Goodall Brook
Watershed Based Management Plan

Sanford Maine

York County
Soil and Water
Conservation District

DEPARTMENT OF ENVIRONMENTAL PROTECTION
STATE OF MAINE

FB
environmental

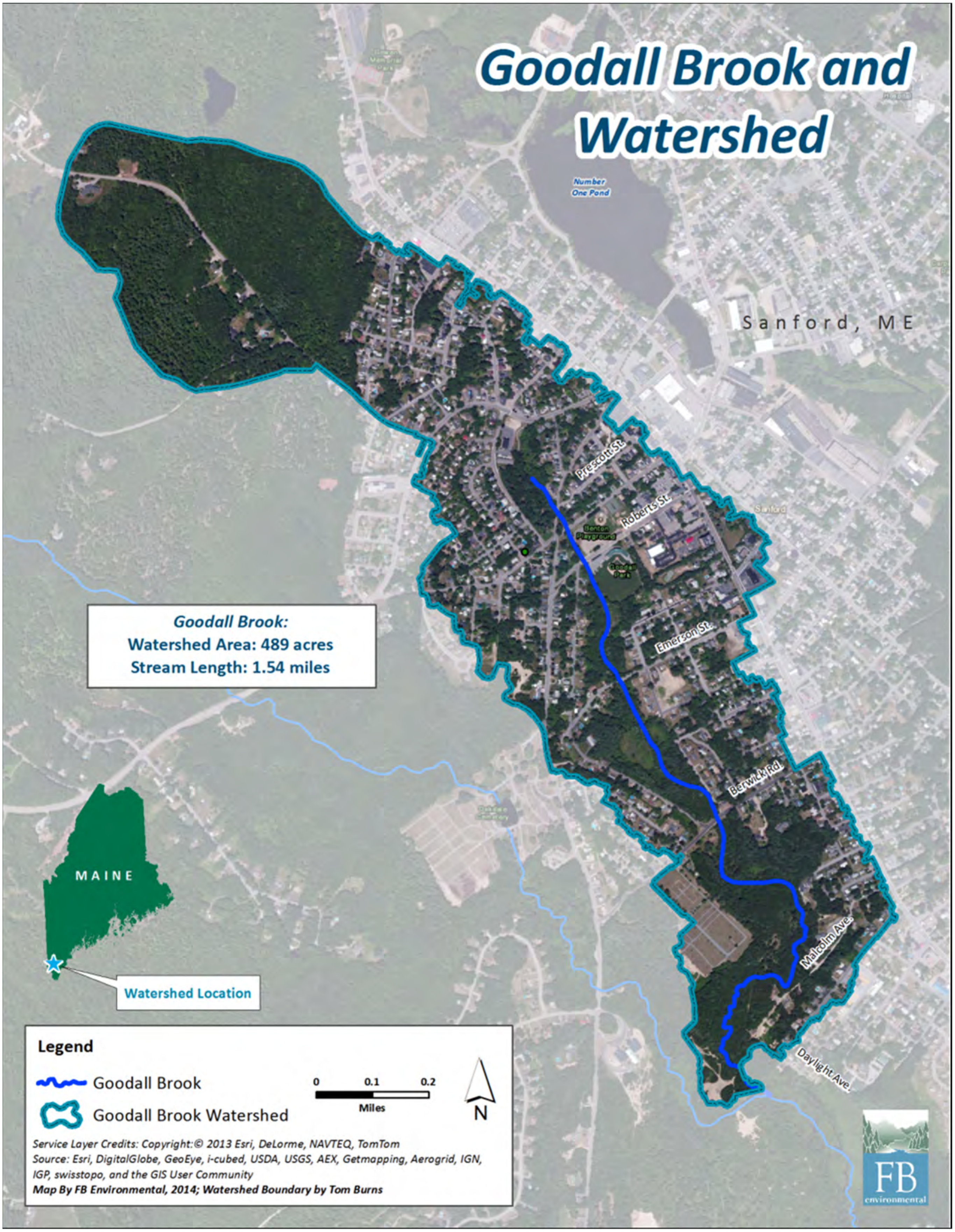


Figure 1-1. The Goodall Brook Watershed.

Goodall Brook Watershed Based Management Plan

Prepared for the City of Sanford, Maine
by FB Environmental Associates,
York County Soil and Water Conservation District and
the Maine Department of Environmental Protection

December 2014

Table of Contents

Appendices

Figures

Tables

Acknowledgements

Charlie Anderson, Public Works, City of Sanford

Joe Anderson, YCSWCD

Whitney Baker, FB Environmental

Luke Beals, Citizen

Mary Blood, Bauneg Beg Lake Association

Marcel Blouin, Parks & Recreation, City of Sanford

Andre Broussard, Sanford Sewerage District

Tom Burns, GIS Mapping and Analysis

Mike Casserly, Engineering, City of Sanford

Jeremy Deeds, FB Environmental

Jeff Dennis, Maine DEP

Brian Desrocher, Parks & Recreation, City of Sanford

Emily DiFranco, FB Environmental

Chris Feurt, Wells Reserve

John Field, Field Geology Services

Theresa Galvin, YCSWCD

Wendy Garland, Maine DEP

Larry Gaudreau, Bauneg Beg Lake Association

Jim Gulnac, Planning, City of Sanford

Mike Hanson, Sanford Sewerage District

Matthew Hill, Public Works, City Of Sanford

Phillip Jacques, Maine DEP

Bud Johnston, Mousam Way Regional Trust Beth

Marass and students, Sanford High School

Cynthia Peedin, Waban Projects

Dana Peterson, Bauneg Beg Lake Association

Ann Rossignol, Waban Projects

Paula Simpson, Treasurer, City of Sanford

Peter Smith, Public Works, City of Sanford

Leon Tsomides, Maine DEP

David Waddell, Maine DEP

All who attended the community kick-off meeting

Funding for this project, in part, was provided by the U.S. Environmental Protection Agency under Section 319 of the Clean Water Act. The funding is administered by the Maine Department of Environmental Protection in partnership with EPA.

