%)	0.1	0.9	9.2	91.7	917.0	9,170.1
						LA (89%)	0.8	7.6	76.5	764.6	7,646.0	76,459.9
Unnamed Tributary MA93-59	B	P	35	325 (90 day)	89%	WLA (9%)	0.1	0.8	7.8	77.5	775.0	7,750.3
						LA (91%)	0.8	7.8	77.9	778.8	7,788.0	77,879.7

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).*
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 TMDL*** *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. North Coastal Watershed Overview

The North Coastal watershed covers an area of approximately 171 square miles (mi^2) in northeastern Massachusetts (Figure 2-1). The watershed contains portions of the Hampton and Seabrook saltmarshes north of the Merrimack River as well an extensive area along the coast bordering the Ipswich River watershed to the west and the Boston Harbor: Mystic watershed to the south (MassDEP, 2007). This area includes the rocky coastline of Cape Ann as well as various peninsulas separated by salt marshes, embayments, and estuaries. There are 89 lakes, ponds, and impoundments identified within the watershed, comprising a total surface area of 2,415 acres (MassDEP, 2007).

The North Coastal watershed overlaps a portion of 26 municipalities in Massachusetts. Of these, Gloucester, Lynn, Manchester, Marblehead, Nahant, Rockport, Salem, Saugus, and Swampscott are completely contained within the watershed. The majority of Beverly, Danvers, Essex, Lynnfield, Peabody, Revere, and Wakefield also lie 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. 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 two Regional Planning Agencies (RPAs) includes the North 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 North Coastal watershed RPAs include:

- Merrimack Valley Planning Commission (MVPC; MVPC, 2022)
- Metropolitan Area Planning Council (MAPC; MAPC, 2022)

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

- Regional stormwater coalitions operate within the RPAs, including MVPC's Merrimack Valley Stormwater Collaborative.
- 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).

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:

- **Eight Towns and the Great Marsh** (ETGM) is a committee that "works with communities and the general public to foster stewardship of coastal resources by heightening public awareness of solutions

to pollution problems, providing technical assistance and supporting local research and education projects" (ETGM, 2022).

- **Salem Sound Coastwatch** (SSC) whose mission is to "protect and improve the environmental quality of Salem Sound and its watershed" (SSC, 2022).
- **Saugus River Watershed Council** (SRWC) was founded in 1991 to "protect and restore the natural resources of the Saugus River watershed" (SRWC, 2022).
- **Massachusetts Office of Coastal Zone Management** (CZM) has a North Shore Regional office that "serves the coastal communities from Salisbury to Revere, which are located in the Merrimack, Parker, Ipswich, and North Coastal watersheds." (CZM, 2022a).
- **Trout Unlimited (TU)** operates two chapters in the geographic area of the North Coastal watershed, including the Nor'east and the Greater Boston. Their mission is to conserve, protect and restore the nation'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).

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.

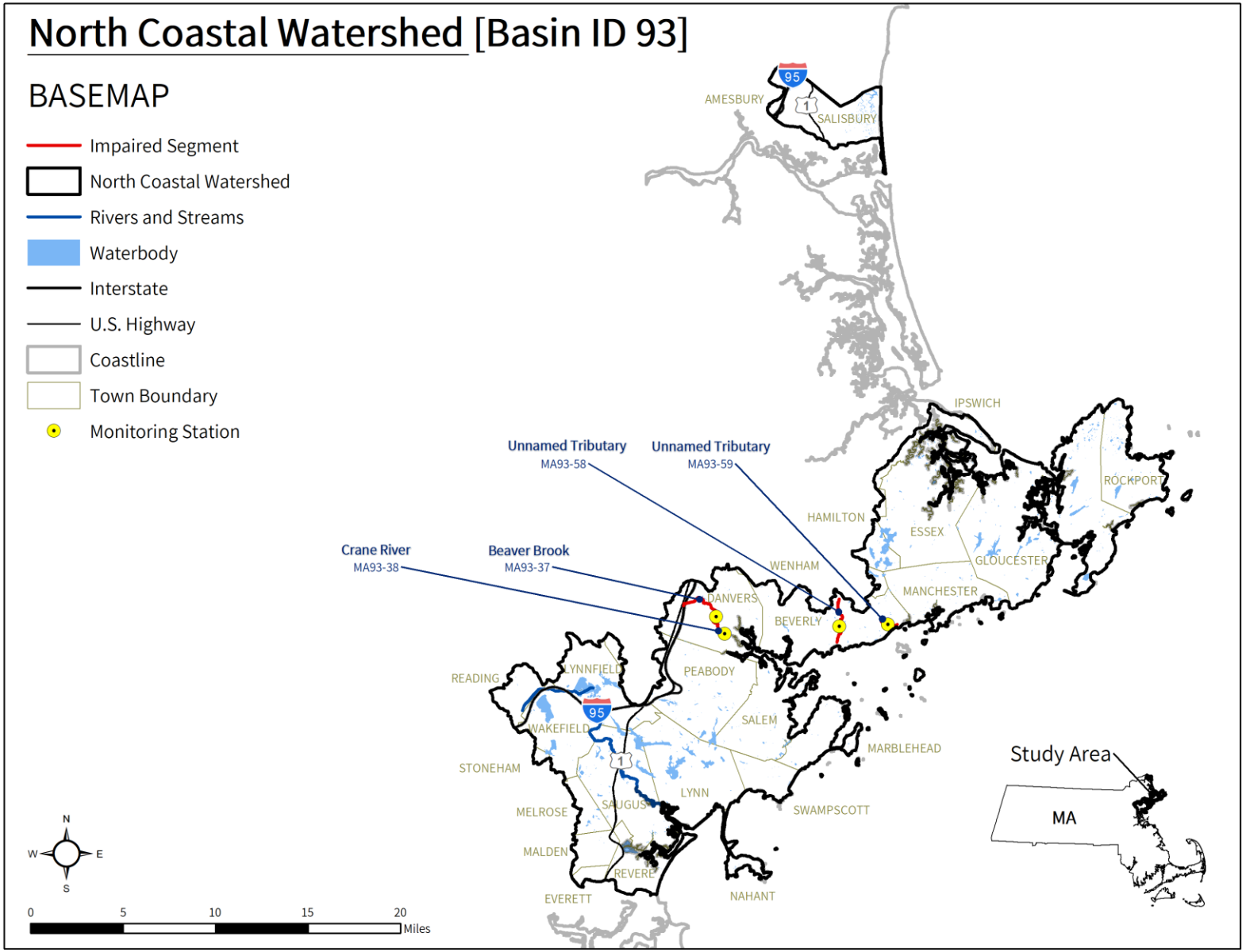


Figure 2-1: Map of all pathogen-impaired segments, water quality monitoring stations, municipal borders, waterbodies, and major roads in the North Coastal watershed.

3. MA93-37 Beaver Brook

3.1. Waterbody Overview

Beaver Brook segment MA93-37 is 2.7 miles long and begins west of Route 95 in Danvers, MA. The segment flows northeast, then generally southeast before ending at Mill Pond, Danvers, MA.

There are several unnamed tributaries to Beaver Brook segment MA93-37. Lakes and ponds in the watershed include a few small unnamed waterbodies. The segment's headwaters are within a highway corridor (I-95, State Route 1). The segment downstream of these roadways flows through wetlands and forest, while the lower segment flows through highly developed areas, with the exception of a wetland just upstream of Mill Pond.

Key landmarks in the watershed include Danvers Community YMCA, Great Oak Elementary School, Green Leaf Open Space, St. John's Preparatory School, and Endicott Park. From upstream to downstream, segment MA93-37 is crossed by Interstate 95 (southbound and northbound), Maple Street (twice), Nichols Street, Maple Street again, Brookside Avenue, Beaver Park Road, Brookside Avenue twice, Pickering Street, Hobart Street, and Holten Street, all in Danvers.

Beaver Brook (MA93-37) drains a total area of 2.3 square miles (mi^2), of which 0.6 mi^2 (26%) are impervious and 0.4 mi^2 (18%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Danvers[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 no landfills or unpermitted land disposal dumping grounds either. See Figure 3-1.

