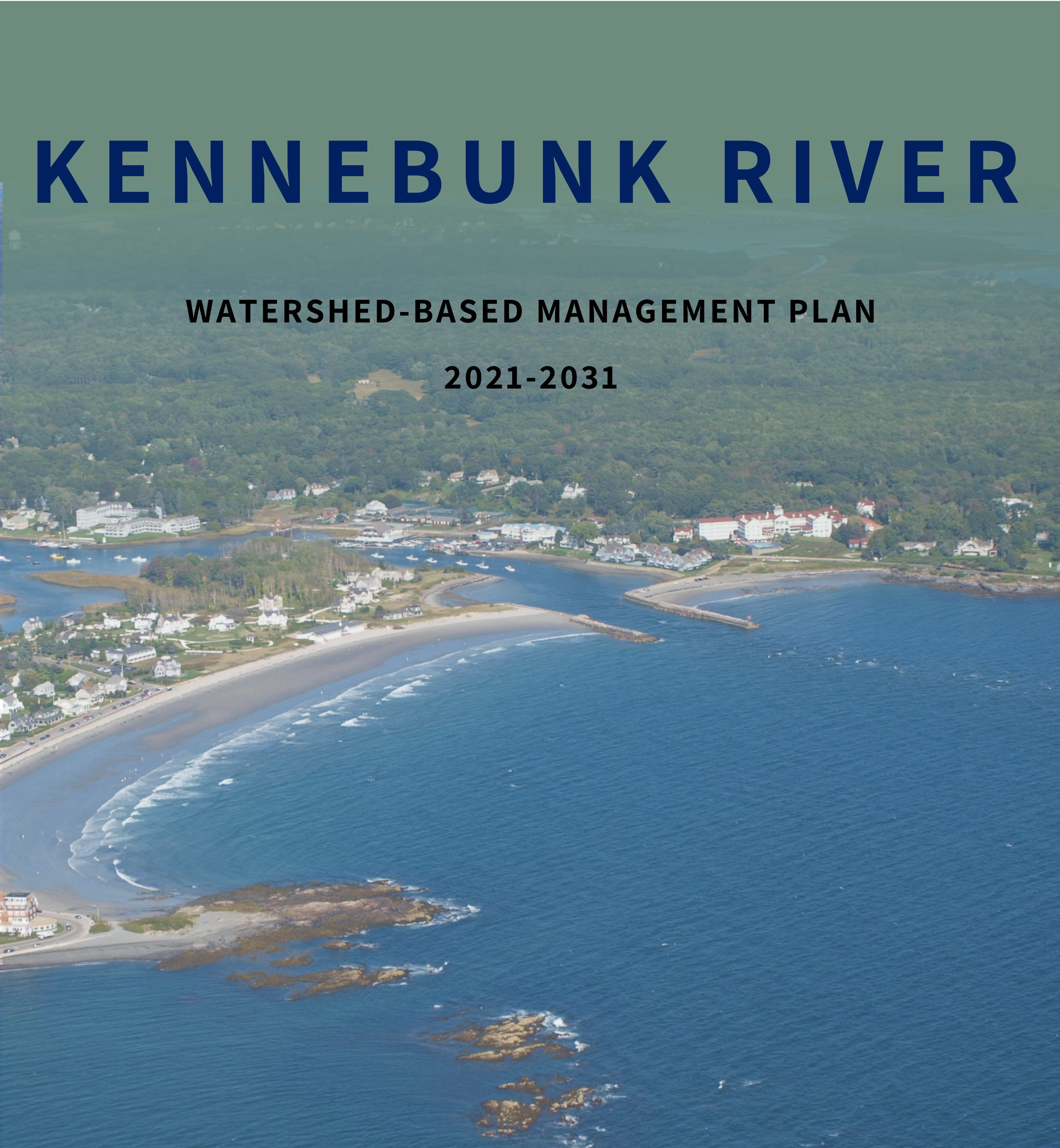
KENNEBUNK RIVER

WATERSHED-BASED MANAGEMENT PLAN

2021-2031



YORK COUNTY SOIL & WATER CONSERVATION DISTRICT

FB environmental

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DEPARTMENT OF ENVIRONMENTAL PROTECTION · STATE OF MAINE

MAINE Healthy Beaches

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

KENNEBUNK RIVER

Watershed-Based Management Plan

A Nine-Element Plan to Guide Restoration of the Kennebunk River from 2021 – 2031

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Maine Department of Environmental Protection
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ACRONYMS

BMP	Best Management Practice
DEP	Maine Department of Environmental Protection
DO	Dissolved Oxygen
ET	Eastern Trail
FBE	FB Environmental
FIB	Fecal Indicator Bacteria
KK&W	Kennebunk, Kennebunkport, and Wells, referring to KK&W Water District
KLT	Kennebunk Land Trust
LID	Low Impact Development
MHB	Maine Healthy Beaches
NPS	Nonpoint source
NRCS	Natural Resources Conservation Service
OB	Optical Brightener
PFAS	Per- and Poly-fluoroalkyl Substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonate
QAPP	Quality Assurance Project Plan
SIP	Survey Implementation Plan
TAC	Technical Advisory Committee
TMDL	Total Maximum Daily Load
US EPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VRMP	Volunteer River Monitoring Program
WBMP	Watershed-Based Management Plan
WNERR	Wells National Estuarine Reserve
YCSWCD	York County Soil and Water Conservation District

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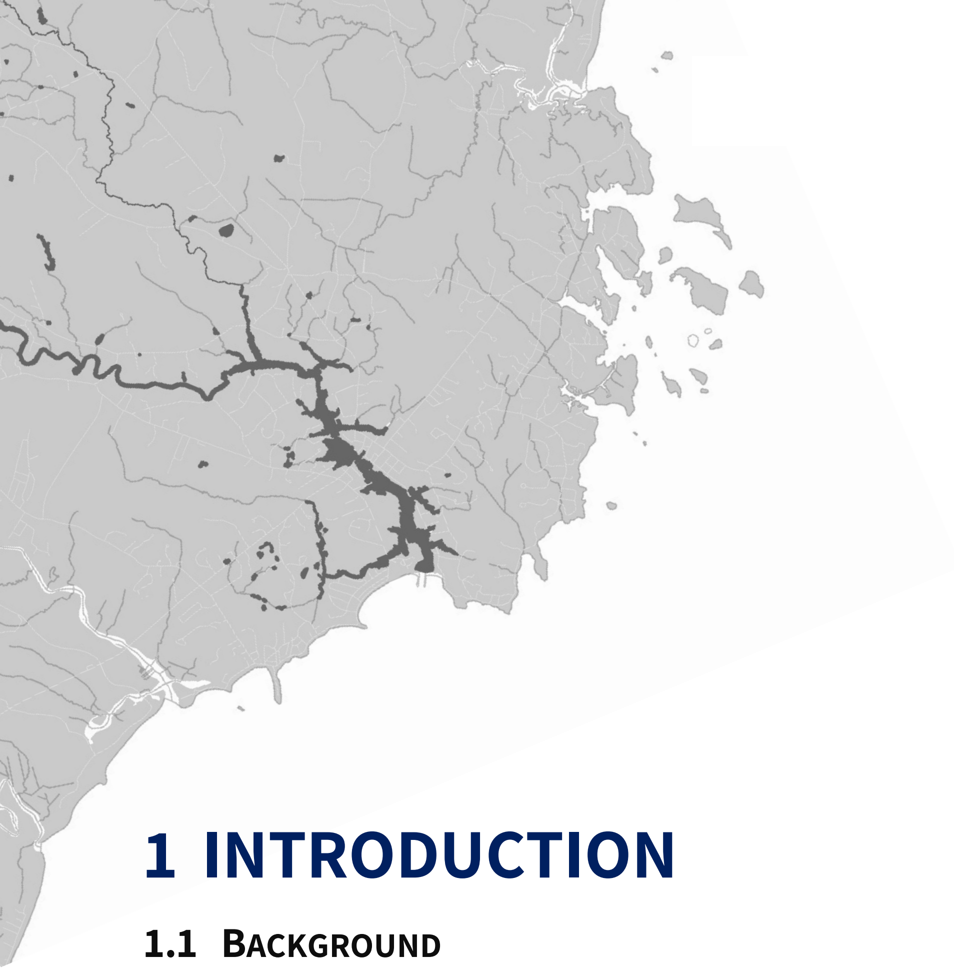


1 INTRODUCTION

1.1 BACKGROUND

The Kennebunk River watershed drains an area of 59 sq. mi. across six towns in York County. The river's headwaters originate in Kennebunk Pond in Lyman where the pond's eastern outlet (Lords Brook) converges with Carlisle Brook to form the Kennebunk River. In the upper reaches of the watershed the landscape is sparsely developed consisting mainly of mixed forest and agricultural lands. The river flows south through the towns of Arundel and Kennebunk where the landscape bordering the main stem of the river is characterized by heavy agricultural use with development increasing as the river nears the coast. Before discharging into the Atlantic Ocean at the eastern end of Gooch's Beach, the river opens to create a wide tidal estuary and enters an area of high-density development. The watershed contains the subdrainages of Kennebunk Pond and Alewife Pond among dozens of smaller ponds and wetlands. Major tributaries include Lords Brook, Ward Brook, Carlisle Brook, Duck Brook, and Goff Mill Brook (Figure 1-1).

The Kennebunk River provides many uses including fishing, swimming, kayaking, and boating. Striped Bass is popularly fished below head-of-tide and brings many anglers to the river each year. The tidal portion of the river is a popular cruising destination. The portion south of the Route 9 bridge is home to 13 marinas providing over 300 slips open to recreational and commercial vessels. The Kennebunk's are largely sustained by the tourism industry and dependent on a healthy river system. Restaurants, hotels, and event venues benefit from the river's scenic and aesthetic qualities. Charter and commercial fishing vessels depend on the quality of the water and the health of the river's fisheries. Gooch's Beach, located at the outflow of the Kennebunk River, is a valuable recreational resource offering opportunity for swimming, surfing, sunbathing, kayaking, and paddle-boarding.

In addition to the direct recreational uses of the river, a network of trail systems, including the Eastern Trail (ET), are located within the Kennebunk River Watershed. The ET is a 65-mile scenic recreational greenway connecting Strawberry Banke in Portsmouth, NH to Casco Bay in South Portland, ME. The ET is part of the East Coast Greenway, a developing trail system that will ultimately connect 2,900 miles of trails between Calais, Maine and Key West, Florida. The Kennebunk River, Ward Brook, and Duck Brook intersect the ET at five locations.

While surface waters are of concern, there are also public water supply sources within the Kennebunk River Watershed. This includes residential private wells, and the Kennebunk, Kennebunkport, and Wells (KK&W) Water District's Kennebunk River Well which yields an estimated 25% of the water supply for this service area.

Understanding population growth and demographics, and ultimately development patterns, provides critical context for watershed management in the Kennebunk River Watershed, particularly as it pertains to water quality in streams. According to the U.S. Census Bureau, the combined total population of Arundel, Lyman, Kennebunk, and Kennebunkport – the four towns that compose the majority of the Kennebunk River Watershed – in 2010 was 21,865, representing a 0.1% increase in population since the 2000 census (US Census Bureau, 2010) (Table 1-1).

Table 1-1. Population growth in Arundel, Lyman, Kennebunk, and Kennebunkport, Maine.

	Population						Annual Growth Rates		
Town*	**1960**	**1970**	**1980**	**1990**	**2000**	**2010**	**50-Yr**	**20-Yr**	**10-Yr**
Arundel	907	1,322	2,150	2,669	3,571	4,022	6.9%	1.7%	1.1%
Lyman	529	864	2,509	3,390	3,795	3,571	11.5%	0.3%	-0.6%
Kennebunk	4,551	5,646	6,621	8,004	10,476	10,798	2.7%	1.3%	0.3%
Kennebunkport	1,851	2,160	2,952	3,356	3,720	3,474	1.8%	0.2%	-0.7%
Total	**7,838**	**9,992**	**14,232**	**17,419**	**21,562**	**21,865**	**3.6 %**	**1.0%**	**0.1 %**

**Alfred and Biddeford compose 4% and < 1% of the watershed and are not included in this table.*
50-year annual growth rates from 1960-2010; 20-year annual growth rates from 1990-2010; 10-year annual growth rates from 2000-2010.

Tributary entrance to the main stem of the Kennebunk River. © FBE

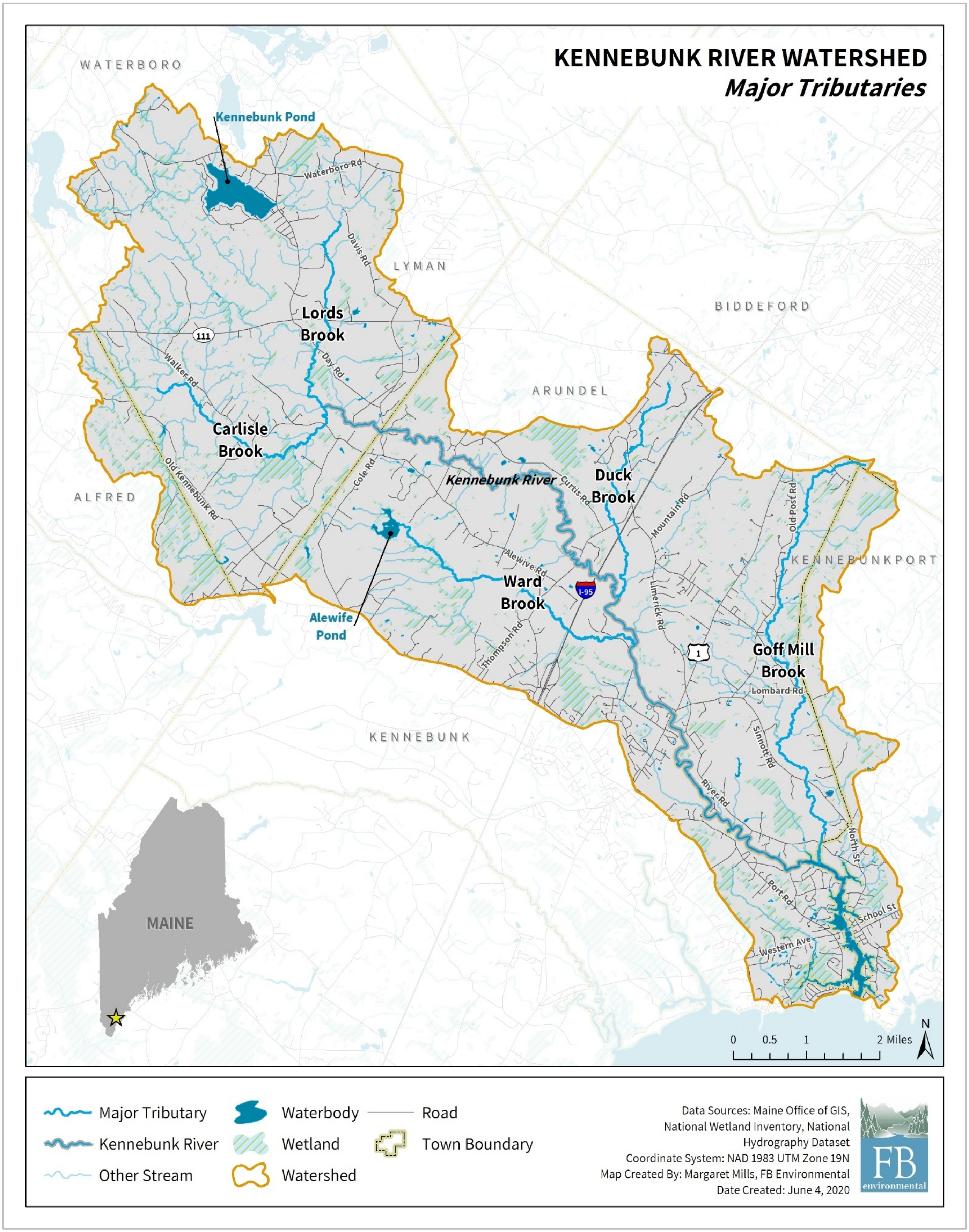


Figure 1-1. Major Tributaries within the Kennebunk River Watershed.

1.2 PROBLEM AND NEED

Freshwater portions of the Kennebunk River watershed have failed to meet attainment for biomonitoring and algae for Class B state water quality standards, indicating impairments for aquatic life. In addition, the 2009 Maine Statewide Bacteria Total Maximum Daily Load (TMDL) indicated that portions of the Kennebunk River are impaired for bacteria nonattainment and that a reduction of 41.6% is needed to meet water quality standards. Historical attainment of Class B standards in the Kennebunk River indicate that the degradation of water quality is potentially reversible if restorative and preventative actions start immediately.

The freshwater portions of the Kennebunk River are classified as Class B. Below head of tide, the river is classified as Class SB. The Maine Department of Environmental Protection (DEP) has conducted biological monitoring in the river since 1995 and results at monitoring station S-270 show attainment in 1995, 2000 and 2010; meeting class B standards. However, in 2005 and 2015 results show the river attaining only class C standards. The Kennebunk River (segment ME0106000301_622R04) is currently listed under Category 3 in the 2016 Integrated Water Quality Monitoring and Assessment Report for streams and rivers with insignificant data or information to determine if designated uses are attained. However, this segment will likely be listed as impaired for aquatic life use (macroinvertebrates and algae bioassessments) in the next Integrated Report (2018). The 2016 Integrated Report also lists the Kennebunk River (segment ME0106000301_622R01) and one of its tributaries, Duck Brook, as impaired under Category 4A – for *Escherichia coli* (*E. coli*) bacteria nonattainment. The Kennebunk River is included in the 2009 Maine Statewide Bacteria TMDL. Duck Brook (segment ME0106000301_622R03) is included in the Maine Statewide Bacteria TMDL 2014 Freshwater Addendum.

Wells National Estuarine Research Reserve (WNERR) and volunteer water quality monitors have monitored the Kennebunk River since 2009. Maine Healthy Beaches (MHB) has monitored Gooch's Beach at the outlet of the Kennebunk River since 2003. Data show increasing bacteria trends across all sampling locations. In 2007, MHB conducted a study of the Microbial Pollution Levels and Transport Pathways in the Kennebunk River and Gooch's Beach revealing circulation of tidal waters just off shore at Gooch's Beach brings contaminants and pollutants back into the beach area instead of flushing them away from the coastline and into the Gulf of Maine. This study listed the Kennebunk River as the most likely source of pollution at Gooch's Beach and recommended an investigation of the Kennebunk River for potential upstream sources of bacteria. In 2011 MHB published the Kennebunk River Watershed Water Quality Project Report which provided an in-depth look at the bacteria problems throughout the Kennebunk River watershed and discussed the work by watershed leaders to address bacteria issues between 2007 and 2010.

1.3 PURPOSE AND GOAL

The purpose of this project was to develop a Watershed-Based Management Plan (WBMP) for the Kennebunk River watershed that includes the United States Environmental Protection Agency's (US EPA) nine minimum required elements. Through the completion of this project, we collected information about the watershed's natural resources, and specific nonpoint source (NPS) and bacteria problems, and worked with the communities, town officials and regional partners to develop locally-supported watershed goals, objectives and action strategies for protecting the Kennebunk River and its tributaries. This WBMP was developed to serve as a guide for watershed protection, restoration, and enhancement efforts over the next 10 years.

The plan goal was to provide stakeholders with a user-friendly guide and roadmap to restore water quality and aquatic habitat conditions in the watershed and prevent future impairments and nonattainment of state water quality standards.

Incorporating EPA's Nine Elements

The plan is divided into six major sections and includes US EPA's nine key planning elements for WBMPs (referred to as elements a through i). Watershed plans that include these nine elements are a prerequisite for projects using Clean Water Act Section 319 funds for plan implementation. These nine elements are (a) identification of causes of impairment and pollutant sources, (b) estimated load reductions from management efforts, (c) nonpoint source management efforts, (d) necessary technical and financial assistance needed, (e) information and education component, (f) project timeline, (g) measurable milestones and indicators of progress, (h) criteria to manage success, and (i) a water quality monitoring plan. The following outlines each chapter in this Plan and the corresponding elements that are addressed in that chapter.

Section 1 (Introduction) describes the purpose of the plan and provides background information about the Kennebunk River, a description of the planning process, and a brief description of recent efforts in the watershed *(element a)*.

Section 2 (Watershed Characterization) describes the watershed, including local climate, land cover, land conservation, soils and geology, and stormwater/sewer infrastructure.

Section 3 (Assessment of Water Quality) describes causes of impairment and applicable water quality standards and summarizes water quality and biological assessment data collected from the watershed as well as environmental and proximate water quality stressors. This section also summarizes the results of Stream Corridor Assessments and Rapid Geomorphic Assessments (July 2019), and a Watershed Inventory (July/August 2019) in key hotspot locations *(element a)*.

Section 4 (Community Engagement) describes the process of developing a community-based watershed management plan and provides an overview of the results of a community survey that gathered public feedback on the priorities for protection and restoration of the Kennebunk River. This section also summarizes an ordinance review of each watershed community *(element e)*.

Section 5 (Management Strategies) describes watershed restoration goals and objectives. Both structural and non-structural restoration opportunities and recommendations are discussed. Action strategies are presented in tables describing what needs to be done, how it will be done, who will help get it done, when it will be done, and an estimate of how much it will cost *(elements, b, c, e, f)*.

Section 6 (Restoration Plan) describes plan implementation, including who is in charge of administering the plan, and summarizes actions, estimated costs, and technical assistance needed to ensure progress *(element d)*.

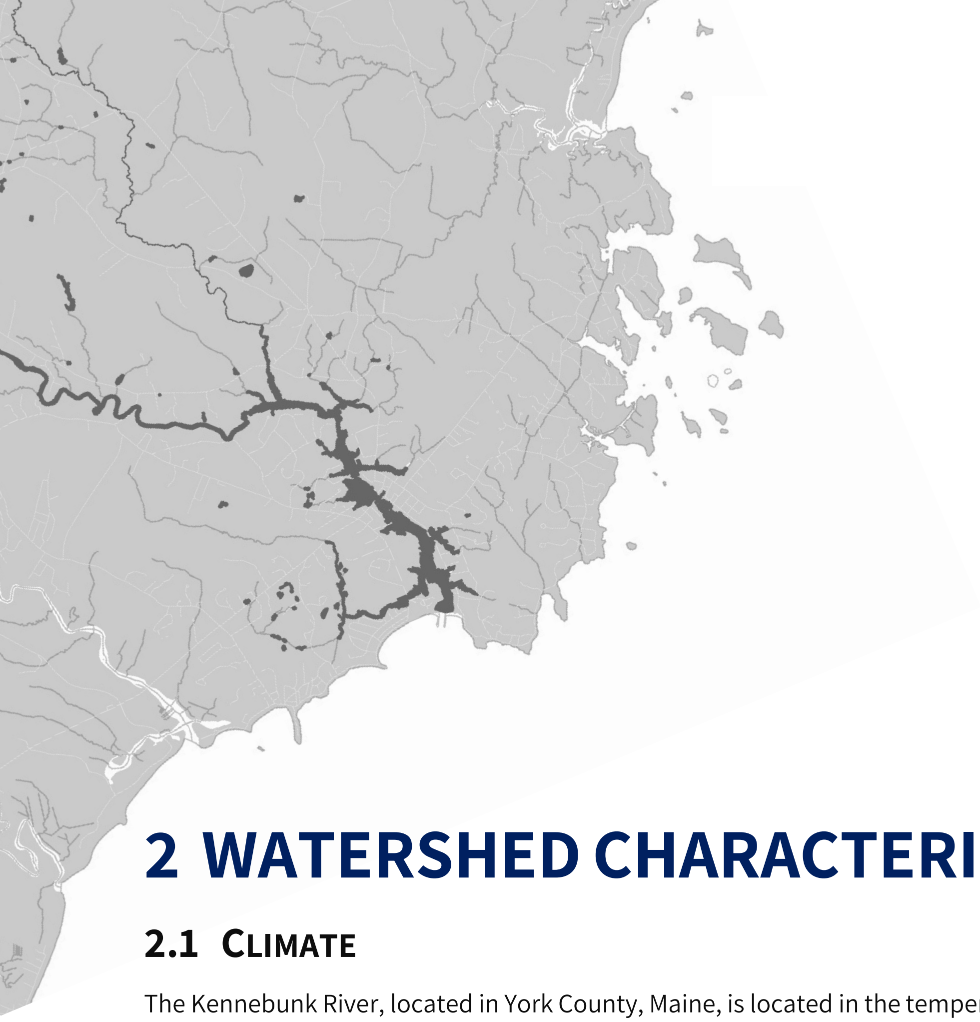
Section 7 (Methodology for Measuring Success) describes specific recommendations for monitoring and evaluating the effectiveness of restoration efforts. This includes criteria for measuring progress and measurable milestones along the way *(elements g, h, i)*.

1.4 Recent Efforts in the Watershed

Ongoing efforts to investigate and mitigate potential pollutant sources in the Kennebunk River Watershed are presented below.

- The Kennebunk River Watershed NPS Survey (supported by EPA Clean Water Act grant funds) identified 88 sites as contributing NPS pollution to the Kennebunk River. Over half of these sites were considered high priority problems (2001).
- Gooch's Beach Bacteria Monitoring by MHB (2003 – present).
- Intensified monitoring of the Kennebunk River by MHB. This project funded the analysis of 551 bacteria samples collected at 82 different locations throughout the watershed. Results indicate widespread bacterial contamination throughout all sites (2005-2010).
- The Oceanographic and Meteorological Study of Microbial Pollution Levels and Transport Pathways in the Kennebunk River by MHB & Maine Geological Survey. Potential sources of bacteria found in this study include septic systems, stormwater, boats, seaweed, waterfowl and pet waste (2007).
- An Optical brightener (OB) study by MHB and US EPA discretely measured OB concentrations at 82 sites. 42 sites had single sample OB concentrations above 200ug/L and bacteria concentrations exceeding safety limits. Flow-through OB monitoring was also conducted over a 5-day period. Higher concentrations were seen in the upper portions of the survey area (specifically between Durrell's Bridge and Riverwynde Drive) with decreasing concentrations approaching the coast (2008-2010).
- Kennebunk River Bacteria Monitoring by WNERR (2009 – present).
- A Watershed Risk Analysis by MHB developed a prioritized list of watershed properties to survey for malfunctioning septic systems. MHB and its partners conducted a sanitary survey of 31 properties considered a "tier 1 risk". 16 properties were marked for follow-up due to surface sewage malfunctions, hydraulic malfunctions, no evidence of a septic system, suspicious drainage pipes, and other unknown malfunctions. Additional survey work is needed to determine the status of the remaining systems that have not been inspected (2009).

- The Statewide Bacteria TMDL for the Kennebunk River indicated that a reduction of 41.6% in bacteria load concentrations is needed to meet water quality standards. Recommended mitigation strategies presented in the report include comprehensive analysis of both public and private wastewater systems, sanitary surveys, and public outreach in agricultural areas to reduce fecal contamination of stormwater runoff from livestock, manure storage areas, and fertilized fields, and to keep farm animals away from surface waters (2009).
- The Kennebunk River Road Crossing Survey by WNERR surveyed 83 stream crossings and identified 21 severe fish barriers in the Kennebunk River. Road crossings on the main stem were all found to be adequate for fish passage. Crossings ranked as severe barriers were mostly located in the upper reaches of the watershed and on major tributaries (2010).
- The Kennebunk River Stream Barrier Survey by WNERR surveyed potential fish barriers in the Kennebunk River and 3 other rivers in Southern Maine. 66 potential barriers were documented within the Kennebunk River and its tributaries (2012).
- Duck Brook in Arundel is included in the Statewide Bacteria TMDL Freshwater Addendum and must see a 48% reduction in bacteria load concentrations to achieve attainment and meet the standards for Class B streams. The TMDL report recommends conducting systematic investigations in the areas surrounding contaminated sites to determine and remediate bacteria sources. This includes organizing sanitary surveys in residential and developed areas and assessing the impact of domestic animal waste from properties with livestock (2014).
- A stream corridor assessment, watershed inventory, and stormwater outfall survey in 2019 were completed by project partners, including WNERR, MHB, DEP, York County Soil and Water Conservation District (YCSWCD), and FB Environmental (FBE). The assessments documented unusual conditions in the Kennebunk River main stem and tributaries, as well as potential pollutant sources. These efforts were undertaken as part of this plan and results are summarized in sections 3.5.2 and 3.5.3.



2 WATERSHED CHARACTERIZATION

2.1 CLIMATE

The Kennebunk River, located in York County, Maine, is located in the temperate broadleaf biome. In Kennebunkport, the town in which the Kennebunk River outlets into the ocean, average annual high temperature is 55 °F (12.6 °C) and the average annual low is 35 °F (1.7 °C). January is the coldest month with an average high of 30 °F (-1.1 °C) and average low of 12 °F (-11.1 °C), while July is on average the warmest month with an average high of 76 °F (24.4 °C) and average low of 57 °F (13.9) (Figure 2). Average monthly precipitation is approximately 3.83 inches (10.81 cm) with August, the driest month, averaging 3.65 inches (9.27 cm) and October, the wettest month, averaging 5.25 in (13.35 cm).

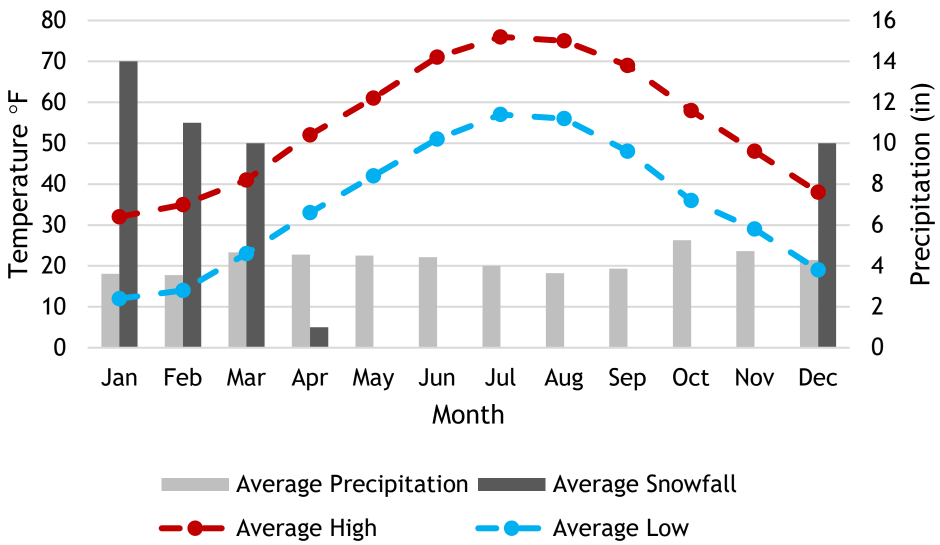


Figure 2-1. Average monthly climate normals for Kennebunkport, Maine. Data from US Climate Data. Climate normal represent three-decade averages for each month of the year.

2.2 Physical Features of the Watershed

Soils and Geology

The Kennebunk River watershed is composed of numerous soil series, with the three most prevalent soil series being Naumburg sand (16.8% of watershed area), Scantic silt loam (10.1%) and Hermon sandy loam (10.0%) (Web Soil Survey, 2020) (Appendix A; Figure 1). All other soil series compose less than 10% of the watershed area. The majority of the soil series in the Kennebunk River watershed are classified as "not prime farmland" (71%), with 26% of the watershed classified as "farmland of statewide importance" and 3% of the watershed classified as prime farmland (Web Soil Survey, 2020) (Figure 2-2).[1] Soils that are classified as farmland of statewide importance are greatest in density along the upper Kennebunk River stem and Ward Brook tributary, which runs parallel to the main stem west to east before joining the Kennebunk River just north of Route 1.

Land Cover

In the upper reaches of the watershed the landscape is sparsely developed, consisting mainly of mixed forest and agricultural lands. The landscape bordering the main stem of the river is characterized by heavy agricultural use with development increasing as it nears the coast. Approximately 66.9% of the land in the Kennebunk River watershed is classified as forest (deciduous, evergreen, and mixed) and 10.4% of the land is composed of crop land or cultivated land (Appendix A; Figure 2). Agricultural land use allows for potential agricultural runoff into the watershed, especially during heavy rain events.

There are approximately fifty-four farms in the Kennebunk River Watershed according to recent 2020 NRCS and YCSWCD records, ranging from small family farms to larger agricultural operations. Of these, nine have active Nutrient Management plans with imminent or recent best management practice implementation activity, and two have active conservation farm, cropland and irrigation practices. Nutrient management plans document the practices and management activities adopted by the landowner to address natural resource concerns related to soil erosion, water quality, manure use and storage, and other by-product disposal.

Developed land (developed open space, developed low, medium, and high intensity) comprises 6.4% of the watershed. Developed land in the Kennebunk River watershed is most dense along the Route 1 corridor and southeast to the Kennebunkport river estuary. Developed areas, such as asphalt and pavement, create impervious surfaces which cause stormwater to carry pollutants into waterbodies that would otherwise soak into the ground. Stormwater, such as from a heavy rain, can carry sediment, nutrients, pathogens, pesticides, hydrocarbons, chloride, and metals into waterways (Center for Watershed Protection, 2003). These pollutants can be harmful to aquatic life.

[1] Prime Farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. Farmland of statewide importance is farmland that does not meet the requirements for prime or unique farmland (Web Soil Survey, 2020).