1.0 Executive Summary

1.1 Project Overview

The ***Goodall Brook Watershed Management Plan*** was developed through a locally-supported planning process. The project was initiated by the City of Sanford and funded by Maine Department of Environmental Protection (DEP) under Section 319 of the Clean Water Act. Plan development was coordinated by FB Environmental Associates (FBE), York County Soil and Water Conservation District (YCSWCD), the City of Sanford, Maine DEP and a Technical Advisory Committee (TAC) composed of watershed stakeholders including engineers, environmental professionals, and residents. Field Geology Services provided technical assistance.

1.2 Goodall Brook and its Watershed

The Goodall Brook watershed covers 0.76 square miles (489 acres) in the City of Sanford in the southwest corner of the State of Maine (Figure 1-1). Goodall Brook's headwaters are located in a forested area along Hanson Ridge Road. At Grandview Avenue, the stream is diverted into a series of pipes and then flows nearly 2000 feet underground until it emerges at Lebanon Street. It then flows southeast through Sanford and then into a large forested wetland before flowing into the Great Works River, which then flows into Bauneg Beg Lake in Sanford and North Berwick, ME.

The Goodall Brook watershed is predominantly developed, with 321 acres (66%) of the watershed consisting of residential or commercial land uses. There are approximately 132 acres (27%) of forest land in the watershed, located primarily in the northern portion of the watershed. Impervious cover totals approximately 23.7% (138 acres) of the Goodall Brook watershed. Studies have shown that the percentage of impervious cover (% IC) in a watershed strongly affects the health of aquatic systems, because land surfaces that block infiltration of rainwater can lead to increased amounts of stormwater runoff into gutters, untreated storm sewers or directly to streams. In general, surface water quality declines as imperviousness exceeds 10% of watershed area (CWP, 2003).

1.3 Existing Conditions and Threats to Water Quality

Goodall Brook was first assessed by the Maine DEP in 2004, and it was determined that the stream does not meet its Class B aquatic life criteria. As a result, DEP listed Goodall Brook as impaired on its 2012 **303(d) list** (Maine DEP, 2012). Subsequent monitoring also indicates that the brook does not meet applicable criteria for dissolved oxygen or bacteria concentrations.

> ***The 303(d) list*** *is a list of all waters that do not meet water quality standards, and are therefore classified as "impaired". The list is named for the section of the Federal Clean Water Act that requires states (Maine DEP) to provide a list of impaired waters to the US EPA every two years.*

The lack of suitable habitat and flow velocity is likely the primary reason that Goodall Brook does not meet State water quality standards. Historic dredging, widening and straightening of the stream channel has left the majority of Goodall Brook as a wide, slow moving stream with thick, soft sediments along the bottom. This type of habitat is not able to support the diversity of aquatic life necessary to meet Class B standards for aquatic life in the stream.

The problems associated with stream alteration are compounded by the high impervious cover (IC) in the watershed. IC is the term used to categorize all surfaces that do not allow water to infiltrate naturally into soils. IC includes hard surfaces such as roads, driveways, parking lots and roof tops – all of which alter the dynamics of watershed hydrology by increasing the amount and energy of stormwater and the pollutants it carries. The combination of pollutants in stormwater, including excess sediment and nutrients, contribute to loss of habitat and the impairment of aquatic life, bacteria and dissolved oxygen in streams.

1.4 Why Develop a Watershed Plan?

A **Watershed Management Plan** helps identify problems, priorities and actions that are needed to improve the water quality of a lake, river, stream or coastal water. Since each watershed is unique, plans must be tailored to address the specific issues and concerns of both the community and the stream.

> ***A Watershed Management Plan*** *serves as a road map to stream restoration, providing a guide to the actions, scheduling, monitoring, and costs along the route to meeting water quality standards.*

A watershed plan provides an opportunity for stakeholders to work together to prioritize, schedule, and fund restoration activities. It is a planning document recognized by the U.S. Environmental Protection Agency (US EPA) and Maine DEP, and it needs to be completed before groups can apply for DEP's 319 grant funding to implement a plan. (See Appendix A for the nine required elements for watershed-based plans.)

In addition to its interest in restoring Goodall Brook, the City of Sanford also views the Goodall Brook Plan as a way to be proactive with its stormwater and water resources management. Currently, Sanford does not fall under federal and state regulations for stormwater management. However, it is anticipated that the Municipal Separate Storm Sewer Systems (MS4) permit will eventually include Sanford, and watershed efforts started now can be gradually and economically phased in over time. Further, proactive efforts by the City will help prevent citizen lawsuits and EPA petitions that have been filed in other communities to force restoration of impaired waters. Perhaps most importantly, the Goodall Brook project serves as a model and pilot for future City-wide efforts to protect and restore the Sanford's abundant water resources.

1.5 Water Quality Goals

Project stakeholders met numerous times throughout the watershed planning process and developed several overriding goals for Goodall Brook. The goals and associated objectives include:

Improve conditions in Goodall Brook so that it meets Class B water quality standards.