The Beaver Brook segment MA93-37 watershed is located in a highly-developed part of Massachusetts. Almost half of the watershed consists of forest and natural lands (44%) and 10%

Reduction from Highest Calculated Geomean: 93%

Watershed Area (Acres): 1,458

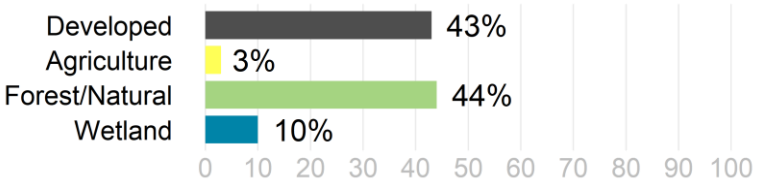
Segment Length (Miles): 2.7

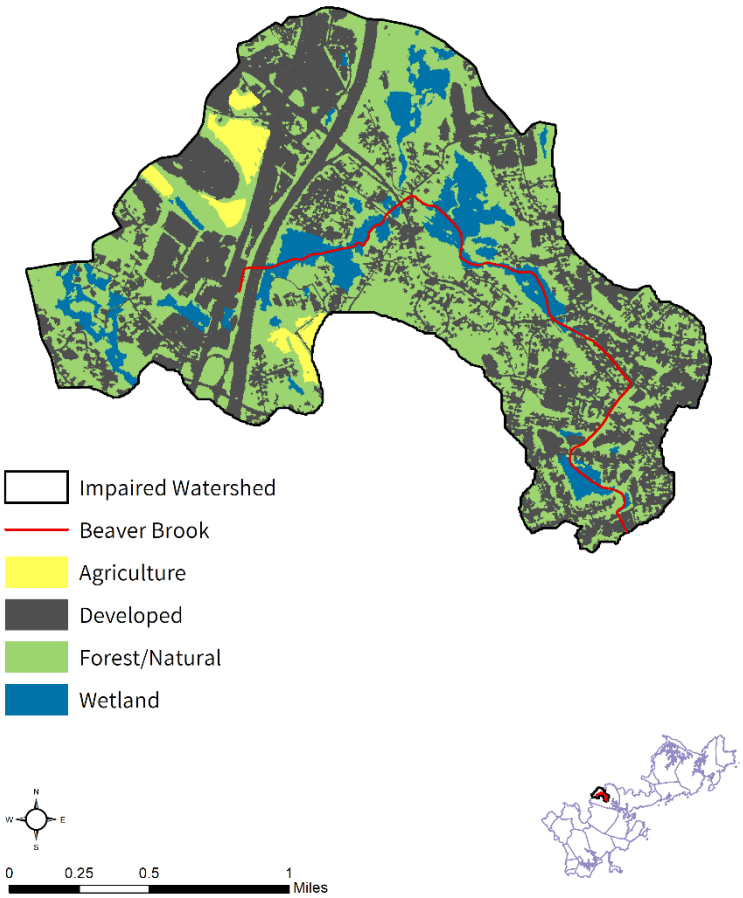
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 383 (26%)

DCIA Area (Acres, %): 259 (18%)





[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.

consists of wetland areas. The remainder of the watershed is covered by development (43%), consisting of industrial and commercial development on the northwest, and mainly residential areas in the east and south. There is little (3%) agricultural activity within the watershed, and it consists of pasture/hay or cultivated fields located near the headwaters of the watershed.

In the Beaver Brook (MA93-37) watershed, there are no areas identified as Priority Habitats of Rare Species or Priority Natural Vegetation Communities, as designated by the Natural Heritage and Endangered Species Program. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 139 acres (10%) of land protected in perpetuity[2], part of 176 acres (12%) 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.

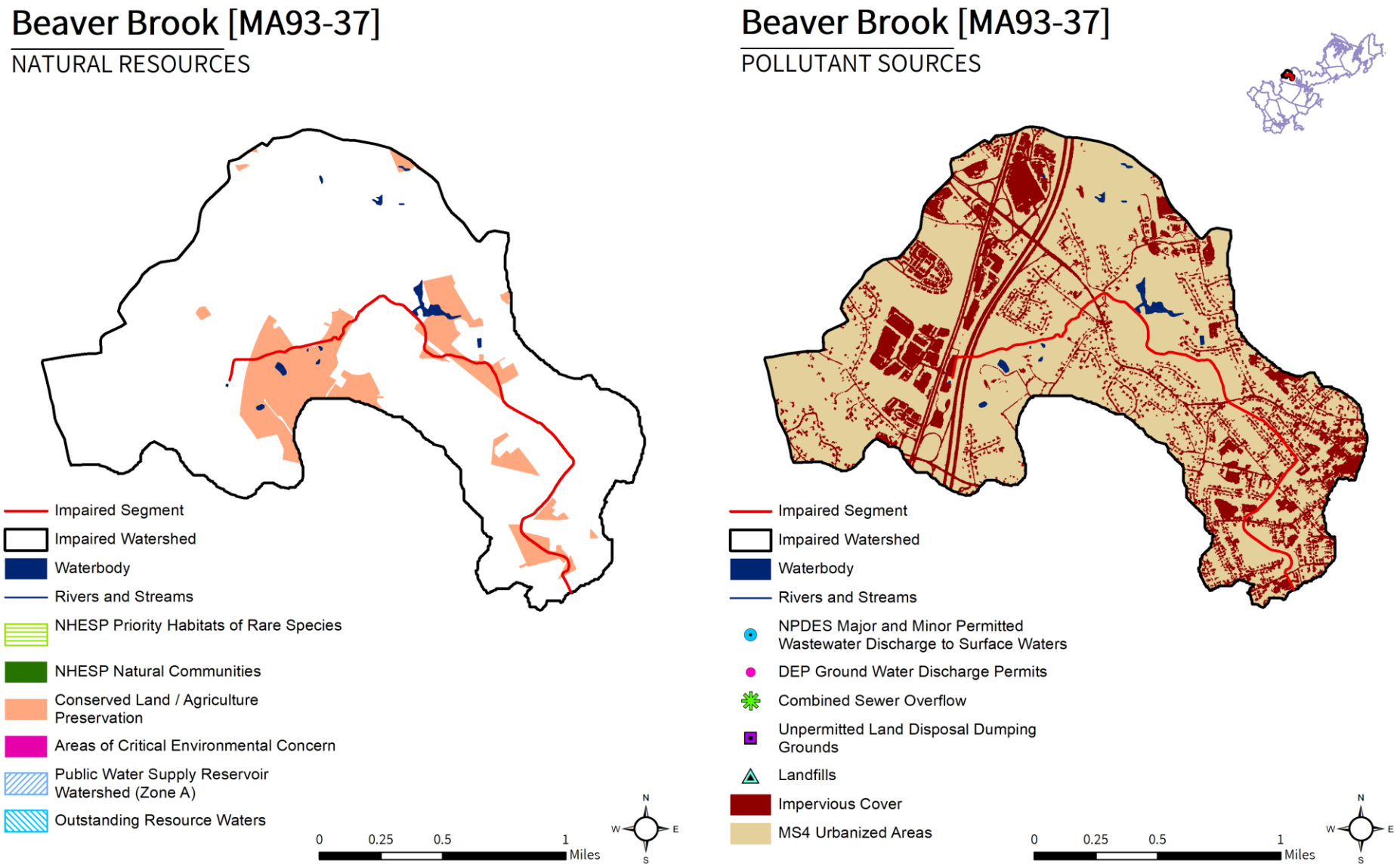


Figure 3-1. Natural resources and potential pollution sources draining to the Beaver Brook segment MA93-37. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

3.2. Waterbody Impairment Characterization

Beaver Brook (MA93-37) 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 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 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 2007, six samples were collected at W1541; 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, five exceeded the STV criterion, one during wet weather and four during dry weather.

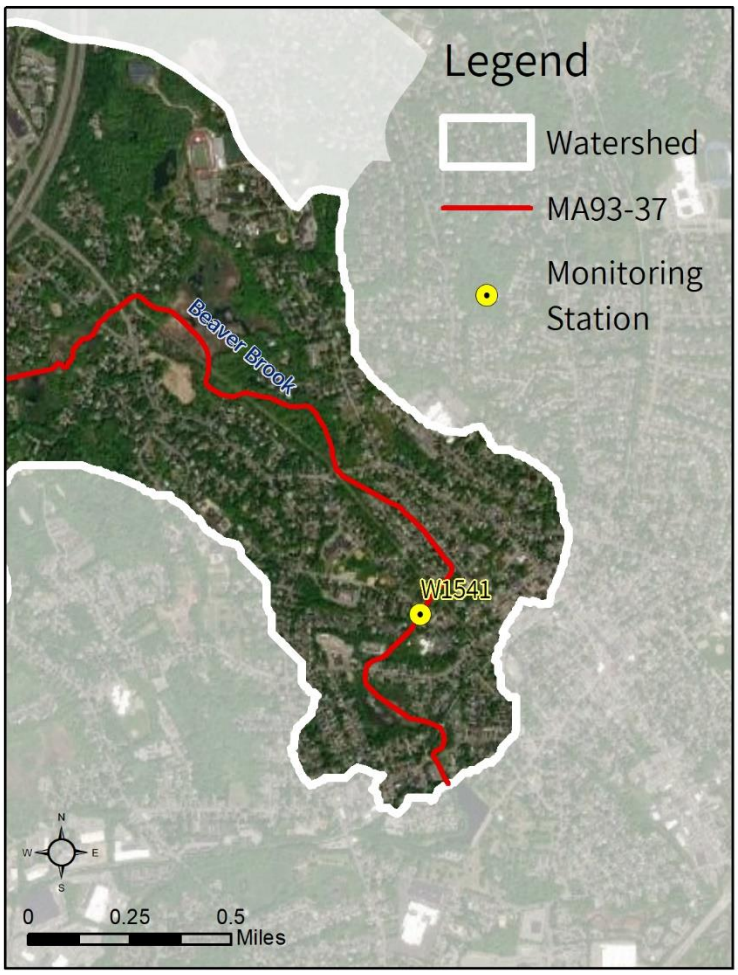


Figure 3-2. Location of monitoring station(s) along the impaired segment.

