MARE BROOK

BASELINE & BEST MANAGEMENT PRACTICES REPORT





PREPARED FOR

Town of Brunswick
85 Union Street
Brunswick, ME 04011

PREPARED BY

FB Environmental Associates
97A Exchange Street, Suite 305
Portland, ME 04101

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1 WHY IS A BASELINE REPORT NEEDED?

1.1 MARE BROOK - AN URBAN IMPAIRED STREAM

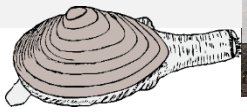
Mare Brook is an urban impaired stream listed on the federal 303(d) list of impaired waters and was included in Maine's Statewide Impervious Cover (IC) Total Maximum Daily load (TMDL) report (Maine DEP 2012) based on data collected in 2001-2003 by the Maine DEP indicating that Mare Brook does not meet water quality standards for aquatic life use. The TMDL report indicates stormwater runoff from the watershed's 18%[1] impervious cover is likely the largest source of pollution to Mare Brook. Much of these impervious areas are located in the residential headwaters (largely the Brunswick growth zone) and Brunswick Landing (former Naval Air Station).

Mare Brook flows through the heart of Brunswick's residential districts, Brunswick Landing (former Naval Air Station or BNAS), and significant public conservation land acreage including the Town Commons and Kate Furbish Preserve (Figure 1.1). Historically, the brook has supported native brook trout populations given its cool groundwater discharge sites and clean sandy substrate. During the development of the town, headwater wetlands were drained and developed for residential neighborhoods, and riparian buffers were compromised. Sea run brook trout are seasonally fished by locals up to the downstream end of the impoundment at Picnic Pond. In a 2015 survey report MDIFW indicated that Mare Brook has a healthy population of brook trout, and other fish in many of its non-tidal reaches.

The Town of Brunswick applied for a Coastal Communities Grant to fund a preliminary assessment of Mare Brook. By completing an updated baseline assessment of the physical and ecological characteristics of Mare Brook, the Town of Brunswick will have the necessary data to engage the public in a facilitated and locally-guided planning process. This report summarizes the work completed over the course of this preliminary assessment and provides recommendations for restoring the stream health. This report provides a "baseline" to determine the current condition of Mare Brook, identify water quality knowledge gaps, and make recommendations for filling in these gaps through additional monitoring, assessment, and/or restoration.

SHELLFISH GROWING AREAS IN HARPSWELL COVE

Mare Brook is economically significant to the local area because the 6-square-mile watershed drains to one of Brunswick's most important shellfish growing areas. Historically, non-point source (NPS) pollution (specifically Arsenic and Lead) are causing sections of the cove to be restricted for harvesting. The Department of the Navy has plans to test shellfish for Perfluorinated Compounds (PFCs), due to elevated levels of PFCs found in the former Brunswick Naval Air Station groundwater.



Harpswell Cove. Photo Credit: FBE.

[1] The impervious cover estimate of 18% used in this report is lower than the 2012 TMDL estimate (21%) due to refinement of the watershed boundary.

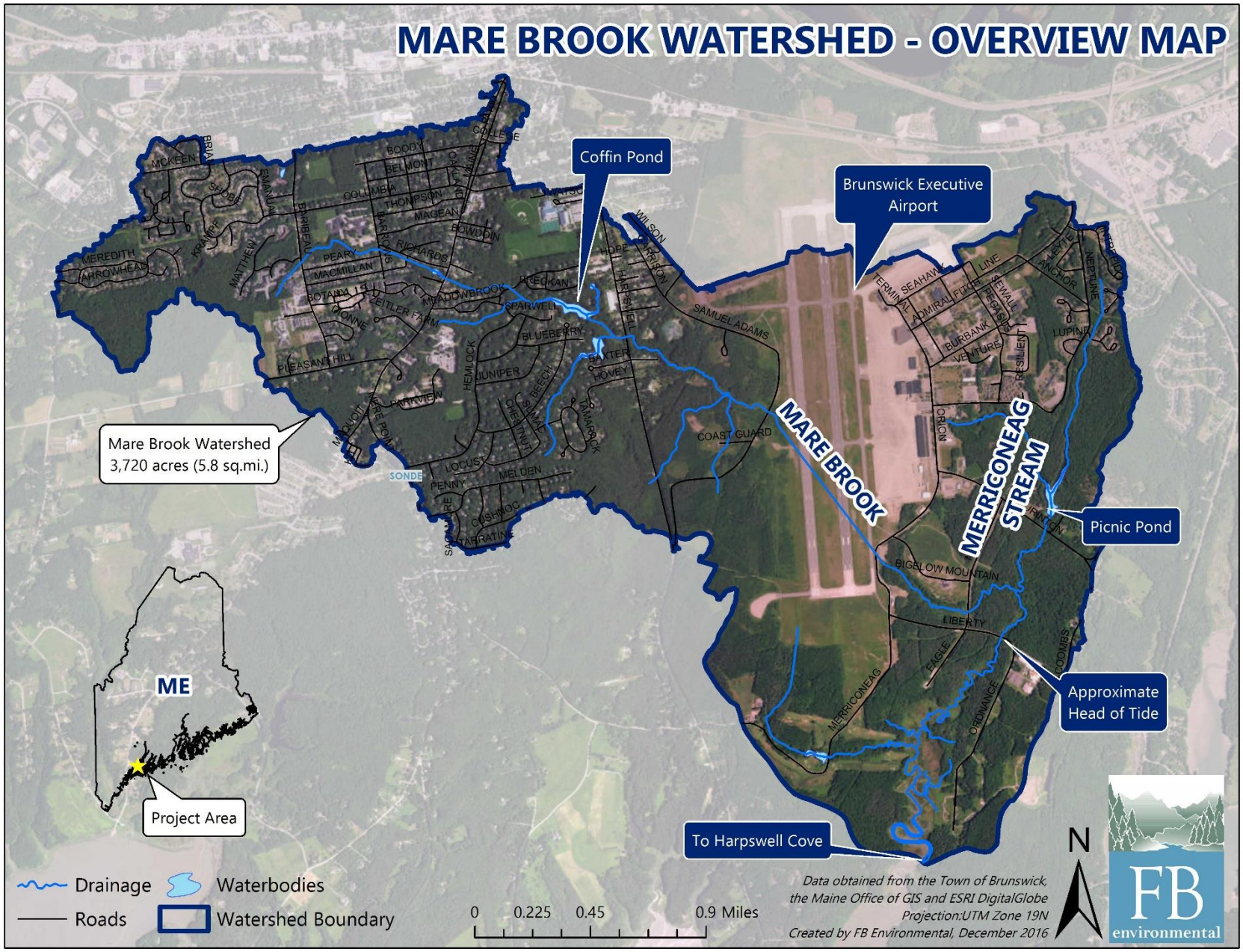


FIGURE 1.1. An overview map of the Mare Brook watershed. This map was created through a combination of detailed delineation by Maine DEP in the freshwater area and the National Hydrography Set HUC boundary into the tidal estuary. Created by FBE.

1.2 WATERSHED AND STREAM CHARACTERISTICS

Mare Brook begins in an area of dense residential development in the northwest corner of the approximately 5.8-square mile Mare Brook watershed above Baribeau Drive in Brunswick. It flows east through these developments toward Bowdoin College's athletic fields on Harpswell Road before reaching Coffin Pond and Coffin Pond Dam upstream of Harpswell Road. The stream continues through land owned by the Midcoast Regional Redevelopment Authority (MRRA) (Brunswick Executive Airport) flowing through a ¾ mile long culvert underneath the airport runway. It then flows an additional 0.7 miles to its confluence with Merriconeag Stream which flows in from the north. Mare Brook is a freshwater stream to head of tide near the Liberty Road crossing, becoming more saline within the Harpswell Cove estuary. This section of the stream passes through land owned and operated by the U.S. Navy and the Kate Furbish Preserve (owned by the Town of Brunswick) and eventually into Harpswell Cove in the southeast corner of the watershed.

Unlike typical urban streams, Mare Brook has large areas of highly buffered shoreline and the watershed contains 38.7% forest and wetland complexes[2]. However, the remaining 61% of land is urban and has led to alteration of the stream and degradation to habitat and water quality. Land-use estimates are from the 2012 Maine DEP TMDL land use file and reflect the methods used in this publication (Maine DEP 2012). It should be noted that land use estimates are not exact, but do offer a general understanding of development distribution within the watershed.

IMPERVIOUS COVER (IC) in the watershed is estimated at 673.4 acres or approximately 18%, and is most concentrated along the Brunswick Executive Airport runway and associated redevelopment east of the runway (Figure 1.2). In addition, significant residential development borders the stream in the upper (western) watershed. Impervious cover was obtained from work completed by the Maine DEP in 2011.

Stormwater drain to Mare Brook. Photo Credit: FBE.

IMPERVIOUS COVER (IC) such as parking lots, roofs, and sidewalks, results in runoff into the stream. Stormwater carrying dirt, metals, and other pollutants is conveyed directly from IC to the stream with minimal pre-treatment, causing increased erosion, sedimentation, increased temperature, and habitat degradation in the stream (CWP 2003).

Merriconeag Stream is an important part of the Mare Brook watershed. This stream begins at Beaver Road in the northeast corner of the watershed, flowing south until it reaches Picnic Pond, upstream of the Purinton Road crossing. After crossing the Picnic Pond Dam, Merriconeag Stream continues winding its way south towards its confluence with Mare Brook. Because of its location on the former Brunswick Naval Air Station (BNAS) property, Merriconeag Stream contributes elevated levels of legacy pollutants into Mare Brook[3]. A detailed map of the IC in the Mare Brook watershed is included on the following page.