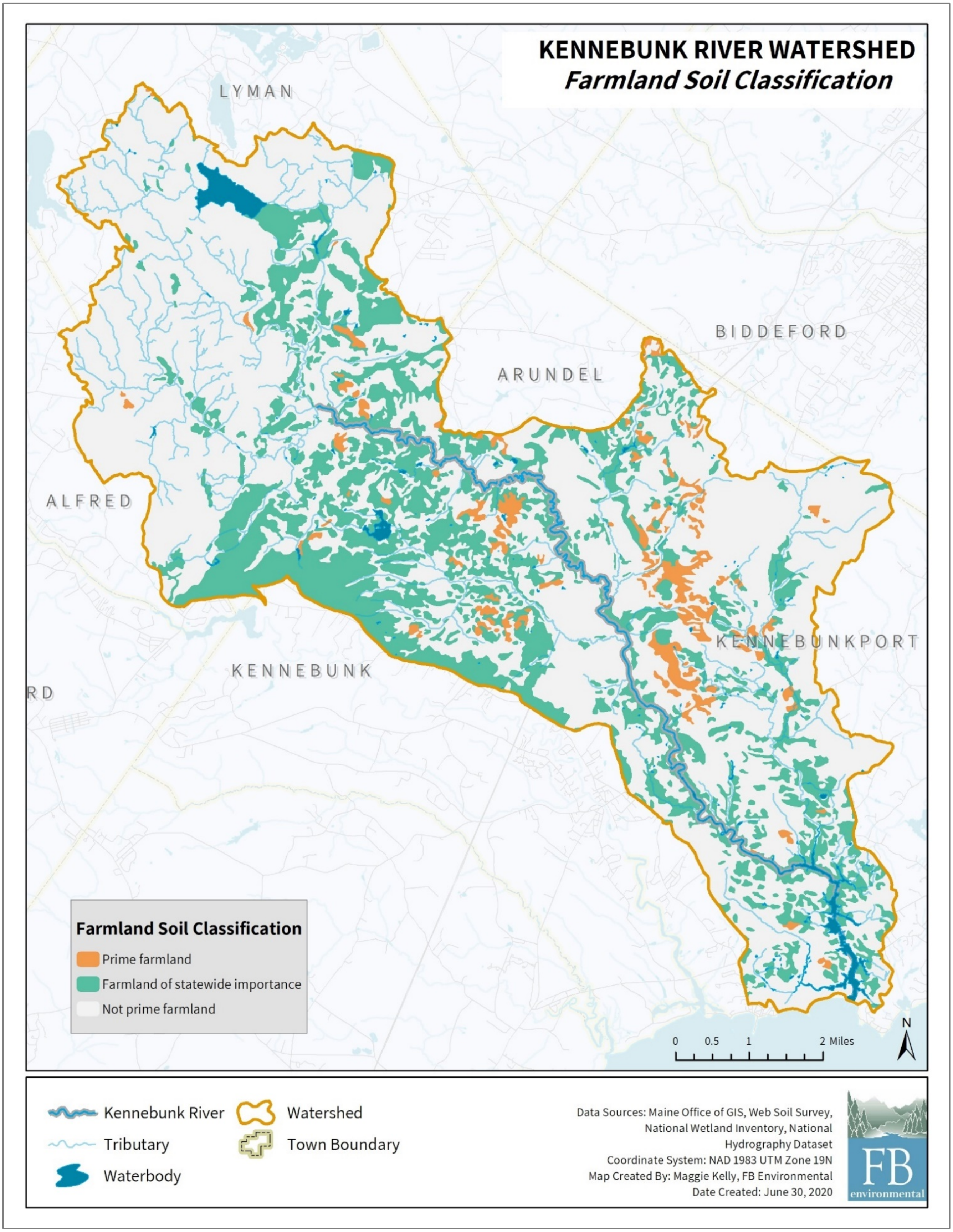
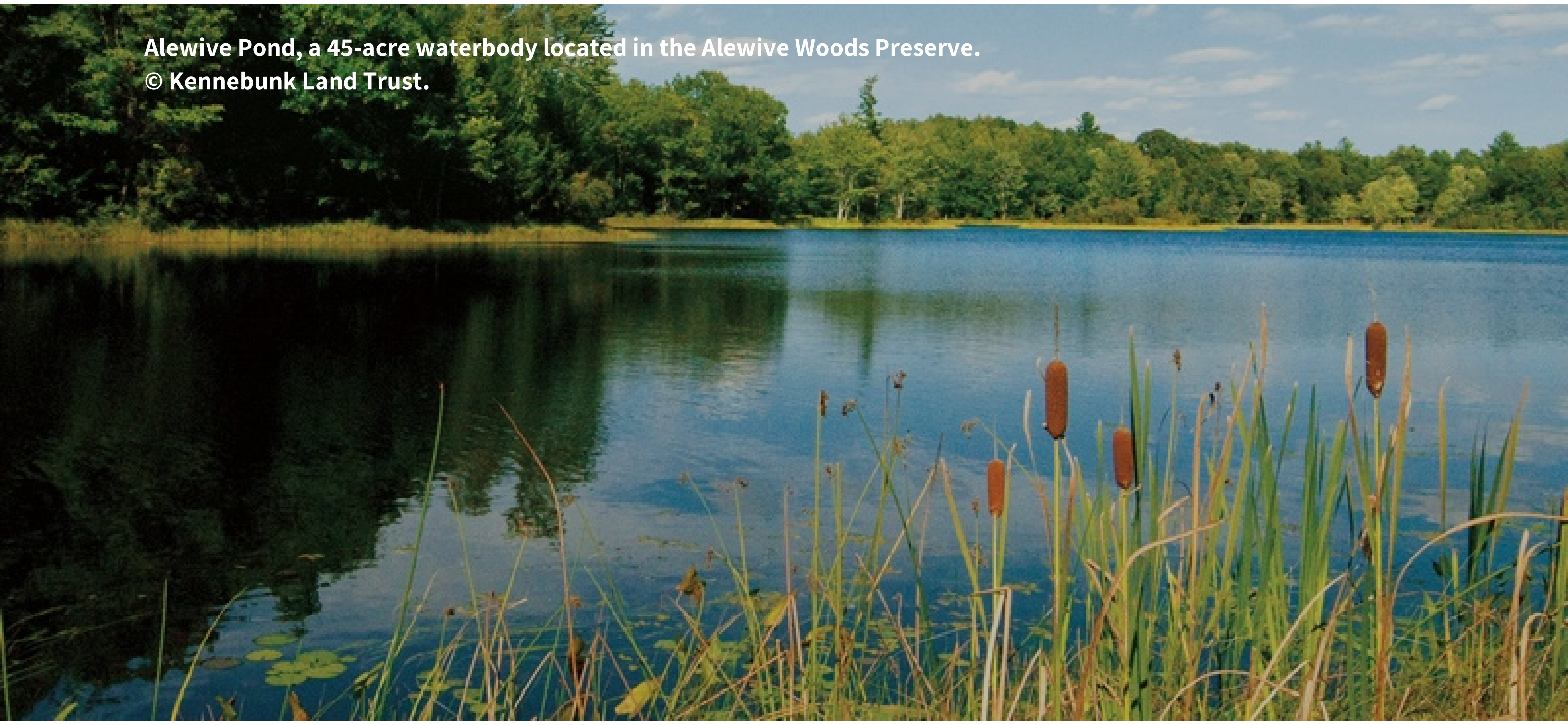


Figure 2-2. Farmland soils in the Kennebunk River watershed.

Habitat Conservation

The principal land conservation agency in the Kennebunk River watershed is the Kennebunk Land Trust (KLT), which holds 1,500 acres of the total 3,446 acres of conserved land in the watershed (Figure 2-3). The Kennebunkport Conservation Trust, Maine Farmland Trust, Maine Minor Civil Division, and US Forest Service also hold conservation parcels. No land trust exists in the Town of Lyman but officials have stated they are interested in establishing a land trust alliance in their community. The largest parcel of conserved land within the watershed is the Massabesic Experiment Forest, located along the southwestern boundary of the watershed, is managed as federal land by the US Forest service. 853 of the total 2,059 acres of the experimental forest are located within the watershed bounds. The Alewive Woods Preserve is the second largest parcel of conserved land, comprised of 662 acres of land located in the central area of the watershed by Alewive Pond, and is managed by the Kennebunk Land Trust.

The Massabesic Experimental Forest is located within the sub-watershed of Carlisle Brook, and is home to several rare species, species of special concern such as the Eastern Ribbon Snake (*Thamnophis sauritus*), Great Blue Heron (*Ardea herodias*), and Hessel's Hairstreak butterfly (*Callophrys hesseli*), and threatened species such as the Ringed Boghaunter dragonfly (*Williamsonia lintneri).* In addition, the Carlisle Brook subwatershed has White Cedar swamp communities, inland waterfowl and wading bird habitat, and large areas of deer wintering habitat. The Alewive Pond and Ward Brook sub-watersheds are also home to significant waterfowl wader and deer wintering habitats. Wild Brook Trout and Brown Trout habitat is found in freshwater portions of the watershed, and Striped Bass is popularly fished below head-of-tide and brings many anglers to the river each year. In addition, the Kennebunk River estuary and inland marsh provide significant habitat for the Saltmarsh Sparrow (*Ammodramus caudacutus*), a rare species only found in 27 sites along the southern and mid-coast regions. The marsh also supports rare plant communities of Saltmarsh False-foxglove (*Agalinis maritima*).



Alewive Pond, a 45-acre waterbody located in the Alewive Woods Preserve.
© Kennebunk Land Trust.

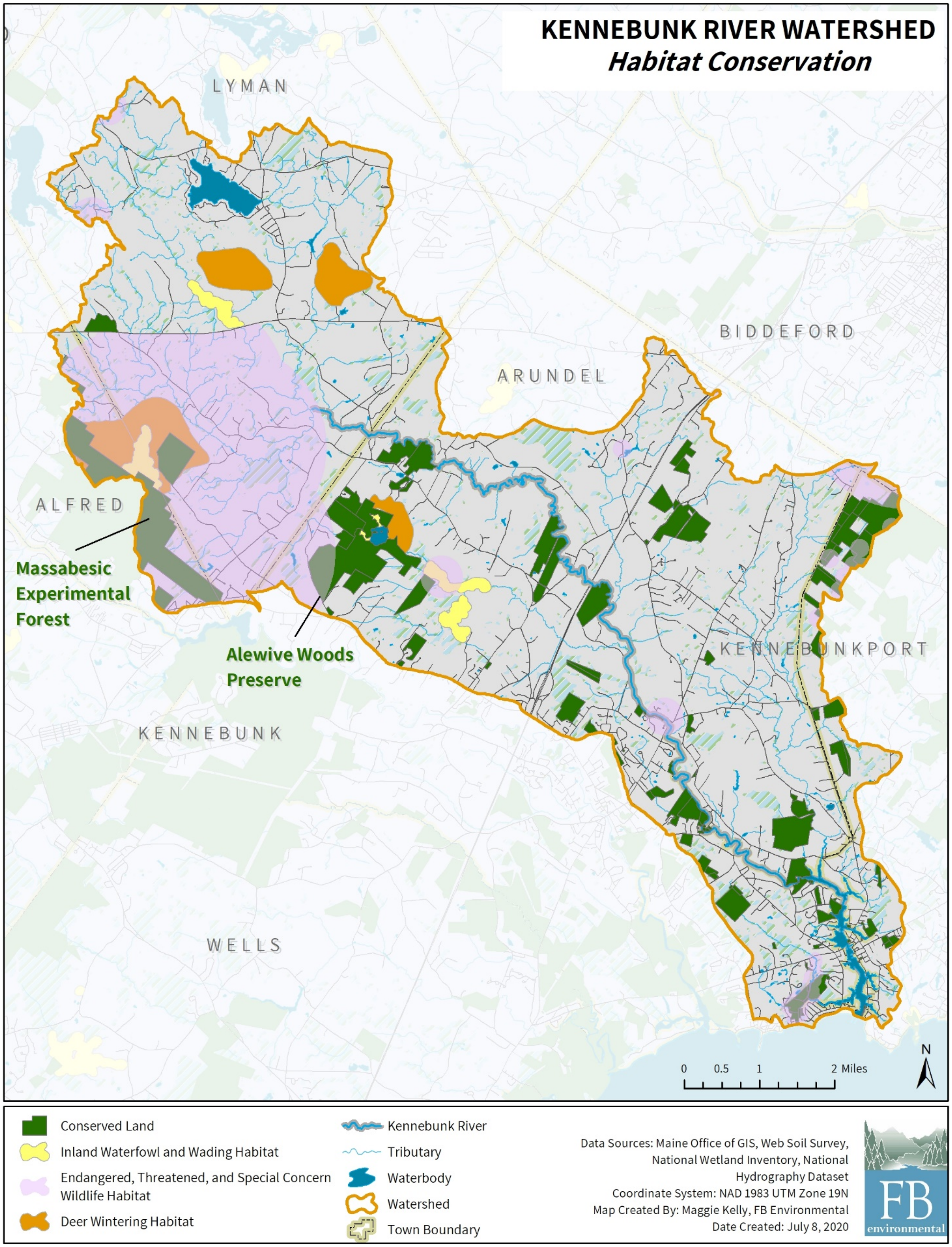


Figure 2-3. Habitat conservation and wildlife habitat within the Kennebunk River watershed.

Hydrology and Water Resources

The main stem of the Kennebunk River is 18 miles long, with an additional 154 miles of perennial and intermittent tributaries. There are five main tributaries – Lords Brook, Carlisle Brook, Ward Brook, Duck Brook, and Goff Mill Brook – which enter the main stem of the Kennebunk River watershed along with the numerous smaller tributaries and streams, many of which are unnamed. The River's headwaters originate in Kennebunk Pond in Lyman where the pond's eastern outlet (Lords Brook) converges with Carlisle Brook to form the Kennebunk River. Head of tide is located approximately five miles upriver, just below the Route 1 crossing. Extensive saltmarsh is present within the estuary portion of the river and along Gooch's Creek. At the mouth of the Kennebunk River are Gooch's Beach and Colony Beach, located at river right and river left respectively.

There are two aquifers, or glacial deposits that are a significant groundwater resource, within the Kennebunk River watershed, located in the northern section of the watershed east of Kennebunk Pond, and in the central southern portion of the watershed below Ward Brook. There are also numerous public wells throughout the watershed.

Water, Stormwater, and Sewer Infrastructure

Water

Within the Kennebunk River watershed, Kennebunk and Kennebunkport are served by the Kennebunk Kennebunkport and Wells Water District which is a quasi-municipal water utility. KK&W Water District has a water filtration plan supplied by Branch Brook, the District's primary source of water. KK&W Water District's Kennebunk River Well yields an estimated 25% of the water supply for this service area.

Sewer & Septic

The Kennebunk Sewer District facility is located at 71 Water Street and services sewer to the Town of Kennebunk through more than 36 miles of gravity sewers, 11 miles of force mains, and 29 pumping stations (Kennebunk Sewer District, 2020). Kennebunk's sewer system is focused in the downtown Kennebunk area which extends into the central southern edge of the Kennebunk River watershed, as well as along the coast of Kennebunk adjacent to Gooch's beach and the surrounding waterfront area (Figure 2-4). Once the sewage reaches the treatment plant on Water Street, it undergoes a six-stage treatment process that utilizes physical, chemical, and biological methods to treat the waste. Following treatment, the effluent is then discharged to the Mousam River. The Sewer District recognizes that the existing biological treatment units "Rotating Biological Contractors" are at the end of their life expectancy and that they will not meet anticipated nutrient (nitrogen) removal requirements. As such, the district is initiating the process to replace these systems for future treatment. This upgrade is outlined in the 2019 – 2021 Strategic Plan and highlights a four-phase approach to this transition, summarized below (Bolduc, 2020):

(1) Relocate administrative offices and the maintenance garage. *Completed in 2018.*
(2) Repurpose administrative space into a new laboratory and operator area. *Completed in 2018.*
(3) Design and construct a new Headworks Facility capable of handling peak flows into the plan. *Expected completion in 2021.*
(4) Design and construct the new biological treatment units. *Expected completion in 2025 – 2027 (following release of nitrogen limits in the 2021 discharge license).*

Sewer in Kennebunkport is served by the Kennebunkport Wastewater Treatment Plan located at 25 Recreation Way. This treatment plant, operated by the Wastewater Department in the Town of Kennebunkport, contains approximately 95,000 feet of gravity sewer lines, 14 major pump stations, and 88 grinder pumps (Town of Kennebunkport, 2020). Sewer line locations are shown in dark red on the map on the following page. Kennebunkport's sewer system serves the town along the southern Kennebunk River main stem and in downtown Kennebunkport, extending south beyond Colony Beach out of the watershed boundary. The remainder of the Town is serviced by septic system, but documentation is unavailable at this time.

Both Arundel and Lyman are serviced by private wastewater disposal systems (septic systems). In 2016, Arundel looked into installing a sanitary sewer along Portland Road (Route 1) and connecting it to the sewer treatment plant in Kennebunk or Biddeford. Arundel is experiencing rapid suburbanization, and the Route 1 corridor within Arundel has a high water table and shallow to bedrock soils that pose challenges for onsite septic disposal (Town of Arundel, 2016). The Arundel Comprehensive Plan, written in 2005 and amended in 2016, identifies an action item to “Explore options to work with the Kennebunk Sewer District and Biddeford Sewer District to provide public sewer service to the Downtown Business District 1 (DB1), Downtown Business District 2 (DB2), Business/Office Park/Industrial District (BI), and the Gateway District (GW)” (Town of Arundel, 2005, Last Amended 2016).

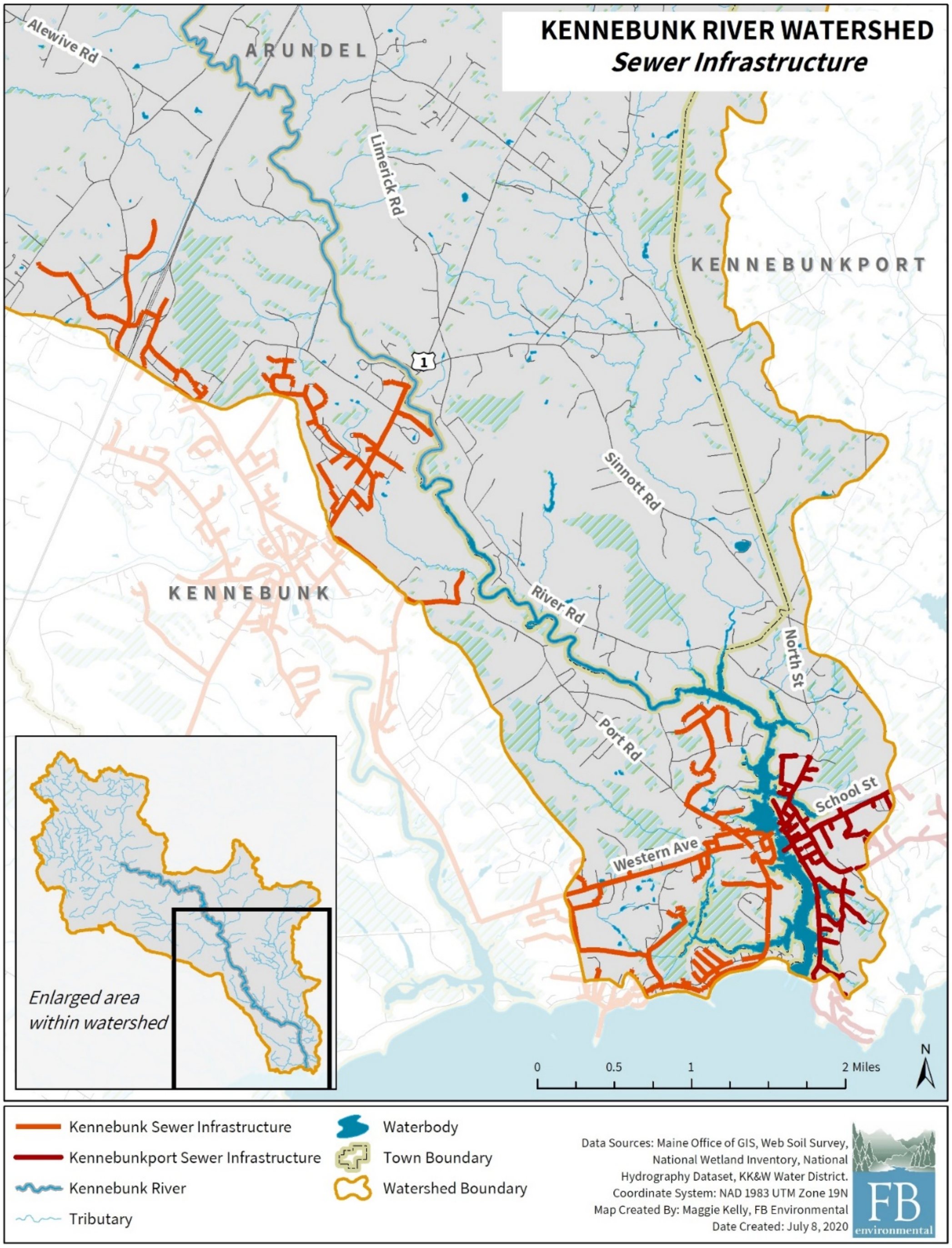
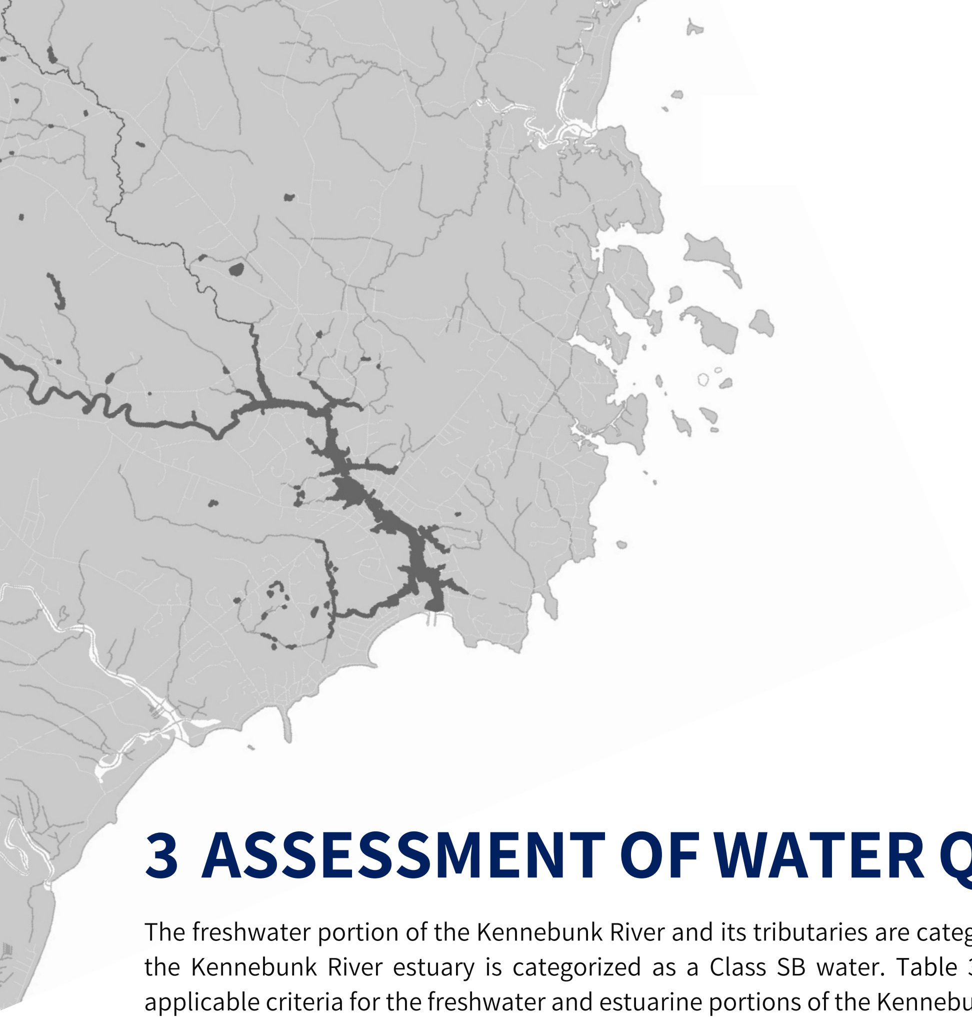


Figure 2-4. Sewer infrastructure in towns of Kennebunk and Kennebunkport. Lyman and Alfred are served by individual septic systems.



3 ASSESSMENT OF WATER QUALITY

The freshwater portion of the Kennebunk River and its tributaries are categorized as Class B waters. Below head of tide, the Kennebunk River estuary is categorized as a Class SB water. Table 3-1, below, lists the Maine DEP and US EPA applicable criteria for the freshwater and estuarine portions of the Kennebunk River and its tributaries.

Table 3-1. Applicable state and federal thresholds for all parameters applicable to the Kennebunk River and its tributaries.

PARAMETER	TYPE	CLASSIFICATION	THRESHOLD JUSTIFICATION	THRESHOLD +
*E. coli**	Freshwater	Class A	Maine DEP	**236 CFU/100mL** (in more than 10% of samples in any 90-day interval);
				64 CFU/100mL (geometric mean over 90-day interval)
		Class B	Maine DEP	**236 CFU/100mL** (in more than 10% of samples in any 90-day interval); **64 CFU/100mL** (geometric mean over 90-day interval)
Enterococci *	Estuarine	Class SB	Maine DEP	**54 CFU/100mL** (in more than 10% of samples in any 90-day interval); **8 CFU/100mL** (geometric mean over 90-day interval) and **35 MPN/100mL** geometric mean for MHB program.
Dissolved Oxygen	Freshwater	Class A/B	Maine DEP	**7 ppm** and **75% saturation****
	Estuarine	Class SB	Maine DEP	**85% saturation**

PARAMETER	TYPE	CLASSIFICATION	THRESHOLD JUSTIFICATION	THRESHOLD +
Temperature	Freshwater	None	Maine DEP	Recommended instantaneous temperature of **<24°C** for fish survival and maximum weekly temperature of **19°C** ***
Total Phosphorus	Freshwater	None	US EPA Ecoregion VIII Water Quality Criteria	12 ppb (threshold set at reference criteria for TP concentration)

** E. coli criteria only applicable seasonally (between April 15th and October 31st)*
***Except for Oct 1 – May 14 during spawning and egg incubation. 7-day mean dissolved oxygen not less than 9.5 ppm and 1-day minimum not less than 8.0 ppm in identified fish spawning areas.*
**** Temperature criteria found to be the limit for juvenile brook trout survival (Brungs, W.S. and B.R. Jones. 1977. Temperature Criteria for Freshwater Fish: Protocols and Procedures. EPA-600/3-77-061. Environ. Research Lab, Ecological Resources Service, U.S. Environmental Protection Agency, Office of Research and Development, Duluth, MN.*
+ CFU/100mL = MPN/100mL

Throughout this document, we use these criteria in Table 3-1 *as a guide* to assess the water quality conditions in each of the tributaries and will refer to these criteria as "State criteria" in our discussions. However, for consistency across sites, we are assessing the geometric mean of each parameter. When used for impairment designations, the criteria listed in Table 3-1 considers nuances in the data, such as sample count and interval of data collection, that are not considered in this analysis. The data presented in this document is truncated to include only sample points within the critical period (between April 15th and October 31st).

3.1 Current State Impairments in the Kennebunk River Watershed

Kennebunk River Main Stem

In order to identify focus sub-watersheds for the stressor analysis, it is important to look at the current impairments. In the 2016 Integrated Water Quality Monitoring and Assessment Report, the Kennebunk River is described as having 'insignificant data or information to determine if designated uses are attained'. However, recent data collected by Maine DEP for assessment indicates that this segment will likely be listed as impaired for aquatic life use (macroinvertebrates and algae bioassessments). In addition, the Kennebunk River is listed as impaired for *E. coli* and was included in the 2009 Maine Statewide Bacteria TMDL.[2]

Duck Brook

In addition to the main stem of the Kennebunk River, a major tributary, Duck Brook, is listed as impaired for *E. coli* and was included in the Maine Statewide Bacteria TMDL 2014 Freshwater Addendum.[3]

3.2 Biological Monitoring

Macroinvertebrate and Algae Monitoring

The Maine DEP Biomonitoring Unit uses macroinvertebrate (aquatic insects, crustaceans, mollusks, mites, leeches, and worms) and algae data to determine if waterbodies are attaining their statutory class and supporting aquatic life. The aquatic life (biological) narrative criteria for Class B waters in Maine (such as those in the Kennebunk River watershed)

[2] https://www.maine.gov/dep/water/monitoring/tmdl/2009/bacteria_report.pdf
[3] https://www1.maine.gov/dep/water/monitoring/tmdl/2014-statewide-bacteria-tmdl-addendum/Appendix_A_Duck_Brook.pdf

states *"Discharges may not cause adverse impact to aquatic life in that the receiving waters must be of sufficient quality to support all indigenous aquatic species without detrimental changes to the resident biological community."*[4]

Biological communities are great indicators of water quality because certain species are understood to be more "sensitive", requiring cold, clean water and natural habitats. The Maine DEP collects macroinvertebrate and algae data on rivers and streams and then analyzes the aquatic communities through a statistical model to determine if the river is meeting its statutory class and supporting aquatic life.

In the Kennebunk River watershed, macroinvertebrate and algae sampling stations exist on the Kennebunk River main stem, Carlisle Brook, Lord's Brook, Ward Brook, and the East Outlet Tributary of Kennebunk Pond. Biomonitoring began in 1995 on the main stem (station S-270) and was most recently conducted in 2015. Given the available data, the first non-attainment occurred on the main stem (station S-270) in 2005. This site then met class in 2010 but not in 2015. Other stations not meeting class are sites S-863 and S-875 on Lord's Brook. Both stations did not meet class in 2008, and station S-863 did not meet class in 2010 (S-875 did meet class in 2010; see Table 3-2 for a summary of biomonitoring and attainment and Table 3-3 for a summary of algae monitoring and attainment in the Kennebunk River watershed).

Table 3-2. Summarized biomonitoring results from the Maine DEP in the Kennebunk River watershed.

STATION NUMBER	LOCATION	SAMPLE DATE	STATUTORY CLASS	ATTAINED CLASS	FINAL DETERMINATION
S-270	Kennebunk River above Route 1	08/22/1995	B	Y	B
		08/31/2000	B	Y	B
		08/15/2005	B	**N**	C
		08/31/2010	B	Y	B
		08/19/2015	B	**N**	C
S-469	Kennebunk River Main Stem at Alewive Road	08/31/2000	B	Y	B
		08/15/2005	B	Y	B
S-792	Carlisle Brook at Walker Road	08/31/2010	B	Y	A
S-863	Lord's Brook at Lords Lane	08/08/2008	B	**N**	C
		08/25/2010	B	**N**	C
S-867	East Outlet of Kennebunk Pond	08/08/2008	B	Y	A
S-875	Lord's Brook Upstream of East Outlet	08/08/2008	B	**N**	NA
		08/25/2015	B	Y	A
S-951	Ward Brook at Alewife Road	08/31/2010	B	I	I
		08/19/2015	B	Y	A

[4] https://www.maine.gov/dep/water/monitoring/biomonitoring/materials/qapp2019.pdf (page 7).

Table 3-3. Summarized algae monitoring results from the Maine DEP in the Kennebunk River watershed.

STATION NUMBER	LOCATION	SAMPLE DATE	STATUTORY CLASS	ATTAINED CLASS	FINAL DETERMINATION
S-792	Carlisle Brook at Walker Road	07/07/2005	B	Y	B
		07/19/2010	B	Y	B
S-862	Lord's Brook Downstream of East Outlet	07/08/2008	B	Y	B
		07/14/2015	B	**N**	C
S-863	Lord's Brook at Lords Lane	07/08/2008	B	Y	B

Bacteria

Indicator organisms (such as *E. coli*, Enterococci, and Fecal Coliform) are used to track a wide variety of potentially harmful pathogens such as viruses and bacteria found in mammalian fecal waste that would otherwise be too expensive to monitor comprehensively (Figure 3-1). Despite their widespread use, research suggests that these indicators have significant limitations and caution should be used in interpreting results of these indicators as a metric for risk management. Similar to other nonpoint source pollutants, addressing pathogen-impaired waters is challenging because fecal waste can come from a number of sources on the landscape (e.g., septic, pet waste, livestock, and wildlife/waterfowl). In addition to these more traditional nonpoint source pollutant challenges, pathogen impairments pose additional challenges because of the limitations of selected fecal indicator bacteria (FIB) currently used to identify and track fecal contamination.

We have summarized below in bullets (1) through (4) the major reasons fecal contamination is one of the most difficult pollutants to remediate.

(1) It is a nonpoint source pollutant, meaning that it can come from many different locations on the landscape.

(2) Human health concerns are caused by potentially harmful pathogens such as viruses and bacteria, that are present within fecal matter. However, it would be too expensive to track and monitor each harmful virus and bacteria individually. Because of this, we use indicator organisms (such as *E. coli*, Enterococci, and Fecal Coliform). These indicator organisms are chosen based on similarities to pathogens in behavior and transport in the environment.

(3) Synchronicity in behavior between FIB and the pathogens-of-concern for public health risk (e.g., salmonella, campylobacter, rotavirus, giardia, norovirus, hepatitis, etc.) may break down under certain environmental conditions. Therefore, caution must be used when interpreting FIB data in the context of risk management decisions.

(4) Fecal contamination tracking is an evolving science, with new technologies consistently making their way to the market. We do our best to use the tools at our disposal while recognizing their limitations.