Table 3-1. Summary of indicator bacteria sampling results by station for Beaver Brook (MA93-37). 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
W1541	5/1/2007	9/18/2007	6	1,893	6	5

Table 3-2. Indicator bacteria data by station, indicator, and date for Beaver Brook (MA93-37). 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)
W1541	*E. coli*	5/1/2007	DRY	150	150	
W1541	*E. coli*	6/5/2007	WET	3,800	755	
W1541	*E. coli*	7/10/2007	DRY	470	645	
W1541	*E. coli*	8/14/2007	WET*	3,800	1,893	
W1541	*E. coli*	8/30/2007	DRY	460	1,329	
W1541	*E. coli*	9/18/2007	DRY	660	858	

* Note: manually changed from "DRY" to "WET" classification because a second proximal weather station (Beverly Municipal) showed antecedent precipitation totaling 0.71" and was determined as likely more representative of true conditions at the site.

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 for Beaver Brook (MA93-37) were elevated during 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 large amount of development in the watershed (43%), consisting of residential areas as well as industrial and commercial development. All of the land area is subject to MS4 permit conditions, 26% is classified as impervious area, and 18% is classified as DCIA. 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 Danvers. 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: Although some of the watershed may be connected to public sewer, there are portions of the watershed that may utilize 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 (3%) of the total land use, with pasture/hay or cultivated fields located near the segment headwaters. Manure storage and spreading activities, if not properly conducted, are possible sources of pathogens to waterbodies.

Pet Waste: There are residential neighborhoods, parks, and sports fields near the Beaver Brook segment MA93-37. 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: Multiple large open wetland areas and mowed recreational lands 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.

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 Danvers

All of Danvers is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041188), 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 2011, Danvers completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. Danvers has a 2019 Stormwater Management Plan (SWMP).

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

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

No Master Plan could be found online for the town of Danvers, but a 2017 Open Space and Recreation Plan was posted. This plan includes inventories and assessments of a variety of environmental resources and needs, including water resources (pg. 16) and resource protection needs (pg. 41; Town of Danvers, 2021).

4. MA93-38 Crane River

4.1. Waterbody Overview

Crane River segment MA93-38 is 0.3 miles long and begins at the outlet of Mill Pond in Danvers, MA. The segment flows southeast to the outlet of the pump house sluiceway at Purchase Street in Danvers. (This segment was formerly a portion of segment MA93-03.)

Tributaries to Crane River segment MA93-38 include an unnamed stream; Crane Brook, which flows through much of the west/south areas of the watershed, enters Mill Pond just upstream of this segment. Lakes and ponds in the watershed include Mill Pond and several small unnamed waterbodies. Some of the tributary segment flows through wetland areas surrounded by development.

Key landmarks in the watershed include Walnut Grove Cemetery, the Liberty Tree Mall, a portion of Brooksby Farm, the Highlands School, Danvers Dog Park, Clark Farm, and a large commercial complex adjacent to Interstate 95 that includes businesses such as Home Depot, Costco, Walmart, Lowes, and many other large stores. From upstream to downstream, segment MA93-38 crosses Sylvan Street, two unnamed roads in Walnut Grove Cemetery, and Ash Street, all in Danvers.

Crane River (MA93-38) drains a total area of 5.3 square miles (mi^2), of which 1.6 mi^2 (30%) are impervious and 1.2 mi^2 (22%) are directly connected impervious area (DCIA). The watershed may be served by public sewer systems in Danvers[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, MassDEP discharge-to-groundwater permits for on-site wastewater discharge, or combined sewer overflows (CSOs) within the watershed. There are two landfills and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 4-1.

The Crane River segment MA93-38 watershed is located in a highly-developed part of

Reduction from Highest Calculated Geomean: 90%

Watershed Area (Acres): 3,375

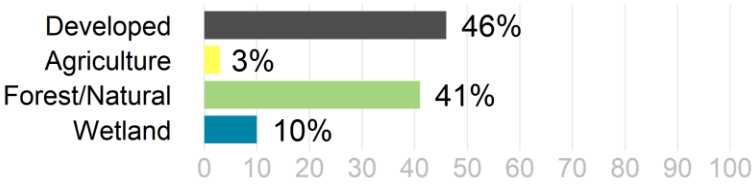
Segment Length (Miles): 0.3

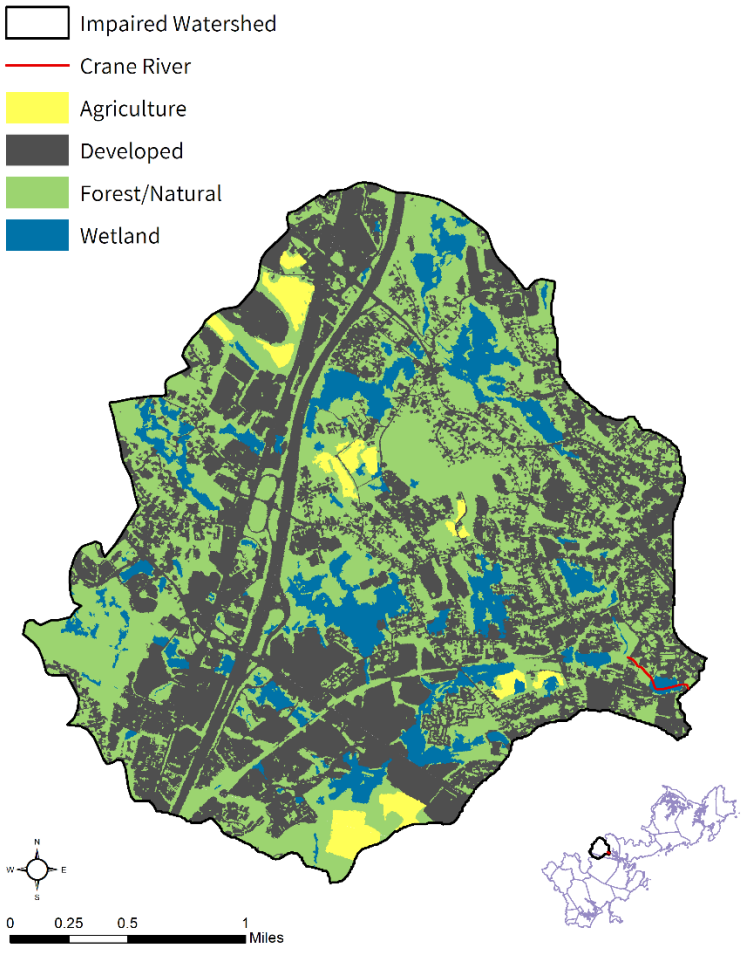
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 1,021 (30%)

DCIA Area (Acres, %): 750 (22%)