[2] A full description of land use calculations is listed in Appendix A. In summary, land use for the watershed was taken from the 2010 Maine DEP IC TMDL file, which was updated from the 2004 MELCD layer. Land use was reclassified for this report into the categories used by the STEPL model in this study.

[3] A summary of legacy toxics in the Merriconeag Stream sub-watershed and within the former Brunswick Naval Air Station can be found in this 2005 U.S. Department of Health and Human Services Public Health Service Report (U.S. Department of Health and Human Services 2005).

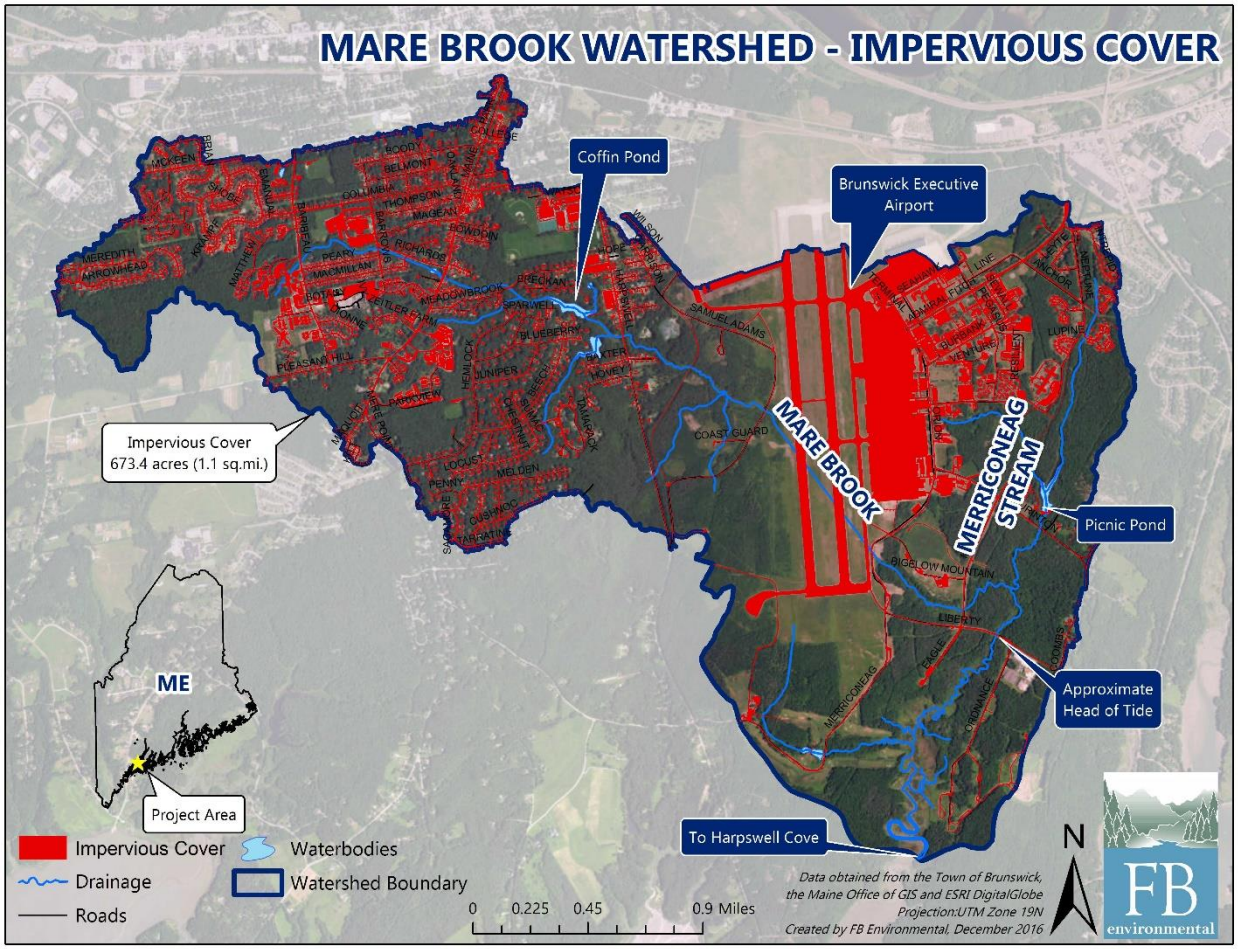


FIGURE 1.2. Impervious cover in the Mare Brook watershed is estimated at 18%. Impervious cover is from work completed by the Maine DEP in 2011.

Aerial examples of IC distribution in the Mare Brook watershed. Residential Development (left) and the Brunswick Executive Airport (right).

2 WHAT DID THE ASSESSMENT INCLUDE?

2.1 PROJECT TEAM AND COMMUNITY INVOLVEMENT

Successful stream restoration requires community participation throughout planning and implementation. Appropriately named, *The Mare Brook Watershed Assessment and Community Engagement Project* aims to bring watershed and community representatives together through the formation of a Technical Advisory Committee (TAC) and public engagement including public meetings and on-site landowner meetings.

2.1.1 TECHNICAL ADVISORY COMMITTEE (TAC)

The purpose of the TAC is to help guide the development of a report that identifies existing watershed issues and stressors, develop potential actions for addressing these issues, and to provide a document that will serve as an accessible resource for private landowners who want to voluntarily improve their land management practices for the health of the watershed. The Mare Brook TAC met three times over the duration of the project; **January 22**, **April 27**, and **November 16**. Members of the TAC include:

- Bowdoin College
- Brunswick Area Citizens for a Safe Environment
- Brunswick Conservation Commission
- Casco Bay Estuary Partnership
- Friends of Casco Bay: Casco Baykeeper
- Maine Department of Environmental Protection
- Midcoast Regional Redevelopment Authority
- Town of Brunswick
- United States Department of the Navy

TAC meetings were led by the Town Planner and technical consultants, FB Environmental, with field and project support from Ecological Instincts and Stantec. All TAC and public meetings were aired on Brunswick Cable TV3. The TAC reviewed all written materials provided by the project consultants and provided feedback on these materials.

2.1.2 PUBLIC MEETINGS & ON-SITE LANDOWNER MEETINGS

In addition to the three planned TAC meetings, two public meetings were held to raise awareness about the Mare Brook project with landowners in the watershed. These meetings were held on **August 9** and **December 19**. Direct abutters of the stream were notified prior to the August 9 meeting and the stream corridor assessment and a mailing was sent to all landowners within the watershed prior to the final meeting. Both meetings were published on local television.

Six on-site landowner meetings were scheduled during the project period and served many purposes: gathering preliminary knowledge about the stream and general watershed characteristics; for learning about the history of the

properties and gaining access to areas that otherwise may not have been accessible on short notice; provided context for conducting water quality analysis and preparing for the 2016 stream corridor assessment; for familiarizing key stakeholders with details of the project, and; for following up with potential nonpoint source pollution identified during the 2016 field assessments. Landowner meetings included the following groups:

- Bowdoin College
- Town of Brunswick School Department
- Department of the Navy
- Midcoast Regional Redevelopment Authority
- Town of Brunswick Public Works Department
- Brunswick Sewer District

On December 22, 2015, Jen Jespersen and Margaret Burns with FB Environmental (FBE) met Jared Woolston (Town of Brunswick) and Tom Brubaker (MRRA Public Works Director) at the MRRA office. Tom provided an overview presentation regarding the land of the former Brunswick Naval Air Station (BNAS) (now privately owned and managed by MRRA with a section east of the runway still owned by the Department of the Navy), and land transferred from the U.S. Navy to private owners, MRRA. Subsequently, Tom provided a tour of Brunswick Landing (the business campus on the former BNAS property), and field stops were made at areas of the stream or tributaries that may be affected by existing development. This area is subject to change considerably over the next few years due to change in ownership. Infill development is likely to occur in the future, which could have unintended consequences for the stream if not planned and managed properly.

Following the meeting with MRRA, Bob LeClerc from the Department of the Navy escorted the group to the U.S. Navy property. Several stops were made along the tour including:

1. The crossing on Major Pope Road where bright green colored algae were observed in the upstream reach and 2) the culvert outlet on Orion Road. (This site receives drainage from the runway.) Bob indicated that a visual inspection of the culvert was underway. Visual observations from the roadway indicated a large buildup of sediment in the stream below the culvert outlet.
2. Picnic Pond, which was previously used as a recreation site for military families with picnic benches and a large baseball field. However, this site was closed due to concerns for public health in the 1990s. The pond had a greenish hue and algal accumulation was noted within the dam structure. There is a gravel road across the dam with a low area for overflow water during large precipitation events (overflow water discharges to rocks), and stream gauges are installed on both sides of the road.
3. The stream crossing off Purinton Road. Bob indicated there are snapping turtles that breed in this area. A stream gauge is located just downstream of the road crossing. A total of 6-7 stream gauges are located throughout the stream which are managed by Tetra Tech, a private consulting, engineering, and construction firm for the U.S. Navy. FBE mentioned that this would be valuable data to have for the Mare Brook study.
4. Sandy Road connecting Purinton Road and Neptune Drive. The stream channel is fairly wide at this point.

The U.S. Navy is currently undergoing a large study of groundwater contamination at Picnic Pond with plans to eventually begin restoration efforts to improve groundwater at this site. This restoration is critical to the improvement of water quality in Mare Brook below its confluence with Merriconeag Stream. Moving forward, coordination and communication with the U.S. Navy is imperative to ensure the success of restoration efforts on Mare Brook.