- Restore the macroinvertebrate community to one that meets aquatic life use criteria
- Improve dissolved oxygen levels in the stream
- Reduce the levels of *E. coli* bacteria in the stream

Prevent future water quality impacts to Goodall Brook and downstream waters, including Bauneg Beg Lake.

- Provide improved stormwater treatment from new and existing development
- Implement municipal ordinances that guide new development and reduce stream impacts
- Coordinate with partners to protect important conservation lands and address future potential impacts

Build community awareness and support for the restoration and protection of Goodall Brook and the City's other water resources.

- Develop and carry out public outreach programs to raise awareness about pollution issues and individual actions to reduce impacts to water quality
- Involve local schools in stream monitoring and restoration activities
- Form a Goodall Brook committee to guide plan implementation

1.6 Recommended Management Strategies

The ***Goodall Brook Watershed Management Plan*** includes a number of strategies to achieve the water quality goals and objectives listed above. Strategies include:

- **Installation of Stream Habitat Improvements**, including streamside buffer plantings and in-stream habitat restoration projects such as the strategic addition of logs to improve the stream's aquatic community (also referred to as macroinvertebrates) and dissolved oxygen.
- **Installation of Stormwater Treatment Practices**, including structural practices (retrofits and installations of tree box filters, level spreaders, etc.) and non-structural practices (educational campaigns, ordinances to promote Green Infrastructure, etc.) to address habitat, bacteria and dissolved oxygen problems in the stream.

Trees and logs in this section of Goodall Brook provide habitat for aquatic organisms.

- **Detection and Elimination of Bacteria Sources**, including sewer camera inspections, monitoring and repair/replacement of faulty sewer lines, and public outreach about proper pet waste disposal.

1.7 Plan Implementation and Funding

A **Goodall Brook Plan Implementation Committee** will be formed to oversee and guide the implementation of the Goodall Brook Watershed Plan. The committee will be set up through the City Council and will include City staff, representatives from the Planning Board and City Council, Bauneg Beg Lake Association and other interested stakeholders. Continued support will also be provided by Maine DEP and YCSWCD staff.

The implementation phase of this plan will take place over 10 years (2015-2025), and costs will be spread out over that time period. Restoration of Goodall Brook will require a coordinated implementation program supported by private, state, City, and federal funding. The watershed action plan (Section 6.3) lists and prioritizes actions to address the water quality impairments in Goodall Brook. Possible funding sources are listed for each action item as well.

The total cost of the plan over the next decade is estimated between $300,000 and $450,000. An estimated 50% of this cost is associated with City staff time spent on the project. As such, many of the items in the action plan will be carried out by City staff with no added costs to the City. Grant funding will also be sought out to help fund more expensive items in the plan and provide cost-share opportunities to improve stream habitat or retrofit existing impervious surfaces with improved stormwater treatment systems. Maine DEP's 319 grants will be pursued as a significant funding source for the plan.

2.0 Purpose and Background

2.1 Why is the plan needed?

Goodall Brook has been identified as not meeting state water quality standards for aquatic life. This means that the stream is not able to support the normal community of aquatic animals that should be living there. The plan and State standards focus primarily on the aquatic insects (or macroinvertebrates) that are the base of the food chain and that spend part or all of their life cycles in the stream. The cause of the impairment to Goodall Brook's macroinvertebrate community is varied. Stressors to Goodall Brook's water quality include past stream modification and the resulting poor aquatic habitat, slow water velocity and poor variability in flow patterns. In addition, the stream is also impacted by excess pollutants such as the nutrient, phosphorus, and bacteria. The purpose of this plan is to develop a road map to restore Goodall Brook to a stream that meets all standards for water quality.

Aquatic Life in Goodall Brook

Aquatic organisms (also called macroinvertebrates) tell a lot about a stream. If sensitive organisms such as caddisflies (below) and stoneflies are abundant, then water quality is good. If only worms and other pollution-tolerant organisms are found, this points to problems with stream habitat and/or water quality.

Goodall Brook supports a healthy bug community in its lower reaches, but the upper reach is considered impaired.

This plan was developed to align with EPA and DEP guidance so that Sanford will be eligible to receive future grants to help implement the plan and restore Goodall Brook. (See Appendix A for EPA's list of required plan elements and where they can be found in the Plan.) In addition, the City of Sanford also views the ***Goodall Brook Watershed Management Plan*** as a way to be proactive with its stormwater and water resources management. Currently, Sanford does not fall under federal and state regulations for stormwater management. However, it is anticipated that the Municipal Separate Storm Sewer Systems (MS4) permit requirements will eventually apply to Sanford, and watershed efforts started now can be gradually and economically phased in over time. Further, proactive efforts by the City will help prevent citizen lawsuits and EPA petitions that have been filed in other communities to force restoration of impaired waters. Perhaps most importantly, the Goodall Brook project serves as a model and pilot for future City-wide efforts to protect and restore the Sanford's abundant water resources.

2.2 How was the plan developed?

This plan was developed using a science-based, watershed approach. Water quality monitoring and field assessments helped identify specific problems in different parts of Goodall Brook. The watershed, including current and future land uses, was then evaluated to determine existing and potential sources of pollution. Local stakeholders were actively involved throughout the project and helped select management strategies and actions that will be implemented to remedy identified problems in the watershed.

Watershed residents attend a project kick-off event.