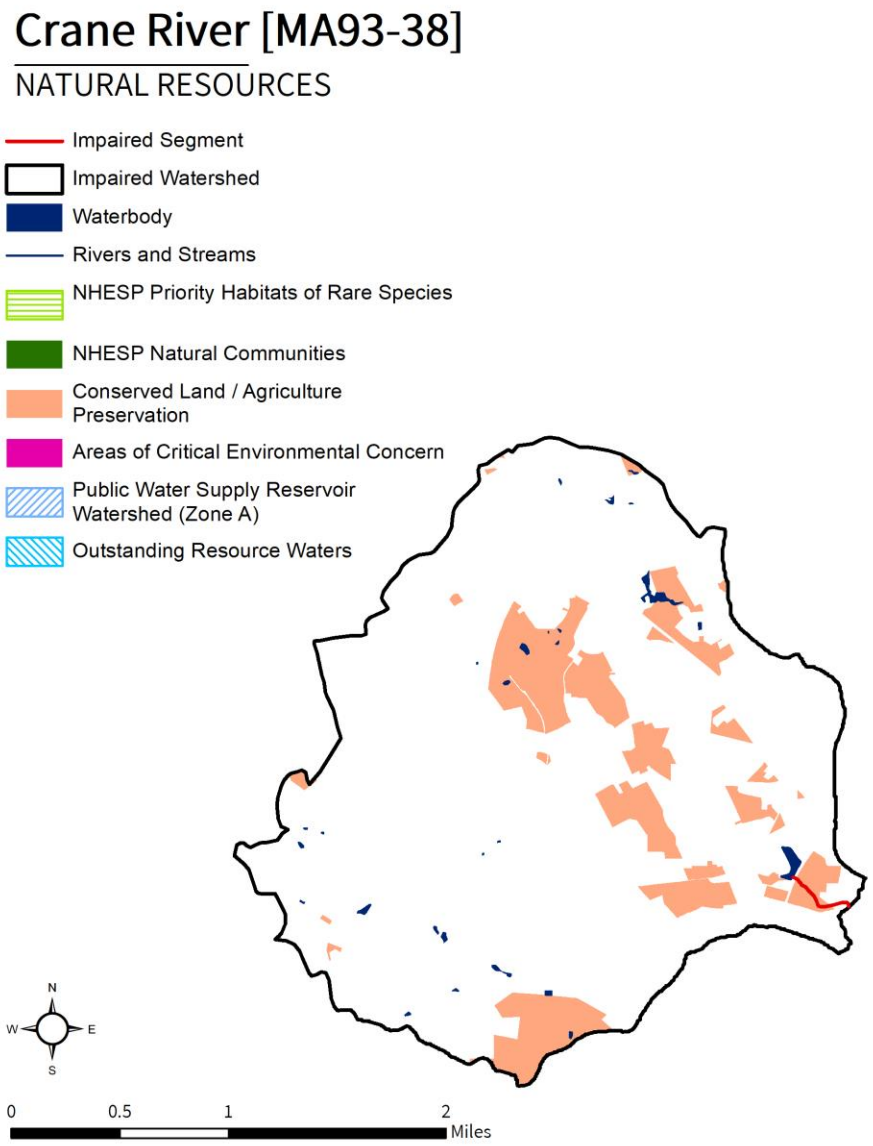


[4] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

Massachusetts. Almost half of the watershed consists of developed land (46%), slightly more than forest and natural lands (41%); development is mostly commercial, with some residential areas in the northern and eastern watershed. Wetland areas cover 10% of the land, and there is very little agricultural activity (3%), mainly pasture/hay or cultivated fields interspersed throughout the watershed (none is directly adjacent to the segment).

In the Crane River (MA93-38) watershed, there are no areas identified as Priority Habitats of Rare Species or as Priority Natural Vegetation Communities, as designated by the Natural Heritage and Endangered Species Program. There are also no acres under Public Water Supply protection, within Areas of Critical Environmental Concern, or Outstanding Resource Waters. Overall, there are 284 acres (8%) of land protected in perpetuity[5], part of 443 acres (13%) 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.



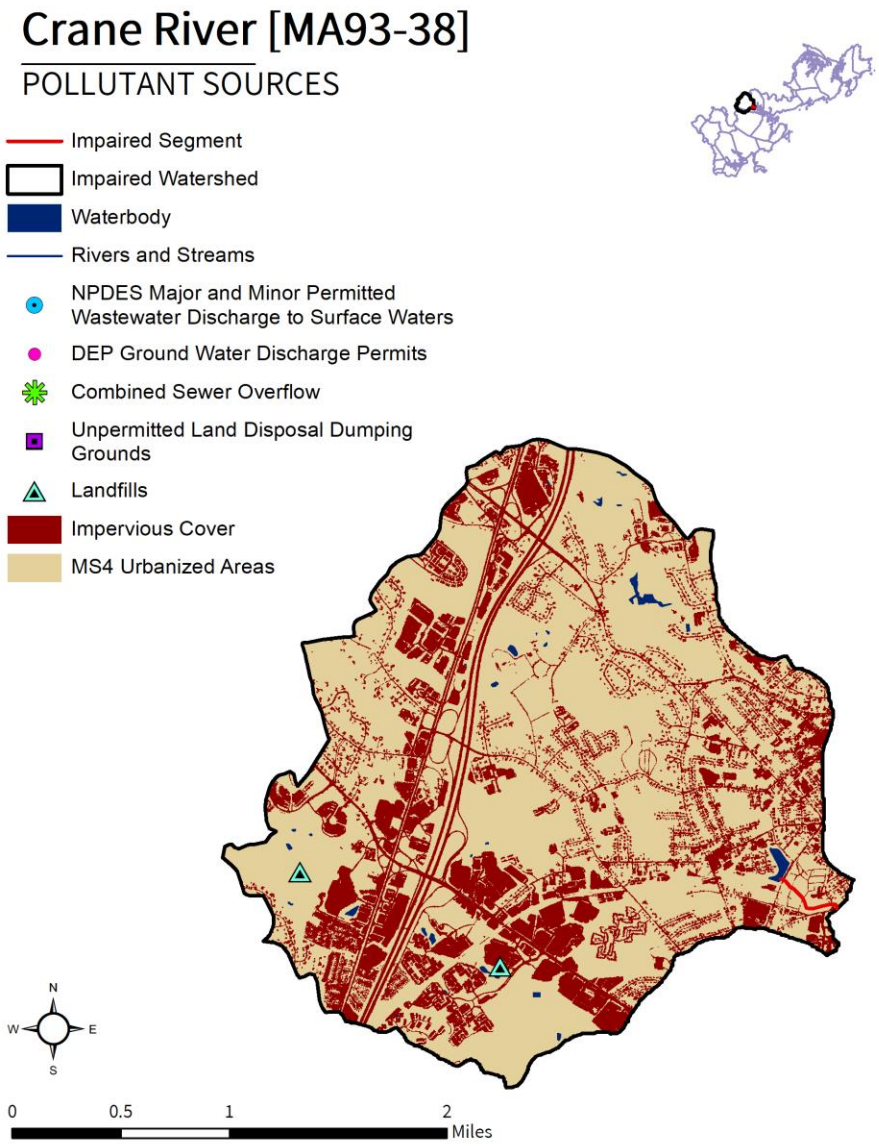


Figure 4-1. Natural resources and potential pollution sources draining to the Crane River segment MA93-38. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

4.2. Waterbody Impairment Characterization

The Crane River (MA93-38) 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 4-1, 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 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 2007, six samples were collected at W0452; 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, two exceeded the STV criterion, one during wet weather and one during dry weather.

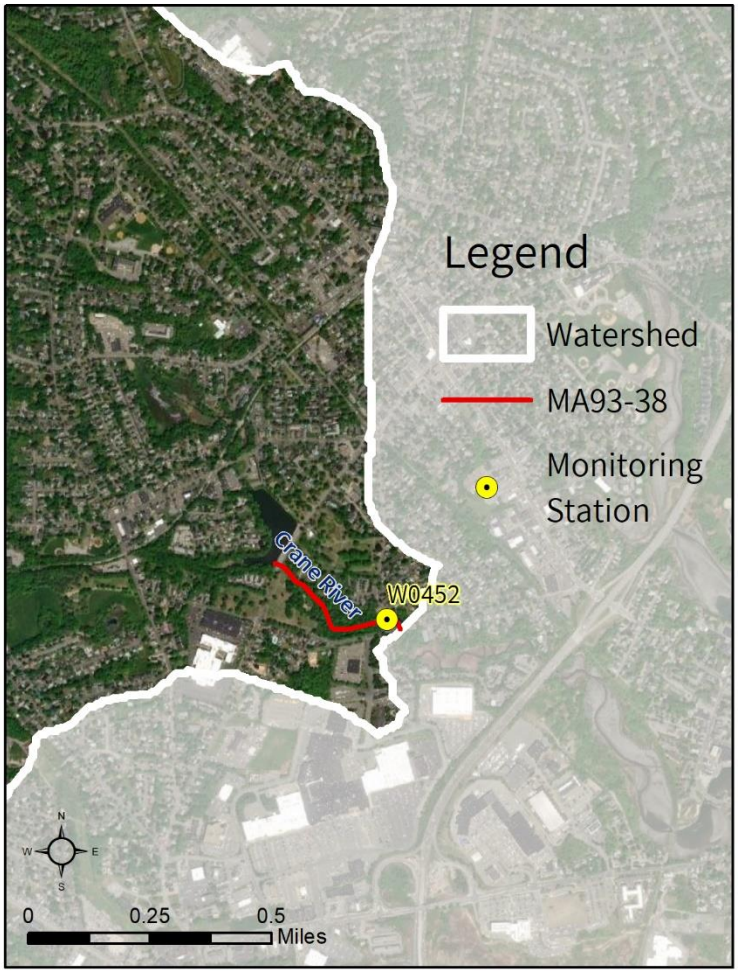


Figure 4-2. Location of monitoring station(s) along the impaired segment.