FBE met up with Jared Woolston (Town Planner) and Catherine Ferdinand at the Bowdoin College Pickard Fields softball field to observe a section of Mare Brook. General observations indicate that the stream channel around Bowdoin College was in good condition, with significant meanders and lots of woody material. A stormwater detention pond behind the Pickard Fields softball field outlets to Mare Brook. The detention pond contains overflow drains at different water levels. At the time of the visit, flow from the pond was observed entering Mare Brook. The pond outlet into Mare Brook is protected with angular stone and no erosion was evident. The major consideration is nutrient inputs (fertilizer) from the fields and discharge of warm water with low dissolved oxygen from the pond. Catherine Ferdinand serves as the representative for Bowdoin College on the project technical advisory committee (TAC), along with the school's contracted engineering consultants (Chris Baldwin, St. Germain Collins).

On November 28, 2016, the Town Planner met with representative staff from the Brunswick Sewer District, School Department, Department of Public Works, and the Mid-Coast Regional Redevelopment Authority (MRRA) to consider the source of high bacteria levels and indicators of soap in Mare Brook within the vicinity of Barrows Street and Richards Drive; and heavy accumulations of sand and a foul odor noted by a representative from Stantec at the downstream end of the culvert that carries Mare Brook under MRRA's airport runway. The source of the high bacteria levels and soap were unknown to the staff but a strategy for locating the source was discussed. The staff indicated that the sewer system in Brunswick has known issues of incoming groundwater to sewer lines in areas where the water table is above the sewer line (infiltration/inflow –or- I/I). When the water table is below the sewer line sewage may be expected to leak and possibly enter groundwater. Areas where the water table is above a sewer line may allow groundwater to enter the sewer system but not escape. The inside of the public sewer system in the neighborhood where the sample was found was documented by the Sewer District with video footage this summer (2016). The Sewer District staff indicated they would review the recent camera footage in the area to look for leaks in the sewer line that could contribute to the bacteria and soap in Mare Brook. The School Department staff indicated no observation of leaks or possible discharge sources from the Coffin Elementary School or Brunswick Jr High School. Stormwater from the Coffin School nearest to the sample location of concern is a sheet flow from the school bus parking area to a forested buffer before reaching Mare Brook. School buses are washed outside on the parking lot when school is in session and wash water flows into the forested buffer. However, the staff do not allow wash water to discharge directly to Mare Brook. At the request of the School Department staff, an information sheet on the carwash soap that is used on school buses was sent to the DEP after the meeting. The DEP staff indicated that the soap was not likely the source of the soap discharge. The soap that was found was considered more likely to be a laundry detergent that contains 'optical brighteners' which were revealed by the lab fluorimeter tested by Maine Healthy Beaches. The School Department staff, and Sewer District staff described their observations of between 30 to 100 ducks routinely visiting residences between Magean Street and Richards Drive. Subsequent to the meeting, the staff observations of ducks in the neighborhood were forwarded to the DEP to consider if ducks could be the source of high bacteria readings. The DEP staff indicated ducks could be a source of bacteria and further investigation was advised. The DEP recommended checking bacteria levels in those areas visited by ducks where drainage enters Mare Brook and compare with the high bacteria readings in Mare Brook. The Public Works staff considered the District's ongoing work in the neighborhood to remove private groundwater sump systems from the public sewer system and reconnect to the public stormwater system. The staff determined there is a possibility that privately-owned sewer connections could also be connected to private groundwater sump systems without the knowledge of the staff. The Department of Public Works, and Sewer District staff indicated further investigation of private sewer connections to the stormwater system may be required pending the review of sewer footage. The staff may request additional technical support from the DEP as well.

Stantec's observations at the downstream end of MRRA's runway culvert were then discussed with the Sewer District, and MRRA staff, specifically observations of a strong odor, and an accumulation of sand in Mare Brook. No bacteria monitoring was available at this location, but the odor was assumed to be a sewer smell and the discussion was focused accordingly. The staff considered the possibility of sewage entering Mare Brook to produce an odor but that was determined by both MRRA, and Sewer District staff to be unlikely due to the long distance from the nearest sewer line to the stream. Also, in partnership between MRRA and the Brunswick Sewer District, the former Brunswick Naval Air Station (BNAS) sewer lines have been videotaped and areas that are unreasonably degraded have been or will be replaced. The more likely source of the odor was determined to be an anaerobic digester facility that is located on the airport runway approximately 300 yards north from the culvert end. The digester uses animal waste, food waste, agricultural waste, and wastewater sludge to produce renewable electricity and is a known contributor of strong odors in the area. Another possibility that was discussed was stagnant air within the ¾ mile runway culvert. The source of the sand that was observed is unknown. The staff considered the possibility of sand entering the culvert beneath the runway but that was determined unlikely. The inside of the runway culvert was recently surveyed and no sources of sand within the culvert were observed. The possibility of the culvert being a conveyance for sand flowing from upstream locations was considered since high volume sand transfer was observed in other areas of Mare Brook.

2.2 UNCOVERING THE WATER QUALITY HISTORY

The water quality history of Mare Brook and Merriconeag Stream is complex, with surface water data collected as far back as 1988. Data methodology and site selection have been variable, creating a robust yet inconsistent dataset. Prior to completing the planned field monitoring in 2016, all historical data (primarily from the Town of Brunswick, Maine DEP, and the U.S. Navy) was compiled into a "Data Directory" to co-locate documents for ease of use, to identify gaps in data collection, and to help develop recommendations for this report. The following section outlines the historical data identified, gaps in the data, and a framework developed through this project to assess water quality stressors in the Mare Brook watershed.

2.2.1 DATA DIRECTORY & GAP ANALYSIS

Significant effort has gone into quantifying the level of contamination to the stream below the airport runway, primarily by the U.S. Navy and their hired consultants. This work includes investigation of surface water, ground water, soils, and streambed sediments. In addition to exploratory research, data is available for all property transfers in the old BNAS property. Unfortunately, less effort has been focused on the freshwater portion of Mare Brook west of the runway. Some monitoring has been conducted by the Maine DEP in the freshwaters of Mare Brook. Additionally, a 2009 Stream Corridor Assessment was performed by the Town of Brunswick, Maine DEP, Americorps, and the Casco Bay Estuary Partnership. The report was prepared by the Maine DEP in 2011 (Maine DEP 2011). The following list summarizes the information compiled within the Mare Brook "Data Directory" which identifies and organizes known historical data related to water quality in Mare Brook. The scope of this project did not include investigation of groundwater or soils, however, all reports through the U.S. Navy are listed in this Data Directory.

- 131 GIS files available for mapping the watershed and stream.
- 52 comprehensive reports from the U.S. Navy, including but not limited to site transfer reports, remedial investigation reports, technical memorandums, and monitoring plans.

- A total of 86 unique sampling site location IDs were referenced within the Mare Brook data directory. From these 86 sites, 24 unique sites were identified as discrete sampling locations, and 29 sites were identified as broad area sites (such as "reaches" of the watershed). Discrete sites refer to locations where numerical data was collected from a specific location, such as a surface water grab sample from the stream, or a sediment core. These sites were located across the entire watershed and were primarily provided by the Maine DEP, the U.S. Navy and the Maine Inland Fisheries and Wildlife (Maine IF&W). Environmental parameters measured at these discrete sites varied from site to site and include a wide range of information including temperature, dissolved oxygen, conductivity, volatile and semi-volatile compounds, metals and other toxics, macroinvertebrates and fishes.
- 17 of the 24 discrete sites had quantitative data with a known location, and include data with water quality parameters of interest to better understanding the stressors in Mare Brook (discussed further in Section 2.2.2). A total of 168 parameters can be found in these 16 sites used to evaluate the stressors in Mare Brook. The earliest data in this dataset are from 1988 through 2015. Broad area sites include sampling locations within stream reaches, tributaries, and catchments, as well as general watershed-wide data collection efforts. In comparison to discrete sites, broad sites were referenced as general regions for sampling without specified coordinates or locations.

The headwaters of Mare Brook by Matthews Drive. Photo Credit: FBE.

2.2.2 STRESSOR ANALYSIS

Based on the immense amount of historical water quality data from the Mare Brook watershed, project consultants (with input from the TAC) devised the key **STRESSORS** influencing water quality in Mare Brook and Merriconeag Stream. The objective of the Stressor Analysis was to provide an efficient means by which to synthesize and evaluate available surface water data in the Mare Brook watershed in order to identify gaps in the data, to develop recommendations for long-term monitoring and assessment, and to provide project partners and the public a simple and dynamic visual tool for understanding the stressors that are affecting water quality (see full report here). A stressor is an environmental factor that has the potential to negatively

STRESSORS are environmental factors that have the potential to negatively affect water quality and result in Mare Brook not meeting Maine's Class B standards for freshwaters, and Class SB standards for estuarine and marine waters.

affect water quality and result in Mare Brook not meeting Maine's Class B standards for freshwaters, and Class SB standards for estuarine and marine waters.[4] Nine 'stressor' categories were selected based on the best available data across all sites in the watershed. The nine stressors proposed for the stressor analysis are as follows: **bacteria, sediment aggradation and mobility, dissolved oxygen, macroinvertebrates, metals, nutrients, pH, toxics,** and **temperature**. For each of these stressor categories, threshold criteria were developed to represent poor "red", moderate "yellow", and healthy "green" water quality for that category.