The Goodall Brook Steering Committee and Outreach Committee provided input on project startup activities and helped plan a public kickoff meeting. In June 2013, about 15 people attended the community kickoff meeting to hear about the project and provide input through a keypad voting activity. In November 2012, Sanford High School students conducted an intercept survey to assess public awareness about water quality issues and Goodall Brook. The project's Technical Advisory Committee (TAC) met numerous times throughout the project and used a series of iterative steps to review monitoring data, identify and prioritize problems, define management goals, and develop protection and remediation strategies. In December 2014, the draft plan was provided to stakeholders and presented to the City of Sanford for review, and feedback was incorporated into the final plan.

2.3 Who was involved?

The Goodall Brook Watershed Management Plan was initiated by the City of Sanford and funded by the Maine DEP and US EPA under Section 319 of the Clean Water Act. Project collaborators included the York County Soil and Water Conservation District (YCSWCD), Maine DEP, Bauneg Beg Lake Association (BBLA), City of Sanford and interested citizens. YCSWCD served as the project manager, and FB Environmental was contracted to participate in the plan development process and to help draft the watershed management plan. Field Geology Services provided technical assistance.

2.4 Who should read this plan?

Because the ***Goodall Brook Watershed Management Plan*** defines existing and future problems that need to be addressed, any group that influences or is affected by water quality and habitat management and land-use decisions should read this report. The City of Sanford and local groups in and around the Goodall Brook watershed should use this plan as a foundation for local action-from stream restoration projects to development ordinance changes. State and federal agencies can use this plan to enhance understanding of local watershed conditions, and as a basis for supporting future grant funding and monitoring efforts.

3.0 Description of the Watershed

3.1 Location

The Goodall Brook watershed covers 0.76 square miles (489 acres) in the City of Sanford in the southwest corner of the State of Maine (Figure 1-1). Goodall Brook is a small tributary to the north branch of the Great Works River and begins in a forested area along Hanson Ridge Road. At the corner of Douglas Street and Grandview Avenue, the stream enters a pipe and travels underground for 2000 feet. It emerges at Lebanon Street and then flows southeast parallel to the Little League fields at Benton Park, passes under Roberts St., and flows adjacent to the baseball field at Goodall Park. After the brook passes under Berwick Rd. it flows into a large forested area where it continues adjacent to St. Ignatius Cemetery and passes several abandoned sand pits. It then continues into a large forested wetland before flowing into the Great Works River between Daylight Avenue and Twombley Road near Margaret Chase Smith Elementary School in Sanford (Figure 1-1).

3.2 Population and Demographics

Goodall Brook is located in York County in southern Maine. As of 2010, York County's population was 197,131, an increase of 10,389 people (6%) since 2000. Thirty-three percent of Maine's total population growth over the last six years has occurred in York County. The City of Sanford is the seventh largest municipality in Maine with population of 20,798 in 2010. The 2010 population was a small increase from the 1990 population of 20,463, but a slight decrease from the 2000 population of 20,806. From 1990 to 2010, the average annual growth rate for Sanford was a small 0.1%, which is much less than the 0.91% for York County (SMRPC, 2013). Population demographics for Sanford are listed in Table 3-1 (below).

Table 3-1: Population Demographics in Sanford Maine (US Census Bureau, 2010)

Population under the age of 19	*Population aged 20-24*	*Population aged 25-44*	*Population aged 45-64*	*Population over the age of 65*	*Median Age*	*Median Household Income*	*Per Capita Income*	*Population below Poverty Line*
25%	6%	25%	29%	15%	38	$44,217	$20,950	18%

Sanford consists of diverse neighborhoods, natural habitats and resources, rural landscapes, and commercial businesses. In decades past, it was a thriving mill town with mills lining the banks of the Mousam River. Sanford, today, continues development toward a more modern economy, and development in the City is increasing each year. The City of Sanford issued 772 building permits between 2000 and 2009 (SMRPC, 2013). Like many other mill towns in Maine, Sanford is working toward redeveloping mill buildings, and creating business opportunities within the City.

3.3 Land Use and Land Cover

Approximately two-thirds of the land cover in the Goodall Brook watershed is developed, with high intensity development (83 acres), medium intensity development (76 acres), low intensity development (34 acres), developed open space (128 acres) and roads (4 acres). There are approximately 132 acres (27%) of forest in the watershed, primarily in the northern portion of the watershed. Scrub/shrub land cover covers about 2% (12 acres), agricultural land including crops, hay land and pasture covers less than 1.5% (7 acres), and the remaining 3% is forested wetland (14 acres)(Figure 3-1, Table 3-2).

Land Use Category	*Land Cover Class*	*Acres in Watershed*	*Percent of Watershed*
Urban & Developed	Developed, High Intensity	83	17%
	Developed, Low Intensity	34	7%
	Developed, Medium Intensity	76	15%
	Developed, Open Space	128	26%
	Road/Runway	4	1%
Forest & Natural Vegetation	Evergreen Forest	12	3%
	Mixed Forest	61	12%
	Deciduous Forest	59	12%
	Scrub/Shrub	11	2%
	Wetland Forest	14	3%
Agriculture	Cultivated Crops	2	0%
	Pasture/Hay	5	1%
Total		***489***	***100%***

Table 3-2. Land Use data for the Goodall Brook watershed.

Areas of development are mainly residential in varying intensities and largely served by the City sewer system. These areas contain many impervious surfaces and lawns. High intensity development is concentrated along major roadways including Main Street, Twombley Road, Kimball Street, and Route 202. In the northern portion of the watershed, Goodall Brook flows mainly through open spaces that provide varied shading for the stream. South of Berwick Rd., the brook enters a forested area and a wetland before flowing into the Great Works River.