Table 4-1. Summary of indicator bacteria sampling results by station for the Crane River (MA93-38). 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
W0452	5/1/2007	9/18/2007	6	1,301	5	2

Table 4-2. Indicator bacteria data by station, indicator, and date for the Crane River (MA93-38). 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)
W0452	*E. coli*	5/1/2007	DRY	67	67	
W0452	*E. coli*	6/5/2007	WET	3,400	477	
W0452	*E. coli*	7/10/2007	DRY	240	380	
W0452	*E. coli*	8/14/2007	WET*	2,700	1,301	
W0452	*E. coli*	8/30/2007	DRY	210	825	
W0452	*E. coli*	9/18/2007	DRY	230	421	

*Note: manually changed from "DRY" to "WET" classification because a second proximal weather station (Beverly Municipal) showed antecedent precipitation totaling 0.71" and was determined as likely more representative of true conditions at the site.

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 Crane River (MA93-38) 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 large amount of development in the watershed (46%), which consists of commercial areas and residential development. Within the watershed, 100% of the land area is subject to MS4 permit conditions, 30% is classified as impervious area, and 22% is classified as DCIA. Stormwater runoff from urban areas is a likely source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within Danvers. 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: Although some of the watershed may be connected to public sewer, there are portions of the watershed that may utilize 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 (3%) of the total land use, with pasture/hay or cultivated fields located in the segment headwaters. 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 Crane River segment MA93-38, and the majority of the stream flows through a cemetery. Conservation lands and parks/cemeteries are 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 no large wetland areas directly adjacent to the impaired segment, though there is a cemetery proximal to the corridor. 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.

City of Peabody

All of Peabody is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID #MAR05D194), and the city has an EPA-approved Notice of Intent (NOI). The city has mapped 100% of its MS4 system and the year-one and year-two Annual Reports have been submitted. In 2013, Peabody 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, pathogen-impaired MS4 receiving waters include 33 stormwater outfalls to Goldthwaite Brook (MA93-05), 56 outfalls to Proctor Brook (MA93-39), one outfall to the North River (MA93-42), and four outfalls to the Waters River (MA93-01).

Peabody has the following ordinances and bylaws, mostly accessible online via the city website https://peabody-ma.gov/ (City of Peabody, 2021):

- Stormwater control ordinance and utility fee
- Wetland protection ordinance;
- Pet waste control ordinance; and
- Contact recreation ordinance.

The City of Peabody has a 2002 Master Plan. This plan includes sections related to the environment and natural resources within the city, including a brief section on water resources, consisting of an inventory of waterbodies within the city. As of 2002, the city has a community sewer system that is shared with five surrounding towns. Additionally, Peabody has a 2015 Recreation and Open Space Plan, which includes a much more in-depth inventory, and descriptions of surface waterbodies (City of Peabody, 2021).

Town of Danvers. See Section 3.4

5. MA93-58 Unnamed Tributary

5.1. Waterbody Overview

The unnamed tributary segment MA93-58 is 2.1 miles long and its headwaters are formed in a wetland upstream of Route 22 in Beverly. The segment generally meanders south, ending at the saltwater wetlands at Beverly Cove, south of Route 127, in Beverly, MA.

Several unnamed streams flow into unnamed tributary segment MA93-58. Lakes and ponds in the watershed include a few small unnamed waterbodies. Much of the stream flows through wetland, forest, and other natural areas. The majority of development adjacent to the segment occurs in the northern reach, upstream of Route 128, and in the southern reach, downstream of the Boston and Maine railroad corridor.

Key landmarks in the watershed include a portion of the Beverly Commons Conservation Area, the Garden School of Beverly, MA, the Waring School, and a small portion of the Endicott College campus (Raymond J. Bourque Arena and some campus buildings). From upstream to downstream, segment MA93-58 is crossed by Boxwood Lane, Essex Street, Groce Street, the Yankee Division Highway/Route 22, Standley Street, Common Lane, Tall Tree Drive, and Hale Street/Route 127, all in Beverly.

The unnamed tributary (MA93-58) drains a total area of 1.6 square miles (mi^2), of which 0.2 mi^2 (11%) are impervious and 0.1 mi^2 (5%) are directly connected impervious area (DCIA). The watershed may be served by a public sewer system in Beverly[7], 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 is one landfill and no unpermitted land disposal dumping grounds within the segment watershed. See Figure 5-1.

The unnamed tributary segment MA93-58 watershed is located in a lightly-developed part of

Reduction from Highest Calculated Geomean: 65%

Watershed Area (Acres): 990

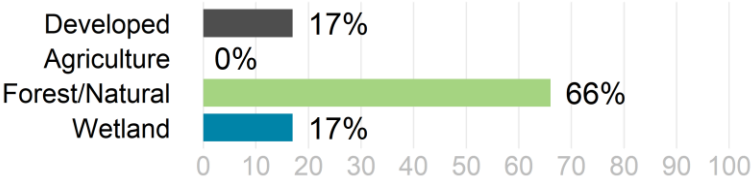
Segment Length (Miles): 2.1

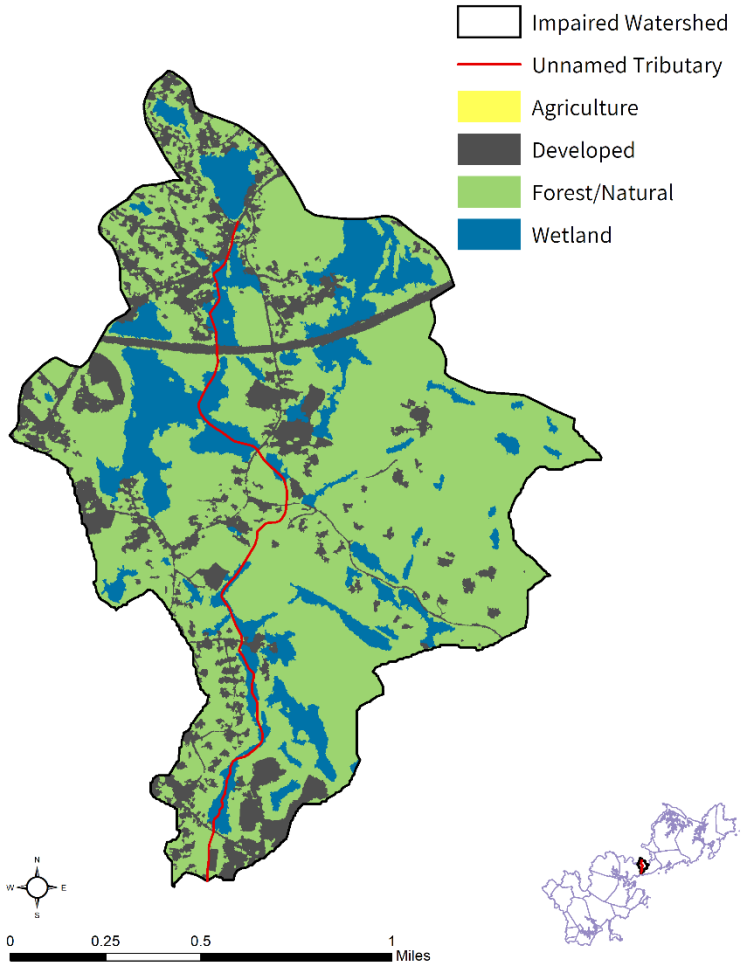
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 106 (11%)

DCIA Area (Acres, %): 52 (5%)





[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.

Massachusetts. More than half of the watershed consists of forest and natural lands (66%) and 17% consists of wetland areas. The remainder of the watershed is primarily covered by development (17%), most of which consists of residential areas with some industrial and commercial development. There is no known agricultural activity within the watershed.

In the unnamed tributary (MA93-58) watershed, there are five acres (<1%) of Priority Habitats of Rare Species and no Priority Natural Vegetation Communities, as designated by the Natural Heritage and Endangered Species Program. There are also no acres under Public Water Supply protection or within Areas of Critical Environmental Concern, and eight acres (1%) of Outstanding Resource Waters. Overall, there are 195 acres (20%) of land protected in perpetuity[8], part of 197 acres (20%) 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.