Synthesis of such a broad data set is difficult due to differences in sampling methodology, laboratory analysis techniques, and spatial and temporal scales. A "stoplight" system was developed to provide an overview of the available water quality data for Mare Brook and its tributaries. A total of nine stressors were evaluated using threshold criteria ranging from "poor" to "moderate" to "healthy" (Table 2.1). The criteria used to create the stoplight system are based on the Maine standards for Class B freshwater streams. While additional water quality parameters have been collected in Mare Brook over the historical sampling period beyond those presented in Table 2.1, they were not included in the analysis if they are not used to assess water quality in Class B streams. Estuarine data is not included in the stressor analysis because the criteria are not uniform across the freshwater-saltwater interface and there is insufficient data to run the analysis.

TABLE 2.1. The nine stressor categories identified.

STRESSOR CATEGORY	BACTERIA
	SEDIMENT AGGRADATION AND MOBILITY
	DISSOLVED OXYGEN
	MACROINVERTEBRATES
	METALS
	NUTRIENTS
	PH
	TOXICS
	TEMPERATURE
QUALITY	
	POOR → HEALTHY

The stressor analysis can be applied to each monitoring site within the watershed to identify areas with degraded water quality as well as areas where the stream is in relatively good condition. Furthermore, the analysis will provide information about existing gaps in monitoring data. An understanding of the existing data and the breadth of the data gaps will help inform recommendations for future monitoring and restoration efforts in the Mare Brook watershed.

2.2.3 2016 WATER QUALITY INFORMATION

Following the qualitative evaluation of historical data in the Mare Brook watershed, the Maine DEP with the support of the Town of Brunswick, conducted targeted water quality monitoring in the summer of 2016. Monitoring efforts focused on gaining a better understanding of perceived water quality concerns (such as elevated bacteria) and to collect baseline data for dissolved oxygen (DO), temperature, and conductivity during summer baseflow. More detailed reports from the Maine DEP can be found on the Mare Brook watershed webpage. A summary of these monitoring activities is provided below.

MACROINVERTEBRATE ENCLOSURES

In the summer of 2016, Maine DEP with the support of the Town of Brunswick conducted a study of macroinvertebrate communities in the Mare Brook watershed to determine if the relative absence of macroinvertebrate communities in Mare Brook and Merriconeag Stream are a result of degraded water quality or poor physical habitat. Maine DEP set up in-stream enclosures which standardize the habitat conditions while allowing

[4] Freshwater, and estuarine and marine water standards in 38 M.R.S. Section 465, and 38 M.R.S. Section 465-B, respectively.

stream water to flow freely through the chamber (Figs. 2.1 and 2.2). Enclosures were deployed at two sites, one near Richards Drive and one below Purinton Crossing on Merriconeag Stream. Additionally, enclosures were deployed at a reference stream in Bowdoin (East Branch Cathance River) that is geographically close to Mare Brook and also meets Class B aquatic life use standards. Five enclosures were deployed for seven days (August 5 – August 12) at each site and were stocked with ten mayflies each (Genus: *MacCaffertium*) from Douglas Brook in Gorham, Maine.

Enclosures on Merriconeag Stream contained no live mayflies and there was a 28% recovery of mayfly bodies.

Bowdoin college intern collecting mayflies for the 2016 study. Photo Credit: Maine DEP.

An example of the macroinvertebrate enclosures on Mare Brook. Photo Credit: Maine DEP.

Presence of Planarian flatworms suggests predation could have contributed to mayfly mortality at this site. Richards Drive saw a 36.7% survival rate with 82.2% of mayflies recovered. Lack of dead bodies suggests scavenging by isopods. Unfortunately, there was no survival in the reference enclosures on the Cathance River. Mayfly bodies were recovered so it is suspected that low dissolved oxygen levels (<2 mg/L) were the cause of mortality. As a result, additional research is needed to make any conclusions from this study.

(Left) Mayfly (genus MacCaffertium) used in this study; (middle) Tubellaria flatworms found in Merriconeag Stream, and (right) Isopoda found in Mare Brook. Both the flatworms and isopoda were found to be predating on the mayflies. Photos from Maine DEP summary report

Overall, monitoring from 2016 supports the assertion that poor habitat and aggradation of sediments is the likely cause of degraded macroinvertebrate communities in Mare Brook. Due to the high toxics in Merriconeag Stream from the former Brunswick Naval Air Station, conclusions at this site are somewhat limited. However, Picnic Pond does appear to have a moderating effect on DO.

CONTINUOUS MONITORING

Continuous monitoring was conducted by the Maine DEP across two periods in the summer of 2016; a ten-day period from June 16 – July 1 and a seven-day period during macroinvertebrate chamber deployment (August 5 – August 12). Monitoring during both periods occurred during uncharacteristically low flows and warm weather conditions. Monitoring is completed with **SONDES,** or loggers that record readings at set intervals (in the case, every 15 minutes). Loggers were deployed at six sites (MB24, MB21, MB14, MB8, MB7, and MB9) shown on the map in Figure 2.1. In general, all three parameters were found to be relatively stable for an urban stream. Dissolved oxygen diurnal swings that would indicate nutrient enrichment were limited, and low DO readings appeared to be due to moderating effects from ponding above impoundments and crossings. Conductivity was typical of urban impaired streams. Noteworthy were the apparent effects on water quality from aggradation of sediments and stormwater runoff. Rain on 6/22 and 6/29 severely affected all readings and loss of data following the 6/29 event suggests significant transport of sediments in stormwater or from aggradation that caused burial of sondes. This was most evident at site MB8 below the Brunswick Executive Airport runway where the logger was buried within two days of deployment prior to any rainfall.

SONDES are continuous data loggers that record environmental conditions in air and water. Sondes were used in Mare Brook to record dissolved oxygen, specific conductivity, and temperature.

BACTERIA SOURCE-TRACKING

Due to elevated levels of bacteria seen in the stream in 2015 at Richards Drive (site MB21), Maine DEP conducted bracket sampling in the upper section of the stream in August and September of 2016 during dry conditions. Sampling was conducted both upstream and downstream of the target area, and the study area was narrowed based on the results. This continued until the likely source was identified; an outfall discharge near the Coffin Elementary School. Across two sampling events (August 30 and September 20), *E. coli* bacteria counts at this discharge were 1,203 MPN and 980 MPN, higher than the allowable threshold for Class B waters in Maine (instantaneous *E. coli* of 236 MPN from May 15 to September 30). It is important to note that bacteria are highly variable, and this only represents one sampling point. Additionally, this discharge could be a combination of stormwater from multiple catch basins and may not be the result of the elementary school. Further investigation is needed to confirm the source of the bacteria at this location.

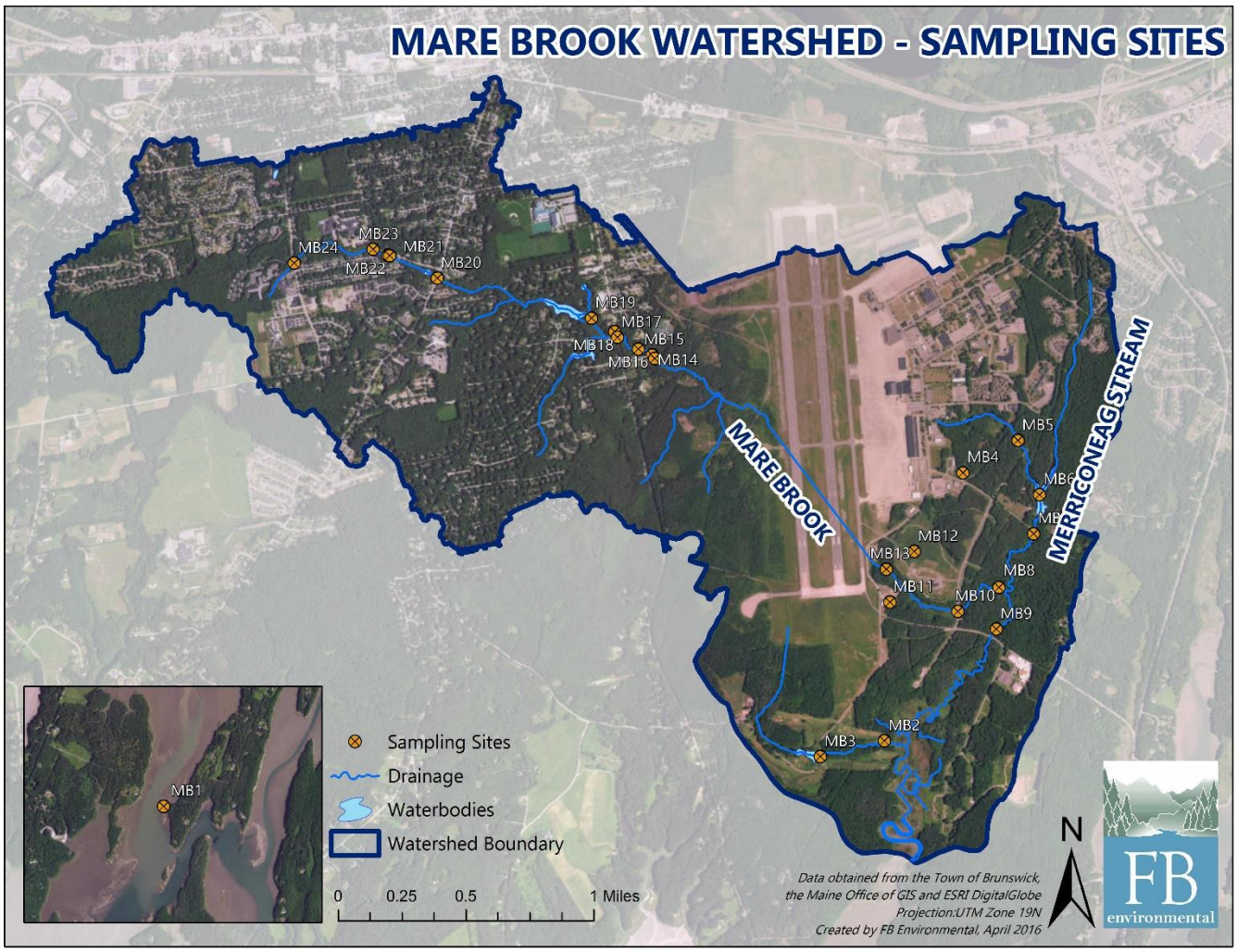


FIGURE 2.1. A map depicting all 24 sites containing current or historic surface water data. Six of these sites were monitored in 2016.