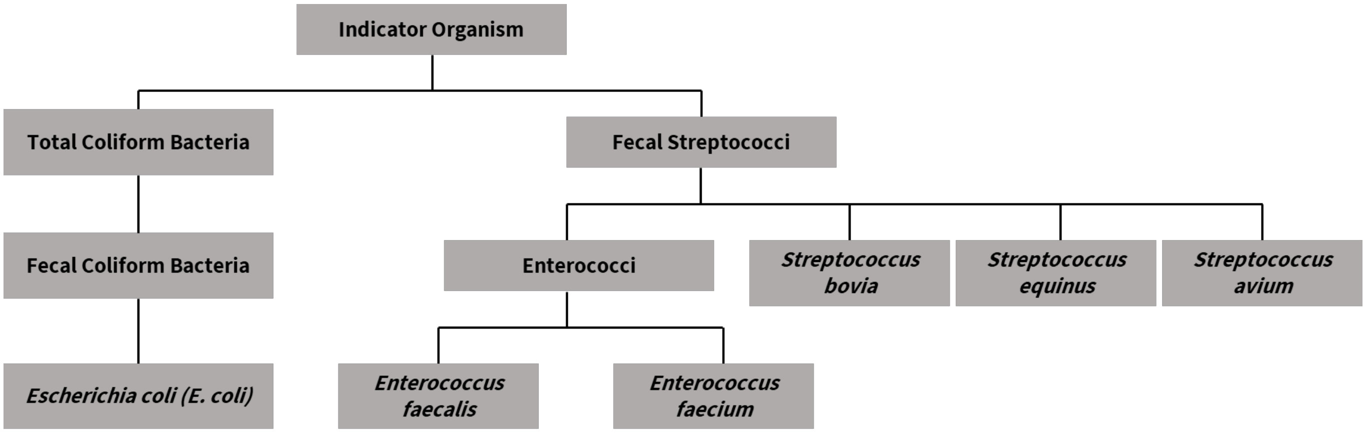


Figure 3-1. A classification tree of fecal indicator organisms commonly used to track pathogens.

Optical Brighteners

Optical brighteners are used as additives in laundry soaps, detergents, cleaning agents, and toilet papers. © MarketResearch.biz

Optical brighteners are commonly used for wastewater detection. Optical brighteners are not naturally occurring and are typically added to laundry soaps, detergents, cleaning agents, and toilet papers to aid in the brightening of fabrics and/or surfaces. A threshold of 100 µg/L is used a guide, consistent with Maine Healthy Beaches methodology.

In waterbodies where tea-colored water (an indicator of humic content) is common, the optical brightener 100 µg/L threshold may not be a good metric for identifying human-sourced pollution due to interference from humic substances (tannins and other dissolved organic compounds) that can artificially inflate optical brightener readings. This results in a “background level” contribution to observed optical brightener concentrations. When identifying contamination “hot-spots”, examining how concentrations from a site deviate from the overall mean can help pull a meaningful signal, especially when most sites exhibit elevated bacteria levels and are suspected to be impacted by organic matter/interference. Sites with positive deviations for both bacteria and optical brightener values represent suspect locations with the potential for human sourced fecal pollution.

3.3 Sub-Watershed Water Quality and Stressors

The following section summarizes the historical water quality data and stressor analysis for each of the major sub-watersheds in the Kennebunk River watershed. This includes Duck Brook (including Tributary A), Carlisle Brook, Goff Mill Brook, Lord's Brook, and Ward Brook (Figure 3-2). We have also included a section on the Kennebunk River main stem which includes sites on the main stem, as well as sites within the direct drainage (i.e. unnamed tributaries/drainages that directly enter the Kennebunk River). The review of each sub-watershed consists of two pages. The first page is a summary of the historical water quality data and information on biomonitoring stations. The second page is an overview of the land use as well as potential sources of nonpoint source pollution in the watershed including a breakdown of the proximate and environmental stressors on that tributary. We have also included a brief summary of the 2019 results from the surveys that were undertaken by project partners to inform this WMP (refer to sections 3.5.2, 3.5.3, and 3.5.4 for full 2019 survey summaries). Additional tables and maps are included for the Kennebunk River direct drainage.

Figure 3-2. Sub-watersheds located in the Kennebunk River watershed, with assigned colors that will be used throughout this section to indicate a specific sub-watershed.

All data presented is truncated to include only samples taken during the critical period (April 15 – October 31) and reflect **all** historical data from that sample site (i.e. all years available). Summarized data was limited to normal environmental samples and excludes field and laboratory duplicates. Data are not summarized by condition (wet or dry) because of a limited dataset and resources; however, this should be considered for future analysis and sampling. It is important to note that synthesized historical data presented in this section does not show any change (e.g. improvements) in water quality in recent years and this analysis should be used in tandem with the data summaries from recent years provided by Maine DEP, MHB, and WNERR.

In addition to water quality data, we have included a brief summary for all relevant field surveying that occurred as part of this Watershed-Based Plan Development Project in 2019. Refer to the approved Sampling and Implementation Plan for details on survey methods and design.

Historical bacteria data is summarized individually by sub-watershed, starting with section 3.3.1 for the Kennebunk River direct drainage, below.

3.3.1 Kennebunk River Direct Drainage

Water Quality Data Summary

This section provides a brief overview of historical water quality data in the Kennebunk River direct drainage. The direct drainage represents the surrounding land that drains to the river without passing through a major tributary. This area is colored tan in Figure 3-2 on the previous page. Data presented in this section is limited to sites with six or greater datapoints for the listed parameter. This is because of substantially more sites within the Kennebunk River direct drainage area. All other sub-watersheds discussed include all data. All data discussed below can be found in Table 3-4 on the following page.

Dissolved Oxygen: Dissolved oxygen (DO) data are available for 26 sites in the Kennebunk River direct drainage. Of these 26 sites, six sites have six or more datapoints with the majority of the other sites having only one reading. These six sites are outlined in Table 3-4. Mean DO is above 7 ppm at all six sites, although five of the six sites have experienced minimums below 7 ppm. The lowest mean is 7.6 ppm at sites KB-02 and KB-04 and the minimum recorded DO is 3.9 ppm at KB-04. Also, important to note is that it is likely many of the times that measurements were taken were not early morning measurements when the DO would be lowest.

***E. coli*:** In the Kennebunk River watershed, *E. coli* is used to track fecal contamination in the freshwater, and Enterococci is used in marine waters. Because of the variability in *E. coli* explained in section 3.2*,* the Maine DEP uses a geometric mean instead of an average. Geometric means are less sensitive to outliers, and therefore, present a more representative view of results.

E. coli data is available for 16 sites in the Kennebunk River direct drainage. Of these 16 sites, four had six or more datapoints with the majority of sites again having only one reading. These four sites are outlined in Table 3-4. Mean *E. coli* (geometric mean) is elevated at all three sites at 175.2, 213.5, 141.8, and 110.1 MPN/100mL for KB-03, KB-04, KB-05, and SKE09, respectively. However, all sites have a high standard deviation (>500) reflecting the extreme variability noted in *E. coli* samples. Maximum *E. coli* was greater than the detection limit (2,420 MPN/100mL) for three sites (KB-03, KB-04, and KB-05). All *E. coli* data within the Kennebunk River direct drainage is presented visually in Figure 3-3, including sites with only one datapoint.

Enterococci (Entero): Entero data is available for 31 sites in the Kennebunk River direct drainage. Of these 31 sites, 10 sites have six or more datapoints. All sites have significantly elevated mean (geometric mean) Entero with the lowest at 23.9 MPN/100mL at site KB-01 and the highest at site SD-03 at 200.3 MPN/100mL.

Optical Brighteners: Optical brightener data is available for 27 sites in the Kennebunk River direct drainage. Of these sites, one has six or more datapoints and optical brighteners were elevated at this site – KR-31 – at 304.1 μg/L.

Temperature: Temperature data is available for 31 sites in the Kennebunk River direct drainage. Of these 31 sites, 10 sites have six or more datapoints. Site 270 has >6,000 points because of a continuous monitoring device deployed at this site in 2005, 2010, and 2015. Mean (geometric mean) temperature is below 24°C (the recommended threshold for aquatic life) for all sites.

Total phosphorus: Total phosphorus data is available for one site in the Kennebunk River direct drainage. Site 270 has six total phosphorus samples with a geometric mean of 33 ppb.

Table 3-4. Summarized data for dissolved oxygen, *E. coli*, Enterococci, temperature, optical brighteners, and total phosphorus in the Kennebunk River direct drainage. Sites were only included if they had greater than six historical datapoints to be consistent with Maine DEP methods to calculate geometric mean. Data was truncated to include only data taken in the summer season. Values that do not meet the applicable state and federal thresholds are in red. (DO was evaluated at 7 ppm; E. coli at 65 MPN/100mL; Entero at 35 MPN/100mL; Optical Brighteners at 100 µg/L; Temperature above 24C, and Total Phosphorus above 12 ppb). OB = Optical Brighteners.

	SITE	COUNT	GEOMETRIC MEAN	STANDARD DEVIATION	MEDIAN	MINIMUM	MAXIMUM
DISSOLVED OXYGEN (mg/L)	270	11	9.4	0.7	9.38	8.3	10.78
	KB-01	76	9.0	1.2	9.2	6.3	11.62
	KB-02	80	7.6	1.2	7.65	5.4	11.57
	KB-03/KR-06	75	9.1	1.1	9.05	5.6	12.3
	KB-04	81	7.6	1.3	7.8	3.9	12.1
	KB-05/KR-25	82	8.9	1.0	8.9	6	12.24
E. COLI (MPN/100mL)	KB-03/KR-06	74	175.2	539.3	147.5	10	2,420
	KB-04	76	213.5	530.2	192	15	2,420
	KB-05/KR-25	77	141.8	519.7	128	4	2,420
	SKE09	8	110.1	747.5	97	11	1,986
ENTERO (MPN/100mL)	KB-01	77	23.9	1,447.8	10	5	9,208
	KB-02	77	78.2	1,516.8	85	5	12,997
	KB-03/KR-06	56	50.6	357.4	41	5	1,500
	KB-05/KR-25	18	107.8	146.0	132.5	10	487
	KR-31	9	97.9	2,118.8	97	5	6,488
	KR-33	6	99.3	947.7	122	5	2,419.6
	KR-35	43	81.2	342.9	84	5	1,553
	KR-47	6	123.7	311.1	157	10	866.4
	KR-58	6	88.8	224.0	219.5	5	520
	SD-03	8	200.3	516.9	330	20	1,515
OB (µg/L)	KR-31	6	304.1	63.0	284	252	417
TEMPERATURE (°C)	270	6164	21.6	2.2	21.6	17.13	27.235
	KB-01	76	16.5	2.4	17.1	10.7	22.7
	KB-02	80	19.1	3.1	19.9	7.7	25.4
	KB-03/KR-06	130	18.1	3.6	19	6.2	26.9
	KB-04	81	17.8	3.3	19	6	24.6
	KB-05/KR-25	99	17.3	3.0	18.5	7	23.3
	KR-31	7	17.9	3.1	17.7	14	22.75
	KR-35	43	16.6	3.9	18	7	23.6
	SD-03	6	17.3	3.9	16.4	14.3	24.8
	SKE09	7	20.7	1.7	21	18	23
TOTAL PHOSPHORUS (ppb)	270	6	**33.2**	3.3	34	29	38

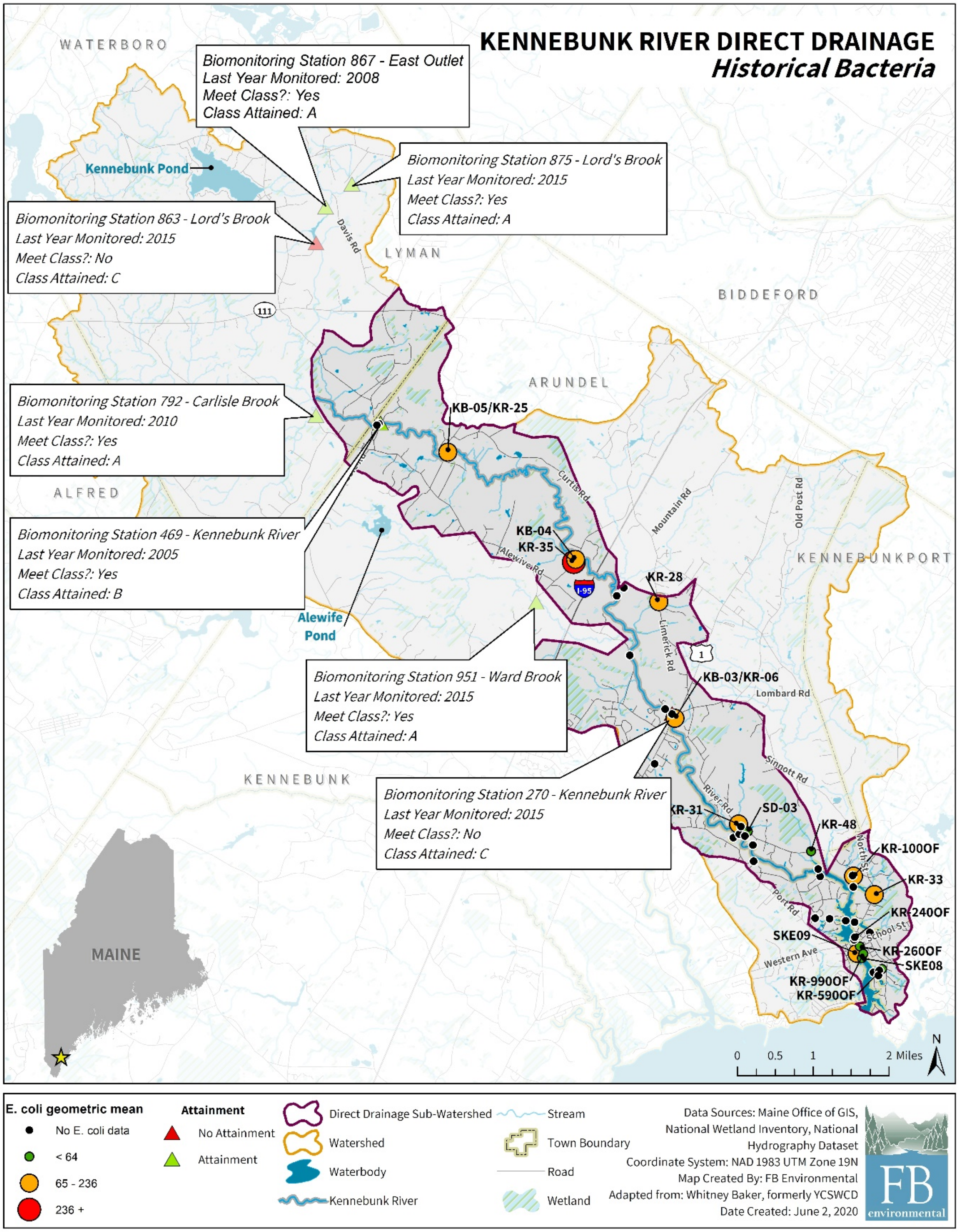


Figure 3-3. Geometric mean (MPN/100mL) for all sites with historical *E. coli* data within the direct drainage of the Kennebunk River. Represented data includes all years with data truncated to the summer season. Scaled/colored dots indicate the magnitude of the historical geomean and represent the Maine DEP geomean criteria (64 MPN/100mL) and tenth percentile (236 MPN/100mL). Black dots represent sampling sites with no *E.* coli data (other parameters only).

Land Use

The Kennebunk River direct drainage sub-watershed is 16.6 sq. mi. and represents the entire length of the main stem of the river from its headwaters in Lyman to its intersection with the ocean in Kennebunkport. Land use in the direct drainage area is diverse, with significant tracks of forest along its length (Figure 3-4). The estuarine portion of the sub-watershed is heavily developed with residential and commercial development. (Developed land includes impervious surfaces such as roads, driveways, sidewalks, and roofs.) Pockets of agriculture (cultivated land and grazing land) exist along the northern portion of the river downstream of Perkins Lane. Other significant land use includes the Cape Arundel Golf Course along the northern banks of the river.

Key Findings from Surveying

A watershed survey[5] was conducted on the sections of the river along Alewive Rd and Curtis Rd between Cole Rd and the I-95 corridor. This area consists of significant agriculture with pastures used for grazing as well as row crops and dairy farms. From the roadways, it was difficult to identify any nonpoint source pollution threats to the Kennebunk River.

A stream corridor assessment[6] took place in the Kennebunk River main stem to provide a different perspective on nonpoint source pollution sites and in-stream conditions. This included a 1.9-mi segment above Route 1 and below biomonitoring station 270 as well as a 1.8-mi section downstream of Perkins Lane. Most notable in these surveys was the occurrence of exposed tree roots, large organic debris, and fallen or leaning trees and fence posts. Areas of significant bank erosion were visible along the channel. Several areas had soft sediment beds and high turbidity below the confluence with Ward Brook, which indicates mobile sediments. Water levels were generally low at the time of survey. Low water levels and high banks prevented observers from documenting the land use beyond the near riparian banks.

Proximate and environmental stressors are listed individually for each sub-watershed for the major tributaries. Because of mixing and dilution in the main stem of the Kennebunk River, it is difficult to identify the specific proximate stressors and causal pathways on the main stem. Observations from the stream corridor survey suggest that turbidity, velocity, and poor habitat are key stressors on the main stem for aquatic organisms. Elevated fecal indicator bacteria *(E. coli* and *Entero*) are a key environmental stressor on the main stem that cause of the bacteria impairment on the river.

Photos taken in the Kennebunk River. (Left) exposed tree roots with undercut banks, (middle) high turbidity along the main stem, and (right) a forested section of the Kennebunk River.

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[5] A watershed inventory is a road survey that identifies possible sources of nonpoint source pollution and focused on development and land use throughout the watershed around hotspot areas.

[6] A stream corridor survey is an in-stream corridor assessment that provides information useful for the management of stream water quality, habitats, fisheries, and riparian lands by identifying streams, reaches or sites having high quality habitat; having moderately or highly degraded habitat; or significant pollution problems that are in need of more detailed follow-up survey or assessment work

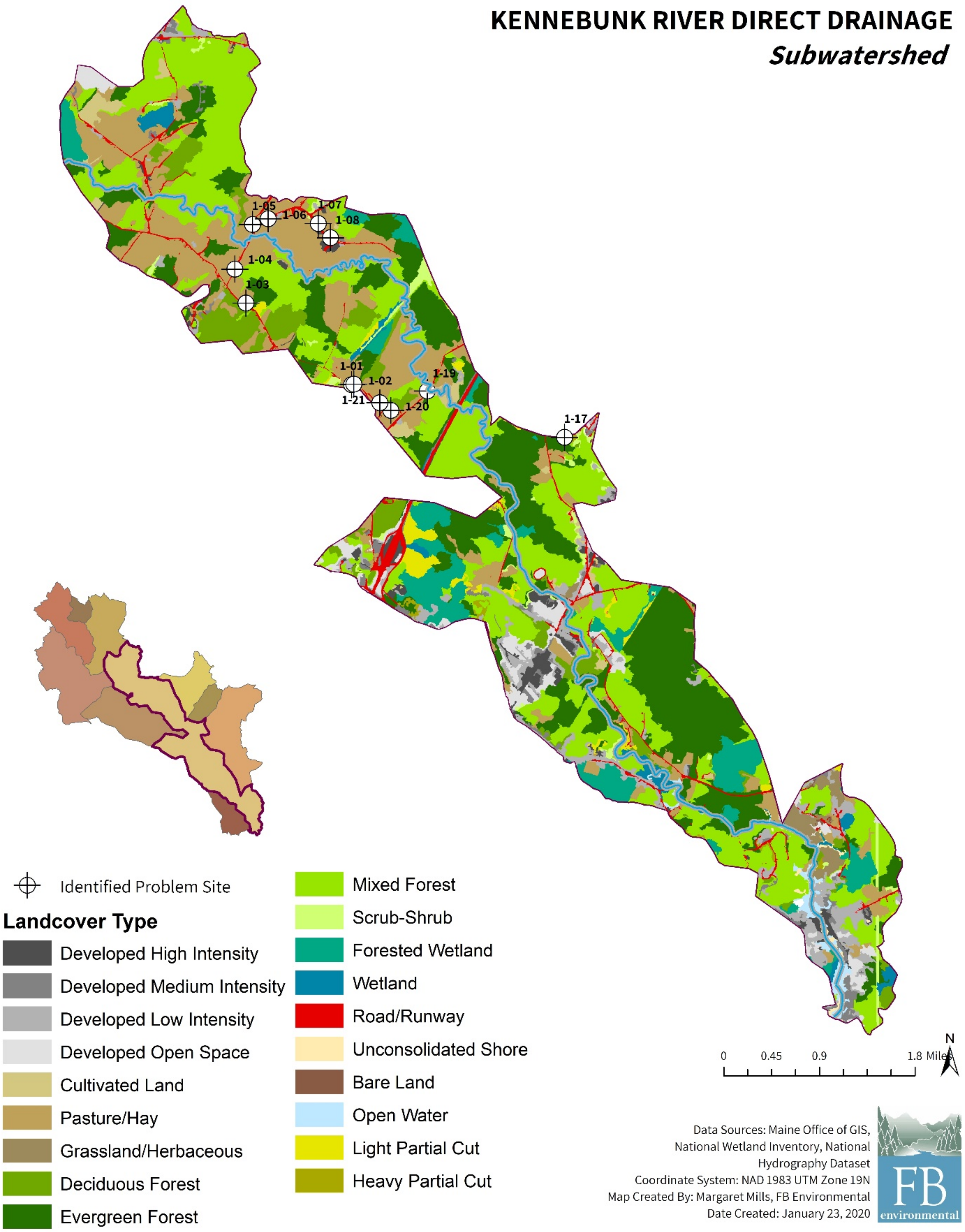


Figure 3-4. Land cover within the direct drainage of the Kennebunk River main stem.

3.3.2 Carlisle Brook

Biomonitoring stations: Site S-792 (Walker Road). Attained class in 2010 for biomonitoring data.

Water quality data summary

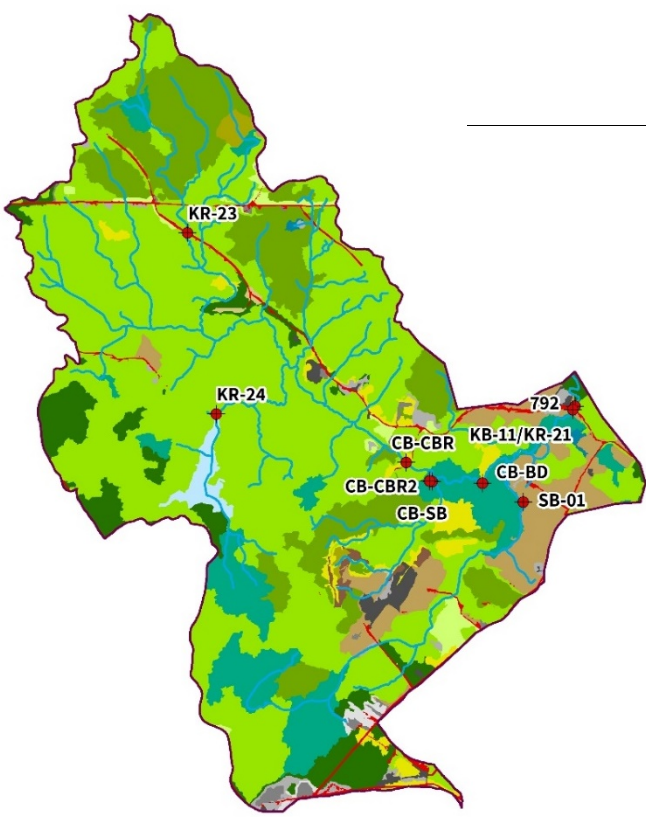
Dissolved Oxygen: Dissolved oxygen data is available for sites 792 (average 7.0 mg/L, n=5), CB-CBR (average 8.1 mg/L, n=4), KB-11/KR-21 (average 6.9 mg/L, n = 17), KB-23 (average 10.8 mg/L, n=1) and KR-24(average 11.5 mg/L, n=1; Figure 3-5a).

E. coli: A total of 47 samples have been collected for *E. coli* in the Carlisle Brook subwatershed across five sites. Three sites have geometric means exceeding the State criteria for Class B waterbodies (sites CB-SB, KB-11/KR-21, and SB-01), however, only one datapoint exists for CB-SB and CB-CBR2, and three for SB-01 (see Figure 3-5b).

Optical Brighteners: A total of 32 samples have been collected for optical brighteners across seven sites. Optical brightener geometric means were slightly elevated above 100 μg/L at sites CB-CBR and KB-11/KR-21, at 108.4 μg/L and 113 μg/L, respectively (Figure 3-5c).

Temperature: Temperature data is available for sites 792 (mean 19.6°C,n=2,522), CB-CBR (2018 only, mean 15.7°C, n=7), KB-11/KR-21 (2017 and 2018, mean 16.6°C, n=20), KB-23 (mean 17.8°C, n=1) and KR-24 (mean 18.2°C, n=1). Mean (geometric) temperature was below the recommended threshold of 24°C for aquatic organisms at all sites with a maximum recorded temperature of 24.5°C at site 792 (continuous logging data from 2010; Figure 3-5d).

Total phosphorus: Three samples at site 792 had a mean total phosphorus concentration of 35 ppb (Figure 3-5e).



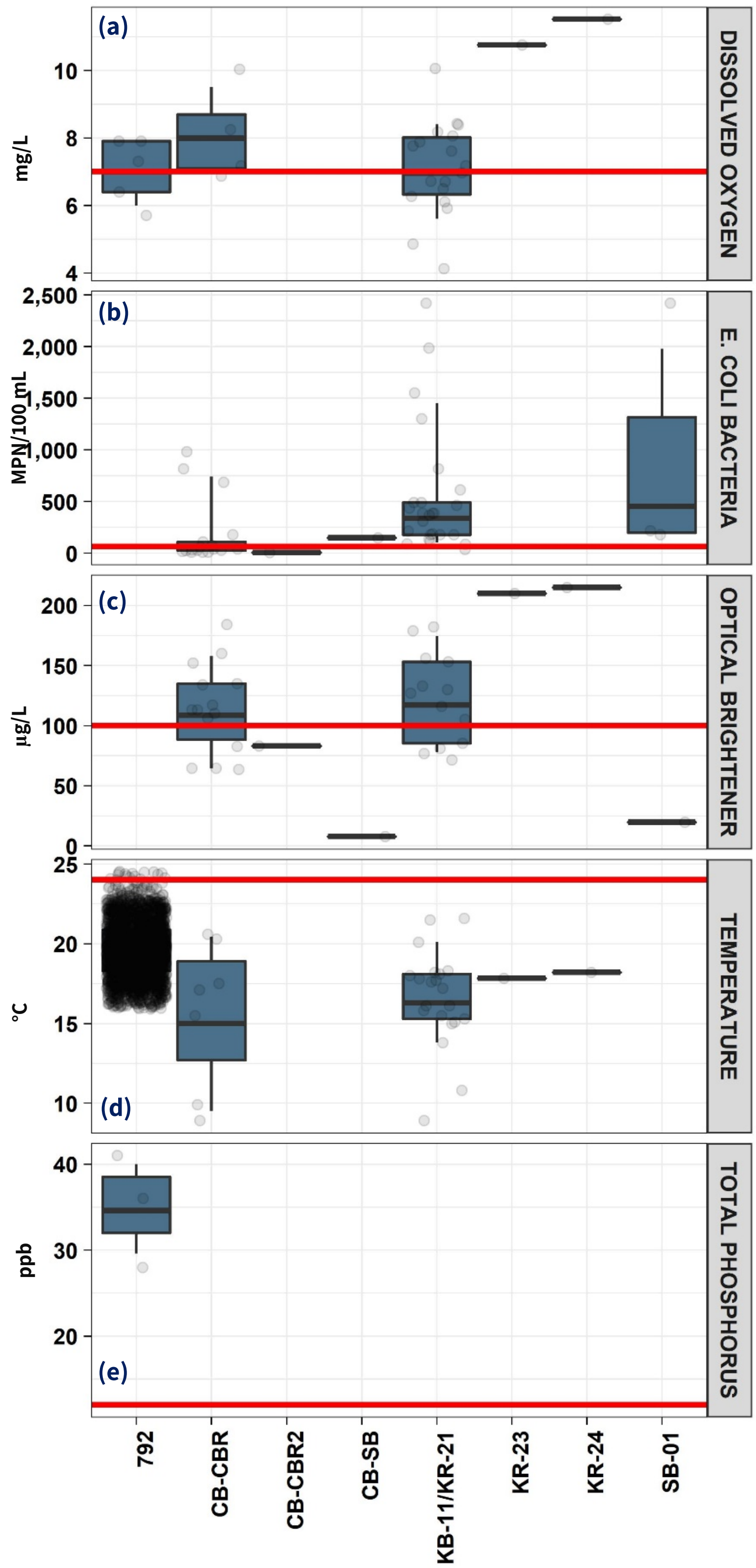


Figure 3-5. Boxplots showing the geometric mean, 25th, and 75th percentiles for (a) dissolved oxygen, (b) *E. coli*, (c) optical brighteners, (d) temperature, and (e) total phosphorus in the Carlisle Brook sub-watershed. Temperature at site 792 reflect a continuous monitoring device. The red line indicates applicable state and federal thresholds for each parameter (refer to Table 3-1).

Land Use

The Carlisle Brook sub-watershed is 8.9 sq. mi. and is located at the headwaters of the Kennebunk River watershed. It is in the Towns of Lyman and Alfred. It has two main branches, one to the northwest and one to the southwest. It is predominantly forested (deciduous and mixed forest) with agriculture and cultivated land in the southeast corner before its intersection with the Kennebunk River.

Key Findings from Surveying

A stream corridor survey above Walker Road was attempted but beaver ponding limited access because of deep pools. The channel was wide and too deep for walking. Surveyors met with stakeholders from the Carlisle Academy for Integrative Therapy & Sports and were able to view the stream channel from this location at a later date. One aging culvert was causing a minor back-up of water into a field on Drown Road (a Town owned and maintained roadway). Otherwise, no notable threats were identified in the surveys outside of the potential impact from beaver, and livestock.

Nonpoint Source Stressors

Proximate stressors: Data too limited to identify proximate stressors.

Environmental stressors: Elevated bacteria, ponding, and low water velocity.

Possible sources: Livestock farms, manure, beaver dams, logging, and excavation.

Photos taken in the Carlisle Brook watershed. (Left) ponding caused by a beaver upstream of Walker Road, (middle) fields at Carlisle Academy Integrative Therapy & Sports, and (right) ponding on a small tributary of Carlisle Brook. Numerous small tributaries feed into Carlisle Brook that have not been surveyed.

3.3.3 Duck Brook

Biomonitoring stations: None

Water Quality Data Summary

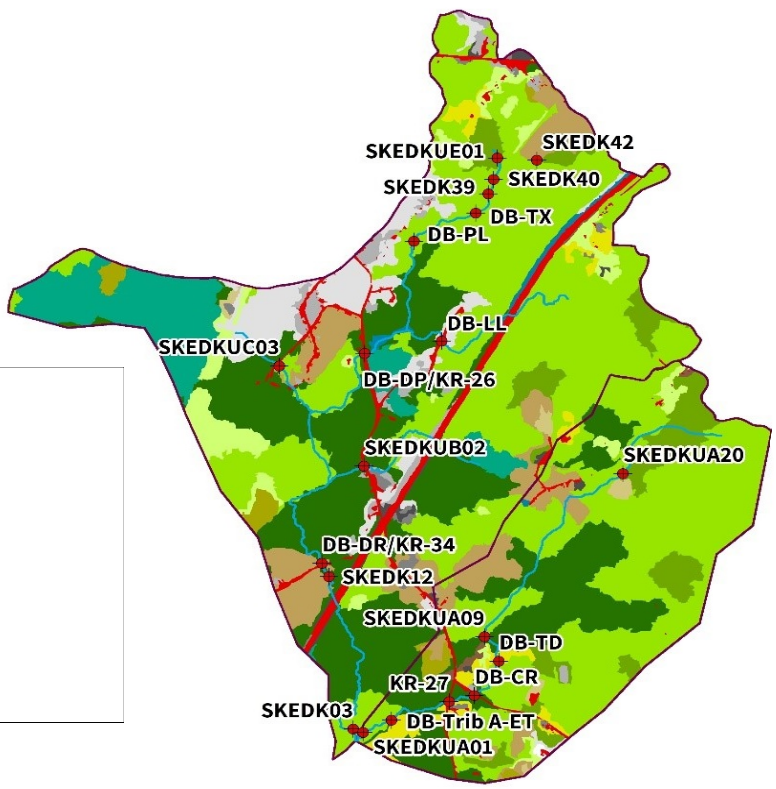
Dissolved Oxygen: A total of 88 samples have been collected for dissolved oxygen across 17 sites. Mean (geometric) dissolved oxygen concentration is above the water quality criteria for class B surface waters of 7 mg/L at only three sites (KR-27, SKEDK03, and SKEDKUA01; Figure 3-6a).

E. coli: A total of 302 samples have been collected for *E. coli* in the Duck Brook subwatershed across 22 sites. All sites have geometric means exceeding the State criteria for Class B waterbodies of 64 MPN/100 mL except sites SKEDK42 and SKEDKUC03 (Figure 3-6b).

Optical Brighteners: A total of 143 samples have been collected for Optical Brighteners across 17 sites. The only sites with optical brightener geometric means below 100 ug/L are SKEDKUA20 (96.6 μg/L) and SKEDKUC03 (97.6 μg/L; Figure 3-6c).