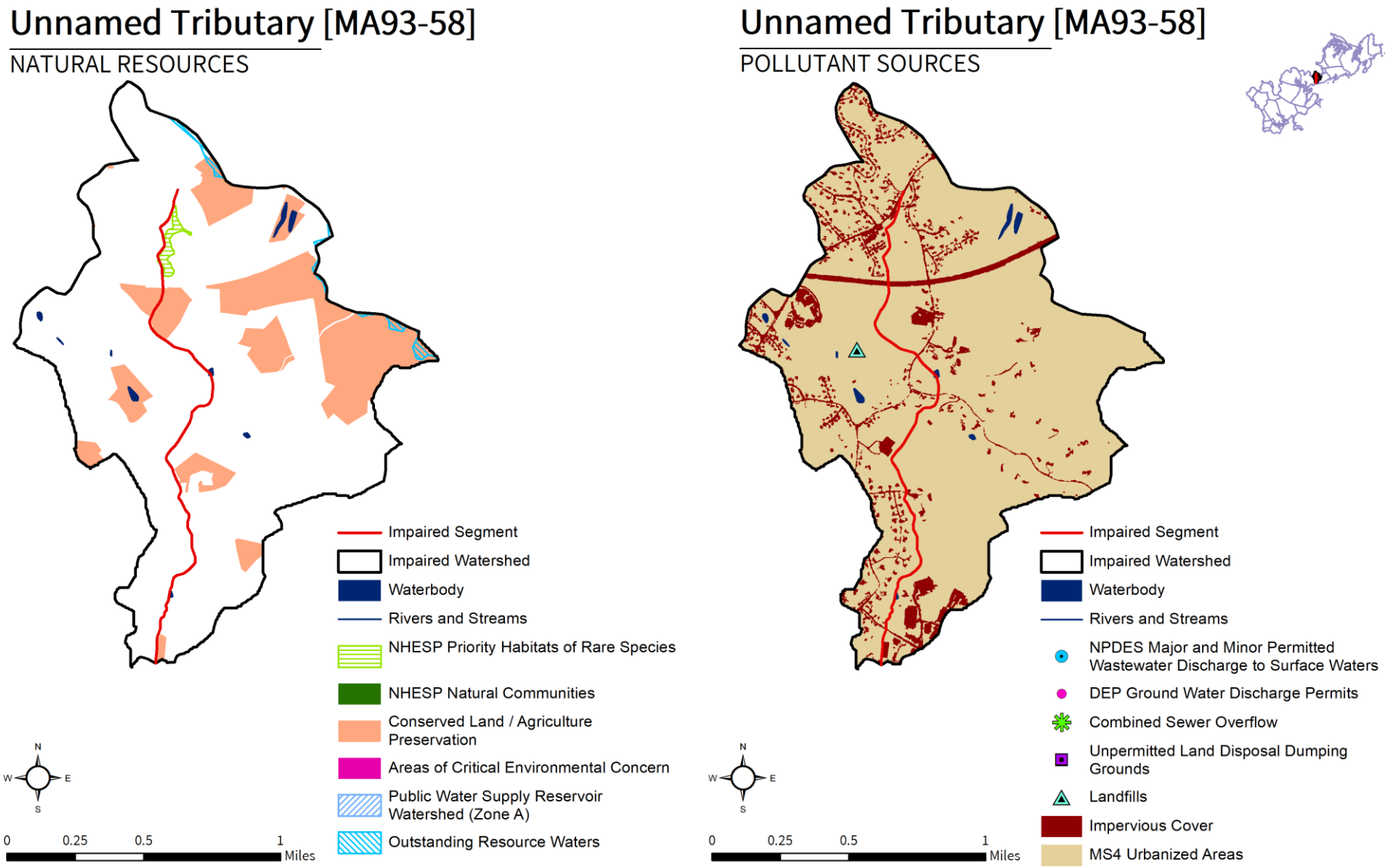


Figure 5-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA93-58. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

5.2. Waterbody Impairment Characterization

The unnamed tributary (MA93-58) 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 2007, five samples were collected at W1543data 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, one exceeded the STV criterion during wet weather.

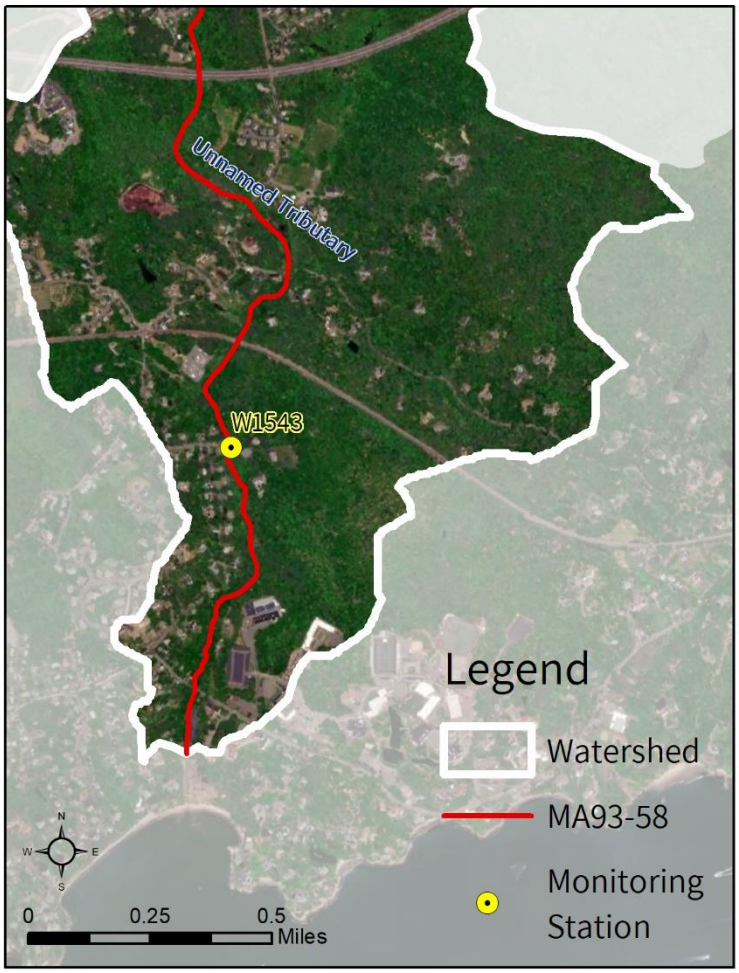


Figure 5-2. Location of monitoring station(s) along the impaired segment.

Table 5-1. Summary of indicator bacteria sampling results by station for the unnamed tributary (MA93-58). 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
W1543	5/1/2007	9/18/2007	5	359	3	1

Table 5-2. Indicator bacteria data by station, indicator, and date for the unnamed tributary (MA93-58). 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 for *E. coli* and 130 CFU/100 mL for enterococci indicator bacteria (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 126 CFU/100 mL for *E. coli* and 35 CFU/100 mL for enterococci indicator bacteria (applied to rolling 90-day geomean).

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1543	*E. coli*	5/1/2007	DRY	43	43	
W1543	*E. coli*	6/5/2007	WET	1,600	262	
W1543	*E. coli*	7/10/2007	DRY	100	190	
W1543	*E. coli*	8/14/2007	WET*	290	359	
W1543	*E. coli*	9/18/2007	DRY	67	125	
W1543	Enterococci	5/1/2007	DRY	63	63	
W1543	Enterococci	6/5/2007	WET	14,000	939	

* Note: manually changed from "DRY" to "WET" classification because a second proximal weather station (Beverly Municipal) showed antecedent precipitation totaling 0.71" and was determined as likely more representative of true conditions at the site.

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 the unnamed tributary (MA93-58) were elevated during wet 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.

Each potential pathogen source is described in further detail below.

Urban Stormwater: There is relatively little development in the watershed (17%), most of which consists of residential areas with a small amount of industrial and commercial development. All of the land area is subject to MS4 permit conditions, 11% is classified as impervious area, and 5% is classified as DCIA. Stormwater runoff from urban areas is a possible source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within Beverly. 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: Some of the development in the watershed may utilize 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: There are a few residential neighborhoods near the unnamed tributary segment MA93-58 as well as conservation 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: The segment flows through a few open wetland areas, and there are some lawns adjacent to 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.

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 Beverly

All of Beverly is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041181), 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. Beverly has completed an illicit discharge detection and elimination (IDDE) plan, an erosion and sedimentation control (ESC) plan, and post-construction stormwater regulations. When reporting impaired receiving waters, the town did not include the waterbody Assessment Unit, but listed 13 outfalls to the Danvers River, 27 outfalls to the Bass River, 18 outfalls to Beverly Harbor, and 10 outfalls to Salem Sound, all impaired by fecal coliform. The NOI also lists the fecal coliform-impaired Miles River as receiving water from nine federal outfalls and no municipal outfalls. It also lists a fecal coliform-impaired “tributary to Beverly Harbor” as receiving water from two federal outfalls, but no municipal outfalls, though it is not possible to determine if the unnamed tributary in question is segment MA93-58.

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

- Stormwater ordinance and stormwater utility fee;
- Wetland protection ordinance; and
- Pet waste disposal ordinance.

Beverly’s 2021 Comprehensive Plan has extensive coverage of environmental issues, especially related to water resources. The plan also includes multiple sections on climate change and coastal resiliency. The plan does not include information specific to bacterial contamination or any impaired streams within its borders. Beverly also has a 2016 Open Space and Recreation Plan (OSRP), which includes additional information about water resources in Beverly. The town is currently updating the OSRP (Town of Beverly, 2021).

6. MA93-59 Unnamed Tributary

6.1. Waterbody Overview

The unnamed tributary segment MA93-59 is 0.8 miles long and its headwaters lie west of Hale Street in Beverly. The segment flows generally southeast before turning sharply east-northeast to flow parallel to a rail line to its confluence with Chubb Creek east of Route 127, Beverly.