2.3 STREAM CORRIDOR ASSESSMENT

Understanding water quality is not limited to the water itself, but instead requires a holistic look at the condition of the watershed and the stream corridor- including riparian areas, wetlands, and floodplains. This project focused on an assessment of the stream corridor. Stantec performed a stream corridor assessment that included three components: (1) a Geomorphic Assessment, (2) a Riparian Assessment, and (3) a Fish Passage Assessment. A summary of the results of this assessment is provided below. The full survey report can be found on the Town of Brunswick webpage. All assessments were reconnaissance-level.

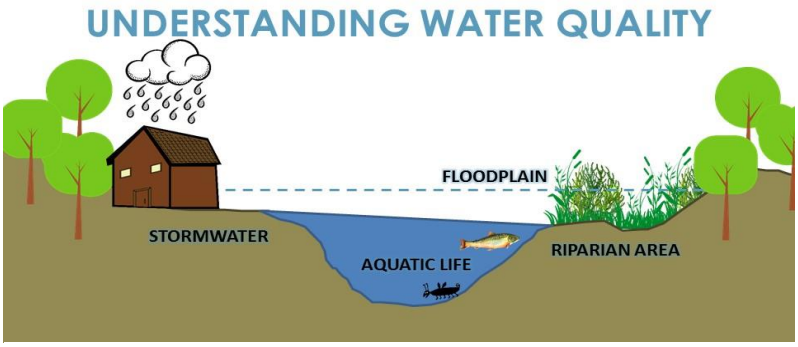


Diagram showing the various components that influence the water quality in a stream.

2.3.1 GEOMORPHIC ASSESSMENT

The geomorphic assessment identified sediment loading, stream channel alteration, and stream crossings as the major stressors to both Mare Brook and Merriconeag Stream. Mare Brook was divided into ten reaches and Merriconeag Stream into an additional two reaches. Each reach was rated on a scale from stable (lateral and vertical stability appears to be in equilibrium with natural channel processes) to unstable (lateral and/or vertical instability compared to natural processes). In total, four of the ten reaches were assigned "stable" ratings, one "stable to moderately unstable", two "moderately unstable", one "moderately unstable to unstable" and two "unstable". The two unstable reaches were Reach 1 (Baribeau Drive to Barrows Street) and Reach 9 (Brunswick Executive Airport to Major Pope Avenue), both experiencing excessive sediment loading and channel alteration. The two reaches along Merriconeag Stream were both rated as "stable". Dramatic increases in sediment load were noted at the outlet of the runway culvert.

An example of excessive sediment supply in Mare Brook. Photo Credit: Stantec.

2.3.2 RIPARIAN ASSESSMENT

Mare Brook experiences significant diversity in riparian corridor vegetation type and abundance, but is overall in relatively good condition, especially compared to other urban impaired streams in the state. Forested wetlands were found to be the most common type of wetland within the Mare Brook riparian corridor, with significantly less scrub-shrub wetlands. Emergent wetlands were located in areas upstream of impoundments due to culverts, road crossings, and dams. Floodplains ranged from intact to heavily disturbed and are described in more detail in the report. Protecting in-tact floodplains should be considered the highest priority in restoring the stream to reach its class requirements. Additionally, Stantec identified seven locations for potential vernal pools (PVPs). Follow-up study is needed to determine if the pools are "significant vernal pools" which would require protection of the pool and its terrestrial habitat under the State's Natural Resource Protection Act (NRPA).

A potential vernal pool (PVP) identified by Stantec downstream of Major Pope Road. Photo Credit: Stantec.

> The State of Maine defines Vernal Pools as *"shallow depressions that usually contain water for only part of the year"*.

2.3.3 FISH PASSAGE ASSESSMENT

Finally, Stantec also completed a fish passage assessment evaluating all stream crossings along Mare Brook and Merriconeag Stream. It is important to note that this assessment was limited to the perspective of the target species (adult brook trout, *Salvelinus fontinalis*) and does not represent an assessment of other species or hydraulic conveyance in the stream. Six of the eleven stream crossings and Coffin Pond Dam were rated as "not passable" for upstream passage of adult brook trout. The remaining five culverts were in "good" condition. On Merriconeag Stream, the Beaver Pond Road crossing was rated as "not passable" and no passage is possible from the impoundment at Picnic Pond.

The Coffin Pond Spillway which was rated as "Not Passable" during the Fish Pasasge Assessment. Photo Credit: Stantec.

2.4 POLLUTANT LOAD MODELING

The Mare Brook watershed is dominated by urban land uses (61%) with the remaining watershed area largely forest or wetlands (38.7%; Figure. 2.2), while a very small portion on the western side of the watershed contains agricultural cropland (0.3%). The urban land-use category was further defined as transportation,

commercial (includes high/medium intensity residential development), open space, and single family residential. The model estimated that 83.8% and 1.2% of the phosphorus load to Mare Brook is coming from urban and agricultural land uses, respectively; this contrasts with forest/wetland areas that make up 38.7% of the watershed, but only contribute 8.3% of the phosphorus load to Mare Brook (Table 2.3). Groundwater contributes 6.7% and is based solely on natural soil conditions (not human-derived pollutants in groundwater).

The model estimated annual loads of 23,687 lbs. N/yr, 3,095 lbs. P/yr, 70,542 lbs. BOD/yr, and 450 tons sediment/yr to Mare Brook (Tables 2.2, 2.3). The largest loads for N, P, BOD, and sediment came from three tributary subwatersheds: H, MS-L, and MS-U (Table 2.2). The largest area-weighted phosphorus and nitrogen load came from four tributary subwatersheds: A, B, G, H, and MS-L (Table 2.2). While phosphorus is generally seen as the limiting nutrient in freshwater systems, coastal systems typically experience limited nitrogen. Because Mare Brook is tidally influenced, both phosphorus and nitrogen should be monitored.

TABLE 2.2. Total annual load (nitrogen (N), phosphorus (P), 5-day biological oxygen demand (BOD), and sediment) for each tributary subwatershed in the Mare Brook watershed.

	TOTAL ANNUAL LOAD BY TRIBUTARY					
Tributary	**N (lbs./yr)**	**P (lbs./yr)**	**BOD (lbs./yr)**	**Sediment (tons/yr)**	**P (lbs./acre/yr)**	**N (lbs./acre/yr)**
A	281	41	819	9	1.1	7.6
B	682	89	1,728	12	1.1	8.2
C	480	43	1,162	6	0.5	6.1
D	122	13	357	2	0.7	6.3
E	2,159	269	6,170	41	0.8	6.7
F	1,669	215	3,853	27	0.8	6.0
G	1,841	235	4,356	34	1.3	10.5
H	3,038	330	11,705	56	1.0	9.0
I	1,438	175	4,269	26	0.8	6.4
Lower Tidal	1,931	319	5,676	41	0.5	3.3
Merriconeag Stream	263	49	783	6	0.6	3.3
MS-L	3,247	461	11,130	71	1.1	7.9
MS-M	2,743	364	7,215	51	0.7	5.3
MS-U	3,700	468	11,057	67	0.9	7.2
Picnic Pond	95	23	262	2	0.5	2.0
Total	**23,687**	**3,095**	**70,542**	**450**		

TABLE 2.3. Total annual load (nitrogen (N), phosphorus (P), 5-day biological oxygen demand (BOD), and sediment) for each major source in the Mare Brook watershed.