Temperature: Temperature data is available for 21 sites in the Duck Brook sub-watershed. Mean (geometric) temperature was below the recommended threshold of 24°C for aquatic organisms at all sites, however maximum recorded temperature at two sites was above the threshold (site DB-DP/KR-26 at 27.6°C and site SKEDK12 at 24.5°C, n= 22 and 11, respectively; Figure 3-6d).

Total phosphorus: No total phosphorus data is available within the Duck Brook sub-watershed.



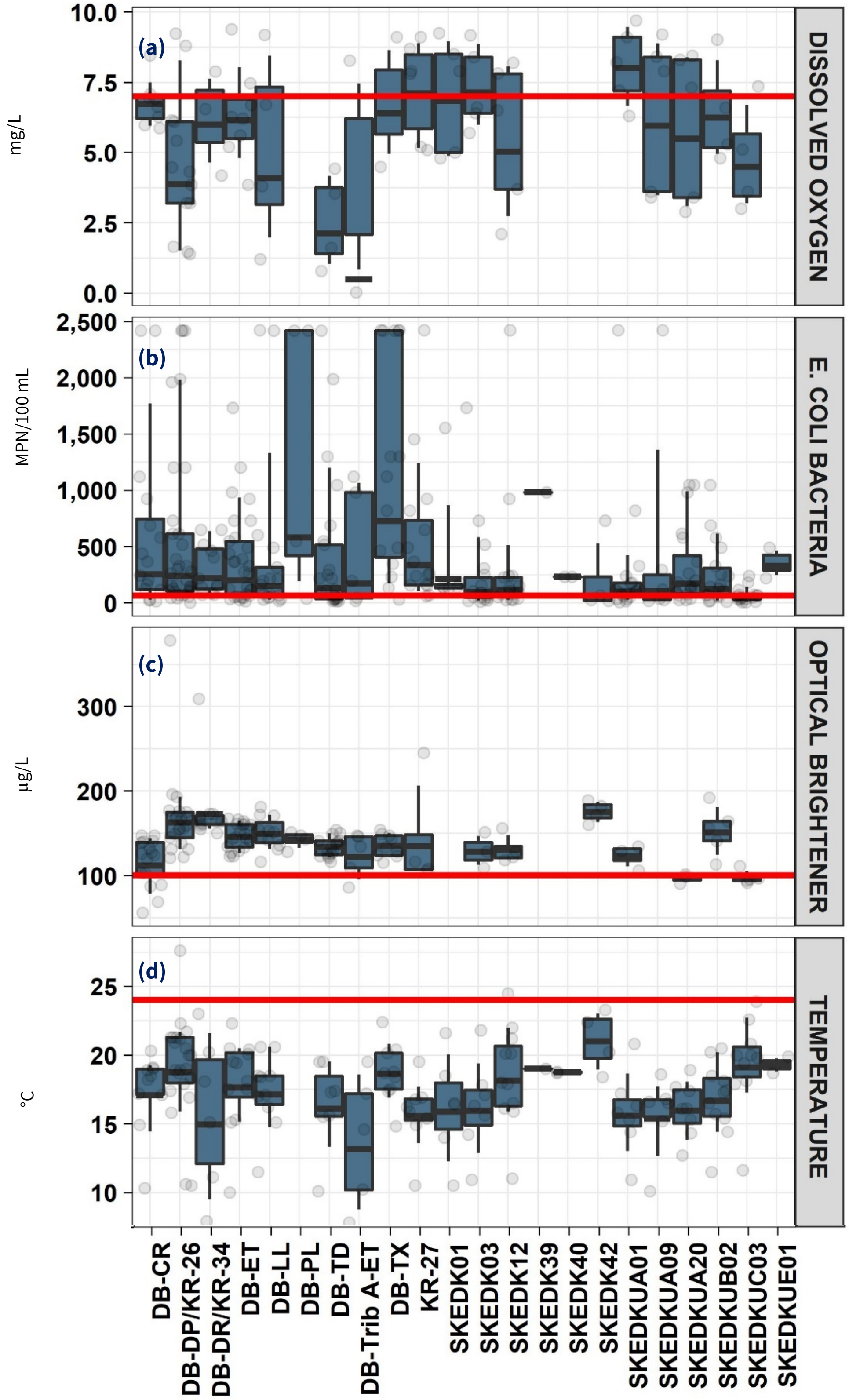


Figure 3-6. Boxplots showing the geometric mean, 25th, and 75th percentiles for (a) dissolved oxygen, (b) *E. coli,* (c) optical brighteners, and (d) temperature. The red line indicates applicable state and federal thresholds for each parameter (refer to Table 3-1).

Land Use

Duck Brook and the Duck Brook Tributary A sub-watershed are 5.2 sq. mi. and are located in the central northern portion of the Kennebunk River watershed, in the Town of Arundel. Duck Brook and Duck Brook Tributary A each have one main branch running north to south before joining the Kennebunk River main stem. The sub-watersheds are predominantly forested (deciduous and evergreen) with agriculture and cultivated land present in both. The Duck Brook watershed also contains some low intensity residential development.

Key Findings from Surveying

In 2019, a stream corridor assessment was performed on a 0.8-mile segment of Duck Brook Tributary A (from the confluence with Duck Brook up to the Talbot Road crossing). An unusual conditions assessment[7] was performed on this segment with the following key observations:

- Bank erosion and slumping across multiple sections with steep banks.
- A small drainage with a mucky, oily sheen and bright green algae located just upstream of the Limerick Rd crossing.

In addition, the Duck Brook sub-watershed was targeted for the watershed survey. Key findings from this survey included:

- Livestock and improper manure storage (not located directly in a waterbody).
- Unstable construction sites.

Nonpoint Source Stressors

Proximate stressors: Low water velocity.

Environmental stressors: Elevated bacteria, stagnant, low gradient stream.

Possible sources: Agriculture, high residential development pressure.

Photos taken in the Duck Brook watershed. (Left) a drainage entering the tributary above, (middle) bank erosion, (right) outlet of the Duck Brook Tributary A at the eastern trail. Small tributaries feeding into Duck Brook Tributary A were not surveyed.

[7] An unusual conditions assessment included walking the full reach and identifying anything ‘unusual’ that could be a cause for concern. Note that the observers did not always know if it was a concern (e.g. a pipe discharge) but rather marked the site for follow-up.

3.3.4 Goff Mill Brook

Biomonitoring stations: none

Water Quality Data Summary

Significant sampling at Goff Mill Brook occurred for the first time in 2019, with the exception of only a few datapoints at sites KR-29, KB-15/KR-61, KR-36, KR-56, and KR-62.

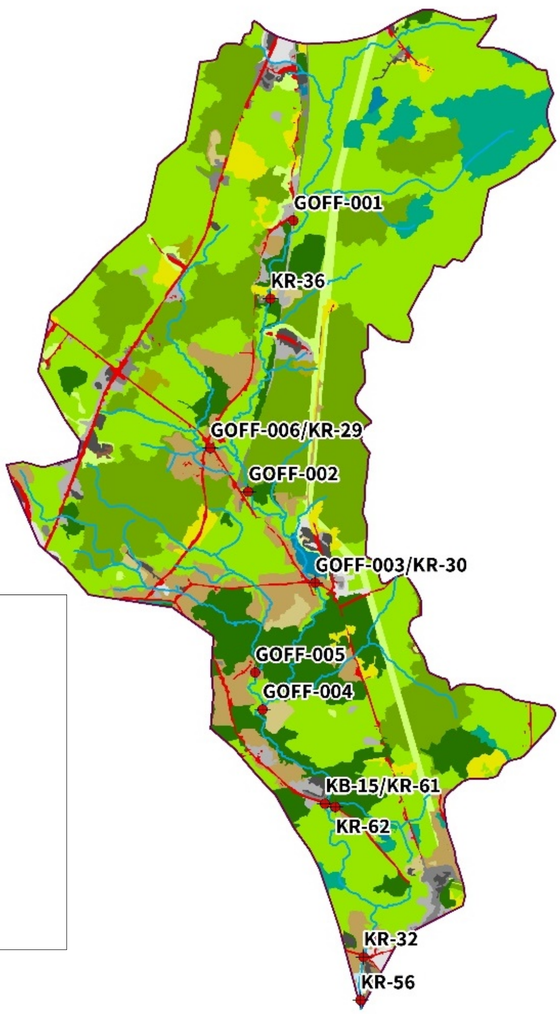
Dissolved Oxygen: A total of 64 samples have been collected for dissolved oxygen in the Goff Mill Brook sub-watershed across 11 sites. Mean (geometric) dissolved oxygen was lowest at site GOFF-001 at 5.7 mg/L, and is below the Maine water quality criteria for Class B surface waters of 7 ppm at 4 sites (GOFF-001, GOFF-003/KR-30, GOFF-006/KR-29, and KB-15/KR-61) (Figure 3-7a).

E. coli: A total of 57 samples have been collected for *E. coli* in the Goff Mill Brook tributary across nine sites. All nine sites have geometric means exceeding the State criteria for Class B waterbodies. GOFF-002 and GOFF-006/KR-29 are the highest at 298.9 MPN/100 mL and 460.7 MPN/100 mL, respectively (Figure 3-7b).

Optical Brighteners: A total of 54 samples have been collected for optical brighteners across 11 sites. Optical brighteners were elevated at all sites and highest at sites GOFF-005 (178.4 ug/L, n=5), KR-32 (292 ug/L, n=5), KR-36 (297 ug/L, n=1), KR-56 (226 ug/L, n=3), and KR-62 (439 ug/L, n=1) (Figure 3-7c). Persistently high optical brighteners that do not correspond with increased *E. coli* could be elevated at this site because of naturally occurring tannins leached from plants (often indicated by brown coloring in the water).

Temperature: Temperature data is available for 67 samples across 11 sites. Geometric mean temperature was below the recommended threshold of 24°C for aquatic organisms at all sites. Maximum recorded temperature at site KR-56 is 24.2°C; Figure 3-7d).

Total phosphorus: No total phosphorus data is available within the Goff Mill Brook subwatershed.



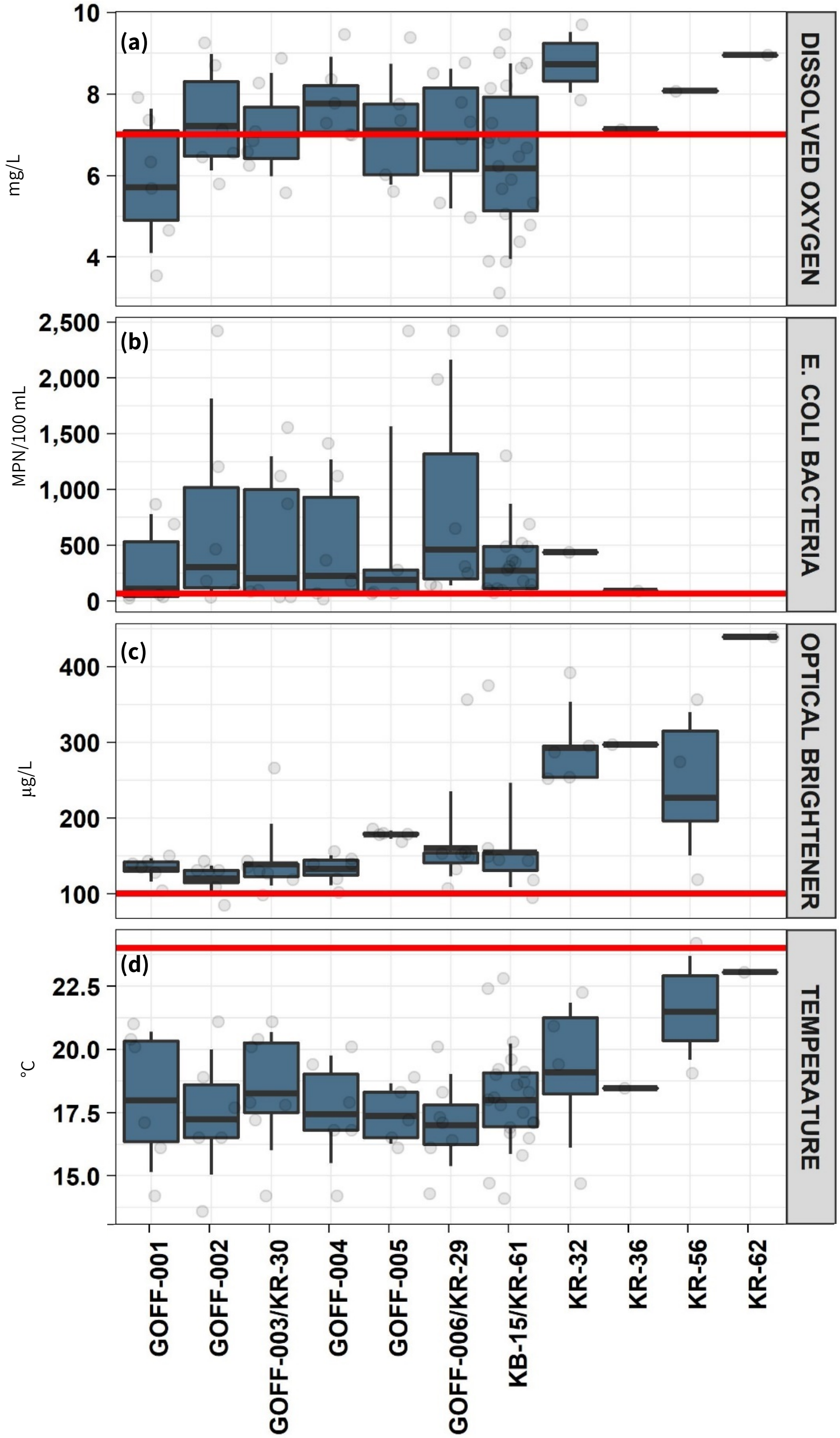


Figure 3-7. Boxplots showing the geometric mean, 25th, and 75th percentiles for (a) dissolved oxygen, (b) *E. coli*, (c) optical brighteners, and (d) temperature in the Goff Mill Brook sub-watershed. The red line indicates applicable state and federal thresholds for each parameter (refer to Table 3-1).

Land Use

The Goff Mill Brook sub-watershed is 8.1 sq. mi. and is located at the eastern edge of Kennebunk River watershed. It is in the Towns of Arundel, Kennebunkport, and a small portion of Biddeford. It has one main branch, running north to south with several tributaries that enter it, including a major forked tributary entering from the west. It is predominantly forested (deciduous and mixed forest) in the northern portion with agriculture and cultivated land present in the central and southern sub-watershed.

Key Findings from Surveying

No surveying was completed in the Goff Mill Brook watershed in 2019 for the Watershed-Based Management Plan development.

Nonpoint Source Stressors

Proximate stressors: Low dissolved oxygen, high temperature, low water velocity.

Environmental stressors: Elevated bacteria.

Possible sources: Low gradient stream, yard waste in stream, undersized culverts, undercut riparian banks, livestock.

Photos taken in the Goff Mill Brook watershed during water quality sampling. (Left) ponding upstream of Log Cabin Road, (middle) site GOFF-04 near Sinnot Road and (right) Wells National Estuarine Research Reserve intern Jacob Watson collecting water at GOFF-003. Photo credit: Jake Aman, WNERR.

3.3.5 Lords Brook

Biomonitoring stations: S-863 did not attain class in 2008 or 2010. S-875 did not attain class in 2008 and attained class A in 2015. S-862 did not attain class in 2015.

Water Quality Data Summary

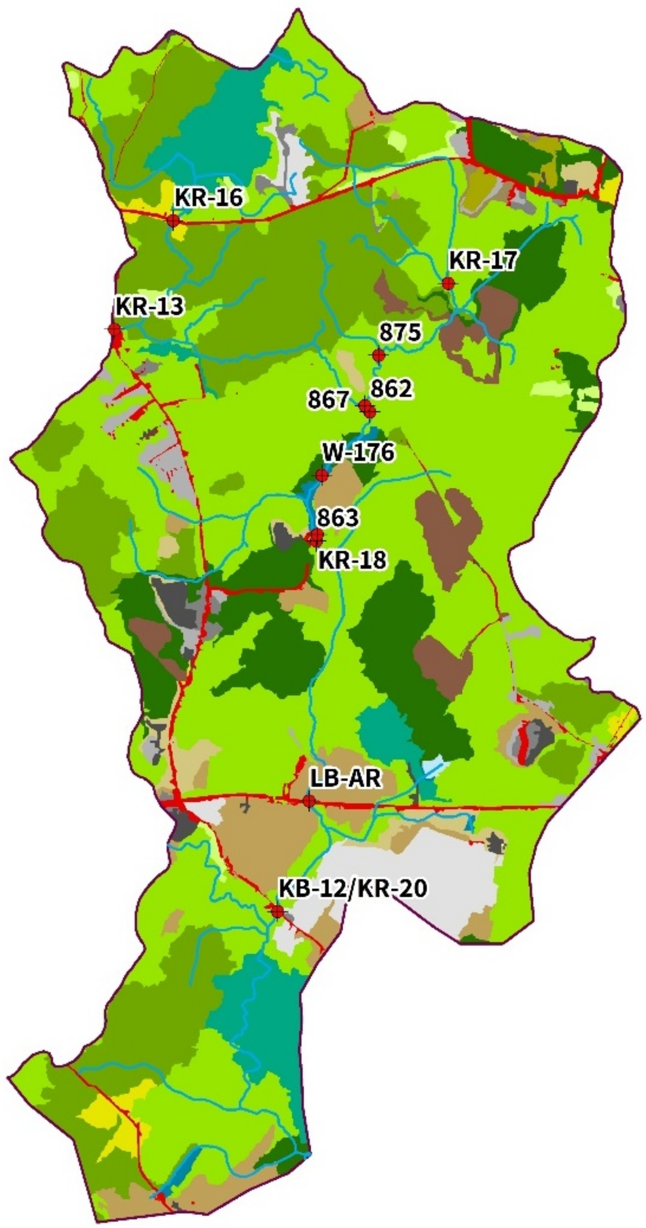
Dissolved Oxygen: A total of 44 samples have been collected for dissolved oxygen across 11 sites. Mean (geometric) dissolved oxygen concentration is above the water quality criteria for class B surface waters of 7 mg/L at all sites except for 875, KR-13, and KR-16 (note that n=1 for KR-13 and KR-16; Figure 3-8a).

E. coli: A total of 22 samples have been collected for *E. coli* in the Lords Brook subwatershed across two sites (KB-12/KR-20, and LB-AR). Both sites have geometric means exceeding the State criteria for Class B waterbodies of 64 MPN/100 mL (309.5 MPN/100mL and 184.9 MPN/100mL, respectively; Figure 3-8b).

Optical Brighteners: A total of 15 samples have been collected for Optical Brighteners at six sites. All sites are above 100ug/L except KR-13, and LB-AR). Only one datapoint exists at all sites except for LB-AR with 10 points; Figure 3-8c).

Temperature: Temperature data is available for 11 sites and has been collected on a continuous monitoring device for sites 863, 867, and 875. Mean temperature was highest at site KR-13 (mean of 22.5°C, n=15; Figure 3-8d).

Total phosphorus: Total phosphorus data is available at five site and is elevated significantly at all recorded sites; Figure 3-8e).



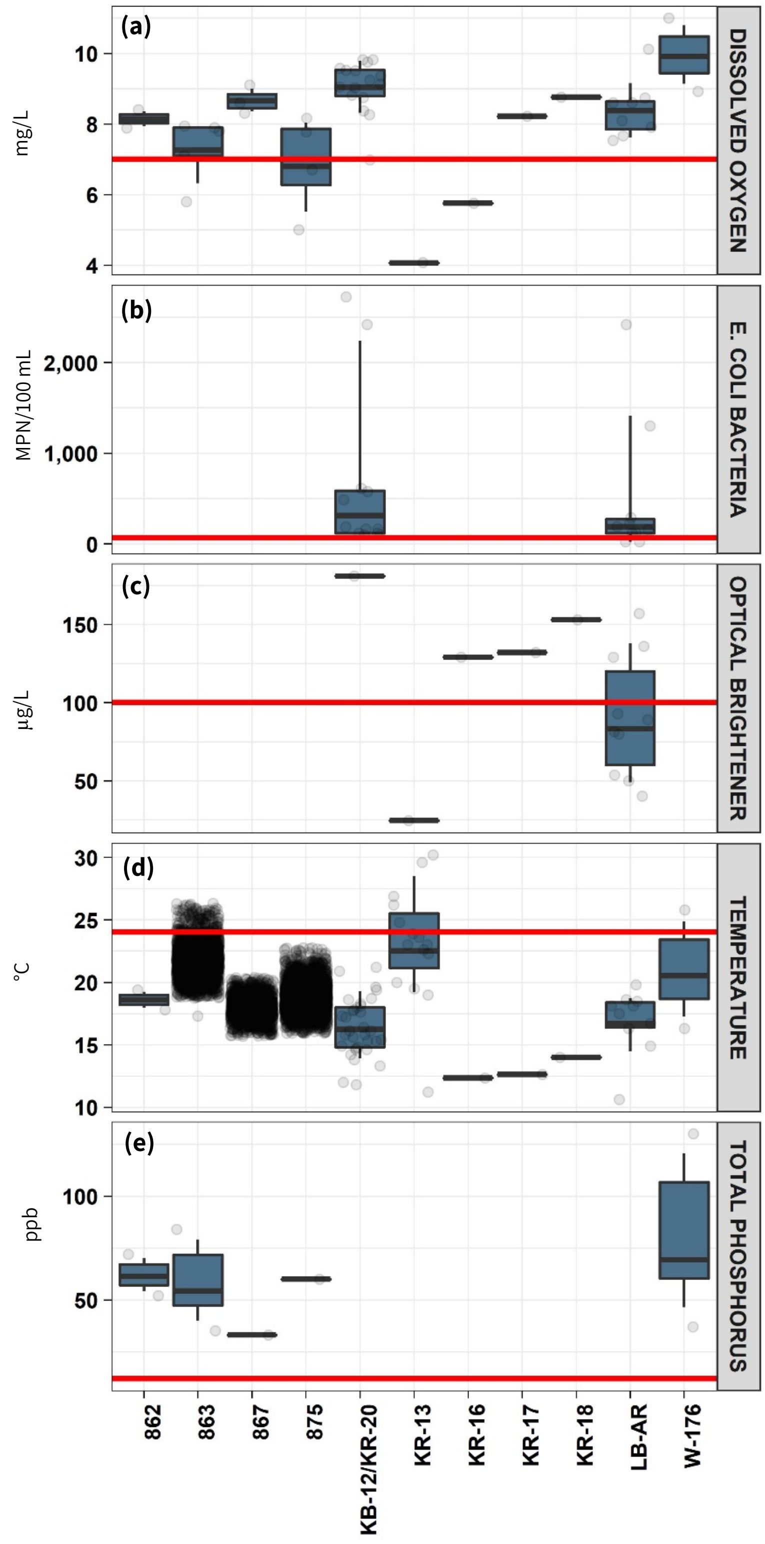


Figure 3-8. Boxplots showing the geometric mean, 25th, and 75th percentiles for (a) dissolved oxygen, (b) *E. coli*, (c) optical brighteners, and (d) temperature, and (e) total phosphorus in the Lord's Brook sub-watershed. Temperature at site 863, 867, and 875 reflect a continuous monitoring device. The red line indicates applicable state and federal thresholds for each parameter (refer to Table 3-1).

Land Use

The Lords Brook sub-watershed is 5.3 sq. mi. and is located in the northern portion of the Kennebunk River watershed at the Kennebunk River headwaters. It is in the Town of Lyman. Lords Brook has one main branch running north to south with multiple tributaries joining it. The sub-watershed is predominantly forested (deciduous, mixed, and evergreen) with agriculture and cultivated land present throughout the area and developed land present in the southern portion of the subwatershed.

Key Findings from Surveying

A watershed survey was conducted on the public roads in the Lord's Brook sub-watershed in July and was followed by a survey of some private roads (residents were provided advanced notice) in August 2019.

Survey results from the public and private roads in this sub-watershed identified many gravel roads with road surface, shoulder, and ditch erosion. Additionally, roads had cross-drainage culverts that were undersized and had unstable inlet and outlet banks. In one area, algae mats were visible in the stream (from the roadway) and it was clearly a waterfowl and wildlife gathering area. Multiple areas were experiencing the smell of manure and had uncovered manure piles.

Nonpoint Source Stressors

Proximate stressors: Data too limited to identify proximate stressors.

Environmental stressors: Elevated bacteria.

Possible sources: Road erosion, agriculture/manure storage, logging, and impoundments and wildlife/waterfowl gathering.

Photos taken in the Lord's Brook sub-watershed. (Left) an unstable culvert bank on Kennebunk Pond Rd, (middle) mobile sediment alongside a bridge crossing Lord's Brook on Lords Road, (right) algae mats in a wetland area alongside the roadway on Waterboro Road near the intersection with Winterwood Rd.

3.3.6 Ward Brook

Biomonitoring stations: S-951 attained Class A in 2015.

Water Quality Data Summary

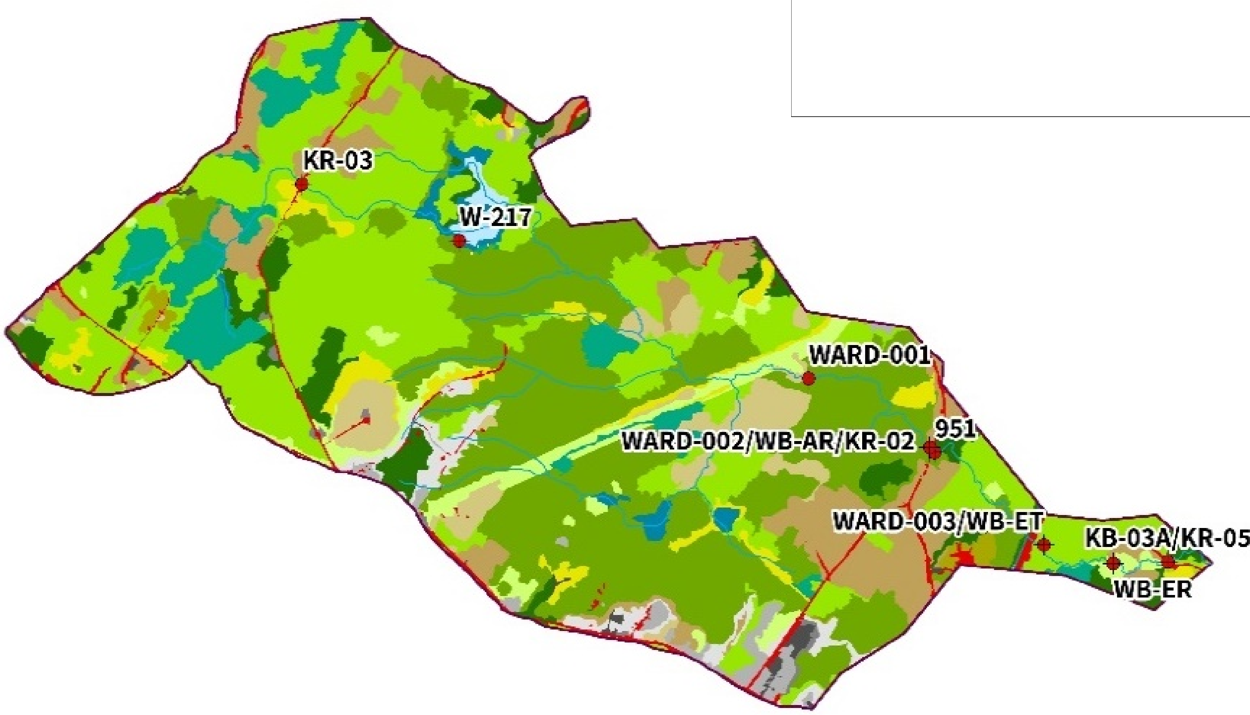
Dissolved Oxygen: A total of 100 samples have been collected for dissolved oxygen across eight sites. Mean (geometric) dissolved oxygen concentration is below the water quality criteria for class B surface waters of 7 mg/L at sites WARD-001 and WB-ER, at 6.4 mg/L and 6.9 mg/L, respectively (also note that n = 1 for KR-03; Figure 3-9a).

E. coli: A total of 97 samples have been collected for *E. coli* in the Ward Brook subwatershed across five sites. All sites have geometric means exceeding the State criteria for Class B waterbodies of 64 MPN/100 mL. Sites WARD-003/WB-ET has the highest geomean at 190.8 MPN/100 mL and site WARD-002/WB-AR/KR-02 has the lowest geomean at 85.9 MPN/100 mL (Figure 3-9b).

Optical Brighteners: A total of 38 samples have been collected for Optical Brighteners across six sites. Optical brightener geometric mean was elevated at site KR-03 at 237 ug/L, but only one sample has been taken (Figure 3-9c).

Temperature: Temperature data is available for ten sites. Mean (geometric) temperature was below the recommended threshold of 24°C at all sites with the maximum mean temperature at site W-217 (geomean of 22.7°C, n=2; Figure 3-9d).

Total phosphorus: Total phosphorus data exists at two sites. One sampling point at site 951 at 31 ppb and two at site W-217 with a mean of 18 ppb, both of which are above the threshold of 12 ppb (Figure 3-9e).



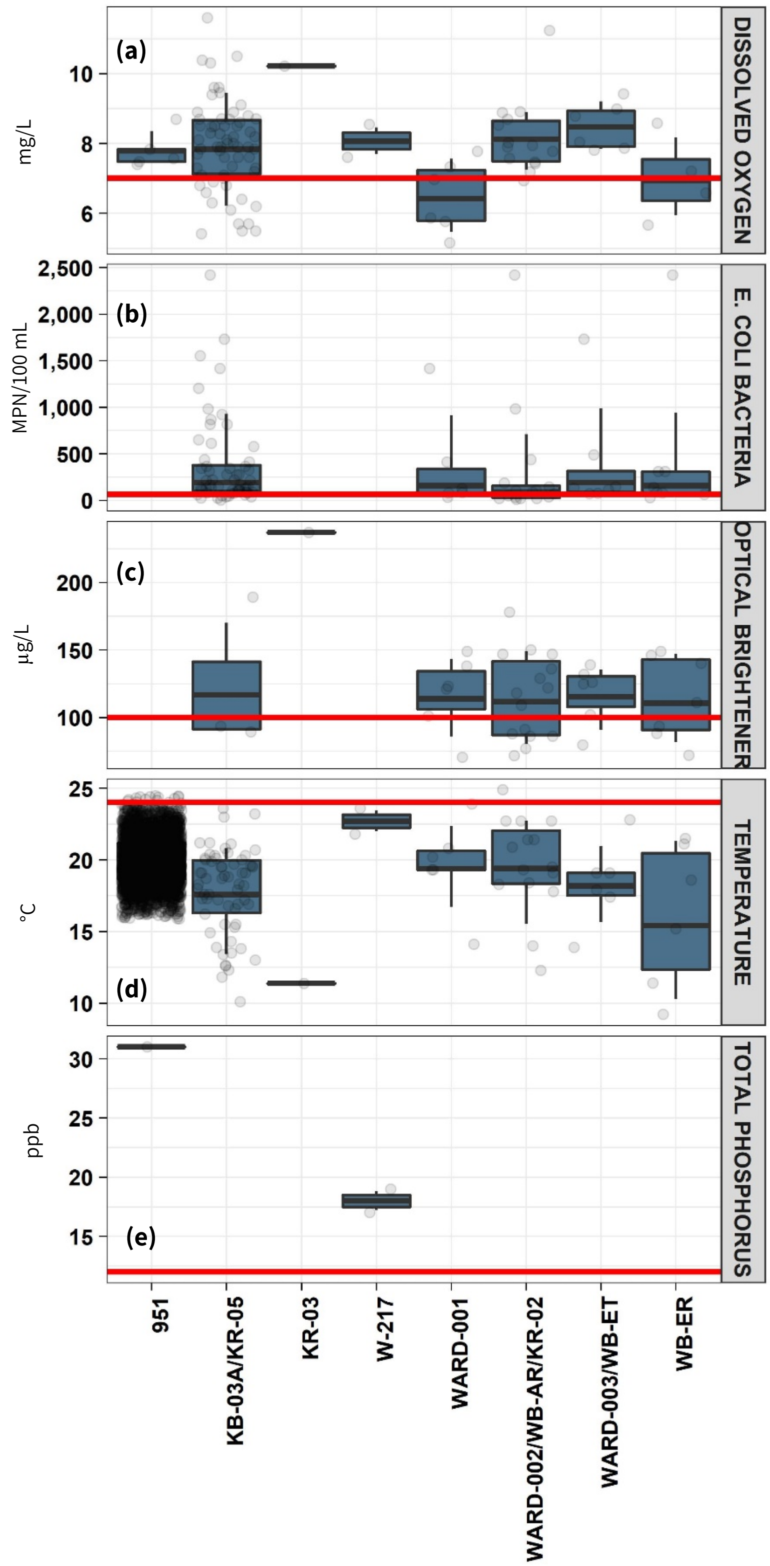


Figure 3-9. Boxplots showing the geometric mean, 25th, and 75th percentiles for (a) dissolved oxygen, (b) *E. coli*, (c) optical brighteners, and (d) temperature in the Ward Brook sub-watershed. Temperature at site 951 represents a continuous monitoring device. The red line indicates applicable state and federal thresholds for each parameter (refer to Table 3-1).

Land Use

The Ward Brook sub-watershed is 6.8 sq. mi. and is located in the central southern portion of the Kennebunk River watershed. It is in the Towns of Lyman and Kennebunk. It has one main branch running northwest to southeast with several tributaries joining from the south before joining with the Kennebunk River main stem. The sub-watershed is predominantly forested (deciduous and mixed) with agriculture and cultivated land present mostly in the southeastern end.