Several unnamed streams flow into unnamed tributary MA93-59. Lakes and ponds in the watershed include a few small unnamed waterbodies. The tributary flows through both wetland areas, forest/natural areas, and some developed areas.

Key landmarks in the watershed include the Beverly Farms Train Station, Dix Park Playground, a portion of the Beverly Commons Conservation Area, and a portion of the Mass Audubon Endicott Wildlife Sanctuary. From upstream to downstream, segment MA93-59 is crossed by Hale Street, Oak Street, Beach Street, and West Street, all in Beverly.

The unnamed tributary (MA93-59) drains a total area of 1.8 square miles (mi^2), of which 0.2 mi^2 (9%) are impervious and 0.1 mi^2 (5%) are directly connected impervious area (DCIA). The watershed may be served by public sewer systems in Beverly[10], and 70% 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 no landfills or unpermitted land disposal dumping grounds within the segment watershed. See Figure 6-1.

The unnamed tributary segment MA93-59 watershed is located in a lightly-developed part of Massachusetts. Almost three-quarters of the watershed consists of forest and natural lands (72%) and 14% consists of wetland areas. The remainder of the watershed is primarily covered by development (14%), most of which consists of residential areas and commercial development.

Reduction from Highest Calculated Geomean: 88%

Watershed Area (Acres): 1,133

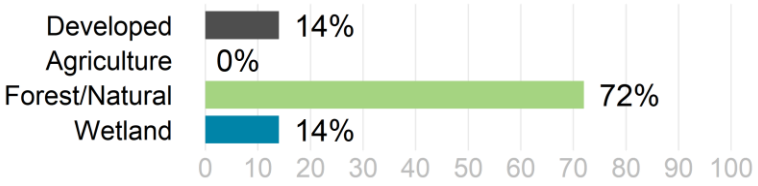
Segment Length (Miles): 0.8

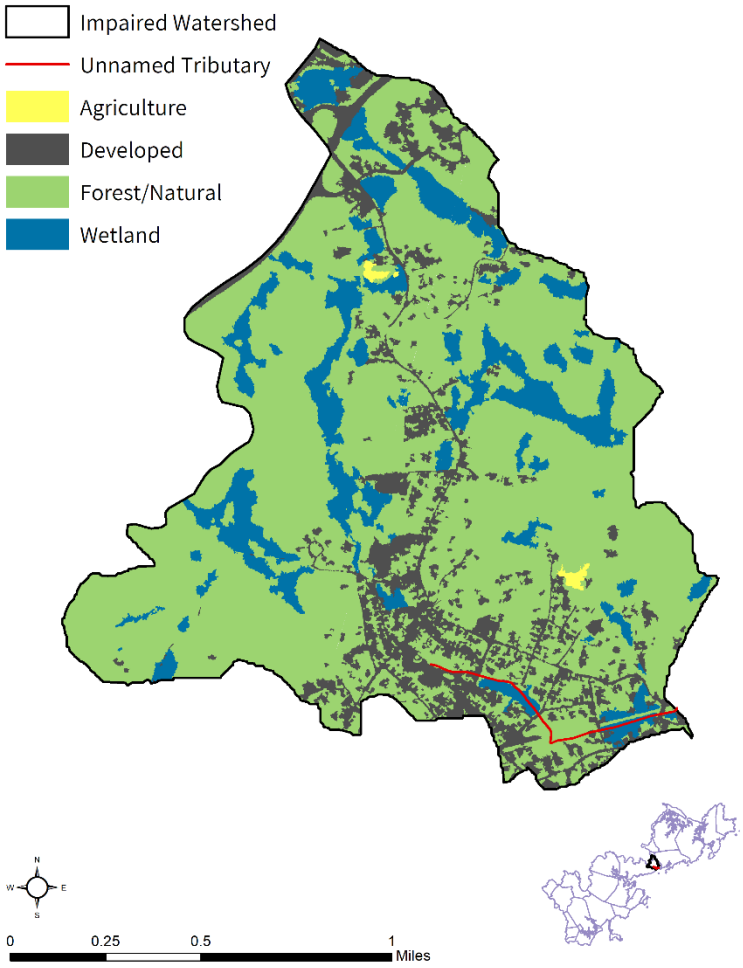
Impairment(s): *E. coli* (Primary Contact Recreation)

Class (Qualifier): B

Impervious Area (Acres, %): 103 (9%)

DCIA Area (Acres, %): 52 (5%)



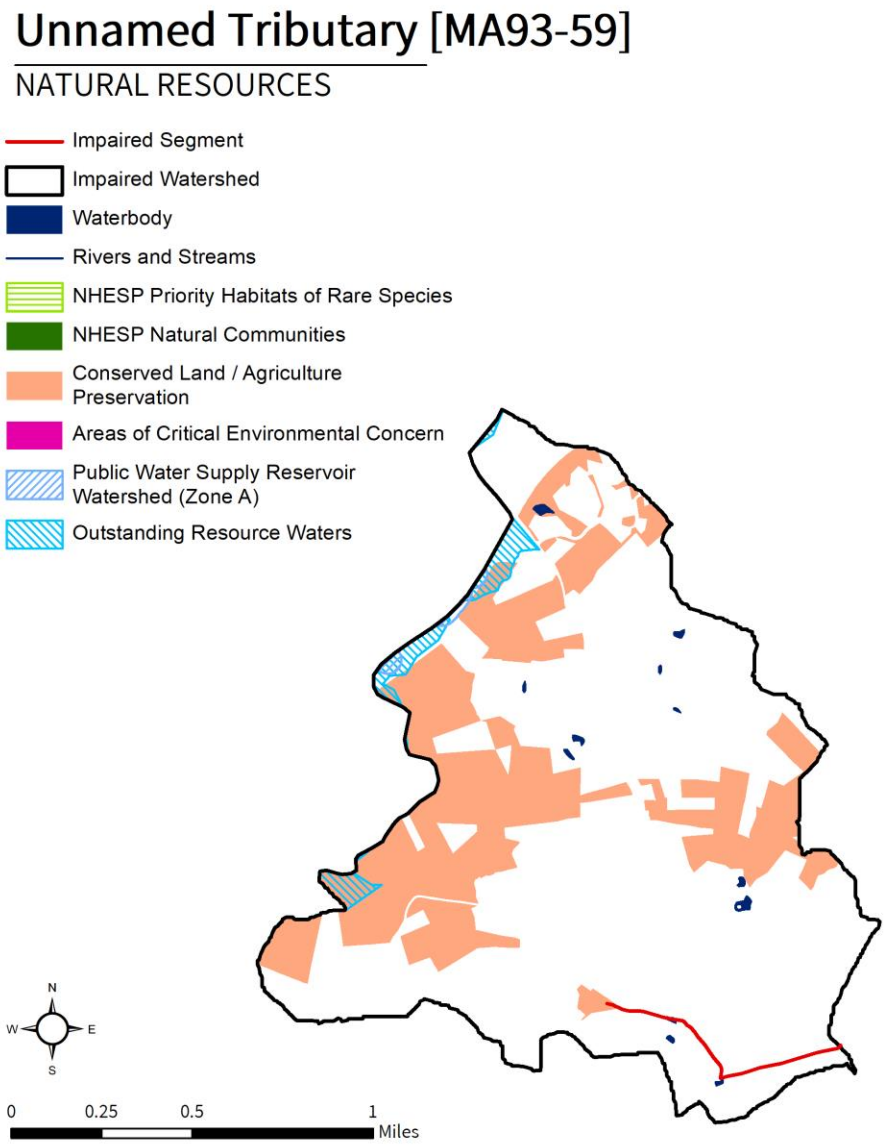


[10] Estimated percentage of developed areas with wastewater infrastructure in the watershed was based on available information: MWRA service areas, MassDEP's Water Utility Infrastructure Mapping Project (MassDEP, 2021b), MS4 reports, and local knowledge.

There is very little (<1%) agricultural activity within the watershed, consisting of pasture/hay or cultivated fields, none of which is directly adjacent to the segment.

In the unnamed tributary (MA93-59) 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 four acres (<1%) under Public Water Supply protection, none within Areas of Critical Environmental Concern, and 25 acres (2%) of Outstanding Resource Waters. Overall, there are 311 acres (27%) of land protected in perpetuity[11], comprising all 311 acres (27%) of Protected and Recreational Open Space[12]. See Figure 6-1.

[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.