	TOTAL ANNUAL LOAD BY SOURCE			
Sources	**N (lbs./yr)**	**P (lbs./yr)**	**BOD (lbs./yr)**	**Sediment (tons/yr)**
Urban	18,510	2,593	69,055	417
Cropland	111	38	226	12
Forest/Wetland	529	257	1,262	21
Groundwater	4,537	207	0	0
Total	**23,687**	**3,095**	**70,542**	**450**

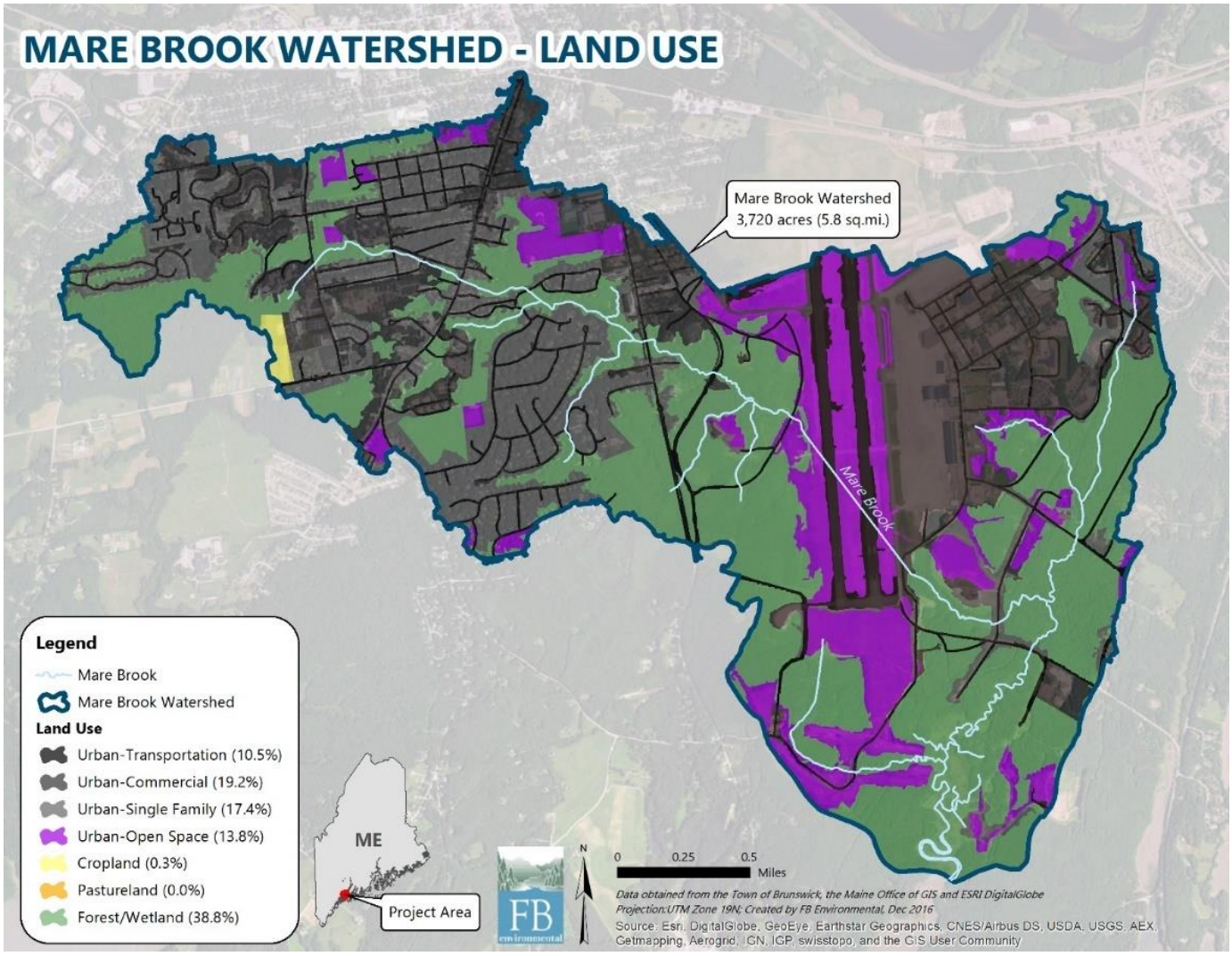


FIGURE 2.2. Map of land use in the Mare Brook watershed using STEPL land use categories.

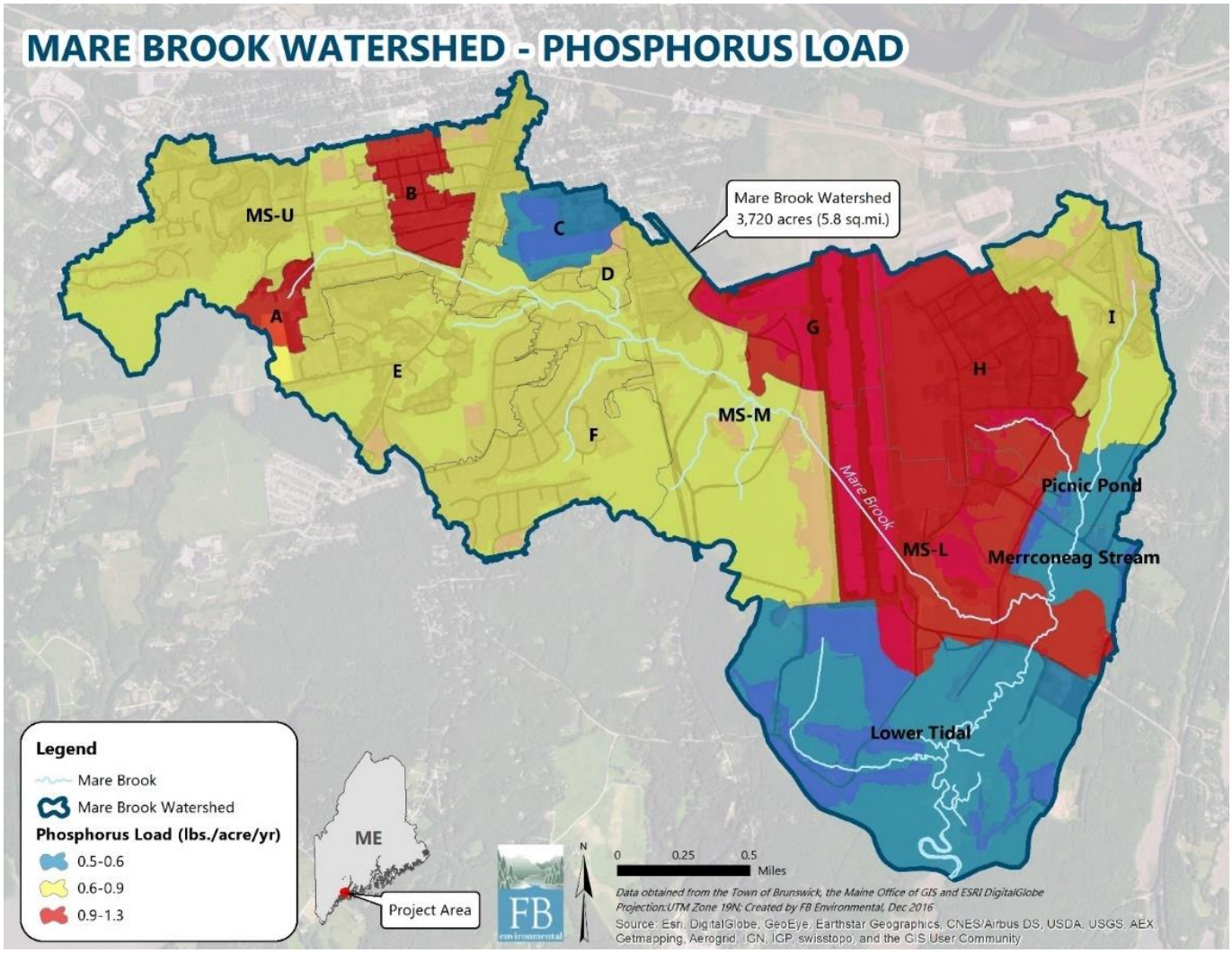


FIGURE 2.3. Map of area-weighted total annual phosphorus load by tributary subwatershed in the Mare Brook watershed.

3 WHAT'S NEXT FOR MARE BROOK?

3.1 SPECIFIC RECOMMENDATIONS

This report serves as a baseline for the restoration of Mare Brook to attain Class B state standards, however, stream restoration is a long-term process. The goal of this report is to provide the Town of Brunswick, the TAC, and local stakeholders and residents a tangible list of recommendations for continuing the process of restoration in the Mare Brook watershed. Recommendations for next steps are outlined below, under five major categories (Water Quality Monitoring, Habitat Restoration, Education and Outreach, Watershed Surveys, and Planning).

3.1.1 WATER QUALITY MONITORING

- Work with U.S. Navy to combine efforts to monitor stage height/flow in Merriconeag Stream. Couple permanent gauging stations deployed by the U.S. Navy with continuous pressure transducers to create a stage-discharge relationship on Merriconeag Stream to characterize flow.
- Install staff gauges and pressure transducers to identify flow dynamics on the main channel of Mare Brook. Recommended sites are MB24 (Baribeau Drive), MB14 (Jonathan Street), and MB9 (Liberty Crossing). This will give the town an idea of the flow characteristics in the headwaters, below Coffin Pond, and below the confluence with Merriconeag Stream.
- Install permanent monitoring sites to establish baseline conditions for temperature and dissolved oxygen at MB24, MB14, and MB9. If possible, deploy loggers for the extent of the season (May – October/November) to identify seasonal/annual patterns in water quality.
- Collect grab samples for chloride, and E. coli at a minimum two times per year (one wet/one dry). Where increases in chloride are evident, consider adding a continuous specific conductivity logger at each of the sites mentioned above (MB24, MB14, and MB9).
- Investigate the storm drain pipe coming from the Brunswick Junior High School/Coffin School culvert to identify and eliminate the cause of the elevated bacteria levels noted in 2016 (note that this bracketing did not have a geometric mean).
- Explore the use of bioassays to evaluate the general toxicity of Merriconeag Stream.
- Coordinate with Maine DEP to perform macroinvertebrate sampling as needed following restoration activities within the watershed. Maintain baseline macroinvertebrate sampling.
- Explore macroinvertebrate community structures in both estuarine and freshwater reaches.