Impervious cover constitutes approximately 23.7% (116 acres) of the Goodall Brook watershed (Figure 3-2). Studies have shown that the percentage of impervious cover (% IC) in a watershed strongly affects the health of aquatic systems because land surfaces that block infiltration of rainwater can lead to increased amounts of stormwater runoff into gutters, storm sewers or directly to streams. In general, surface water quality declines as imperviousness approaches 10% of watershed area (CWP, 2003).

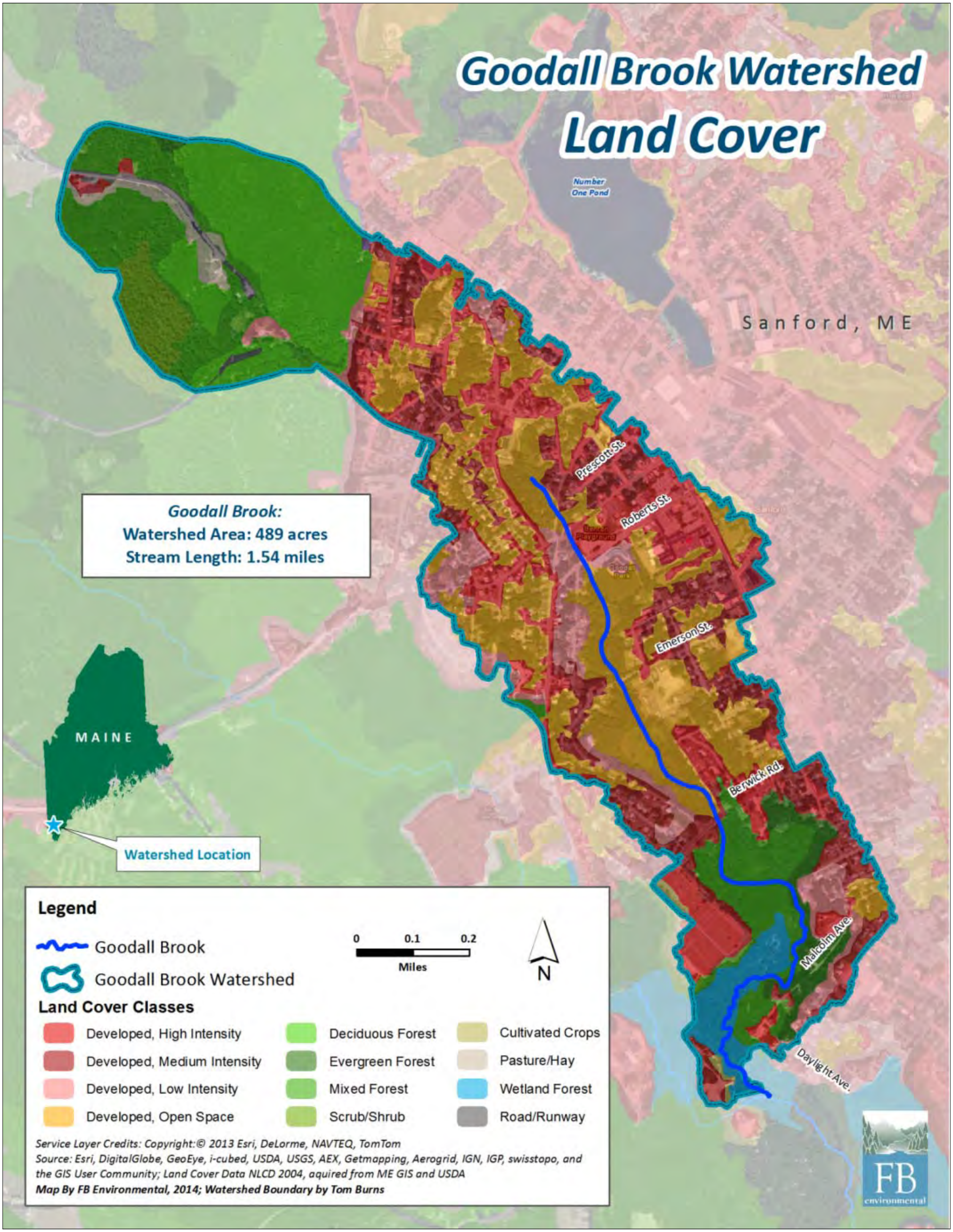


Figure 3-1: Land Use in the Goodall Brook Watershed.

3.4 Physical Features

Topography

The highest point in the Goodall Brook watershed is the forested headwaters, where the elevation is about 540 feet above sea level. The elevation is 236 feet where the stream flows into the Great Works River. Slopes in the watershed range from 0 to 15%. The stream itself has a relatively low gradient with almost no change in elevation between Roberts Street and Berwick Road.

Soils

There are two general soil associations found in the watershed: Adams Urban Land Complex and Adams Loamy Sand. Both soils are derived from glacial outwash sand parent material. Adams Urban soils consist of excessively drained Adams soils characterized by gently sloping to nearly level areas mixed with areas of urban development. These soils have been altered by streets, buildings and houses and are generally made up of 50% Adams soils, 40% urban areas, and 10% other soil types. These soils are poorly suited for vegetation and gardens due to their sandy texture and affinity for drought, hence their suitability as a site for development. Adams urban complex accounts for 135 acres within the Goodall Brook watershed and makes up the largest portion of watershed soils.

Adams Loamy Sand commonly occurs on sloping and rolling areas. It is excessively drained and very deep. Its sandy texture makes permeability rapid and surface runoff slow. This also leads to high drought potential making these soils poorly suited for cultivation, and limits productivity significantly. The surface layer is commonly found to be strongly acidic, and most areas are wooded. Adams Loamy sand makes up the second largest soil type within the watershed and covers an area of about 53 acres.