Key Findings from Surveying

A stream corridor survey was conducted on a 1.4-mile segment of Ward Brook above its confluence with the Kennebunk River. Unusual conditions were noted at three locations in the stream segment and represented the following:

- a horse and chicken farm with a drainage ditch entering the stream
- a stream-side structure and bonfire area with no bathroom facilities
- a crossing of Ward Brook by the Eastern Trail. The Eastern Trail provides recreational access to a significant number of users and represents a threat from dog or horse waste.

Nonpoint Source Stressors

Proximate stressors: Elevated baseflow.

Environmental stressors: Elevated bacteria at downstream sites.

Possible sources: Beaver dams, undersized culverts, human and dog waste (from recreational trail users).

Photos taken in the Ward Brook sub-watershed. (Left and right) Ward Brook crossing at the eastern trail.

3.4 WATER QUALITY SUMMARY

Compiling historical data showed long term trends of elevated bacteria (*E. coli*, and/or Enterococci) in the Kennebunk River and its tributaries, with notably very high bacteria in Lord's Brook and Carlisle Brook and high bacteria in Duck Brook, Goff Mill Brook and Ward Brook as well as the mid to lower main stem of the Kennebunk River (Table 3-5). Carlisle Brook, Duck Brook, Goff Mill Brook, Ward Brook, and the mid main stem by Downing Road and lower main stem by Durrell's bridge have also historically experienced low dissolved oxygen. Water temperatures are warm at the mid main stem by Route 1. Total phosphorus is elevated in Lords Brook, Carlisle Brook, Ward Brook, data at the mid main stem by Route 1, indicating potential nutrient enrichment and should be investigated. These data are a reflection of all historical monitoring data, and therefore, should be paired with more recent analyses by the Maine Healthy Beaches Program and Maine DEP to monitor changes and improvements.

Table 3-5. Summarized stressors in the Kennebunk River and its tributaries, used to help determine priority stressors by subwatershed. Sites were analyzed based on the criteria presented in Table 3-6. All historical data between April 15 and October 31 was included. *Table created by K. Feindel, Maine DEP.*

Subwatershed	Site #	Dissolved Oxygen	Chloride and SPC	Bacteria	Temperature	Total Phosphorus	Biological Monitoring
Lords Brook	KB-12	Adequate	Good	**Very High**	Good	**High**	**Mixed** (several stations and results)
Carlisle Brook	KB-11	**Poor**	Good	**Very High**	Good	**High**	2010 – Class A
Upper Main Stem – Perkins Ln	KB-05	Good*	Good	Moderately High	Good	-	2000 – Class B 2005 – Class B
Mid Main Stem – Downing Rd	KB-04	**Poor**	Good	**High**	Good	-	-
Duck Brook	DB-ET	**Poor**	Slightly High	**High**	Good	-	-
Ward Brook	KB-03A	**Poor**	Slightly High	**High**	Good	**High**	2015 – Class A
Mid Main Stem – Route 1	KB-03	Good	Good	**High**	**Warm**	**High**	**2015 – Non-attaining** 2010 – Class B **2005 – Non-attaining**
Lower Main Stem – Durrell's Bridge	KB-02	**Poor**	-	**High**	Moderately Warm	-	-
Goff Mill Brook	KB-15	**Poor**	Slightly High	**High**	Good	-	-
Estuary Main Stem – Dock Square	KB-01	Adequate	-	Moderately High	Good	-	-

**Dissolved oxygen readings earlier in the day (prior to 8 AM) should be taken to confirm.*

Table 3-6. Water quality criteria indicators used to determine overall water quality summary to help determine priority stressors by subwatershed. These are not criteria for listing purposes. *Table created by K. Feindel, Maine DEP.*

Parameter	Very High	High/Poor/Warm	Moderately or Slightly High/Adequate	Good
Dissolved Oxygen	-	26% or more <7 mg/L *or* 3 readings or more <6 mg/L	25% or less <7 mg/l, but >6 mg/l	2 readings or less <7 mg/l, but >6 mg/l
Specific Conductance	-	-	Maximum 200-300 µs/cm	Maximum <200 µs/cm
Temperature	-	Max > 26 °C Mean > 22 °C	Max 25° to 26 °C Mean 20° to 22 °C	Max ≤ 24 °C Mean ≤ 19 °C
E. Coli	Geomean ≥ 300 MPN	Geomean 150-299 MPN	Geomean 65-149 MPN	Geomean ≤ 64 MPN
Enterococcus	Geomean ≥ 105 MPN	Geomean 36-104 MPN	Geomean 9-35 MPN	Geomean ≤ 8 MPN

3.5 Pollutant Source Identification

3.5.1 General Pollutant Descriptions

The following section contains general descriptions for common nonpoint source pollution in urban, coastal, watersheds.

Pet Waste

The proper disposal of pet waste is critical for protecting downgradient surface waters. Pet waste can carry pathogens harmful to human health. During storm events, pet waste on land surfaces can be mobilized and delivered to downstream waterbodies. And remember, never dispose of pet waste into the stormwater drains – those lead directly to downstream waterbodies.

Septic Systems

Septic systems, outhouses, and even portable toilets help manage our wastewater and prevent harm to human health, aquatic life, and water resources. However, aging, poorly maintained, and/or improperly sited systems pose a threat to the health of surface waters. Within a septic system, approximately 20% of the phosphorus is removed in the septic tank (due to settling of solid material) and a further 23-99% is removed in the leachfield and surrounding soils (Lusk, Toor, & Obreza, 2011; Lombardo, 2006)). The degree of phosphorus removal efficiency of a septic system depends on site-specific soil and groundwater characteristics, including pH and mineral composition. Depending on the circumstances, older systems may still retain up to 85% of the input phosphorus in the top 30 cm of the soil (Zanini, Robertson, Ptacek, Schiff, & Mayer, 1998), though a slow, long-term transport of phosphate over long distances in the groundwater table can also occur in older systems (Harman, Robertson, Cherry, & Zanini, 1996). Phosphorus generally migrates through the soil slower than other dissolved pollutants in groundwater, but studies have shown that this degree of phosphorus reduction and movement is correlated with unsaturated infiltration distance (Weiskel & Howes, 1992), suggesting it is important to have septic systems well above the seasonal high groundwater table.

The Kennebunk River watershed is host to many private septic systems. Sewer lines exist only in Kennebunkport and Kennebunk, with both towns also hosting private systems. Septic system data for these communities is not yet digitized but individual systems can be found via the Maine Septic System permit database.

Marinas

The Kennebunk River watershed is home to thirteen (13) marinas that provide over 300 slips that are open to recreational and commercial vessels. These marinas are located in the tidal portion of the river. These marinas are host to a thriving tourism industry that supports many restaurants and businesses in Kennebunk and Kennebunkport.


Marinas visible from above the Kennebunk River. © A. Jensen/Wells Reserve.

Marinas have been shown to have an impact on coastal waters as a result of the accumulation of heavy metals and petroleum hydrocarbons, however, this impact has been shown to be similar to other urban environments (McMahon, 1989). However, one of the greater risks of marinas is the disposal of sewage from boats. Sewage can carry pathogens that are harmful to people's health and can impair water quality. Federal law prohibits the discharge of sewage in waters three-miles from the coast. Federal law also requires the use of marine sanitation devices to treat all sewage generated from boats and provides the process for states to create “No Discharge Areas”. Maine law requires pump out stations at facilities categorized as marinas that is accessible and functional during normal working hours and at all stages of tide or water level. In Maine, a marina is *“defined as any facility on coastal or inland waters that provides services and has 18 or more slips or moorings for boats greater than 24-feet in length”.*

The Kennebunk River and its estuary are listed as a “No Discharge Area” under state law. In the Kennebunk River, there are three pier side pump out stations (Chicks Marina, Kennebunkport Marina, and Yachtsman Marina). In addition, there is a Kennebunk Pump out self-service float that was deployed in the river center near Seagrass Lane (43° 21’ 26.238” N, 70° 28’ 36.446” W) that is currently *inactive*. A map of all pump out locations can be found at the Maine DEP website.[8] The Maine DEP manages a statewide Pump out Grant Program, funded by the United States Fish and Wildlife Service with funding from the Clean Vessel Act Grant Program. Through these funds, the state can offer a non-competitive program to provide a 75% grant for the “installation, operation and maintenance of boat holding tank pump out equipment to marinas, boatyards, and municipalities”.[9]

Per- and Poly-fluoroalkyl Substances (PFAS)

PFAS are a class of over 4,000 compounds that include industrial chemicals used in a variety of everyday products like that of stain, oil, heat, and water resistant materials as well as in Class B firefighting foam. The two most common PFAS chemicals, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonate (PFOS), are persistent in the environment and have been shown to cause human health effects such as cholesterol levels, thyroid function, birth weight, liver function, infant development, and immune development. The state of the science for understanding the risks of PFAS exposure is under development, and therefore regulations and methodologies to address PFAS have varied by state (Tipton, et al., 2020).

In 2019, by Executive Order, Governor Janet Mills created a Maine PFAS Task Force to investigate the presence and severity of these chemicals in Maine. While PFAS was first discovered at former military installations in the state, the discovery of PFAS in the Kennebunk, Kennebunkport, Wells Water District supply well, was the first evidence of more widespread contamination in the state. Following this discovery, the Maine DEP began monitoring for PFAS in a variety of environments across the state and evaluated environmental transport pathways for these contaminants, when detected. When appropriate, treatment systems are installed; as was done at the Kennebunk, Kennebunkport, Wells Water District (Tipton, et al., 2020).

Due to limitations in funds and time, this report is focused on nonpoint source pollution typically resulting from excess stormwater runoff (primarily sediment, nutrients, and bacteria) and the consequences of this runoff on downstream surface waters (e.g. temperature, dissolved oxygen, turbidity) and recreators. However, we recognize the importance of supporting state efforts in identifying instances of PFAS exposure in both groundwater/drinking water and surface water. As such, we have included PFAS investigation and support in our action plan (Table 5-1).

Climate Change

Climate change will have important implications for water quality that should be considered and incorporated to watershed management plans. Over the last 124 years, annual temperature statewide in Maine has increased 3.2 degrees Fahrenheit (°F) and *the Northeast is warming faster than any other region in the U.S.* (Fernandez, et al., 2020). Furthermore, the 2020 Update to the Maine Climate Future reports that average annual precipitation has increased 15 percent (5.8 inches) since 1895. Rain, in contrast to snow, has been responsible for this increase, with a concurrent 20 percent decrease

[8] Maine Boat Pump outs and No Discharge Areas:
https://maine.maps.arcgis.com/apps/webappviewer/index.html?id=d7c7e6027dce4109897f95289ac00f40

[9] https://www.maine.gov/dep/water/grants/pumpout/index.html

in the annual depth of snowfall. Precipitation has been delivered at increased frequencies and greater intensities than historically documented.

Shifts in annual precipitation and temperature can have significant effects on rivers and streams. Out of 28 rural stream flow stations throughout New England, 25 showed increased flows over the record likely due to the increase in frequency of extreme precipitation and total annual precipitation in the region. In 79 years of recorded flooding in the Oyster River in Durham, NH, three of the four highest floods occurred in the past 10 years (Ballestero, Houle, Puls, & Barbu, 2017).

Flooding in downtown Kennebunkport in 2018. © Portland Press Herald, Gregory Rec.

Greater intensity storms can result in flooding and damaged infrastructure; most significantly on infrastructure built within the natural floodplain of the river.

These trends will likely continue into the future to impact both water quality and quantity. Climate change models predict a 10-40% increase in stormwater runoff by 2050, particularly in winter and spring and an increase in both flood and drought periods as seasonal precipitation patterns shift. We must design resiliency into our public stormwater infrastructure based on temperature changes, precipitation, water levels, wind loads, storm surges, wave heights, soil moisture, and ground water levels (Ballestero, Houle, Puls, & Barbu, 2017). There are nine strategies which can aid in minimizing the adverse effects associated with climate change and include the following (McCormick & Dorworth, 2019).

1. **Installing Green Infrastructure:** Planning for greener infrastructure requires that we think about creating a network of interconnected natural areas and open spaces needed for groundwater recharge, pollution mitigation, reduced runoff and erosion, and improved air quality for the communities being developed. Examples of green infrastructure include forest, wetlands, natural areas, riparian (banks of a water course) buffers, agricultural land, and flood plains; all of which already exist in the watershed and have minimized the damage created by intense storms in the past. As future development occurs, we must be able to maintain or even increase these natural barriers to reduce runoff of pollutants into freshwaters.

2. **Using Low Impact Development (LID) Strategies:** Use of LID strategies requires that we replace the traditional approaches to stormwater management using curbs, pipes, storm drains, gutters, and retention ponds with innovative approaches such as bioretention, vegetated swales, and permeable paving.
3. **Minimizing Impervious Surfaces:** Today two-thirds of our impervious surfaces come from roads, highways, and parking lots; we must minimize impervious surfaces by creating new ordinances and building construction design requirements which reduce the imperviousness of new development. Parking lot design requirements should promote infiltration of runoff, and roads should consider space for pedestrians, bicyclists, and mass transit. Increasing our transportation choices reduces the need for more pavement. Private property owners can also increase the permeability for their lots by incorporating permeable driveways and walkways.
4. **Encouraging Riparian Buffers and Maintaining Floodplains:** Town ordinances should forbid construction in floodplains, and in some instances, floodplains should be expanded to increase the land area which will accommodate larger rainfall events. We also need to preserve and create riparian (vegetated) buffers and filter strips along waterways to slow runoff and filter pollutants.
5. **Protecting and Re-establishing Wetlands:** Wetlands are increasingly important for preservation because wetlands hold water, recharge groundwater, and mitigate water pollution.
6. **Encouraging Tree Planting:** Trees help manage stormwater by reducing runoff and mitigating erosion along surface waters. In addition, trees cool heat islands in more developed areas and provide shade for pedestrians.
7. **Promoting Landscaping Using Native Vegetation:** Communities should promote the use of native vegetation in landscaping, and landscapers should become familiar with techniques which minimize runoff and the discharge of nutrients into waterbodies (Chase-Rowell, et al., 2012).
8. **Slowing Down the Flow of Stormwater:** To slow and infiltrate stormwater runoff, roadside ditches can be armored or vegetated and equipped with turnouts, settling basins, check dams, or infiltration catch basins. Rain gardens can retain stormwater, while water bars can divert water into vegetated areas for infiltration. Water running off roofs can be channeled into infiltration fields and drainage trenches (Maine Department of Environmental Protection (Maine DEP), 2016).
9. **Coordinating Infrastructure, Housing, and Transportation Planning**: We should coordinate planning for infrastructure, housing, and transportation to minimize impacts on natural resources. Critical resources including groundwater must be conserved and remain free of pollutants especially as future droughts may deplete groundwater supplies.

3.5.2 Stream Corridor Assessment

The following sections provide an overview of the survey efforts undertaken in 2019 as a component of developing this plan. Assessing current river and stream conditions allows us to inventory current nonpoint source pollutant problems to mitigate and prevent future nonpoint source pollution.

Overview of Stream Corridor Assessment

The Kennebunk River Stream Corridor Assessment followed the approved methods outlined in the Survey Implementation Plan (SIP) approved by the Maine DEP on 06/17/2019, which included techniques from the "Generic Quality Assurance Project Plan for Maine Stream Corridor Survey" dated November 27, 2018. The purpose of the survey was to provide project stakeholders with the tools and information to restore the Kennebunk River and its tributaries by identifying potential sources of NPS pollution near known hotpots and assessing habitat characteristics of the stream reaches. This goal is in support of the larger project objective of collecting information on the Kennebunk River watershed's natural resources and specific nonpoint source pollution bacteria issues in order to better protect the river and its tributaries.

Survey Techniques

In-stream corridor assessments were performed on segments of the Kennebunk River main stem and tributaries with a focus on areas identified as hotspots for fecal contamination and/or non-attainment for aquatic life use through historical monitoring. These assessment surveys took place across five days (July 24, August 7, August 22, September 11, September

13, 2019) and included survey teams made up of a technical leads and support staff. Survey areas included two segments[10] of the Kennebunk River main stem (KR_1 and KR_2) and three tributaries, Carlisle Brook (CB_1), Duck Brook Tributary A (DB_1), and Ward Brook (WB_1). KR_1 was further broken into five sub-sections (later referred to as reaches 1-5, Figure 3-12 which were determined by geomorphic/hydrologic characteristics representing sections of uniformity.

Survey teams assessed river and tributary conditions by walking in the waterway or via canoe. Survey methods followed those outlined in the "Maine DEP Stream Corridor Survey Quality Assurance Project Plan (QAPP)" (2018) and were guided by Unit 5 of the Maine DEP Stream Survey Manual. Three in-stream surveys types were used:

(1) Stream Corridor Habitat Survey to assess overall condition of the habitat and corridor;

(2) Rapid Geomorphic Assessment to evaluate the general fluvial geomorphological characteristics of the stream reach;

(3) Unusual Conditions documenting locations of nonpoint source pollution through local land use and/or riparian zone conditions.

KR_1 was assessed using the Steam Corridor Habitat Survey and the Rapid Geomorphic Assessment, as this area is located above a Maine DEP biomonitoring station that does not meet class requirements. The Stream Corridor Habitat Survey and Rapid Geomorphic Assessment Field Forms were used to assess waterway characteristics according to previously mentioned established protocols. The remaining reaches and tributaries (CB_1, DB_1, WB_1, KR_2,) were assessed using the Unusual Conditions survey only. Survey teams used the Stream Corridor Assessment Unusual Conditions Field Form to document observations and potential causes, and to rank severity, correctability, and access, if possible. Field photographs were also taken.

Survey Results

The goal of the in-stream corridor assessment was to identify potential sources of NPS pollution near known hotspots and assess habitat characteristics of the stream reaches. Survey results are summarized by tributary according to the assessments performed: Unusual Conditions Survey, Stream Corridor Habitat Survey, Rapid Geomorphic Assessment. A brief description of survey points is provided and a summary of river reach characteristics. See Figure 3-10 for site locations for Unusual Conditions Survey and refer to Figure 3-12 for river segments and sub-reach locations. It is important to note that documented "unusual conditions" may not represent NPS pollution to the stream, but rather document anything out of the ordinary that warrants follow-up review.

[10] These segments were referred to as "reaches" in the SIP, however, have been renamed here to distinguish them from the reaches identified through geomorphic/hydrologic characteristics in the rapid geomorphic and habitat assessments.

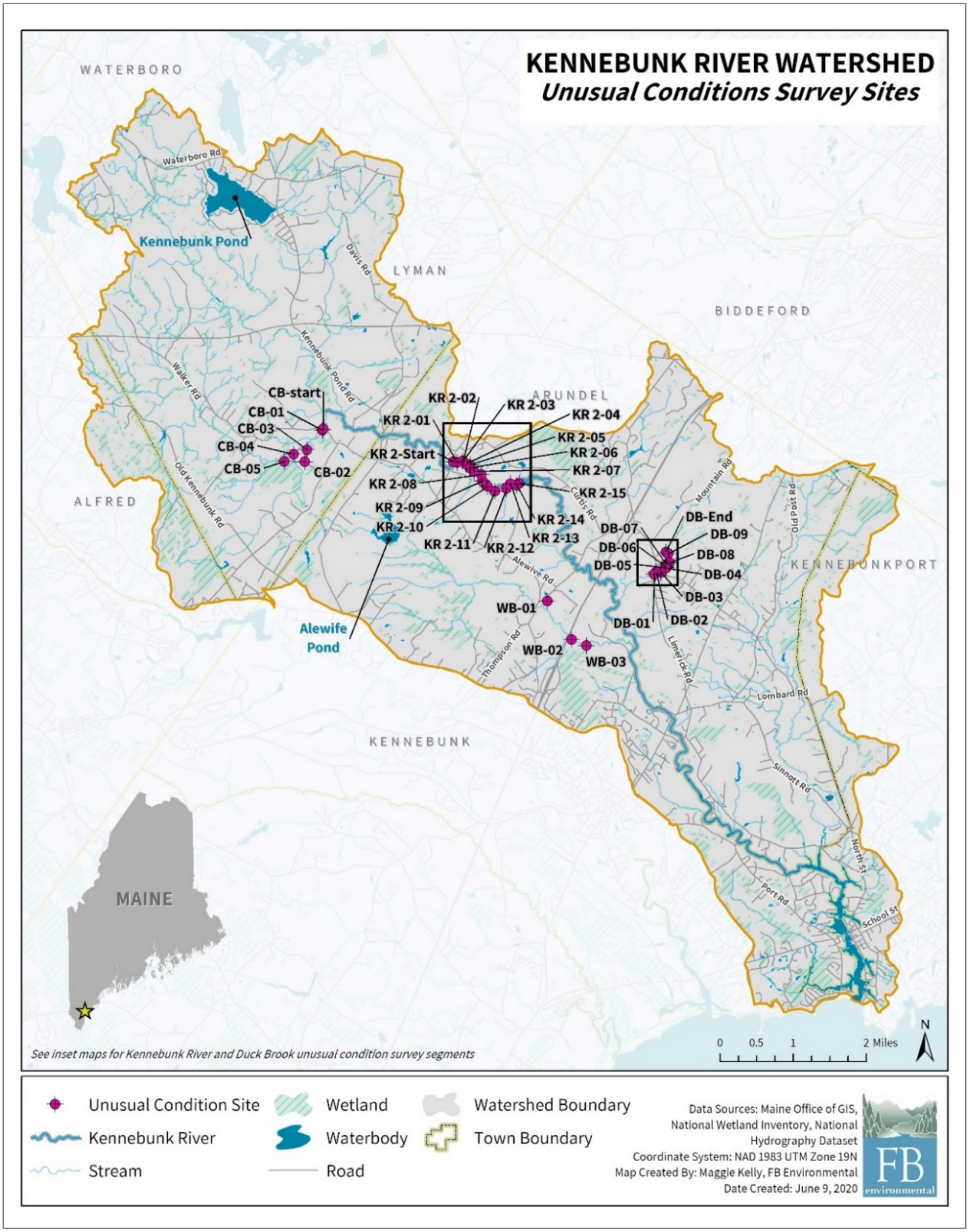


Figure 3-10. Map of unusual condition survey sites in the Kennebunk River watershed. See Figure 3-11 and Figure 3-13 for insets of DB and KR_2, respectively.

Carlisle Brook

Assessments completed: Unusual Conditions

- CB-01 (43.45851323, -70.62294298): Area of deer bedding causing backup to stream.
- CB-02 (43.45220296, -70.62746678): Aging and clogged culvert crossing Drown Road which is causing a minor water backup in nearby field.
- CB-03 (43.45457411, -70.62689764): Livestock, including horses and sheep, in close proximity to pond and stream.
- CB-04 (43.45368324, -70.63056506): Small tributary entering to Carlisle Brook.
- CB-05 (43.45218925, -70.63306941): Beaver dam present.

Duck Brook Tributary A

Assessments completed: Unusual Conditions

Site locations identified in Figure 3-11 on the following page.

- DB-01 (43.43128152, -70.53194175): Turbid conditions and algal mats observed.
- DB-02 (43.43169516, -70.53146624): Small drainage entering tributary with bright green algae present upstream in drainage. Natural oily sheen and mucky conditions present.
- DB-03 (43.43162928, -70.53011114): Drainage entering, river right, below crossing of Campground Road.
- DB-04 (43.43251613, -70.52882846): Tributary entering, river left.
- DB-05 (43.43260732, -70.52869502): Large drainage entering, river right.
- DB-06 (43.43275883, -70.52884178): Drainage entering, river left, with wetland above and residential area on Talbot Drive.
- DB-07 (43.43312901, -70.52869317): Slumped bank and bank erosion.
- DB-08 (43.43365008, -70.52782682): Steep eroding bank located downstream of Talbot Drive crossing.
- DB-09 (43.43539678, -70.5282206): Bank erosion located upstream of Talbot Drive.

Photos presented in this section for each tributary represent examples of observed conditions.

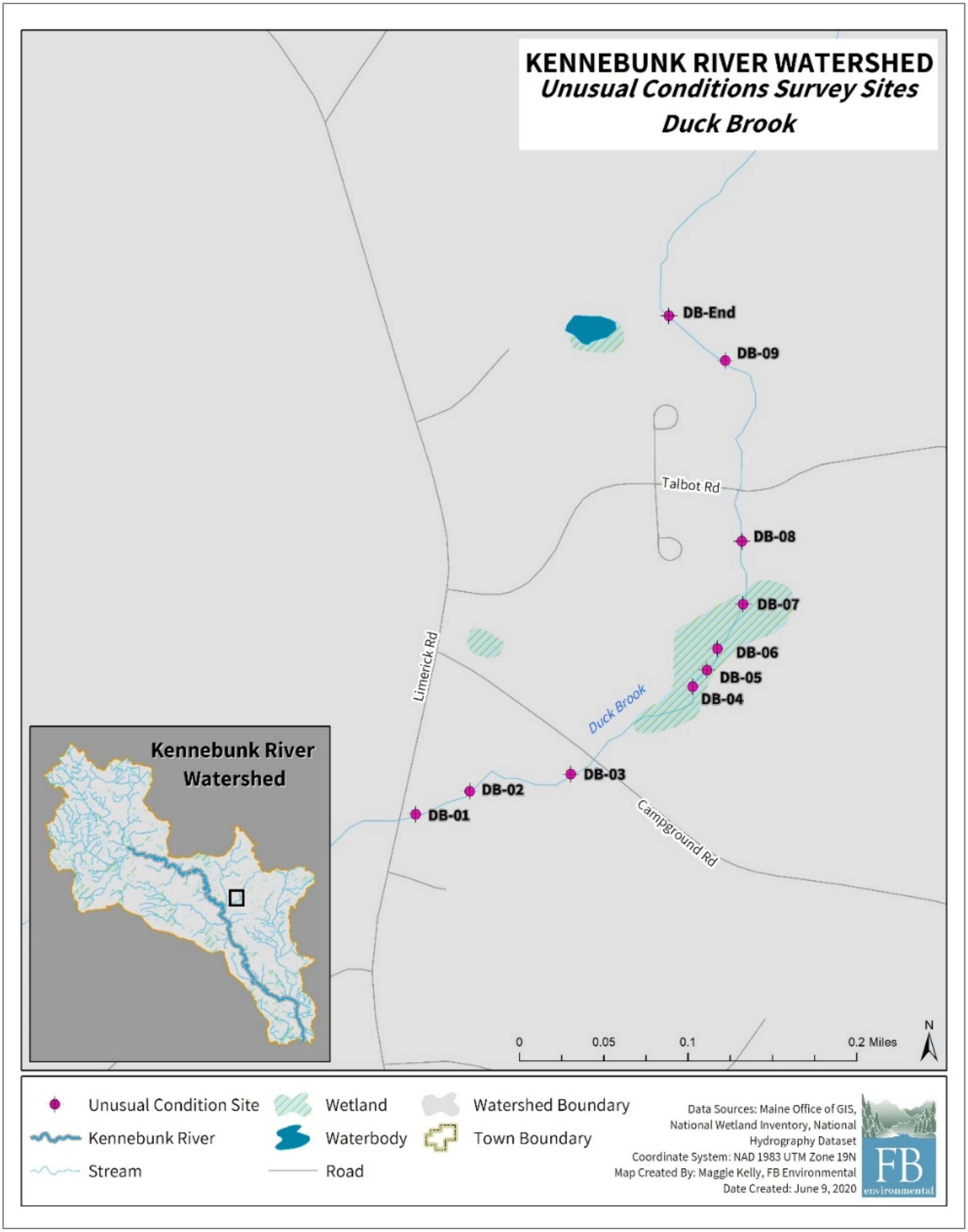


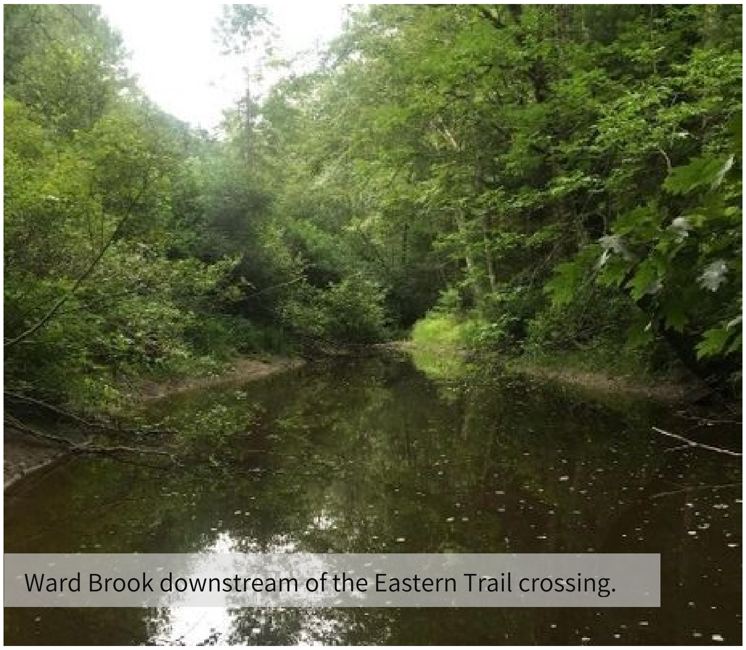
Figure 3-11. Unusual conditions survey sites along Duck Brook Tributary A.

Ward Brook

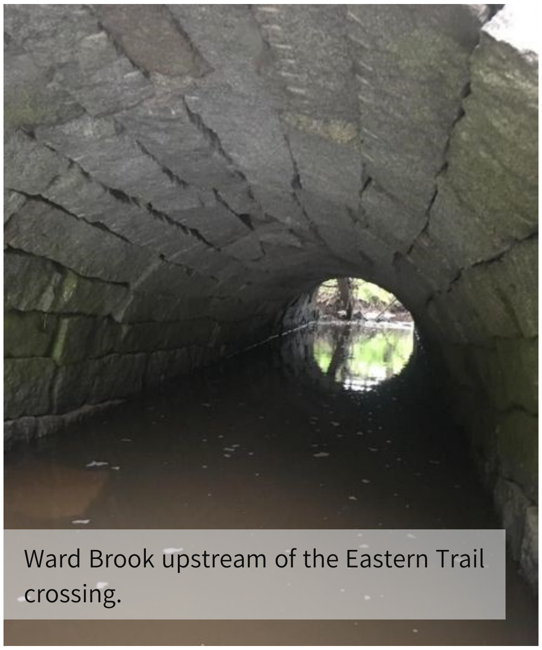
Assessments completed: Unusual Conditions

- WB-01 (43.42556162, -70.5608454): A large-sized farm with horses and chickens present at 19 E Mark Road. A large field, possibly used as pasture for grazing, in close proximity to the stream. Possible drainage ditch to the stream through buffer. Observations were made from the road.
- WB-02 (43.42556162, -70.5608454): Fecal waste present, possible sources suspected to be canine, horse, or human. Location at the crossing of the Eastern Trail.
- WB-03 (43.4168799, -70.54999636): Cleared area with built structure and bonfire use. No bathroom facilities apparent.

No photos were available of sites WB-01, -02, and -03.



Ward Brook downstream of the Eastern Trail crossing.



Ward Brook upstream of the Eastern Trail crossing.

Kennebunk River Main Stem

Two segments of the Kennebunk River were assessed during the 2019 Stream Corridor Assessment, segments KR_1 and KR_2. Segment KR_1 included a comprehensive Habitat Assessment and Rapid Geomorphic Assessment at five identified sub-reaches, shown on the map below. Segment KR_2 was assessed using the Unusual Conditions Assessment only.

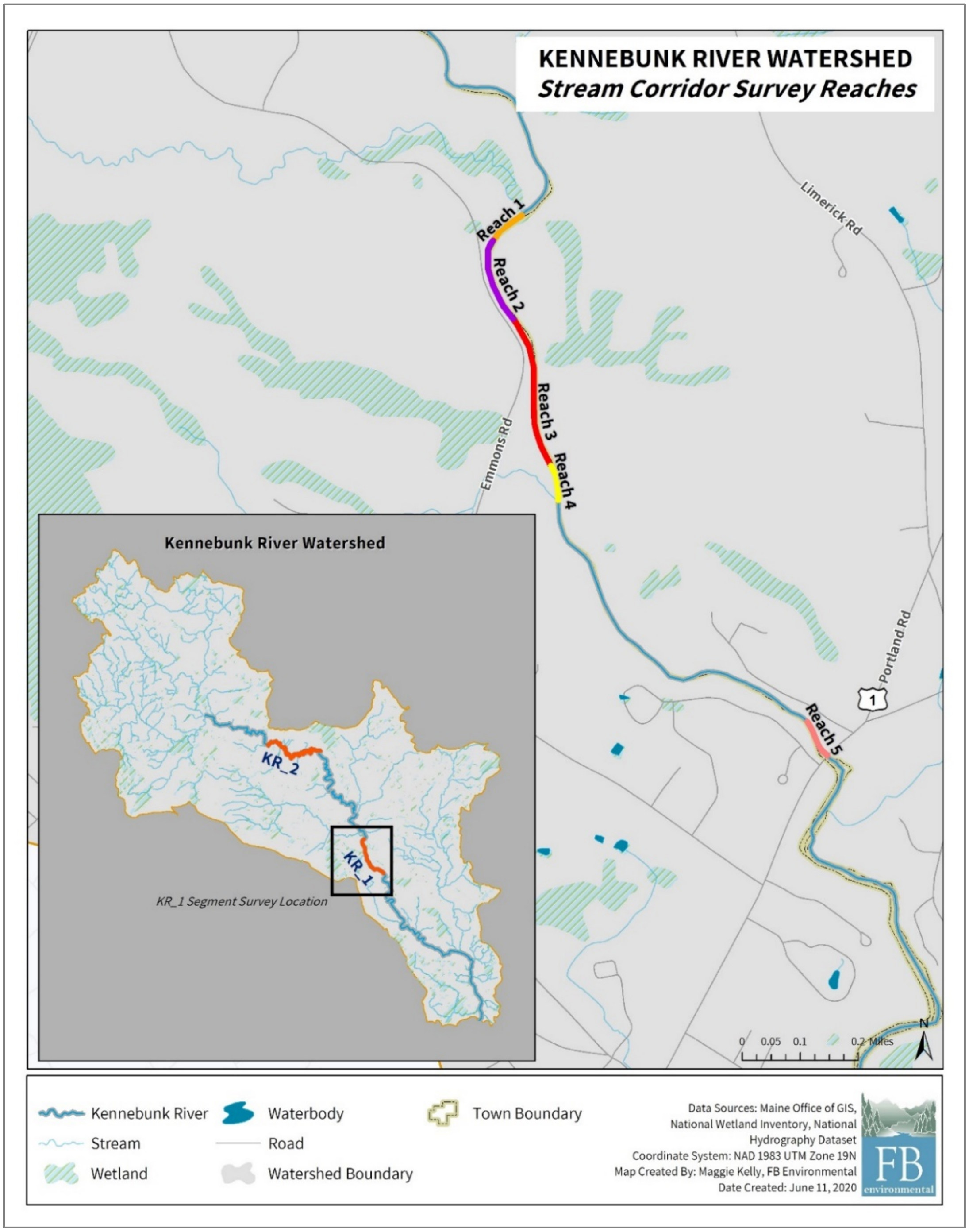


Figure 3-12. Stream segments surveyed on the Kennebunk River. Segment KR_1 is broken into five sub-section reaches based on channel uniformity. The section of river between reach 4 and 5 is characterized by rapids, which the survey team could not navigate through.