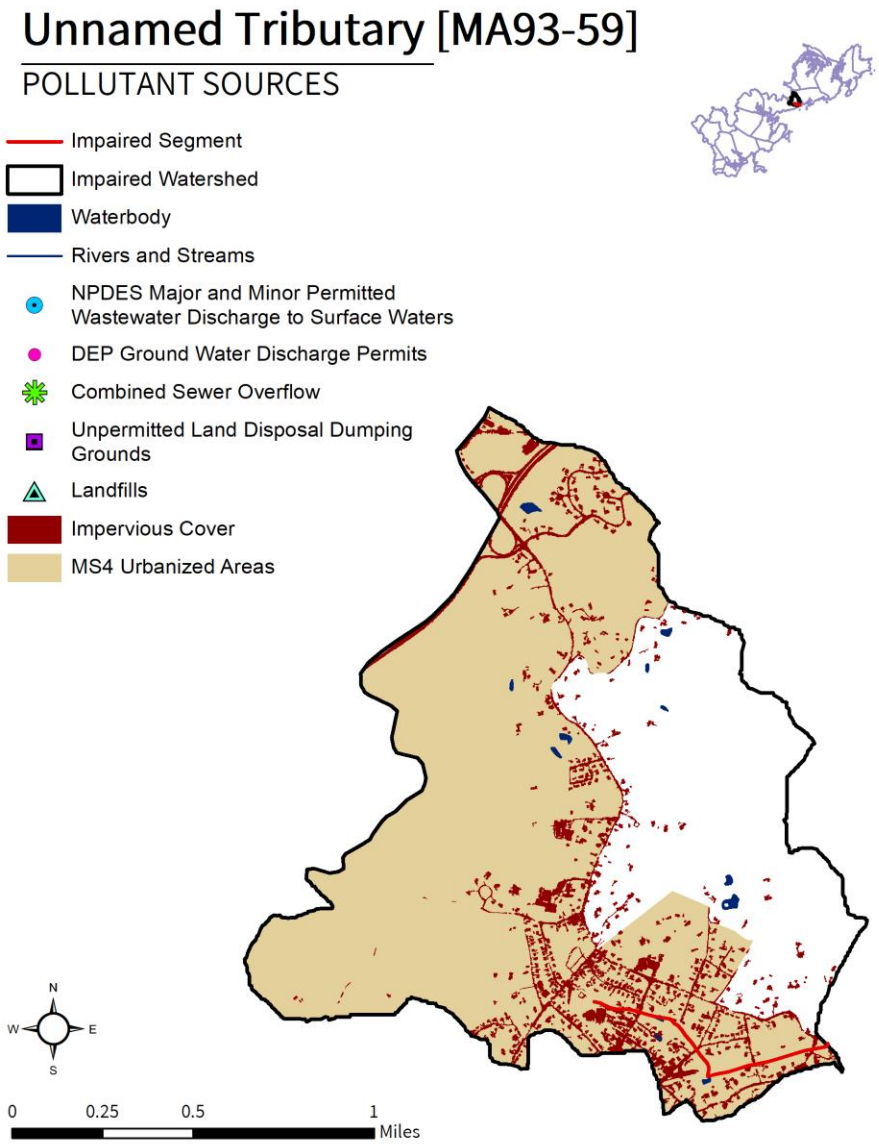


Figure 6-1. Natural resources and potential pollution sources draining to the unnamed tributary segment MA93-59. The map on the left shows critical habitat, water features, and conserved land. The map on the right indicates potential and known pollutant sources, including impervious cover, MS4 areas, permitted facilities, etc.

6.2. Waterbody Impairment Characterization

The unnamed tributary (MA93-59) 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 6-1, 6-2; 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 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 2007, six samples were collected at W1542; 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, three exceeded the STV criterion during dry weather.

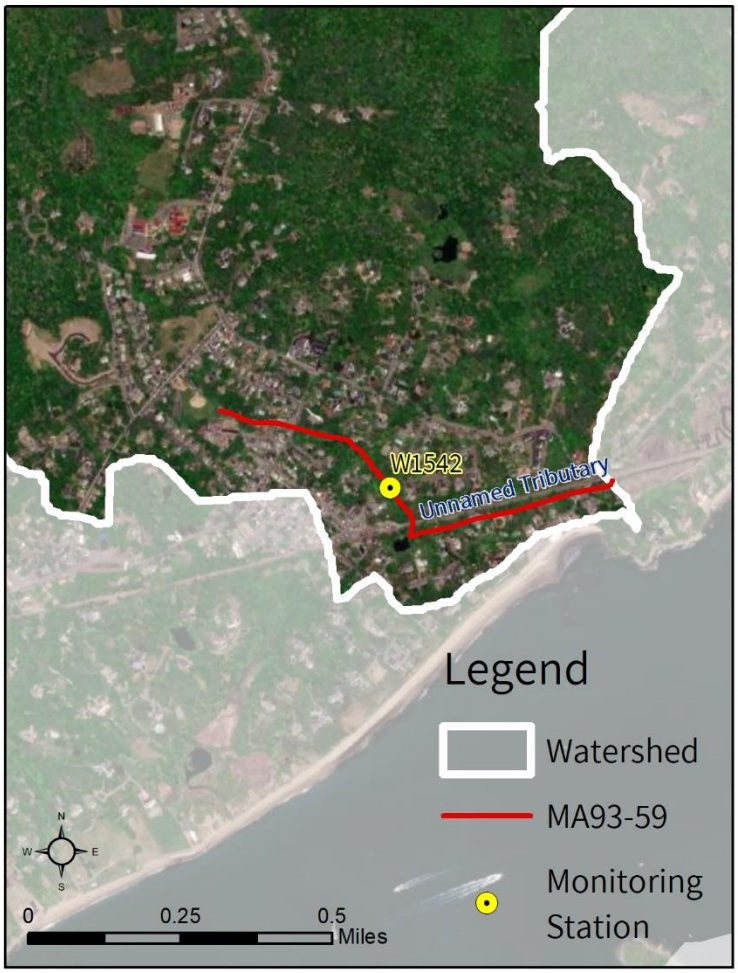


Figure 6-2. Location of monitoring station(s) along the impaired segment.

Table 6-1. Summary of indicator bacteria sampling results by station for the unnamed tributary (MA93-59). 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
W1542	5/1/2007	9/18/2007	6	1,078	4	3

Table 6-2. Indicator bacteria data by station, indicator, and date for the unnamed tributary (MA93-59). 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 for *E. coli* and 130 CFU/100 mL for enterococci indicator bacteria (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 126 CFU/100 mL for *E. coli* and 35 CFU/100 mL for enterococci indicator bacteria (applied to rolling 90-day geomean).

Unique Station ID	Indicator	Date	Wet/Dry	Result (CFU/100mL)	90-Day Rolling Geomean (CFU/100mL)	90-Day Rolling STV (CFU/100mL)
W1542	*E. coli*	5/1/2007	DRY	19	19	
W1542	*E. coli*	6/5/2007	WET	330	79	
W1542	*E. coli*	7/10/2007	DRY	3,000	266	
W1542	*E. coli*	8/14/2007	WET*	910	966	
W1542	*E. coli*	8/30/2007	DRY	190	643	
W1542	*E. coli*	9/18/2007	DRY	2,600	1,078	
W1542	Enterococci	5/1/2007	DRY	23	23	
W1542	Enterococci	6/5/2007	WET	4,600	325	

**Note: manually changed from "DRY" to "WET" classification because a second proximal weather station (Beverly Municipal) showed antecedent precipitation totaling 0.71" and was determined as likely more representative of true conditions at the site.*

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 direct wildlife and domesticated animal waste (including pets).

Indicator bacteria data for the unnamed tributary (MA93-59) were elevated during dry and wet 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 relatively small amount of development in the watershed (14%), most of which consists of residential areas and commercial development. 70% of the land area is subject to MS4 permit conditions, 9% is classified as impervious area, and 5% is classified as DCIA. Stormwater runoff from urban areas is a possible source of pathogens.

Illicit Sewage Discharges: Public sewer service may be available in the watershed within Beverly. 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: Some of the development in the watershed may utilize 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, most of which are conducted in the segment headwaters (pasture/hay, 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 some conservation lands near the unnamed tributary segment MA93-59. 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 impaired segment flows through a residential area where some large lawns appear to be mowed right up to the stream bank. 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 Beverly. See Section 5.4

Town of Wenham

The majority of Wenham is subject to stormwater regulations under the NPDES General MS4 Stormwater Permit (Permit ID # MAR041230), 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. Wenham completed an illicit discharge detection and elimination (IDDE) plan in 2008, and an erosion and sedimentation control (ESC) plan and post-construction stormwater regulations in 2009. No pathogen-impaired waterbodies within the North Coastal watershed were reported on the town's NOI.

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

- Wetland protection bylaw;
- Stormwater control bylaw;
- Contact recreation bylaw;
- Stormwater Utility: None found; and
- Pet Waste: None found.

Wenham has a Master Plan dated 1960, although funding for an updated Master Plan was approved in 2021. The town has a 2019 Open Space and Recreation Plan, which contains a water resources section identifying stormwater runoff and failing sewer system infrastructure as major sources of pollution to waterbodies. The plan also includes a section about specific impaired waterbodies that identifies the Miles River as impaired by fecal coliform (Town Wenham, 2021).

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