Both major soil types within the Goodall Brook watershed are poorly suited for certain urban uses such as septic systems and infiltration of contaminated runoff due to their sandy texture and high permeability causing a hazard of groundwater contamination (USDA/NRCS 2013). At the same time, these soils are highly suitable for stormwater treatment practices that infiltrate relatively clean runoff.

3.5 Land Resources

The City of Sanford is home to a variety of land uses ranging from urban development, to protected natural areas such as deer wintering areas, vernal pools, conserved forests, and inland bird habitat. However, within the Goodall Brook watershed, few natural land resources are identified. The small watershed is highly developed, and open areas are surrounded by development and sited as residential or commercial zones. Forestland and natural vegetation accounts for about 32% of total watershed land area. Though they make up only a small portion of the watershed, woodlands and small parcels of forested open spaces provide habitat to a variety of animals near Goodall Brook.

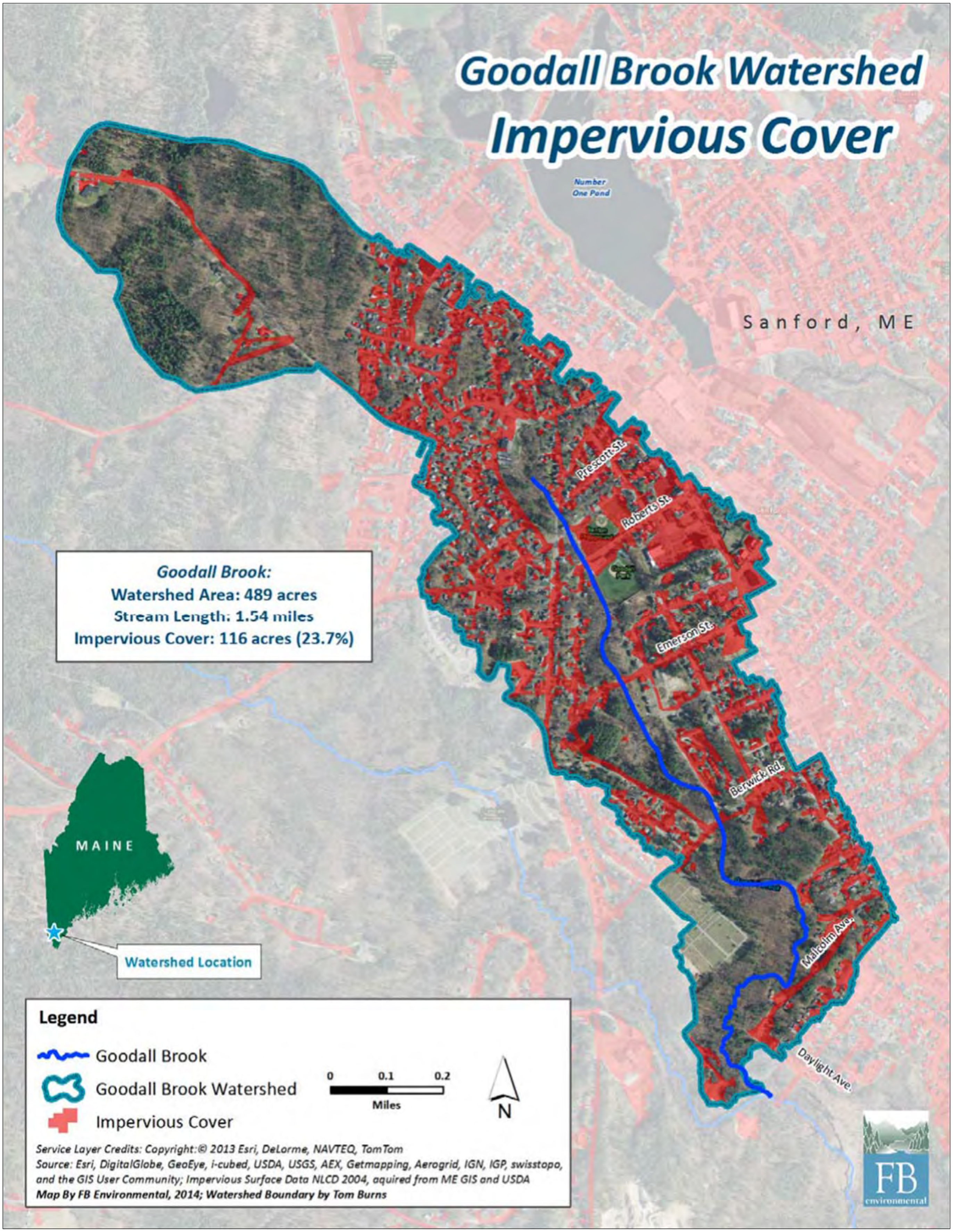


Figure 3-2: Impervious Cover in the Goodall Brook Watershed.

3.6 Water Resources

Aquatic vegetation in Goodall Brook.

Goodall Brook is fed by springs in the forested area along Hanson Ridge Road. The stream is intermittent until Grandview Avenue, where it is diverted into a series of pipes and then flows nearly 2000 feet underground. Several residential streets in the vicinity of Nason Street and State Street are also part of the upper watershed and have stormwater pipes that drain directly into this piped section of stream. Goodall Brook then emerges at Lebanon Street and flows 1.54 miles to its confluence with the Great Works River.