3.1.2 HABITAT RESTORATION

- Maintain in-tact riparian buffers and restore areas with poor buffers as indicated in 2016 Stream Corridor Assessment.
- Perform regular maintenance at the Samuel Adams Drive culvert, specifically at the inlet debris gate, to make sure that no blockages form.
- Additional study is needed at the Runway Culvert, specifically with regard to behavioral factors that may prevent upstream fish passage through this culvert.
- Identify the cause of the excess sediment below the Brunswick Executive Airport runway (around Site MB8) and consider conducting a sediment mobility study during a storm event to evaluate the impact of sediments on water quality.

- In the Spring of 2017, work with the Department of Marine Resources and the Casco Bay Estuary Partnership to initiate a study to identify the extent to which Mare Brook is used as Smelt habitat.
- Consider re-routing the stream channel to pass south of the runway to daylight the section of stream underneath the runway and investigate the original stream course.
- Additional study at the Beaver Pond Road stream crossing on Merriconeag Steam focused on whether the existing stream crossing is hydraulically adequate to convey high flows.
- Explore option of dam removal at Coffin Pond Dam and gauge landowner interest in the project. Alternatively, consider repairing the current dam structure.
- Perform invasive species control within the stream corridor.
- Develop a strategy for assessing toxic bioaccumulation below head of tide. Consider sampling ribbed mussels (*Geukensia demissa)*, benthic worms, and or predator species.

Ribbed Mussels (*Geukensia demissa)* remove toxics from the water through filter feeding. This can improve water quality but can also cause elevated toxics in the mussel tissue (Chesapeake Bay Program). **Photo Credit:** Chesapeake Bay Program.

3.1.3 EDUCATION AND OUTREACH

- Increase conserved land within the watershed with a focus on preserving floodplains. Work with the Brunswick-Topsham Land Trust to secure land in conservation and improve access to the community. Encourage signage along trail systems (for example at the Coffin Pond Dam).
- Continue to improve public access to the Kate Furbish Preserve envisioned through the RTOS Management. This will increase the value of natural resources to local residents and help with the protection of these resources.
- Build upon the relationship between the Town of Brunswick and Bowdoin College. Specifically, work with undergraduates to help with water quality monitoring and educational outreach.

3.1.4 WATERSHED SURVEYS

- Perform a full retrofit-reconnaissance inventory (RRI) of impervious areas to identify locations within the watershed that would reduce and/or treat stormwater runoff to the stream. An RRI is a watershed-wide assessment of impervious surfaces that are contributing stormwater runoff to the stream.
- Work with the U.S. Navy to conduct a comprehensive summary report of all monitoring activities on the U.S. Navy land.
- Identify government grant funds available for more aggressive restoration – specifically addressing the toxics built-up in the sediments behind Picnic Pond. Coordinate with the Defense Environmental Restoration Program (or other appropriate agencies) and the Environmental Protection Agency to acquire funds.

3.1.5 PLANNING

- Develop a detailed watershed action plan to incorporate above recommendations and assign roles and responsibilities.
- Perform a comprehensive ordinance review to identify tools to improve water quality in Mare Brook.
- Identify a process for integrating new data into the 2016 Data Directory.
- Supplement the stormwater management standards in the draft Zoning Ordinance with specific standards for Mare Brook.

Mare Brook as it runs through the U.S. Navy property.

3.2 FUNDING RESTORATION OPTIONS

US EPA/MAINE DEP 319 GRANTS – This nonpoint source (NPS) grant is designed to assist municipalities with restoring waters named as NPS Priority Watersheds and are available for the implementation of watershed-based management plans. http://www.maine.gov/dep/water/grants/319.html

US EPA URBAN WATERS SMALL GRANTS - The Urban Waters Small Grants program helps local residents and their organizations, particularly those in underserved communities, restore their urban waters in ways that also benefit community and economic revitalization. Grants are awarded every two years, with individual award amounts of up to $60,000. https://www.epa.gov/urbanwaters/urban-waters-small-grants

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. http://www.nfwf.org/fivestar/Pages/home.aspx

CLEAN WATER BOND – Maine voters approved the Clean Water Bond in November 2012. Of the $10 million bond, $5.4 million will be used to upgrade stream crossings and culverts to help reconnect habitat for fish and other wildlife. http://www.maine.gov/dep/land/water_bond_rfp.html

MAINE COASTAL PROGRAM GRANTS – Municipalities and regional organizations in Maine's coastal zone are eligible to apply for small grants that provide funds for projects designed to improve water quality, increase resiliency and adaptation to erosion and flooding, conserve coastal habitat, promote sustainable development, and enhance the

coastal-dependent economy while preserving natural coastal resources. In Fiscal Year 2016, $250,000 was awarded to eleven projects ranging from $5,000 - $48,000, including Mare Brook. The Town of Brunswick could apply for a second round of funding; however, funding cannot be used for implementation efforts.
http://www.maine.gov/dacf/municipalplanning/index.shtml

COMPENSATION FEE UTILIZATION PLAN – The Stormwater Management Law authorizes the DEP to accept a compensation fee in lieu of meeting all or part of water quality standards, and Chapter 500, Section 6, establishes compensation fee requirements for projects located in the watersheds of urban impaired streams. Bangor has an established CFUP that should be used to mitigate stormwater runoff.

STORMWATER UTILITY FEE – A stormwater utility fee can be used to generate revenue towards mitigating the effects of development on downstream water quality.

4 TIPS FOR PROTECTING MARE BROOK

4.1 RESIDENTIAL & COMMERCIAL PROPERTY OWNERS

Due to the intense residential development along the stream, it is important that all private landowners contribute to stream restoration through both structural implementation projects on their property as well as non-structural community support.

1. IMPROVE/CREATE RIPARIAN BUFFERS: Riparian buffers are critical to stream health. They filter and slow down stormwater runoff from the developed landscape to reduce the impact to the stream channel. Additionally, they reduce stream bank erosion which can contribute to the aggradation seen in the stream channel. Buffers also shade the stream, lowering the water temperatures and creating refuge for aquatic life.
2. INFILTRATE STORMWATER: Operating on the same principles as discussed above, infiltrating stormwater into the ground reduces the volume of water reaching the stream during precipitation events and also filters out nutrients and harmful pollutants. Care should be taken to infiltrate polluted stormwater only where appropriate to avoid impacts to groundwater.

An example of a rain garden implemented on a residential property in Kittery, ME, before implementation (left) and after (right). Photo Credit: FBE

3. REDUCE SALT APPLICATION: Chloride levels in Mare Brook are typical of urban impaired streams and do not raise any significant concerning flags. However, once chloride dissolves in the water from winter salt application, it is nearly impossible to remove. Therefore, it is imperative that the town and local residents be aware of salt use and minimize exposure to the stream. This will keep the chloride levels low and reduce toxicity to aquatic life.
4. REDUCE PESTICIDE/FERTILIZER APPLICATION: Pesticide and fertilizer application on residential properties, specifically those bordering the stream, can degrade water quality. Pesticides contain substances toxic to aquatic life and fertilizers contribute excess nutrients that interfere with the natural balance of the ecosystem, often fueling algal growth which then consumes oxygen through its decomposition process.

5. GET INVOLVED! Become a volunteer with Bowdoin College, the Brunswick-Topsham Land Trust, or the Town of Brunswick to support ongoing monitoring and assessment throughout the watershed.

4.2 MUNICIPAL/PUBLIC LANDOWNERS

It is the role of both the residents and the Town of Brunswick to work towards restoration of the stream. The following provides suggestions for ways that municipal staff and public landowners can work towards this goal.

1 MAINTAIN A FUNDING MECHANISM: It is the responsibility of the town to maintain funding and momentum for restoration projects. This can be a combination of grant funding, private donations, and municipal funding. (See Funding Restoration Options for possible grant opportunities, Section 3.2).

2 IMPROVE MAPPING OF STORMWATER SYSTEM: Mapping of stormwater systems can improve maintenance demands, help identify water quality problems, and increase response time to infrastructure failures.

3 INCREASE LAND IN CONSERVATION: The Brunswick-Topsham Land Trust holds land in conservation in the northwest corner of the Mare Brook watershed at Crystal Springs Farm. Additionally, the town has the newly acquired Kate Furbish preserve located to the southeast of the Brunswick Executive Airport. The town should continue to work with the U.S. Navy to preserve U.S. Navy-owned land as it is assessed and remediated.

4 INVESTIGATE SEWER SYSTEM: Investigate sewer system to identify any possible leaks and/or sections of infrastructure that need maintenance.

5 CREATE PLAN FOR CULVERT IMPROVEMENTS: Using the 2016 assessment by Stantec and the Maine Stream Habitat Viewer as a guide, the town should create a strategic plan for repairs and/or replacements to poor culverts in the Mare Brook watershed. Include an assessment of the hydraulic conveyance of culverts in the watershed and work with key stakeholders to prioritize goals for restoration.

6 PARTICIPATE IN RETROFIT RECONNAISSANCE INVENTORY (RRI): Assist consultants and stakeholders in conducting a RRI. This survey would identify areas to reduce the volume or pollution of stormwater runoff by recommending treatment practices such as wet ponds, filters, vegetated swales, and gravel wetlands.

REFERENCES

Center for Watershed Protection (CWP), 2003, Impacts of IC on Aquatic Systems. Retrieved from http://clear.uconn.edu/projects/tmdl/library/papers/Schueler_2003.pdf.

Chesapeake Bay Program, Atlantic Ribbed Mussel, accessed: January 4, 2017. http://www.chesapeakebay.net/fieldguide/critter/atlantic_ribbed_mussel

Maine DEP, 2011, Mare Brook Watershed (Town of Brunswick-Cumberland County) Stream Corridor Survey – Summary Report.