Segment KR_1: Section of the Kennebunk River east of I-95 and west of Route 1 crossing. Segment KR_1 was broken into 5 sub-reaches discussed below (refer to Figure 3-12 for a map of the sub-reaches).

Assessments completed: Stream Corridor Habitat Survey, Rapid Geomorphic Assessment

Stream Corridor Substrate Sizing

Nature of Particles	Diameter
Silt/Clay/Mud	<0.002”
Fine or Medium Gravel	0.08-0.6”
Coarse Gravel	0.6-2.5”
Cobble	2.5-10”
Rubble	10-20”
Boulder	>20”
Bedrock	n/a

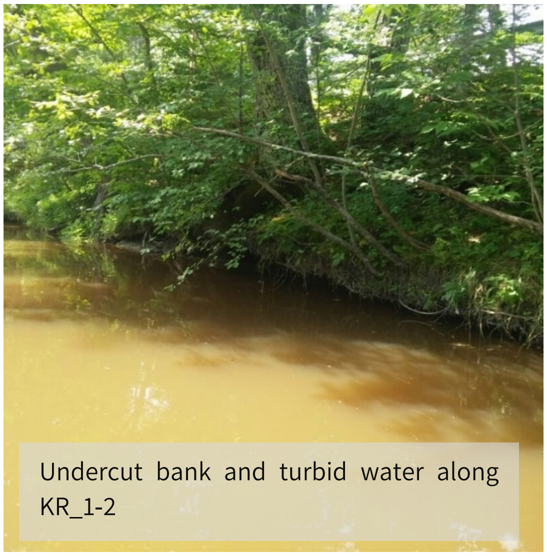
Reach 1:

- Characterized as one large pool habitat, with silt/clay/mud substrate dominating the streambed, with no naturally-occurring organic material, and water appearance characterized as dark brown/tea color and turbid.
- Streambanks were vertical/undercut and steeply sloping (>30°) for 0-25% of the reach, as well as areas of gradual/no slope (<30°).
- Overhanging vegetation was common along the stream bank, woody debris was present; trees, woodlands, bushes, and shrubs were common and open lawn was present upland (up to 25 yards) of the stream.
- Mud, silt, and sand was commonly observed entering the stream.
- Nearby land use consists of residential single-family home, lawns, paved roads/bridges, and natural woodland.
- Some amphibians and fish were present, but rare. Aquatic plants were plentiful.
- Rapid geomorphic assessment showed some evidence of aggradation[11] and degradation[12] as well as evidence of river widening.

Vegetated buffer along KR_1-1

Reach 2:

- Characterized as one large pool habitat, with silt/clay/mud substrate dominating the streambed with some coarse gravel, with occasional naturally-occurring organic material, and water appearance characterized as dark brown/tea color and turbid.
- Streambanks were vertical/undercut and steeply sloping (>30°) for 0-25% of the reach.
- Overhanging vegetation and undercut banks were common along the stream bank, woody debris was present; trees, woodlands, bushes, and shrubs as well as pavement and structures were common, open soil and tall grass or ferns were present upland (up to 25 yards) of the stream.
- Natural streamside plant cover was commonly degraded and banks were commonly collapsed and eroding. Livestock were observed near unrestricted stream access, as were actively discharging pipes to the stream.
- Nearby land use was dominated by paved roads or bridges inactive agricultural fields and natural woodland was present.
- Waterfowl and fish were present but rare, free-floating aquatic vegetation was occasionally observed.



Undercut bank and turbid water along KR_1-2

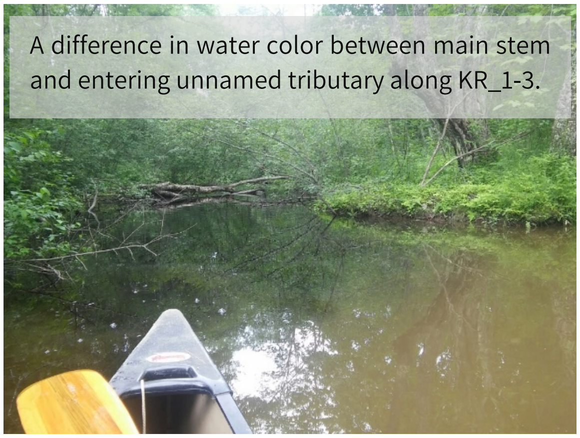
[11] Deposition of sediment in a river system resulting in increased elevation
[12] Lowering of a riverbed through erosion

- Rapid geomorphic assessment showed some evidence of aggradation and degradation as well as evidence of river widening.

Reach 3:

- Characterized as one large pool habitat, with silt/clay/mud substrate dominating the streambed, with occasional naturally-occurring organic material, and water appearance characterized as dark brown/tea color and turbid with many observations of logs or large woody debris in the stream.
- Streambanks were vertical/undercut and steeply sloping (>30°) for 0-25% of the reach, as well as areas of gradual/no slope (<30°).
- Overhanging vegetation, undercut banks along the stream bank, and woody debris were common; trees, woodlands, bushes, and shrubs were common upland (up to 25 yards) of the stream.
- Nearby land use consisted of natural woodland.
- Fish were present but rare and attached aquatic plants were occasionally observed in the stream margins.
- Rapid geomorphic assessment showed some evidence of aggradation and degradation as well as evidence of river widening.


Overhanging bank with exposed tree roots along KR_1-3.


A difference in water color between main stem and entering unnamed tributary along KR_1-3.

Reach 4:

- Characterized by pools, rapids, and riffle, made up of primarily rubble and cobble substrate, with occasional naturally-occurring organic material, and water appearance characterized as dark brown/tea color and turbid.
- Streambanks were vertical/undercut and steeply sloping (>30°) for 0-25% of the reach.
- Overhanging vegetation and boulders/rocks were common along the stream bank, woody debris was present; trees, woodlands, bushes, shrubs, tall grass and ferns were common upland (up to 25 yards) of the stream.
- Multi-family homes, lawns, commercial property, and natural woodland were all present on nearby land.
- No fish or other wildlife were observed in the stream, occasional aquatic plants were present; filamentous brown and green algae was plentiful.
- Rapid geomorphic assessment showed minimal evidence of aggradation, some evidence of degradation as well as evidence of river widening.


Rapid and riffle habitat made up much of KR_1-4 reach and downstream section.

Reach 5:

- Characterized by rapids and riffles, with boulders and bedrock dominating the substrate, with occasional naturally-occurring organic material, and water appearance characterized as dark brown/tea color and turbid.
- Streambanks were steeply sloping (>30°) for 25-50% of the reach.
- Boulders/rocks were common along the stream bank and woody debris was present; trees, woodlands, bushes, shrubs, tall grass and ferns were common, some open soil was present, upland (up to 25 yards) of the stream.
- Some garbage was present adjacent to the streamside.
- No fish or other wildlife were observed in the stream, occasional aquatic plants were present; there was an occasional heavy coating of brown algae.
- Rapid geomorphic assessment showed minimal evidence of aggradation as well as evidence of river widening.

Vegetated buffer and riffle habitat along KR_1-5.

Segment KR_2: Section of the Kennebunk River running south of Curtis Road and north of Alewive Road, west of I-95. Site locations identified in Figure 3-13, on the following page.

Assessments completed: Unusual Conditions

- KR_2-01 (43.45264016, -70.58611248): Riverbank erosion, river right.
- KR_2-02 (43.45297845, -70.58452084): Woody debris jam.
- KR_2-03 (43.45301759, -70.58451103): Small tributary entering, draining from fields above bank on river left.
- KR_2-04 (43.45242491, -70.58359455): Lack of vegetated buffer on riverbank, river left.
- KR_2-05 (43.45222777, -70.58249912): Lack of vegetated buffer on riverbank and bank is eroding.
- KR_2-06 (43.45165040, -70.58264966): Noticeable filamentous algae in the water.
- KR_2-07 (43.45093557, -70.58147184): Vehicle access area in close proximity to the river.
- KR_2-08 (43.45034674, -70.57943202): Tributary entering the river, river left.
- KR_2-09 (43.44906092, -70.57917838): Sporadic riverbank erosion.
- KR_2-10 (43.44803464, -70.57763846): Pipe, possibly tile drainage from field, and continued lack of vegetated buffer.
- KR_2-11 (43.44711782, -70.57562990): Tributary entering the river.
- KR_2-12 (43.44769492, -70.57253614): Tributary entering the river, river right.
- KR_2-13 (43.44863281, -70.57146309): Drainage, or possible tributary, into the river, river left.
- KR_2-14 (43.44837385, -70.56972795): Substantial beaver dam.
- KR_2-15 (43.44877371, -70.56913175): Tributary entering the river, river left.

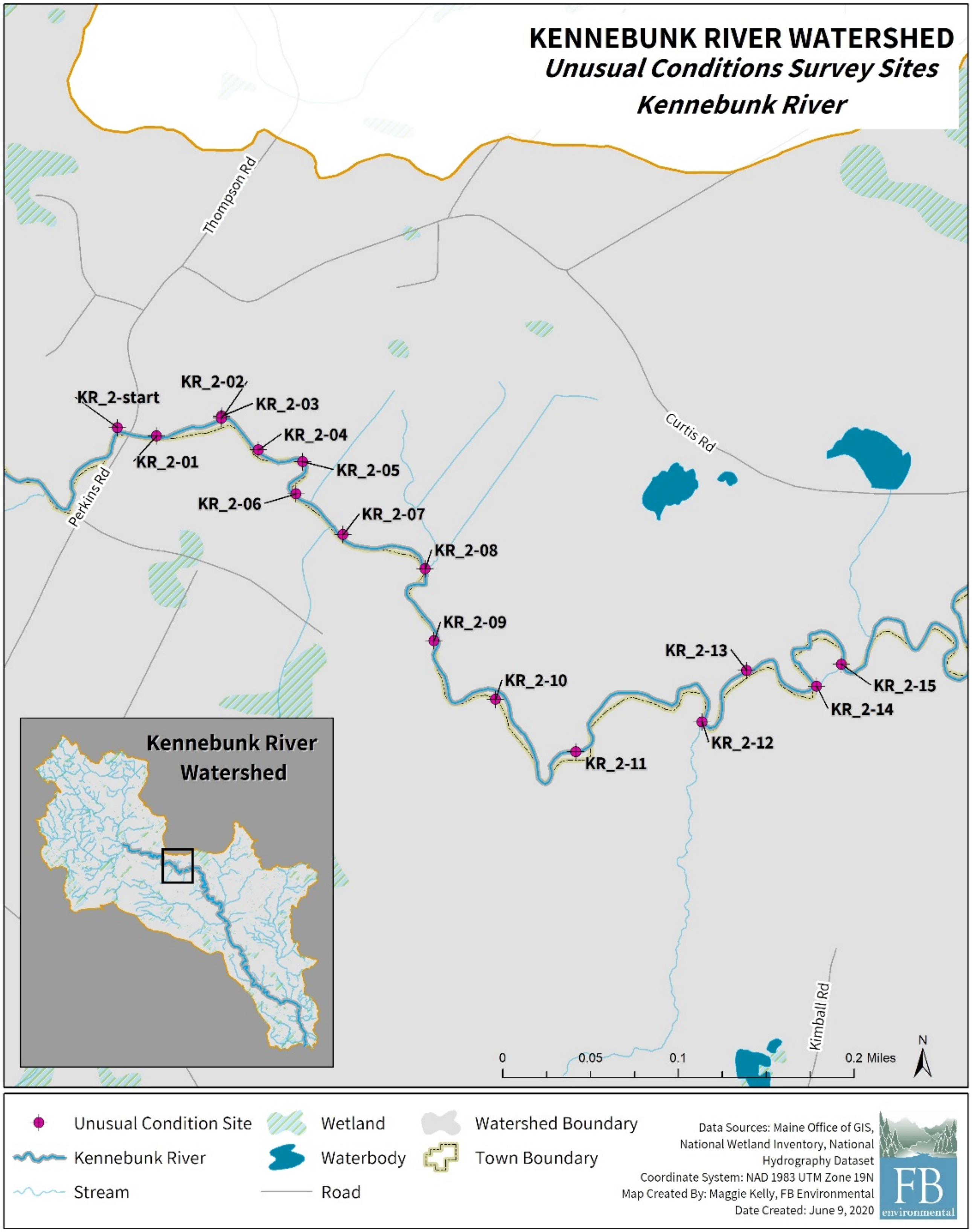


Figure 3-13. Unusual conditions survey sites along segment KR_2.

3.5.3 Watershed Inventory

Overview of Watershed Inventory Work

The Kennebunk River Stream Corridor Assessment and Watershed Inventory satisfied a required deliverable as part of Task 4 of the Kennebunk River Watershed-Based Plan Development Project (#2018006).

The watershed survey followed approved methods outlined in the Survey Implementation Plan approved by the Maine DEP on 06/17/2019, which included techniques from "Maine Lake and Stream Watershed Survey Generic Quality Assurance Project Plan" dated April 6, 2015. The purpose of the surveys was to provide project stakeholders with the tools and information to restore the Kennebunk River and its tributaries. This goal is in support of the larger project objective of collecting information on the Kennebunk River watershed's natural resources and specific nonpoint source pollution bacteria issues in order to better protect the river and its tributaries.

Watershed Inventory Techniques

The watershed inventory took place across three days (July 24, August 28, August 29, 2019) and was conducted by two survey teams. Each survey team consisted of a technical leader and support staff. The assessment was focused on development and land use around hotspot areas in the Kennebunk River main stem and tributaries. Due to the size of the watershed, this assessment was performed on roads concentrated to two main areas: (1) within the central northern portion of the watershed in the Duck Brook and Kennebunk River direct drainage subwatersheds, and (2) within the northern watershed within Lord's Brook subwatershed (Figure 3-14).

The teams drove along public roadways (and some specific private roads where landowners were notified) to look for possible nonpoint pollution sources. Particular attention was paid to known hotspot sites and land use adjacent to these sites as well as land uses with a predisposition for fecal contamination, such as agriculture, densely developed land, and residential or commercial land. Survey teams used methods from the "Maine Lake and Stream Watershed Survey Generic QAPP" (2015) and collected data on tablets using the Watershed Inventory Field Form. More detailed methods on data collection and data storage are described in the SIP.

At each assessment site, survey teams collected information on NPS sources including land use, issue present, best management practice (BMP) recommendations, and impact. Each site was rated on the size of impact (rated numerically 1-3 for small, medium, large), pollutants involved (rated numerically 1-2 for single or multiple), and for transport to stream (rated numerically 1-2 for limited or direct flow). Numerical ratings were added together for a total score to determine an overall impact rating of high (6-7 points), medium (5 points), or low (3-4 points). Survey results presented here are sites ranked with a high impact rating and are thus of highest priority for addressing NPS pollution in the Kennebunk River watershed.

Watershed Inventory Results

The watershed inventory identified 36 total assessment sites. These sites are marked in Figure 3-14. Land use at these sites was categorized as the following: agriculture (12 sites), construction (2 sites), gravel pit (2 sites), logging (1 site), municipal (4 sites), private road (4 sites), town road (9 sites), waterbody (2 sites). Impact rating of the sites included 21 low impact sites, 10 medium impact sites, and five high impact sites. The five high impact sites are highlighted below with observations and recommendations summarized from the watershed survey.

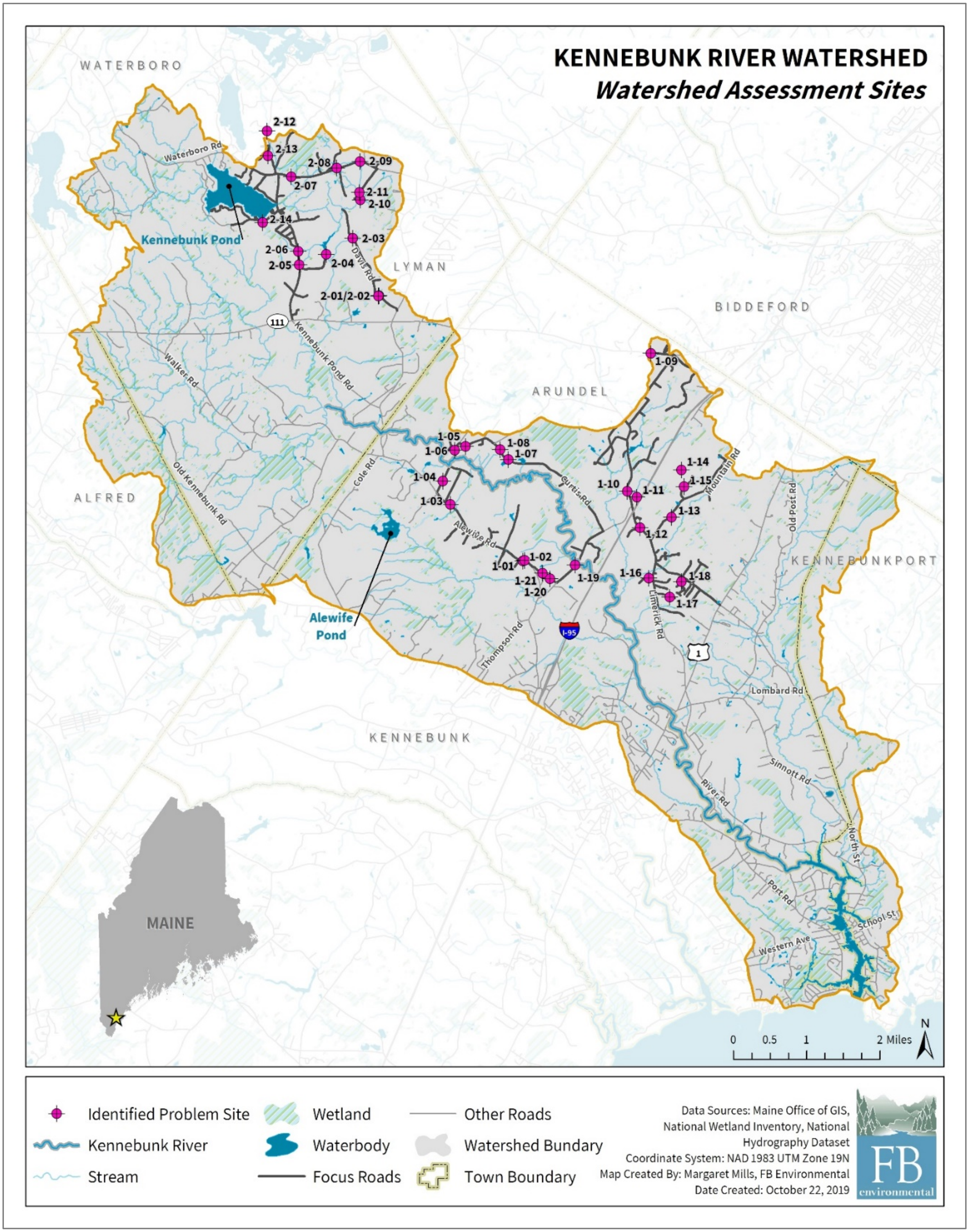


Figure 3-14. Map of all potential NPS sites identified during the 2019 watershed inventory.

(1) Waterboro Road, near Winter Road Intersection (site ID 2-08)

Observations: Culvert running under the road is crushed and damaged and adjacent road is cracked. Algae mats were observed in the stream and waterfowl and wildlife were gathering nearby.

Recommendations: Repair or replace the current culvert to prevent further damage. Investigate upstream sources of nutrients responsible for algae growth.

(2) Not A Road (site ID 2-11)

Observations: There are two undersized culverts passing through a dirt road. The runoff is creating an unstable bank and ditch erosion around the culvert.

Recommendations: Replace the current culvert with a larger culvert to accommodate flow and stabilize the bank to prevent future erosion. Increase frequency of culvert maintenance, remove leaves and sand to prevent clogging. The road may need to be raised or built up to accommodate a properly sized culvert.

(3) Poor Farm Road (site ID 2-14)

Observations: The culvert is undersized and degrading. The inlet and outlet areas surrounding the culvert are unstable and eroding. There is soil erosion and sedimentation from nearby construction site, with an area of cleared trees. There is a large wetland complex nearby.

Recommendations: Replace the existing culvert with a larger and longer culvert to allow proper drainage. Armor culvert inlets and outlets to prevent erosion and reduce water flow. Ensure proper erosion and sediment control best management practices are installed at the construction site, such as silt fences, to prevent sediment runoff to nearby wetland and pond.

(4) Casella Waste Systems (site ID 1-14)

Observations: This is a municipal waste disposal site. Observed dumpster leachate may include toxins, trash, or bacteria.

Recommendations: Consult with the Town to ensure proper waste management containment practices are being implemented, such as keeping dumpsters covered to prevent leachate, performing regular maintenance and replacement of damaged waste containers, and ensuring proper disposal of liquid and hazardous waste.

(5) Russell Farm Road (site ID 1-21)

Observations: There is a large pasture with livestock and possible improper manure storage in close proximity to the river.

Recommendations: Work with landowner to ensure proper agricultural waste management practices are in place.

3.5.4 Stormwater Outfall Survey

The Wells National Estuarine Research Reserve performed stormwater outfall mapping in Spring 2019 from the Kennebunk River head of tide to the mouth of the river. WNERR mapped 78 outfalls, with the majority of the outfalls concentrated in the developed area around downtown Kennebunkport (Figure 3-15). Of the mapped outfalls, 20 were discharging when initially mapped. Five were sampled for *E. coli* bacteria during dry weather sampling on 9/10/2019. *E. coli* bacteria concentrations ranged from 1 – 138 –MPN/100ml. No site exceeded the instantaneous criterion of 236 MPN/ml.

Documenting an outfall (white pipe extruding from grassy bank in left of photo) during the 2019 stormwater outfall survey. © WNERR

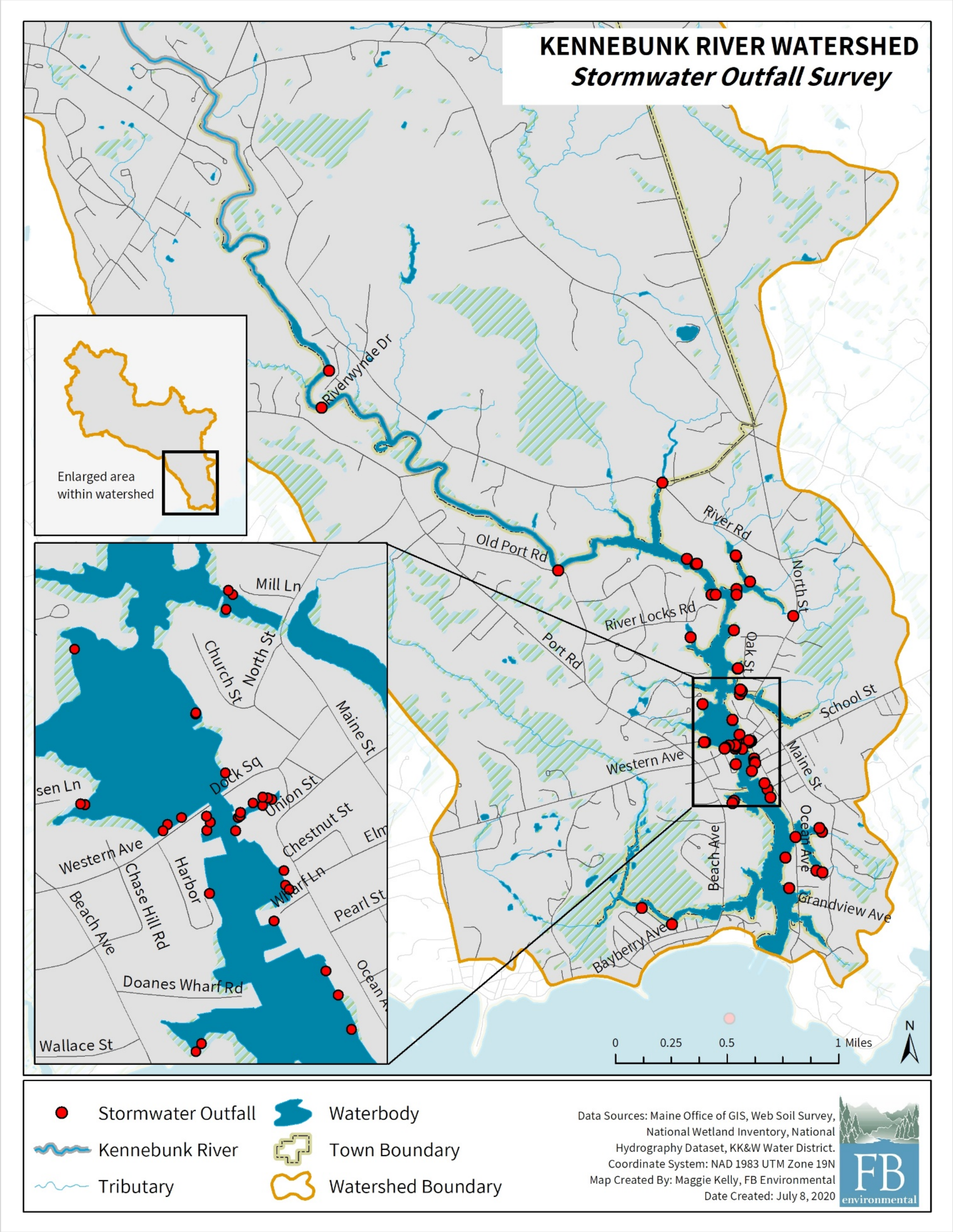


Figure 3-15. Stormwater outfalls mapped in the Kennebunk River watershed from the head of tide to river mouth during the 2019 stormwater outfall survey.

4 Community Engagement

4.1 Developing a Community-Based Watershed Management Plan

A WBMP helps identify problems, list priorities, and outline actions that are needed to restore the water quality of a stream (USEPA, 2008). A good plan acts as a road map pointing out where to start, how long it will take to get there, how much it will cost, and how you know you've arrived. Since each watershed is unique, the WBMP is also unique in order to address the major issues and concerns of the watershed's community. The goals and objectives of the Kennebunk River WBMP should be collaboratively revisited and revised on an annual basis (Figure 4-1).

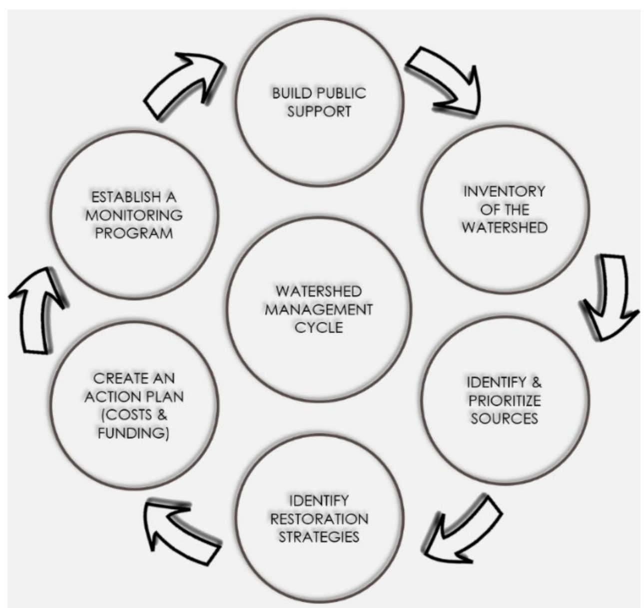


Figure 4-1. The watershed management cycle.

Successful development of this watershed restoration plan depended heavily on the commitment and involvement of community members. These partnerships helped strengthen the plan by increasing both public awareness of the problems and public commitment to the solutions. Many of the recommendations in the plan will require landowner cooperation within the Kennebunk River watershed to implement best management practices on private land. As such, it will be important to continue to develop a strong education and outreach program that targets residents of the watershed in an effective and transparent way. Once landowners understand the importance of restoring the Kennebunk River, they may be more likely to participate in the restoration process. The WBMP is a 'living, breathing, document', meaning that it should be revisited and updated as restoration continues in the Kennebunk River watershed.

The following groups or individuals have been identified as potential public participants to help implement recommendations described in this plan:

- Local Elementary, Middle, and High Schools

- Watershed Landowners
- Towns of Arundel, Lyman, Kennebunk, and Kennebunkport (City Council, Planning Board, Recreation Department)
- Maine DEP
- US Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS)

Local partners have demonstrated a strong commitment to improving water quality conditions in the Kennebunk River and surrounding tributaries. In addition to representatives from each community, the project steering committee was composed of representatives from the following organizations:

- Arundel Conservation Trust
- Cape Arundel Golf Course
- Kennebunk, Kennebunkport, Wells Water District
- Kennebunk Conservation Commission
- Kennebunk Harbor Master
- Kennebunk Public Works
- Kennebunk Sewer District
- Kennebunkport Conservation Trust
- Maine Healthy Beaches
- Mousam Kennebunk Rivers Alliance
- State of Maine Department of Environmental Protection
- USDA/Natural Resource Conservation Service
- Wells National Estuarine Research Reserve

The steering committee held four meetings over the course of the project on December 24, 2019, January 24, 2020, May 7, 2020, and July 29, 2020.

In addition to the steering committee, the project had a technical advisory committee (TAC) to oversee the technical elements of the plan. Meetings were held on April 4, 2019, November 1, 2019, and January 24, 2020, enabling productive discussions that helped guide the watershed planning process. The TAC provided valuable insight in both preparation and synthesis of 2019 field surveys.

4.2 Public Participation

The following section was written in collaboration with the Wells National Estuarine Research Reserve (WNERR); WNERR led the public outreach portion of the project and provided the following information (summarized by FB Environmental) for this final Plan.

In August 2020, a GIS StoryMap (the Clean Water for Kennebunk River Story Map) was developed to share about the Kennebunk River Watershed-based Management Plan project and findings from the Kennebunk River Water Quality Report & Watershed Stressor Guide (FB Environmental Associates, 2020). A GIS StoryMap is an interactive platform used for sharing spatial data. Participants were asked to take a survey after reading the Story Map and to join a community-led Zoom discussion. Below are the findings from the survey and highlights from the Zoom discussions.

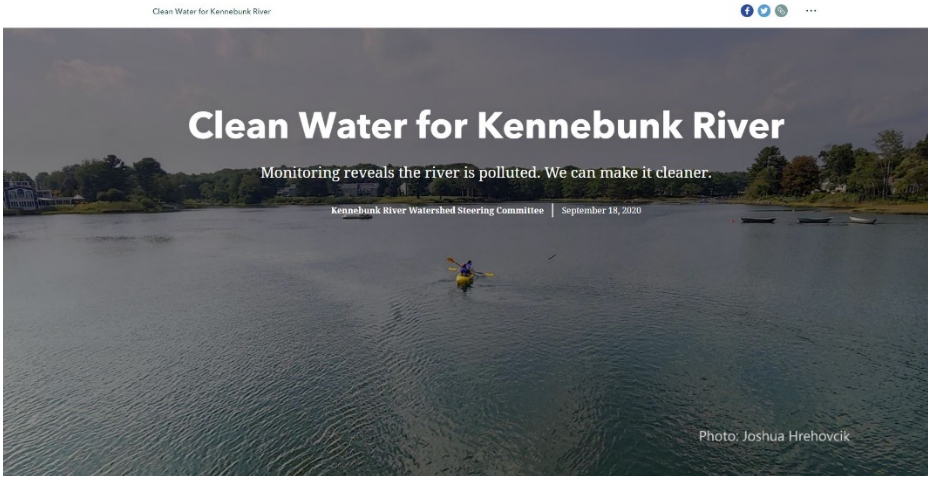


Figure 4-2. A screenshot of the cover page for the Kennebunk River StoryMap.