As mentioned in the previous section, 5% of the watershed is covered by wetlands. Most of these wetlands are directly adjacent to the lower portions of the stream. Public water is supplied to Sanford by eight subsurface wells, which are not located within the Goodall Brook watershed. However, the watershed lies directly above a significant aquifer covering about 24.5 square miles within the City of Sanford. Goodall Brook empties into the Great Works River, which continues to flow southeast through Sanford and then into Bauneg Beg Lake. The impounded lake covers 188 acres and is located along the Sanford and North Berwick line. The Great Works River then continues to flow south through North and South Berwick until its confluence with Salmon Falls River, which forms the border between Maine and New Hampshire.

Goodall Brook and Bauneg Beg Lake

Goodall Brook flows into the Great Works River, which is the primary tributary to Bauneg Beg Lake in North Berwick and Sanford, Maine. As such, water flowing from Goodall Brook has a direct effect on Bauneg Beg Lake, most notably in the form of sediment and nutrients being transported into the lake.

The Bauneg Beg Lake Association (BBLA) has been conducting regular water quality testing on Bauneg Beg Lake for the past 40 years and has also been active in the Goodall Brook watershed in recent years. BBLA raised funds and coordinated the installation of the three tree box filters to treat stormwater runoff at Roberts Street and participated in this planning process for the development of the ***Goodall Brook Watershed Management Plan***.

Although this plan focuses specifically on water quality and habitat within Goodall Brook, the downstream effects of water quality enhancement projects were considered during the planning process. Note that while some action items in the plan are ranked as lower priority for Goodall Brook, these projects may have a great benefit to downstream waters. BBLA has been identified as a partner in the implementation of this plan moving forward. There will likely be collaborations on water quality monitoring and implementation projects between BBLA and the Goodall Brook Committee that will benefit water quality for all stakeholders.

4.0 Watershed Conditions

4.1 Applicable Water Quality Standards

The Maine Legislature (Title 38 MRSA 464-468) has established water quality classification standards for all surface waters in the State of Maine. This system provides water quality goals and criteria and guides management efforts so individual waters can be protected and restored to meet these goals. There are four classes of freshwater streams (AA, A, B and C). Goodall Brook is designated as a Class B stream. Class B waters are general purpose waters and are managed to attain good physical, chemical, and biological water quality. The following table summarizes the specific numeric and narrative water quality standards applicable to Goodall Brook.

Table 4-1: Goodall Brook Applicable Water Quality Standards (Class B) (38 MRSA § 465)

Water Quality Parameter	Class B Water Quality Criteria
Dissolved Oxygen (Numeric Criteria)	7 ppm, 75% saturation
E. coli bacteria (Numeric Criteria)	64 colonies/100 mL (geometric mean); 236 colonies/100 mL (instantaneous)
Habitat (Narrative Criteria)	Unimpaired
Aquatic Life (Biological) (Narrative Criteria)	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community.

The Federal Clean Water Act requires states to provide the US EPA with a report every two years about the condition of waters in the state. This Integrated Water Quality Monitoring and Assessment Report includes a list of impaired waters that do not meet their designated standards. Goodall Brook was first included on this list of impaired waters (also referred to as 303(d) list), in 2012 because it did not meet aquatic life criteria at the DEP's Roberts Street biological monitoring station.

4.2 Available Water Quality Data

Since 2004, several groups have collected water quality data from different monitoring stations along Goodall Brook. The Great Works River Watershed Coalition and volunteers from BBLA collected data at Roberts Street in 2004 and 2006. Maine DEP has collected biological and water quality data at two stations through its Biomonitoring Program. Maine DEP and York County SWCD also collected data at seven monitoring stations to better understand the stream and possible stressors through this watershed planning process (Figure 4-1). The following section highlights the findings of this past work. More detailed information can also be found in Appendix B.