Maine DEP. 2012. Maine Impervious Cover Total Maximum Daily Load Assessment (TMDL) for Impaired Streams. Document #: DEPLW-1239.

U.S. Department of Health and Human Services, 2005, Public Health Assessment for Naval Air Station Brunswick, Cumberland County, Maine EPA Facility ID: ME8170022018.

OTHER LINKS

General Link for the Mare Brook Watershed Assessment and Community Engagement Website

http://www.brunswickme.org/departments/planning-development/mbwsa/

The following documents can be found on this webpage:

- Press Release – Coastal Community Planning Grants Awarded
- Mare Brook Progress Report July – December 2015
- Mare Brook TAC Meeting PowerPoint Presentation – January 2016
- Mare Brook TAC Meeting Notes – January 2016
- Mare Brook Stressor Analysis
- Mare Brook TAC Meeting PowerPoint Presentation – April 2016
- Mare Brook TAC Meeting Notes – April 2016
- Mare Brook 2016 Monitoring Plan
- Mare Brook Monitoring Site Map
- Mare Brook TAC Feedback 2016

Links for More Information Regarding BMP Implementation:

- City of South Portland Stormwater Manual: http://www.southportland.org/index.php/download_file/view/280/254/
- EPA Soak up the Rain: https://www.epa.gov/soakuptherain
- UNH Stormwater Center: https://www.unh.edu/unhsc/

APPENDIX A: POLLUTANT LOAD MODEL

METHODS

The Spreadsheet Tool for Estimating Pollutant Loads (STEPL) is a simple, Excel-based model that calculates nitrogen, phosphorus, sediment, and 5-day biological oxygen demand (BOD5) loads from general land uses, including urban, cropland, pasture, forest, and other user-defined categories. The tool also inputs annual rainfall, number of agricultural animals, and septic system load to generate a total watershed load by pollutant and subwatershed. Load reductions from implemented Best Management Practices (BMPs) by subwatershed and dominant land use can also be calculated by the model.

STEPL INPUTS AND ASSUMPTIONS:

- Divided watershed into 15 tributary subwatersheds. The tributary subwatersheds were taken from DEP's 14 tributary delineations of Mare Brook's freshwater portion, plus the lower tidal area.
- Updated land use layer from 2004 MELCD. Land use for the Mare Brook watershed was last updated in 2010 as part of the Maine DEP IC TDML. However, Maine DEP land use layer was clipped to the old watershed boundary. A new land use layer was generated by clipping the Maine DEP land use layer to the new watershed boundary and adding 0.5 square miles of land use from the 2004 Maine Land Cover Database (MELCD) to account for new delineated watershed areas. 2004 MELCD land use categories were reclassified per STEPL land use categories. High and Medium Intensity Development was reclassified as Urban-Commercial; Low Intensity Development was reclassified as Urban-Single Family; Developed Open Space was reclassified as Urban-Open Space; all forest, wetland, logged, meadow, and water categories were reclassified as Forest. A brief check of land use against recent ERSI imagery showed that significant updates were necessary. A 25-foot buffer was applied to E911 roads in the watershed, overlaid on to the land use layer, and reclassified as Urban-Transportation.
- Selected Portland International Jetport, Cumberland County, Maine as the representative weather station. The next closest weather station available through the model was Augusta, which showed a lower average rainfall per event compared to Portland, likely due to coastal effects; since Brunswick is located along the coast, Portland is likely more representative of local weather patterns.
- No agricultural animal counts or irrigation amounts available. A small (0.3%) portion of the Mare Brook watershed is cropland (and no information is available on the amount of irrigation used). Anecdotal information suggests that there are very few, if any, agricultural animals in the watershed. An aerial land use review from recent ESRI imagery showed no evidence of penned areas or grazing fields in the watershed. Therefore, no agricultural animal counts were included in the model. Note: the model can account for beef cattle, dairy cattle, swine, sheep, horse, chicken, turkey, and duck, as well as manure application to hayfields. The model can easily be updated in the future if evidence of agricultural pollutant sources becomes available.
- Most of the watershed is serviced by sewer. STEPL requires inputs for the number of septic systems in each subwatershed and calculates loadings based on researched estimates of nutrient and organic concentrations from septage effluent. Most of the Mare Brook watershed is serviced by sewer; therefore, septic system inputs were not accounted for in the model. This assumes that sewer lines are properly maintained and sealed with no leakages.

- Used Cumberland County average USLE figures for each land use category. More site-specific USLE parameters for each land use category in the Mare Brook watershed were unavailable, but can be updated in the future for more accurate pollutant load estimates.
- Updated average soil hydrologic group (SHG). Soil information was obtained from Web Soil Survey online. The average soil hydrologic group (SHG) was determined for each tributary subwatershed. Most sites were rated A for high infiltration; four sites (Lower Tidal, Merriconeag Stream, MS-L, and Picnic Pond) were rated D for low infiltration.
- Updated soil N and P concentration values. Soil nitrogen (N) and phosphorus (P) concentrations were derived from a STEPL-provided map of N and P concentrations for the United States. The average of the range for coastal Maine (0.10-0.19) was used (0.15).
- Further defined urban land use. STEPL allows for more detailed distinctions in the urban land use category, such as residential development, commercial development, developed open space, and roads. While all urban categories were first input to the model as a lump sum, the urban categories of Commercial, Transportation, Single Family, and Open Space were also added to the model to better account for differences in runoff volume and pollutant concentrations from the various types of urban surfaces.
- Streambank erosion not accounted for in model. STEPL can calculate additional sediment load from erosional features (e.g., streambanks and gullies). A geomorphic assessment was completed by Stantec (report dated October 25, 2016), which found six out of twelve reaches to be unstable (i.e., the channel appears to have lateral and/or vertical instability as compared with natural channel processes). Loads from unstable streambanks can be included in the model if specific information on streambank length, height, lateral recession rate, and soil textural class can be determined.
- Assumed direct atmospheric nutrient load minimal. STEPL does not account for atmospheric nutrient loading, but this was assumed to be minimal for Mare Brook given the small surface area to watershed ratio of the stream (compared to a lake or pond).
- Reality check data minimal. One of the major weaknesses of STEPL is the capacity of the model to use real data to check model outputs. Some back-handed calculations were attempted using grab samples collected by the Maine DEP in August 2003 during moderate flow conditions. Two biomonitoring stations draining only a portion of the watershed were used in the basic calculations (concentration x flow = load). STEPL may be underestimating the nitrogen load (unless nitrogen fixation was high during sampling, which is likely during the peak growing season and would not represent average annual conditions). The phosphorus load is likely on target since STEPL reported phosphorus load higher than the reality check data. Since a single grab sample in summer was used to represent average year-round conditions, it would be expected that the annual phosphorus load be higher when accounting for storm events and spring snowmelt (that the August 2003 sample does not account for).
- Toxic groundwater inputs unique to Mare Brook not estimated. There are known underground toxic and hazardous substances that leach into local groundwater and streams that were not accounted for in this simple model.

ADDITIONAL RESULTS

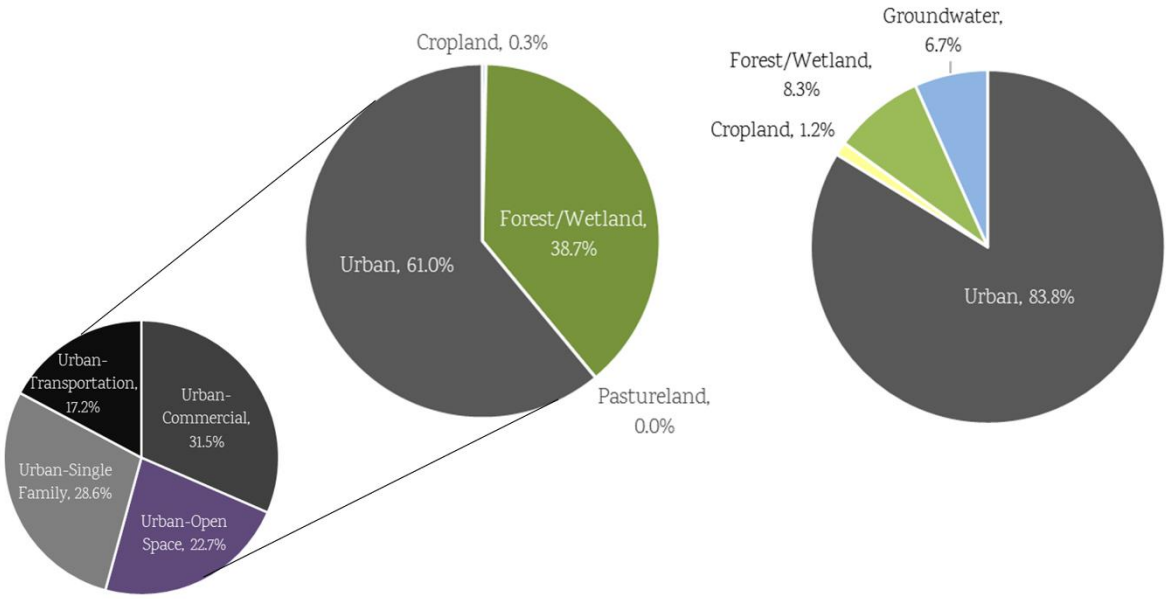


FIGURE A.1. Percent area coverage of STEPL land use categories in the Mare Brook watershed (left). Percent of total annual phosphorus load by STEPL land use category (right).