4.2.1 Survey Results

WNERR Coastal Training Coordinator, Annie Cox, developed an online community survey that was designed to gather public feedback on the priorities for protection and restoration of the Kennebunk River. The reader was first guided through the StoryMap, where they were introduced to the watershed area, the river and its tributaries, and the pollution issues in the river. At the end of the StoryMap was a link to a survey administered through Google Forms. The survey was designed to be a short survey asking respondents about their relationship/understanding of the river and their priorities for future protection and restoration. The goal of the survey was to incorporate the needs and priorities of the community into this WBMP. It is important to note the limitations of the online survey; there was a total of 137 respondents and 67% of those were residents of Kennebunk or Kennebunkport (Figure 4-3). As such, the rural portion of the watershed predominately located in Arundel and Lyman, was under-represented. Of the 137 responses, the majority lived within the watershed (about 75%).

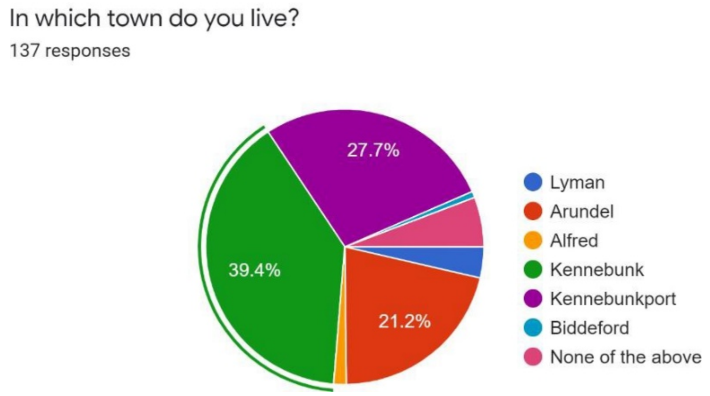


Figure 4-3. Location of survey respondents.

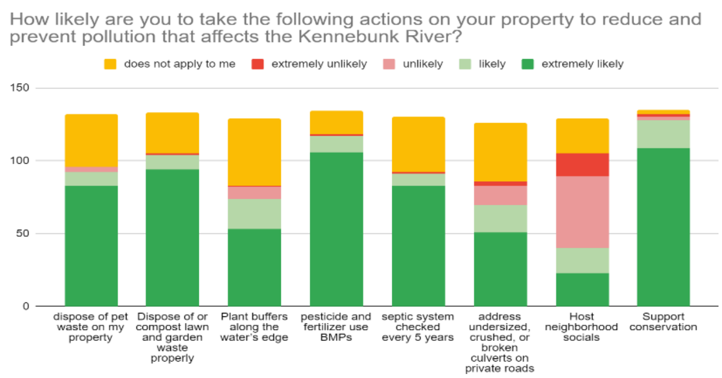


Figure 4-4. The results of the survey for the question "How likely are you to take the following actions on your property to reduce and prevent pollution that affects the Kennebunk River?"

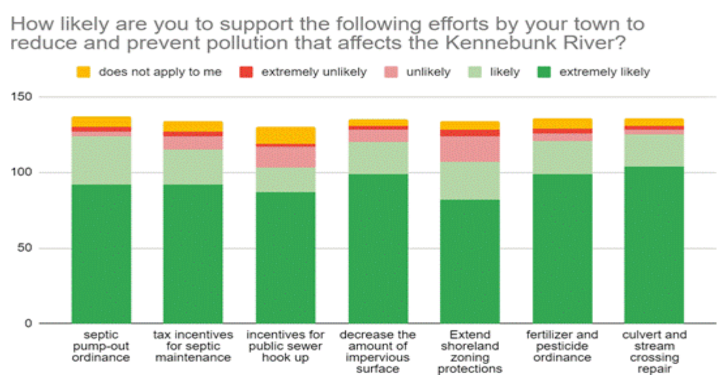


Figure 4-5. The results of the survey for the question "How likely are you to support the following efforts by your town to reduce and prevent pollution that affects the Kennebunk River?"

When asked why they considered the river important, the majority of respondents indicated that it was a place to enjoy nature (recreate) and an important place for wildlife. Additionally, a significant portion of the respondents indicated that they appreciated the views from the river. Other respondents noted that it provides important ecosystem services (e.g. water supply, clean ocean water, flood protection). Respondents primarily recreate in the watershed on the water (canoeing/kayaking/paddleboarding) and by hiking. Other activities include swimming, fishing, picnicing, bird watching, dog-walking, golfing, and more.

89.8% of respondents indicated that cleaning up sources of pollutants in the Kennebunk River was "very important". The respondents were then polled on their likliehood of taking action to protect the river, both on their own property (Figure 4-4) and at the town level (Figure 4-5). Of the actions recommended, the majority of participants were willing to support conservation, and reduce pesticide and fertilizer use through best management practices. However, respondents were either "extremely likely" or "likely" to support most recommended actions on private property. When polled on their liklihood of taking action at the town level, respondents were overwhelmingly supportive of all recommendations.

> ***"Being smart about development is important. Having higher density developments that then keep 'common space' or conservation space near the river are important." – Watershed Resident***

The respondents were then asked about their priorities for action items to reduce pollution to the Kennebunk River. Respondents were given the following choices to select from:

(1) Prevent pollution entering the river along the Route 1 corridor;
(2) Fixing/replacing culverts and stabilizing banks;
(3) Fix ponding and algal growth with culvert improvements;
(4) Optimize fish passage with culvert improvements;
(5) Determine Kennebunk River mainstem riverbank erosion causes through geomorphic study;
(6) Increase stream bank vegetated plantings to optimize pollutant removal;
(7) Establish funding strategies for land conservation and protection;
(8) Support best practices for agricultural landowners, such as through funding assistance for pursing BMP installations;
(9) Sustain the Kennebunk River Watershed Steering Committee to implement actions identified in this plan;
(10) Develop and implement a baseline water quality monitoring program to measure if efforts to reduce pollutants are working; and
(11) Increase awareness around the importance of septic system maintenance.

> ***"I think most people want to be good stewards of the watershed, but need leadership from their towns, and state/federal funding incentives to follow through." – Watershed Resident***

For all choices, the majority of respondents identified action items to be "very important" or "important", with the choices to develop a baseline water quality program, establish funding strategies for land conservation, and support best management practices for individuals being the highest ranking options for "very important" (Figure 4-6). A geomorphic study to understand riverbank erosion was the lowest ranking option for "very important".

All survey comments on thoughts or concerns for developing the Watershed Based Management Plan for the watershed are included in Appendix B.

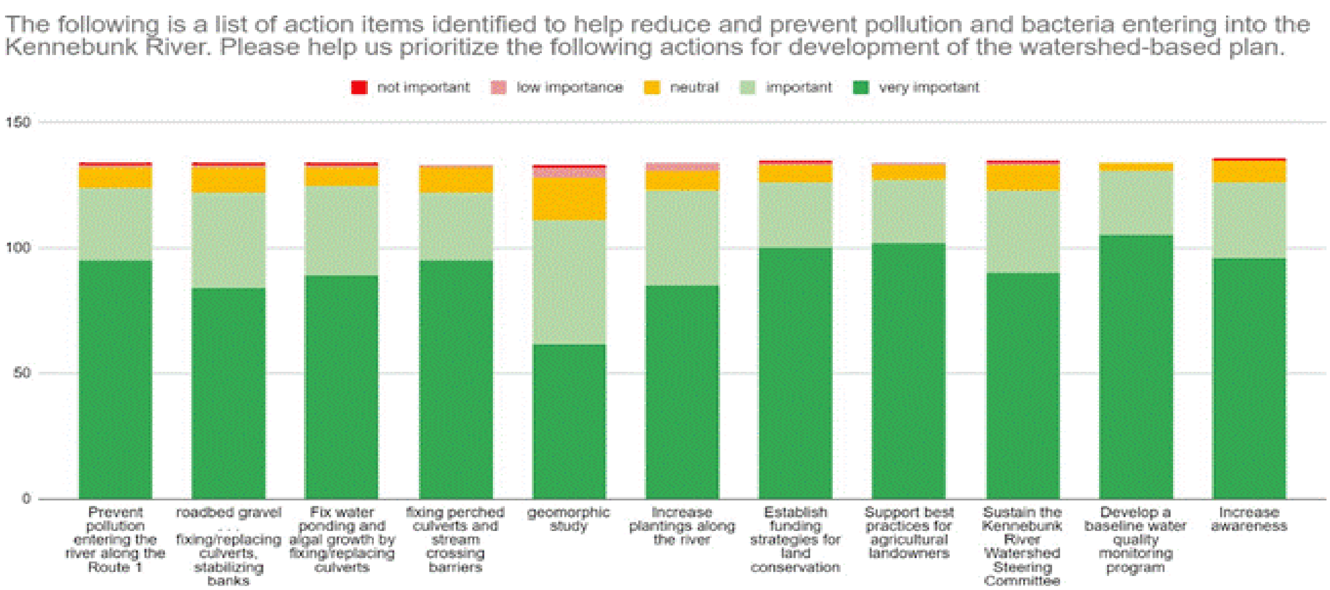


Figure 4-6. The results of the survey question for prioritized action items identified to reduce and prevent pollution and bacteria entering the Kennebunk River.

4.3 ORDINANCE REVIEW

The Wells National Estuarine Research Reserve spoke with representatives from each major community in the watershed (Arundel, Kennebunk, Kennebunkport, and Lyman) to identify existing ordinances in place to protect natural resources and water quality. Table 4-1 outlines ordinances these ordinances by town.

Table 4-1. Ordinance review results for the four primary communities in the Kennebunk River watershed (Kennebunk, Kennebunkport, Arundel, and Lyman).

	ORDINANCE	CURRENTLY PRESENT?	DETAILS	CURRENTLY PRESENT?	DETAILS	CURRENTLY PRESENT?	DETAILS	CURRENTLY PRESENT?	DETAILS
		Kennebunk		**Kennebunkport**		**Arundel**		**Lyman**	
Regulatory	Shoreland Zoning beyond state minimum			✓	Portions are stricter (non-conforming structure expansion, septic locations, etc.)	✓	Shoreland Overlay District (additional protections for perennial streams and wetlands) and setbacks for perennial and intermittent streams outside of Shoreland district		
	Cluster or open space provisions for subdivisions			✓	Clustering has to be considered; open space required but can do an in-lieu of fee on a case by case basis	✓	Anything greater than 4 lots	✓	
	Septic pump out ordinance		Recommended in 2020 CP		Bi-annual; documentation to town upon request				
	Growth cap		Repealed (year unknown)	✓		✓			Min. 5-acre lot
	Beginning with habitat criteria in ordinances		Recommended in 2020 CP		Recommended in CP; comes into play for DEP review				
	Watershed protection regulations or overlay					✓			
	Phosphorus loading analysis required for freshwater bodies								

ORDINANCE	Kennebunk: CURRENTLY PRESENT?	Kennebunk: DETAILS	Kennebunkport: CURRENTLY PRESENT?	Kennebunkport: DETAILS	Arundel: CURRENTLY PRESENT?	Arundel: DETAILS	Lyman: CURRENTLY PRESENT?	Lyman: DETAILS
Nitrogen loading analysis required for estuarine/saltwater bodies					N/A		N/A	
Low impact development requirements and standards	✓	Recommended in 2020 CP		Recommended by planning board, generally LID is cheaper for a developer				
Uses detrimental to water quality not permitted outside of Shoreland Zoning			✓	Town-wide regulation for Water Quality	✓			
Fertilizer and/or pesticide ordinance		Recommended in 2020 CP						
On-site stormwater retention requirement more stringent than state requirements								
Storm frequency for design standards more stringent than minimum		Use DEP requirements		Use DEP requirements		Use DEP requirements		
Sea level rise overlay zone and associated development standards							N/A	
Future marsh migration overlay zone and associated development standards							N/A	

	ORDINANCE	Kennebunk: CURRENTLY PRESENT?	Kennebunk: DETAILS	Kennebunkport: CURRENTLY PRESENT?	Kennebunkport: DETAILS	Arundel: CURRENTLY PRESENT?	Arundel: DETAILS	Lyman: CURRENTLY PRESENT?	Lyman: DETAILS
	Animal husbandry and agriculture use		Agriculture and keeping of horses permitted in many zones, need special exceptions in resource protection area or Branch Brook Aquifer District. Standards for keeping of horses ~1 horse/2-acre fenced open area		Agriculture is allowed in most zones. Animal husbandry is allowed in limited areas (Free Enterprise Zone; Village Residential & Village Residential East Zone (accessory unit subject to appeals review); Farm and Forest Zone).		5 animal units allowed in most zones but must be approved by the Planning Board as a conditional use. There are specific standards for animal husbandry.		The keeping of animals other than household pets may be permitted on lots 3 acres or greater in the Residential District and 2 acres or greater in all other districts
	Development transfer overlay district								
Conservation Funding Strategies	Conservation impact fees								
Conservation Funding Strategies	Wetland mitigation fund								
Conservation Funding Strategies	Fee in lieu of land dedication								
Conservation Funding Strategies	Stormwater utility district								
Conservation Funding Strategies	Open space fund								
Conservation Funding Strategies	Open space plan	✓							
Conservation Funding Strategies	Land Trust	✓	Kennebunk Land Trust	✓	Kennebunkport Conservation Trust	✓	Arundel Conservation Trust		

	ORDINANCE	Kennebunk CURRENTLY PRESENT?	Kennebunk DETAILS	Kennebunkport CURRENTLY PRESENT?	Kennebunkport DETAILS	Arundel CURRENTLY PRESENT?	Arundel DETAILS	Lyman CURRENTLY PRESENT?	Lyman DETAILS
	Watershed tax increment financing								
Non-Regulatory Approaches	State approved comprehensive plan	✓	Pending 2020 update		Needs update, adopted 2012			✓	
Non-Regulatory Approaches	Incentive-based programs for voluntary LID implementation	✓	Can increase from 50 to 75% impervious coverage if use LID						
Non-Regulatory Approaches	Incentive and/or encourage property owners to implement LID stormwater practices								
Non-Regulatory Approaches	Incentive-based programs for stormwater reduction efforts								
Non-Regulatory Approaches	Conservation commission review of development applications	✓	Advisory					N/A	
Non-Regulatory Approaches	Encourage property owners to put land into farmland/tree growth programs		State incentive		State incentive	✓	Open space tax exemption	✓	

5 MANAGEMENT STRATEGIES

Watershed studies and community stakeholder involvement provide an excellent framework for identifying and understanding the sources of pollution affecting water quality and aquatic habitat in the Kennebunk River watershed. This information has led to the development of locally-driven solutions, organized and prioritized in the action plan. Successful restoration of the river requires setting goals and developing objectives to help meet those goals. The following restoration plan provides key actions needed to restore the river, the timing of these actions, and the mechanisms by which these actions will be accomplished.

5.1 Goals and Objectives for Restoration

The Kennebunk River Technical Advisory Committee in coordination with the Steering Committee set the following goals for this WBMP:

- Restore Kennebunk River by providing sound management recommendations that will help the Kennebunk River meet Class B and Class SB water quality standards in the freshwater and estuarine portions of the watershed, respectively, through improvement of aquatic habitat and water quality of the stream. Protect the stream and its tributaries from current and future impacts.
- Remove the Kennebunk River main stem from impaired listing due to aquatic life use (macroinvertebrates and algae bioassessments) and *E. coli* bacteria impairment.
- Remove Duck Brook from impaired listing due to *E. coli* bacteria impairment.
- Identify, and if necessary, reduce sediment and nutrient inputs to the river and tributaries caused by erosion from agriculture and development.

These ambitious goals can only be achieved through the energy and commitment of a coordinated group of local community leaders who manage and partner with conservation groups, state and federal partners, and citizens of the watershed.

5.2 Action Plan to Protect and Restore Water Quality and Habitat

Actions are needed to address the major environmental stressors in Kennebunk River (impairments for *E. coli* bacteria and aquatic habitat for macroinvertebrate and algae). Table 5-1 provides a list of these actions.

This action plan outlines executable steps to address water quality impairments in the main stem of the Kennebunk River and its tributaries. Additionally, it outlines protection measures for waterways with declining water quality. This action plan focuses on both structural and non-structural action items. Structural action items are those that use the construction of stormwater control devices to reduce stormwater nonpoint source pollution (e.g. bioretention basins, vegetated buffers, underground storage). Typically, structural BMPs focus on reduction or treatment of stormwater by directing or redirecting stormwater drainage to engineered soil and/or vegetative filter systems or natural vegetated areas, pervious pavement, or detention or retention ponds. Non-structural BMPs are those which involve operational changes, such as allowing natural vegetation to grow along stream banks rather than aggressively mowing, enacting pet waste ordinances or stormwater ordinances, reducing fertilizer application in agricultural areas, regular street sweeping, and maintaining existing stormwater treatment systems. Non-structural action items hold equal importance in an effective Watershed-Based Management Plan and contain actions such as changes to regulatory policy (e.g. ordinances), maintenance, and education and outreach. A combination of structural and non-structural BMPs is usually the most effective and both will be needed to restore the Kennebunk River and its tributaries.

Survey Work Action Steps

The 2019 survey results of the Kennebunk River and tributaries provide identified, site-specific action items that can be taken to progress towards reaching the goals of this document. In summary, the results of the Kennebunk River Stream Corridor Assessment and Watershed Inventory conducted in 2019 identified sites of NPS pollution concern and documented river characteristics that could be contributing to known hotspots of fecal contamination and nonattainment for aquatic life. The Unusual Conditions survey pointed to several small drainages and tributaries, as well as eroding riverbanks and potential areas of high nutrients resulting in algal growth. The Stream Corridor Habitat Surveys and Rapid Geomorphic Assessments allowed for a better understanding of stream and watershed characteristics that could be degrading overall habitat quality, leaving the waterway vulnerable to other anthropogenic stressors. The Watershed Inventory indicated that upgrades to roadside buffers, culverts, waste management, and agricultural practices could improve river and watershed health. The stormwater outfall survey indicated that additional sampling may be needed to determine if outfalls are contributing to high bacteria counts.

5.3 Actions to Raise Public Awareness and Community Support

Public awareness and support are critical to the Kennebunk River and surrounding tributaries' restoration and protection. This WBMP provides action items to use for building and maintaining this support over time. Table 5-1 on the next page lists recommendations, potential partners, timeframes, and costs for action items that raise public awareness and community support. Often, these action items are linked closely with the success of structural BMPs (i.e. stormwater infiltration system) and thus, are included in the same action table.

Education & Outreach action items will promote awareness of the connection between watershed citizen's actions and the health of their local streams, rivers, and lakes. Therefore, efforts should focus on engaging community groups, commercial businesses, city, state and private maintenance crews, residents, and school groups to optimize engagement and restoration.

Administrative & Funding action items are a vital part of bringing both structural and non-structural BMP recommendations to fruition. While some activities can be undertaken with minimal to know funding, other actions require funding. Funding should be a high priority throughout plan implementation but should never stymie progress; there are always actions that can be accomplished. But for the larger more aggressive activities such BMP retrofits or agricultural landowner engagement in restoring riparian buffers, the watershed towns and their partners should be aware of and apply for funding opportunities as they arise. Information on applicable grant funding opportunities is presented in section 6.1.

Table 5-1. Action plan for the Kennebunk River watershed.

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
BACTERIA STRESSORS				
Reduce pet waste disposal around Eastern Trail intersections	Add signage, trash cans, and bags around the sections of the Eastern Trail that cross the tributaries of the Kennebunk River to encourage pedestrians to clean-up dog poop near surface waters. Use these opportunities to educate the public on the connection of these tributaries to the Kennebunk River. Cost includes annual funding for signs, trash cans, bags, increased clean-up and trash clean-out efforts.	Towns of Arundel and Kennebunk	Ongoing	$7,500 - $10,000
Partner with the USEPA on investigative monitoring in hotspots	Partner with USEPA (in process) to perform investigative sampling on Duck Brook and Duck Brook Tributary A, where fecal contamination has been elevated. Use a combination of robust tracking measures and bracket sampling to further isolate the timing and location of high bacteria.	USEPA with support from MHB	2021 and annually as available	Cost covered by Maine DEP/U.S. EPA
Include co-indicators in baseline monitoring for tracking fecal contamination*	Build on the existing VRMP monitoring program to include co-indicator parameters in baseline sampling. Recommendations include ortho-phosphate, ammonia, and nitrate-nitrite to accompany the existing optical brighteners and *E. coli* /*Entero* sampling. Cost estimated at $150 per site for 10 sites sampled six times per season. Six seasons included. (Labor not included because sampling would be in addition to routine measures.)	VRMP	Annually from 2021 - 2026; re-assess data and continue until 2031 if needed	$54,000 - $60,000
Promote septic system awareness in rural portions of the Kennebunk River watershed	Pursue changes in local ordinances and tax incentives for septic maintenance, such as a septic pump-out ordinance (does not exist in any of the four communities). Cost estimated for labor to hire consultant for ordinance writing.	All communities, Consultant	Draft pump-out ordinances by 2026, implement by 2031	$10,000 - $20,000
Partner with the marinas on the Kennebunk River to prevent any recreational boat pollutant discharges	Work with local marinas to ensure all recreational boat users are following mandated discharge of pollutants laws. Use clear signage at river entrance and around marinas to direct boaters to properly discharge all wastewater. Consider incentivizing marinas to have free pump out stations. Cost estimate includes signage along river to enforce prevention of pollutant discharge and educational signage at marinas about protecting water quality.	Towns of Kennebunk and Kennebunkport; marinas	2021	$1,000 - $5,000

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
Incentivize hook-ups to public sewer through amnesty or grant funding	Encourage community members with old septic systems to connect to public sewer. Cost unknown - depends on outreach methods.	Kennebunk and Kennebunkport	2025	NA
NUTRIENT STRESSORS				
Create robust nutrient dataset	At minimum, collect co-indicator parameters listed above (ortho-phosphate, ammonia, nitrate-nitrite) concurrent with VRMP E. coli and *Entero* sampling to improve nutrient dataset. Current data on Lords Brook, Carlisle Brook, and Ward Brook show high total phosphorus and require investigative sampling. Cost here is estimated at $150 per site for 3 sites (one on each brook) sampled six times per season. (Labor not included because sampling would be in addition to routine measures.)	Maine DEP, VRMP, WNERR	Annually from 2021 - 2026; re-assess data and continue until 2031 if needed	$16,200 - $19,200
Communicate with agricultural landowners the importance of manure storage as well as spreading and management of animal manure and runoff	Begin with sites identified in the watershed survey as possibly having uncovered manure storage and/or manure storage close to surface waters. Work collaboratively with agricultural landowners to identify funding opportunities to assist in constructing covered manure storage and to manage spreading of animal manure and runoff. Cost estimated based on eleven possible manure storage locations.	YCSWCD, NRCS, University of Maine Cooperative Extension	Ongoing	$220,000 - $275,000
Collaborate with small or hobby farm owners to ensure proper nutrient management	Identify and work with local horse or hobby farm owners to identify nutrient sources and implement best management practices on their property. Cost estimated for labor to attend meetings for one season.	YCSWCD, NRCS	Meet with landowners in 2021	$1,000 - $2,500
Create Nutrient Management Plans	Work with agricultural landowners to create Nutrient Management Plans that provide recognition and/or awards. Cost estimated at $10,000 - $15,000 per plan and estimated for four sites.	YCSWCD, NRCS	Complete NMPs for four sites by 2031	$40,000 - $60,000
Identify riparian buffer widths that currently exist and areas that need improved riparian buffers	Work with agricultural landowners to identify fields with established wide buffers to avoid heavy equipment on the banks. Expand on sites identified in the survey from public right-of-way, identify areas on private land that require improved wide buffers.	YCSWCD and NRCS	2021	$1,000 - $5,000

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
Improve and maintain private gravel roads (four sites)*	Address undersized, crushed, and broken culverts on the private gravel roads around Kennebunk Pond. Cost estimated at $5,000-$10,000 for each site.	YCSWCD and Town of Lyman	2021 - 2023	$20,000 - $40,000
Implement recommendations for remaining watershed survey sites*	This includes two construction sites, two gravel pits, one logging site, four municipal road sites, nine town road sites, and two sites directly on a surface waterbody.	Four Towns	2023 - 2025	$78,000 - $200,000
Identify stormwater infiltration and treatment retrofit opportunities in developed Route 1 corridor and in the Kennebunkport Dock Square area*	Perform a watershed survey of the Route 1 developed corridor to identify opportunities for stormwater infiltration. Prioritize results and pursue funding for implementation.	YCSWCD, Consultants	2022	$7,500 - $10,000
Work with local marinas to follow stormwater management regulations	Engage with local marinas to ensure all stormwater and wastewater is being properly managed and is not entering adjacent surface waters.	Towns of Kennebunk and Kennebunkport; marinas; YCSWCD	2021	$1,000 - $2,000
Reduce impervious cover	Reduce impervious cover in both new development and retrofits of existing development through ordinances. Cost estimate is for consultant to review and modify existing ordinance.	Four Towns	Ongoing	$40,000 - $80,000
IN-STREAM HABITAT AND CHANNEL GEOMORPHOLOGY STRESSORS				
Improve riparian buffer and reduce bank erosion on the main stem of the Kennebunk River*	Fund in-depth geomorphic study of the Kennebunk River main stem to identify the cause of bank erosion and high turbidity noted during the rapid geomorphic assessment in 2019. Likely causes include volume control, and reduced riparian buffer. Estimated costs include a full geomorphic study as well as restoring approximately 10,000 linear feet of unbuffered shoreline (estimated using Google Earth imagery).	Consultant (geomorphologist)	2021 - 2022	$60,000 - $120,000

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
Extend shoreland zoning protections, particularly in Kennebunk and Lyman	Extend shoreland zoning protections further than state requirements in Kennebunk and Lyman (Kennebunkport and Arundel have already implemented stricter shoreland protections). This could include shoreland overlay districts for perennial and intermittent streams and wetlands, septic location requirements, and requirements for non-conforming structures. Cost estimated at $10,000 - $20,000 per Town for consultant to review and modify existing ordinances.	Four Towns, DEP	2021 - 2023	$40,000 - $80,000
Prioritize conservation land in areas focused on water resource protection*	Work with the Kennebunk Land Trust on prioritizing conservation land in the watershed that protects the Kennebunk River headwaters and riparian corridor. Collaborate with the Kennebunk, Kennebunkport, & Wells Water District to identify sensitive locations for conservation. Cost includes plan development for conservation priorities, but does not include land purchase costs.	KLT, KKW Water District, Land for Maine's Future Grant Program	2021	$10,000 - $20,000
Perform stream crossing surveys on sites with "potential barrier" and "barrier" identified in the Maine Stream Habitat Viewer	This includes site 4029 (Downing Rd) and 4041 (Perkins Lane) on the main stem which have been identified as potential barriers as well as the dam at Alewife Road. Survey barriers and identify recommendations. Estimated cost includes one survey visit for each site.	Consultant (hydrologist)	2023	$2,200 - $2,500
Install continuous monitoring devices for temperature and dissolved oxygen	Use continuous loggers to track temperature and dissolved oxygen at 15-minute intervals during the critical summer season at the outlets of Duck Brook, Ward Brook, and Goff Mill Brook.	Consultant	Annually from 2021 - 2026; re-assess data and re-deploy until 2031 if needed	$85,000 - $120,000 for 2021-2026
EDUCATION AND OUTREACH				
Conduct outreach to stream abutters*	Install signage and host neighborhood socials to educate residents on the connection of small tributaries to the Kennebunk River. Introduce residents to the concept of holistic watershed management, including concepts such as maintaining a robust riparian buffer, and fertilizer reductions.	YCSWCD	2021	$2,500 - $5,000

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
Raise public awareness and education regarding fertilizer and pesticide application*	Work with residential neighborhoods to raise awareness with regard to fertilizer and pesticide application and disposal of lawn waste. Encourage residents to use natural landscapes. Explore possibility of a fertilizer and pesticide ordinance (such as South Portland and Falmouth).	Four Towns; YCSWCD	Annually; Establish Ordinance committee by 2023	In-house
Educate animal agricultural landowners on conservation practices	Manage grazing (pasture and range) to minimize erosion and runoff, and stabilize drainage ditches and the streambank to minimize erosion.	YCSWCD	2021-2023	$2,500 - $5,000
	Restrict animals from certain sites (stream areas or drainage ditches) and fence streambank to keep livestock out of water course.			
	Install and maintain manure handling systems (houses and lagoons) and manage barnyard storm water. (Estimated cost for all items does not include implementation.)			
Educate crop agricultural landowners on conservation practices	Reduce exposed soil and improve soil health with winter cover and conservation tillage (cover crop, leaving grain stubble or mulch).	YCSWCD	2021 - 2023	$2,500 - $5,000
	Use at a minimum a three-year crop rotation cycle.			
	Install grass or rock-lined waterways to reduce erosion where there is concentrated flow. Ensure that waterway outlet structures are stable and dissipate water before discharging to a buffer or ditch. (Estimated cost for all items does not include implementation.)			
Collaborate with the Cape Arundel Golf Course on real-time meteorological data	The Cape Arundel Golf Course has a weather station with rainfall and temperature data. Collaborate with them to create a real-time online platform with precipitation and temperature data available to the public and researchers. Estimated cost does not include system maintenance or data analysis.	Cape Arundel Golf Course; Consultants	2021	$2,500 - 5,000
Collaborate with schools within the watershed to engage students in water quality protection efforts*	Work with Kennebunk High School and other students in the watershed to perform and analyze water quality sampling.	Schools in Four Towns	2021-2025	NA

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
Collaborate with Maine Audubon's Stream Explorers Program	Work with Maine Audubon to get watershed volunteers involved in the Audubon Stream Explorers Program to gather data and educate watershed residents on benthic macroinvertebrates.	Maine Audubon	2021-2031	NA
Create or update Open Space Plans for each of the Four Towns	Arundel is currently establishing an Open Space Committee. Kennebunk has an Open Space Plan from 2004. Work with the other two Towns to establish Open Space Committees and write comprehensive open space plans that prioritize natural resources and water quality protection and work with Kennebunk to update their Open Space Plan.	Four Towns; Open Space Committees; Consultants	2025	$120,000 - $180,000
Interview/survey municipalities on salt storage and salt use practices	Existing data on specific conductance and chloride does not suggest chloride contamination, however, prevention is important in a developed watershed such as the Kennebunk River. Interview/survey municipalities to identify current salt storage and salt use practices to identify any needed improvements for the prevention of surface water contamination in freshwater portions of the watershed.	YCSWCD; Four Towns	2022	$5,000 - $7,500
ADMINISTRATION AND FUNDING				
Establish open space funds*	Establish an open space fund for land conservation and protection in all four communities (following the update/completion of Open Space Plans).	Four Towns	2021 - 2025	In-house
Establish funding strategies for agricultural BMP installation*	Support best management practices for agricultural landowners through funding assistance programs.	Four Towns	2021 - 2025	In-house
Consider conservation funding strategies targeted at commercial development	Establish conservation funding strategies such as wetland mitigation funds, stormwater utility districts, conservation impact fees, and watershed TIFs.	Four Towns	2021 - 2023	In-house
Extend land trust jurisdictions to Lyman and/or create new land trust	At the time of writing, there are no local land trusts holding land in Lyman. Work with existing local land trusts, such as the Kennebunk Land Trust, Arundel Land Trust, and Kennebunkport Conservation Trust, to identify the best way forward to establish land trust relationships in the Town. Recommend reaching out to the	Kennebunk Land Trust; Southern Maine Conservation Collaborative	2025	NA

ACTION	HOW	WHO	COMPLETION DATE	ESTIMATED 10-YR COST
	Southern Maine Conservation Collaborative for assistance and advice.			
Maintain a consistent funding mechanism for Plan implementation	Apply for state and federal grants and/or seek other funding to support implementation of planning recommendations in this action plan.	Four Towns	Annually	NA
Ensure sufficient support to enact Plan*	Host annual meetings to re-visit milestones and action items identified in the Plan via a Kennebunk River steering committee. Implement programs, enforce ordinances, oversee construction, and create educational programs.	Four Towns; Steering Committee	Annually	In-house
Consider incorporating the Kennebunk River Watershed-Based Management Plan into the Town Comprehensive Plans	Incorporate the WBMP into the next round of Comprehensive Plan updates (all Towns have recent comprehensive plans except for Arundel, which was amended most recently in 2016). Create amendments to recent Comprehensive Plans to include protection of the river through adoption of this plan.	Four Towns	2021	In-house

**Recommendations were supported by the community via the survey and survey comments and/or the public meetings.*

5.4 POLLUTANT REMOVAL

Pollutant loading present in the Kennebunk River watershed was modelled and estimated using two models; a bacteria source calculator to estimate fecal coliform loading in the watershed (section 5.4.1), and the Model My Watershed model that calculates stormwater runoff, sediment, and nutrient loading in a watershed (section 5.4.2). The results of these two models were used to calculate pollutant reduction targets for the watershed (section 5.4.3).

5.4.1 Bacteria Source Calculator

Estimates of bacteria loading in the Kennebunk River Watershed were calculated for fecal coliform using a bacteria source loading estimates calculator created by FBE in collaboration with the New Hampshire Beaches program in 2010 (Bell & Dalton, 2010). This model is a deterministic bacteria load estimation, meaning potential sources were identified, quantified using literature values and spatial mapping data, then summed. Bacteria source loads estimated included 1) developed area runoff, 2) failing septic systems, 3) agricultural area runoff from livestock; and 4) natural area runoff from wildlife.

Annual bacterial loads estimated in the spreadsheet model from all sources totaled 511 trillion fecal colonies per year. Model results indicated that the majority of the fecal coliform load in the Kennebunk River Watershed is coming from failing septic systems.

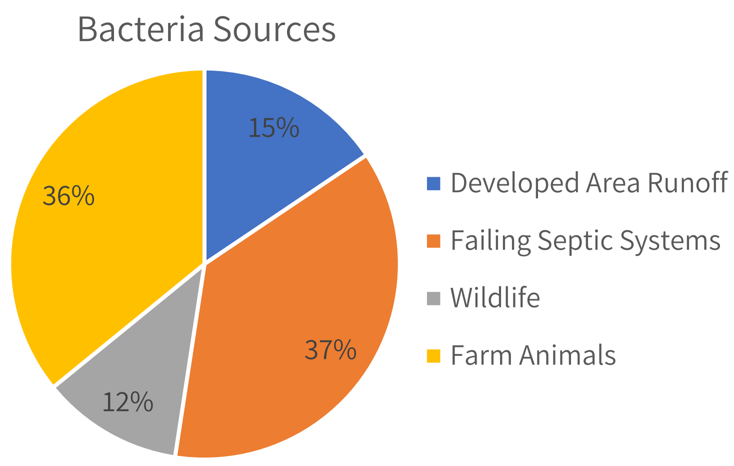


Figure 5-1. Bacteria sources contributing to the Kennebunk River Watershed, broken down by source (developed area runoff, failing septic systems, wildlife, and farm animals).

Table 5-2. Estimated fecal coliform load (fecal colonies per year) to the Kennebunk River watershed.

Category	Fecal Coliform Load (fecal colonies per year)
Developed Area Runoff	7.97E+13
Failing Septic Systems	1.88E+14
Wildlife	5.99E+13
Farm Animals	1.83E+14
TOTAL	**5.11E+14**

Potential Sources of Bacteria

Developed Area Runoff

Stormwater runoff is surface water flowing from developed surfaces during storm events. As rainwater moves over the land and into local surface waters, it transports pollutants, such as bacteria, from various sources across the landscape. In the absence of vegetated buffers or other treatment practices, this stormwater runoff flows untreated into nearby storm drains or directly into surface waters and can cause elevated bacteria concentrations. Developed land use included in the analysis includes roadways, parking lots, roofs, and lawns and is sourced from the Maine Landcover Dataset (MELCD, 2006). Developed area within the Kennebunk River watershed is primarily concentrated around the Kennebunk and Kennebunkport town centers and along Route 1.

Livestock and Agriculture

Agricultural activities and livestock can impact water quality by contributing nutrients and bacteria from sources such as fertilizer application, uncovered manure piles, manure spreading, and livestock access to stream channels. Delivery of nutrients and bacteria from agricultural land is exacerbated in areas with poor riparian buffers, causing the delivery of untreated runoff to surface waters. The Kennebunk River Watershed has many crop or livestock farms, concentrated mostly in the central watershed adjacent to the upper main stem of the river, as well as smaller hobby farms. Livestock present in the watershed are estimated using the Model My Watershed animal populations estimated from county-level data from the United States Department of Agriculture and included cows (beef and dairy), chickens (broilers), pigs, sheep, horses, and turkeys (National Agricultural Statistics Service, 2020). Estimates were adjusted based on information about number of farms and farm livestock present within the watershed provided from York County Soil and Water Conservation District (YCSWCD) and NRCS. However, the estimates should be treated as such and are meant to provide a general idea of fecal coliform loading due to presence of farm animals in the watershed.

Septic Systems

If not sited or maintained properly, malfunctioning or failing septic systems can contaminate the local groundwater and surface water. Compromised septic systems may be due to infrastructure issues, such as aging wastewater systems installed prior to modern design requirements, systems which have never been maintained or pumped out, errors in design or construction, or excessive or improper usage. Additional environmental risk factors may increase the bacterial loading to rivers from failing systems, including locations next to streams or wetland, those which experience high groundwater or frequent flooding, or those surrounded by soils which do not provide natural bacteria reduction in case of failure. (e.g., very high levels of sand, clay, or rock outcrops). These combined factors allow pollutants such as bacteria and excess nutrients to enter groundwater and can cause adverse effects on water quality, aquatic life, and recreation. Parcels on septic systems within the watershed were assumed to be all tax parcels not connected to town sewer infrastructure. People per parcel were estimated using 2010 census data (United States Census Bureau, 2010). An estimated failure rate of septic systems of 20 % was used (Wood & Lee, n.d.).

Wildlife

Wildlife has the potential to contribute bacteria to local waterbodies. This includes large mammal (e.g. deer), small mammal (e.g. racoon and beaver) as well as waterfowl (e.g. geese). Wildlife and waterfowl are notoriously difficult to quantify but can have an impact on fecal contamination in nearby waterbodies. Canada geese can congregate adjacent to surface waters for feeding. In addition, beaver dams can create quality wetlands that can serve as a habitat for dozens of bird species, mammals, amphibians, invertebrates, and fish, including those that are threatened or endangered. However, this habitat can also increase fecal contamination in local waterbodies from both the beavers themselves, as well as the wildlife and waterfowl gathering that area.

Model Limitations

Bacteria comes from many dispersed sources on a landscape and bacteria counts during ambient conditions can change quickly based on environmental conditions. As a result, bacteria loading estimation has significant uncertainty and should be considered to be order-of-magnitude types of estimations. Key source characteristics cannot be precisely specified – such as source amount, proximity to surface waters, transport, and bacteria die-off rates. The bacteria load estimates used in this watershed management plan are intended to support watershed planning and restoration prioritization efforts at a screening level only.

Model Assumptions

Developed Land Runoff

None

Septic Load Estimates

1) Population estimates for watershed area within town uses ratio of town area in watershed and out of watershed and applies it to total town population. It does not take population densities into account.
2) Parcels within 150 feet of mapped sewer lines were assumed to be on sewer.
3) The town of Alfred was assumed to be entirely on septic systems.
4) The portion of Biddeford within the watershed was assumed to be on septic systems. Biddeford Sewer maps available online were reviewed, and they show the Biddeford area within the watershed boundary is likely not connected to sewer.
5) The bacteria attenuation factor through failing septic systems is one order of magnitude reduction from the daily human organism shedding rate of 2e+9 fecal coliform (US EPA 2001). Local insight has indicated that many homes are aging and/or in close proximity to streams in many areas, and there is a heavy influx of people in the summer which can put strain on septic systems. There are also very sandy soils in parts of the watershed. These factors make it appropriate to use a lower level of attenuation (i.e. higher bacteria loading to streams from failing septic systems). Therefore, a loading rate of 2e+8 was used.
6) Estimated fecal coliform loader per system assumes every failing system was contributing equally.

Agriculture

a. Assume in-stream time for all animals is zero.
b. Assume grazing time for all animals is 25% to account for relatively long Maine winter when grazing is unlikely (cows, horses, pigs and sheep). Chicken grazing time is 20%.
c. Amount of manure assumed left in the barnyard is 10% for beef/dairy cows, pigs and sheep.

Wildlife

d. Assumed deer habitat was cultivated land, pasture/hay, forests, forested wetland (adapted from Bell & Dalton, 2010). Note that this is not specifically deer wintering area.
e. Assumed racoon habitat was developed areas, developed open space, cultivated land, forest, forested wetland, wetlands (adapted from Bell & Dalton, 2010)).
f. Assumed goose habitat was open water (adapted from Bell & Dalton, 2010)).

5.4.2 Model My Watershed

Introduction and Model Overview

Model My Watershed is a model that uses land use and soil data and models stormwater runoff, sediment, and nutrient (nitrogen and phosphorus) loads from a watershed given variable size source areas such as agriculture, forested, and developed land. The Watershed Multi-Year Model is a tool within Model My Watershed that simulates 30 years of daily water, nutrient, and sediment fluxes using the generalized Watershed Loading Function Enhanced model, develop by Barry M. Evans, Ph.D., and Penn State University.

Model parameters used to estimate total phosphorus, nitrogen, and sediment loading in the watershed include land cover data (adapted to use Maine 2005 Land Cover Data), soils data (USDA-NRCS GSSURGO), 30 meter elevation data (United States Geological Survey (USGS)), USEPA national climate data, point source data (US EPA), estimates of shallow nitrogen concentration (USGS), county level farm animal populations (USDA), estimates of baseflow (USGS), estimates of soil phosphorus concentration (USGS), and estimates of soil nitrogen concentration.

The number of users on septic systems are calculated in Model My Watershed using an estimate of the average number of persons per acre in Low-Density Mixed areas. In these areas, it is assumed that the populations therein are served by septic systems rather than centralized sewage systems. All homes in such areas are assumed to be connected to normally functioning systems (non-failing).

Model Results

Model results have indicated that total annual load in the Kennebunk River watershed is 4,232,254.3 kg of sediment, 26,838.4 kg of total nitrogen, and 3,093.0 of total phosphorus (Table 5-3 and Table 5-4). The source breakdown has indicated that the highest contributor to sediment and total phosphorus is likely streambank erosion, the highest source contributor to total nitrogen is likely subsurface flow (Figure 5-2).

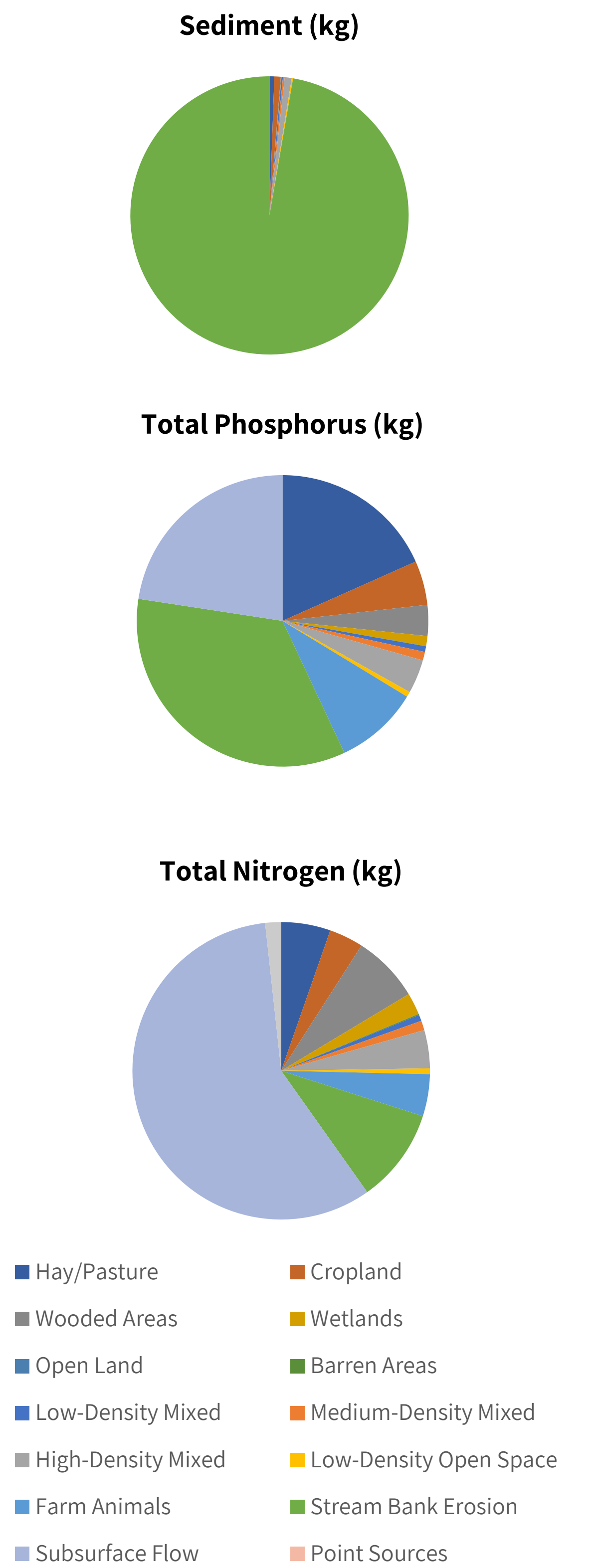


Figure 5-2. Average annual loads of sediment, total phosphorus, and total nitrogen estimated by the Model My Watershed model for the Kennebunk River Watershed.

Table 5-3. Average annual loads from 30-years of daily fluxes.

Sources	Sediment	Total Nitrogen	Total Phosphorus
Total Loads (kg)	4,232,254.3	26,838.4	3,093.0
Loading Rates (kg/ha)	285.5	1.8	0.2
Mean Annual Concentration (mg/L)	66.0	0.4	0.1
Mean Low-Flow Concentration (mg/L)	148.7	0.8	0.1

Table 5-4. Average annual loads from 30-years of daily fluxes for specific land cover areas.

Source	Sediment (kg)	Total Nitrogen (kg)	Total Phosphorus (kg)
Hay/Pasture	23,501.8	1,445.5	570.2
Cropland	31,441.8	1,003.4	152.6
Wooded Areas	2,893.6	1,976.0	106.6
Wetlands	712.7	640.2	34.3
Open Land	12.5	1.6	0.0
Barren Areas	6.1	30.2	1.0
Low-Density Mixed	6,944.7	181.9	19.5
Medium-Density Mixed	8,635.7	281.5	29.4
High-Density Mixed	34,395.4	1,121.0	116.9
Low-Density Open Space	6,407.5	167.8	18.0
Farm Animals	0.0	1,235.6	289.9
Stream Bank Erosion	4,123,710.0	2,768.0	1,070.0
Subsurface Flow	0.0	15,686.7	702.5
Point Sources	0.0	0.0	0.0
Septic Systems	0.0	466.8	0.0

5.4.3 Pollutant Reduction Targets

Table 5-5, below, present bacteria reduction targets to meet the State geometric mean criteria. These targets are identified for each of the main sites along the Kennebunk River main stem (KB-03/KR-06, KB-04, KB-05/KR-25, and SKE09) but represent necessary reductions needed upstream in the river and its tributaries. An average reduction of 57% is needed in the geometric mean for *E. coli* at these four sites. Site KB-04 requires the greatest reduction, 70%, to meet the state criteria of 65 MPN/100mL.

Because these targets require significant reduction in *E. coli* counts in surface water, Table 5-6 presents interim goals for the years 2023, 2025, 2027, and 2029. This will assist watershed planners in identifying progress and success of restoration efforts over the next ten years.

Table 5-5. Summarized data for *E. coli* in the Kennebunk River direct drainage and the percent reduction needed to meet in-stream standards for sites. Sites were only included if they had greater than six historical datapoints to be consistent with Maine DEP methods to calculate geometric mean. Data was truncated to include only data taken in the summer season. Values that do not meet the applicable state thresholds are in red; *E. coli* was evaluated at 65 MPN/100mL.

	SITE	COUNT	GEOMETRIC MEAN	STATE STANDARD (MPN/100mL)	PERCENT REDUCTION NEEDED ACHIEVE STATE STANDARD
E. COLI (MPN/100mL)	KB-03/KR-06	74	175.2	65	63%
	KB-04	76	213.5	65	70%
	KB-05/KR-25	77	141.8	65	54%
	SKE09	8	110.1	65	41%

Table 5-6. Interim *E. coli* reduction targets for each site to meet state geometric mean criteria for Class B waters. It is important to note that these percent reduction targets do not account for new sources of fecal contamination to the river and its tributaries. Increased development and climate change are likely to account for even more sources of fecal contamination in the watershed in the next 10-yrs.

	SITE	E. COLI GEOMETRIC MEAN INTERIM GOALS				
		2023	2025	2027	2029	2031
E. COLI (MPN/100mL)	KB-03/KR-06	13%	25%	38%	50%	63%
	KB-04	14%	28%	42%	56%	70%
	KB-05/KR-25	11%	22%	32%	43%	54%
	SKE09	8%	16%	25%	33%	41%

6 RESTORATION PLAN

6.1 Plan Oversight and Adoption

It is the recommendation of this plan that a Stewardship Committee be formed to direct administer the Kennebunk River WBMP over the course of the next 10 years, 2021 - 2031. This committee will be guided by the York County Soil and Water Conservation District who will take a lead role in convening the group, and will continue to be formed by representatives from Wells National Estuarine Research Reserve, Maine DEP, Maine Healthy Beaches, and representatives from the towns within the watershed. Other stakeholders to involve include elected officials, landowners, local conservation organization members and volunteers, and the general public living the watershed. We recommend the Committee meet annually to provide periodic updates to the plan, track and record progress made toward restoration, maintain and sustain action items, and make the plan relevant on an ongoing basis by adding new tasks as needed.

Restoration of water quality in impaired watersheds requires a long-term and dedicated effort. The plan will likely take 10 or more years to implement, depending on community drive and commitment, funding sources, and availability. The success of the goal of this plan to restore the Kennebunk River and its tributaries to state water quality standards will be dependent on community involvement, landowner commitment to preventing nonpoint source pollution, funding sources, and staff availability. A vested environmental and economic interest in the health of the Kennebunk River, cooperation by property owners, sustainable funding, and good administration are factors that will lead to success of the plan. If the Kennebunk River and its tributaries meet attainment for aquatic life and bacteria before implementation of recommended actions are complete, then the goal of the plan has been met. However, the Stewardship Committee should continue their efforts to protect their community resources. Actions to build climate resiliency, restore water quality, and protect aquatic habitat will help maintain watershed health.

Establishing a committee with a passion to restore and protect the Kennebunk River is critical to long term success, along with developing a funding plan, which garners the approval of the community. A community restoration effort should include the collaboration and support of the entire community, including local businesses and property owners, community groups, conservation groups, corporate sponsors, and municipalities. In some cases, it may be possible to attain additional state or federal grants to help implement the plan. Broad community support is a major strength when applying for such funding. Adoption of the WBMP by the towns within the watershed is highly recommended to help raise local awareness about the need for restoration efforts and to garner support needed to implement various aspects of the plan.

6.2 Estimated Costs and Technical Assistance Needed

The total cost of successfully implementing the Kennebunk River WBMP is estimated at approximately $830,000 - $1.4 million over the course of the next 10 years (2021 – 2031) based on the recommended actions in Section 5. Table 6-1, below, outlines the estimated costs broken down by “Structural” action items and “Non-structural” action items. It is important to note the costs outlined here (and reflected in the associated Action Plan in Table 5-1) are preliminary and are for planning purposes only.

Table 6-1. Estimated costs for implementing the Kennebunk River WBMP.

10-YEAR COST ESTIMATE FOR RESTORING THE KENNEBUNK RIVER (2021– 2031)		
	Category	**Estimated 10-Year Costs**
STRUCTURAL		
	Agricultural BMP Implementation	$262,000 - $342,500
	In-stream Habitat & Geomorphology	$62,200 - $122,500
	Residential, Commercial, and Roadway BMP Implementation	$120,000 - $274,500
	Land Conservation & Protection	$10,000 - $20,000
NON-STRUCTURAL BMPS		
	Administrative & Funding	In-house
	Education & Outreach	$7,500 - $15,000
	In-Stream Habitat and Geomorphology	$40,000 - $80,000
	Land Conservation & Protection	$120,000 - $180,000
	Residential, Commercial, and Roadway BMP Support	$50,000 - $100,000
MONITORING PROGRAM		
	Monitoring	$157,700 - $204,200
	ESTIMATED TOTAL (10-YR) COST:	**$829,400 - $1,338,700**

7 METHODOLOGY FOR MEASURING SUCCESS

While this plan provides specific goals and key actions needed to restore the Kennebunk River and its tributaries, it is inevitable that new information, technology, and techniques will be learned and developed in the years to come that may change the priorities of identified goals and actions. Therefore, the goals and priority of actions identified in this plan should be revisited and revised on an annual basis using an adaptive management approach.

7.1 ADAPTIVE MANAGEMENT APPROACH

An adaptive management approach is widely recommended for restoring developing watersheds. Adaptive management enables stakeholders to conduct restoration activities in an iterative manner. This provides opportunities for utilizing available resources efficiently through BMP performance testing and restoration monitoring activities. Stakeholders can evaluate the effectiveness of one set of restoration actions and either adopt or modify them before implementing effective measures in the next round of restoration activities. The adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short-time frame (e.g., 2 years). Rather, adaptive management establishes an ongoing program that provides stakeholder involvement, adequate funding, and an efficient coordination of restoration activities. Implementation of this approach will ensure that required restoration actions are implemented and that the Kennebunk River is monitored to document restoration over an extended period.

The adaptive management components of the Kennebunk River WBMP will include:

Creating an Organizational Structure for Implementation – A Stewardship Committee for the Kennebunk River Watershed should be established. Stakeholders should include conservation groups, watershed residents, state and federal partners, and other interested community groups will also be involved.

Maintaining a Funding Mechanism - The following list summarizes seven possible outside funding options available to the Kennebunk River restoration project. A combination of grant funding, private donations, and municipal funding must be used to ensure completion of the plan.

- **US EPA/Maine DEP 319 Grants –** This NPS grant is designed to assist municipalities with restoring waters named as NPS Priority Watersheds and are available for the implementation of WBMP.

http://www.maine.gov/dep/water/grants/319.html. We recommend contacting the DEP regional office for more information 207-764-0477.

- **Five Star and Urban Waters Grants** – Projects seek to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Grants are awarded annually and range from $20,000 to $50,000 with an average size of $30,000. This project is funded by US EPA, United States Forest Service, the US Fish and Wildlife Service, Southern Company, FedEx, and Shell Oil Company. http://www.nfwf.org/fivestar/Pages/home.aspx
- **Clean Water State Revolving Fund –** The CWSRF is a low interest loan program which can be used to control NPS pollution, improve wastewater infrastructure, and protect estuaries. Funds come from a combination of federal and state funds, as a partnership between the EPA and state CWSRF programs. https://www.maine.gov/dep/water/grants/srfparag.html.
- **United States Department of Agriculture – Natural Resources Conservation Service** (all quoted text from the USDA NRCS webpage for the State of Maine). While links to the national websites are provided, we recommend also talking directly to the local USDA office at 207-764-4155.

  Agricultural Management Assistance *– Monies from this program provide cost share assistance to "…agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations."* *https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/programs/financial/?cid=nrcs141p2_002873*

  Conservation Innovation Grants *– "Voluntary program intended to stimulate the development and adoption of innovative conservation approaches and technologies…".* *https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/programs/financial/cig/?cid=nrcs141p2_002875*

  Conservation Stewardship Program *– "NRCS provides financial and technical assistance to eligible producers to conserve and enhance soil, water, air, and related natural resources on their land."*

  https://www.nrcs.usda.gov/wps/portal/nrcs/main/me/programs/financial/csp/

  Environmental Quality Incentives Program *– "…provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation or improved or created wildlife habitat."* *https://www.nrcs.usda.gov/wps/portal/nrcs/detail/me/programs/financial/eqip/?cid=nrcs141p2_002867*

Determining Restoration Actions - This plan provides a unified watershed restoration strategy with prioritized recommendations for restoration using a variety of methods, including structural, non-structural, in-stream, and riparian restoration actions. The Kennebunk River Stewardship Committee should use the proposed designs in this Plan as a starting point for implementing the plan.

Improving the Community Participation Process - Implementation of this plan will require ongoing community outreach efforts to involve more local citizens, both in the watershed and in the larger community. A sustained public awareness and outreach campaign is essential to secure the long-term community support that will be necessary to successfully implement this project. Much of the success of implementing the recommendations will be contingent on the energy and passion of local residents to restore and protect their watershed and landowner cooperation. The US EPA has developed an excellent stormwater outreach program, Soak Up the Rain, which is intended to help municipalities educate the community about the effects of stormwater and ways to eliminate the volume of water (i.e. "soak up") reaching the stream channel. Their website offers customizable tools and program material. https://www.epa.gov/soakuptherain

Continuing the Field Monitoring Program - A field monitoring program is necessary to track the anticipated improvements to aquatic health within the Kennebunk River watershed as restoration actions are implemented. The Kennebunk River watershed has historically had a multitude of monitoring programs which provide valuable resources to understanding water quality within the watershed. Continuing a monitoring program will provide feedback on the effectiveness of restoration practices at the catchment and/or subwatershed level, and will support optimization of restoration actions through an adaptive management approach. See Section 6.2, below, for details of the recommended monitoring plan.

Establishing Measurable Milestones - A restoration schedule that includes milestones for measuring the implementation of restoration actions and monitoring activities in the Kennebunk River watershed is critically important. Once the stewardship committee has been formed and as funding sources are secured for action strategies that can be implemented each year, a detailed schedule featuring iterative implementation and monitoring activities should be developed.

7.2 MONITORING PROGRAM

An overall goal of the monitoring program is continuing to track the improvement of the Kennebunk River and its tributaries. A representative set of aquatic health indicators should be measured and interpreted on a predetermined timeframe and should take advantage of both using past information from and contributing to the comprehensive database. Regularly measuring, recording, and analyzing these characteristics will support accurate assessment of the restorative actions.

Investigative monitoring from various organizations limits the ability to synthesize changes at specific sites and tributaries over-time. We suggest a unified monitoring approach across organizations to establish baseline conditions at a sub-set of sites. Any investigative monitoring would occur above and beyond these baseline conditions. This could build upon the volunteer river monitoring program (VRMP) work that is already established and should address the tributaries where we have insufficient data to assess proximate and environmental stressors. We recommend that future monitoring efforts be linked to antecedent moisture conditions and precipitation to identify patterns in the indicator parameters discussed in this document.

Water quality monitoring should include the general components outlined in the bullets below. Specific recommended water quality monitoring actions are included in the Action Plan in Table 5-1.

- Monitor water quality conditions before and after any structural management changes in the watershed, such as BMP implementation. When a BMP implementation project is selected, identify appropriate parameters to monitor the impact of implementation on water quality.
- Monitor water quality conditions before, during, and after storm events to continue tracking locations with high runoff contamination.
- Analyze and compare monitoring results to previous data.

This data collection program and data analysis and interpretation protocol will support assessment of progress in restoring the Kennebunk River Watershed.

7.3 MEASURABLE MILESTONES

It is critically important that a watershed restoration project schedule be established that provides clear and measurable milestones for success. These include environmental milestones, which measure response of the stream, as well as programmatic milestones, which measure actions taken, and social milestones, which measure financial and community support (see Tables 7-1 through 7-3). Once funding mechanisms and oversight authority have been established for the Kennebunk River restoration effort, a more detailed list and schedule of measurable milestones may be developed. Measurable milestones are presented based on three “benchmarks” at 2023, 2027, and 2031 that represent estimated completion by the benchmark date.

Table 7-1. Environmental milestones used to monitor the progress and success of the Kennebunk River watershed restoration project. Benchmarks are cumulative from year one.

Indicator	Benchmarks		
	2023	2027	2031
Concentrations of *E. coli* at site KB-03/KR-06 meet state geometric mean criteria of 65 MPN/100mL.*	13% reduction	38% reduction	63% reduction
Concentrations of *E. coli* at site KB-04 meet state geometric mean criteria of 65 MPN/100mL.*	14% reduction	42% reduction	70% reduction
Concentrations of *E. coli* at site KB-05/KR-25 meet state geometric mean criteria of 65 MPN/100mL.*	11% reduction	32% reduction	54% reduction
Concentrations of *E. coli* at site SKE09 meet state geometric mean criteria of 65 MPN/100mL.*	8% reduction	25% reduction	41% reduction
Monitoring for co-indicator parameters at VRMP sites and tributary outlets.	Add co-indicator parameters at VRMP sites.	Add co-indicator parameters at tributary sites.	Reassess need for investigative sampling that requires co-indicator parameters.
Continuous monitoring of dissolved oxygen and temperature at sites with evidence of low oxygen and/or warm waters.	Purchase and install three dissolved oxygen/temperature loggers	Evaluate logger data to determine if new sites are needed	Purchase and install third dissolved oxygen/temperature logger

**E. coli reduction targets do not account for new sources of fecal contamination (and E. coli) to the watershed as a result of increased development, climate change, or changes in watershed management.*

Table 7-2. Programmatic milestones used to monitor the progress and success of the Kennebunk River watershed restoration project.

Indicator	Benchmarks		
	2023	2027	2031
Digitized meteorological data at the Cape Arundel Golf Course.	Digitize Meteorological Data	Updates as needed	Updates as needed
Number of manure piles investigated (11 identified).	3	5	11
Linear feet of riparian buffer restoration (Estimated at 10,000 linear feet of poor buffer).	2,500	5,000	10,000
Number of stream crossing barriers removed (2 identified).	1 surveyed	2 surveyed	Remove barriers if safe and appropriate
Number of private gravel road culverts addressed (4 identified).	2	3	4
Nutrient Management Plans written for agricultural landowners without current planning documents.	2 Plans	3 Plans	4 Plans

Indicator	Benchmarks		
	2023	2027	2031
Number of animal and crop agricultural landowners engaged (54 farms identified).	15	35	54
Number of signs installed for pet waste and boat discharges.	3	4	5
Number of ordinances reviewed.	2	4	8
Number of voluntary septic system dye tests and inspections within the watershed.	3	5	10
Number of septic system upgrades.	1	3	5
Number of parcels added with conservation easements and/or permanent conservation.	1	2	3
Communities with updated open space planning documents and funding mechanisms.	1	2	4
Amount of funding secured for Plan implementation.	$250,000	$500,000	$1-million

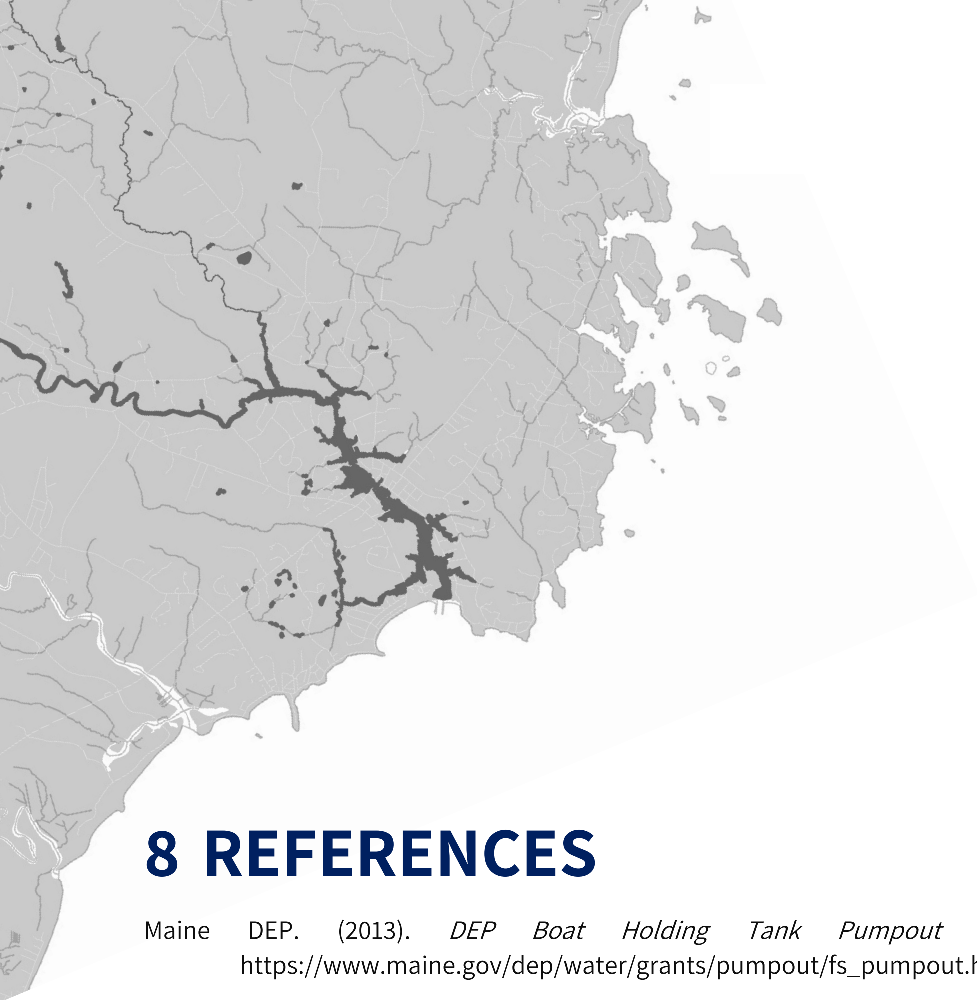
Table 7-3. Social milestones used to monitor the progress and success of the Kennebunk River watershed restoration project.

Indicator	Benchmarks		
	2023	2027	2031
Number of volunteers participating in educational campaigns.	25	50	100
Number of people participating in workshops, trainings, or BMP demonstrations.	10	25	50
Number of new trained VRMP volunteers.	5	10	15
Percentage of residents making voluntary upgrades or maintenance to their septic systems.	5%	10%	15%
Number of students engaged from the Kennebunk High School.	25	50	75
Number of new volunteers for Maine Audubon's Stream Explorers Program.	3	5	15

7.4 Conclusion

This planning document provides the four main communities in the Kennebunk River watershed (Arundel, Kennebunk, Kennebunkport, and Lyman) with the tools and strategies to restore water quality in the Kennebunk River and its tributaries. Successful plan implementation requires collaboration, commitment, and careful tracking using the measurable milestones listed in the previous section. Additionally, the estimated total 10-year cost of $830,000 - $1.4-million will require significant fundraising through private, public, and grant-funded sources. This is possible only with the continued support and dedication of the communities and the watershed residents.

The Kennebunk River watershed is unique, serving as a home to many locals as well as operating as one of the strongest tourist destinations in the State of Maine. Because of this, it is experiencing rapid development pressure and growth. This Plan focuses on restoring the water quality of the Kennebunk River and its tributaries based on existing land use and land management strategies. It recommends specific action items for these landowners to improve management strategies to reduce fecal contamination to local surface waters. Confounding these efforts is the future impact of climate change on this ecosystem. Changes to climate – including changes in the frequency and intensity of precipitation – will be significant forces in stormwater management and contaminated runoff in the next ten years. It is critical to stream restoration that future development in the Kennebunk River watershed is designed to create a watershed resilient to these changes.



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