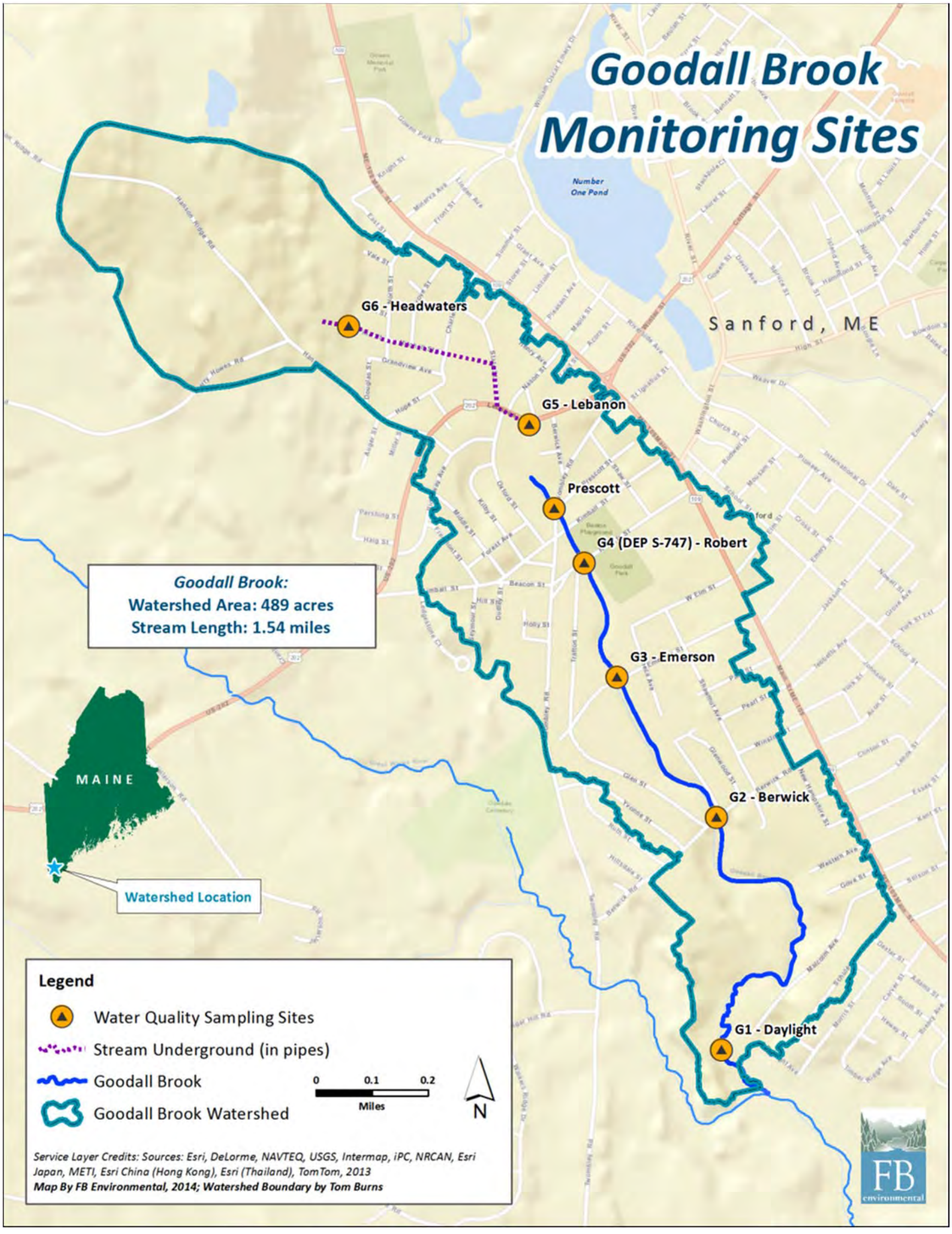


Figure 4-1: Map of Project Monitoring Sites.

DEP Biomonitoring

Maine DEP makes aquatic life use determinations using a statistical model that incorporates 30 variables of data collected from rivers and streams, including the diversity and abundance of streambed organisms, to determine the probability of a sample meeting Class A, B, or C conditions. Biologists use the model results and supporting information to determine if samples comply with standards of the class assigned to the stream or river.

Goodall Brook was sampled by Maine DEP in the summer of 2004 near the stream crossing on Roberts St., across from Goodall Park (DEP S-747 and G4 on Figure 4-1) and downstream of Daylight Avenue near the mouth of the watershed (DEP S-748 and G1 on Figure 4-1). The results for that sampling event displayed that the upstream reach of Goodall Brook did not meet Class B water quality for aquatic life criteria while the downstream reach actually met Class A standards (ME DEP, 2004) (Table 4-2).

Table 4-2: ME DEP Biomonitoring Data (2004a, 2004b.)

	Sampling Station G4 or S-747	Sampling Station G1 or S-748
Station Location	Above Roberts St.	Below Daylight Ave.
Final Determination	Non-Attaining	A
Total Abundance of Individuals	509	1,224
Generic Richness	40	46
Five Most Dominant Taxa	*Limnephilus* *Brillia* *Limnodrilus* *Tubifex* *Prodiamesa*	*Simulium* *Dolophilodes* *Polypedilum* *Hydropsyche* *Diplectrona*

2013 Stream Walk

On October 9, 2013, Jeremy Deeds from FB Environmental led a stream walk to conduct a qualitative assessment of macroinvertebrates found in different parts of the stream. Macroinvertebrates were collected using a kicknet at seven locations from Prescott Street to Berwick Road. A summary report of the work included the following *preliminary* inferences made from the taxa and habitat conditions observed during this survey.

Organisms called isopods were found throughout the segment of Goodall Brook surveyed (Prescott St. to Berwick Rd.). This suggests that water quality in Goodall Brook is generally compromised, as these organisms are somewhat tolerant of organic pollution. According to ME DEP, Isopods “cope especially well with organic waste”, and therefore may be indicative of current or legacy pollution from sewer discharges in Goodall Brook. Isopods constituted greater than 5% of the individuals in the samples, making them the sixth most common taxa in the community observed during 2004 ME DEP biomonitoring assessment.

The differences in taxa observed at two locations above Roberts St. support the field observation that the streambed (also referred to as substrate) below a large stormwater outfall pipe may be considerably disrupted during storm events. Above the outfall pipe, the stream has a firm substrate of sand and cobble, and a clearly defined channel. The substrate was much softer below the outfall pipe, with approximately 2-3 feet of loose sand and silt on top of a firmer streambed buried below. The channel below the pipe was less clearly defined, and some channel braiding was evident which suggests a shifting streambed. Chironomidae and Oligochaeta (generally tolerant taxa that burrow in fine sediments and would be expected here) were not observed below the pipe, despite being encountered above the pipe. However, these taxa were observed in abundance below the pipe outfall next to Roberts St. in the ME DEP 2004 macroinvertebrate biomonitoring survey. If this stormwater discharge is increasing sedimentation and dislodgement of the streambed, it may be responsible for habitat impairment.

Despite water quality concerns, the absence of flow may be the largest cause of impaired biological community in Goodall Brook. In this survey, nearly 0.5 miles of stream was observed that had a channel approximately 30-35 feet wide, water depth generally six inches or less, and around three feet of sediment depth (muck, silt, sand and organic matter) for the majority of the channel reaches. Flow was negligible for nearly this entire reach. However, in places where the channel width or water depth was constricted, thereby inducing flow, areas of habitat were created that appeared to be suitable for colonization of a variety of macroinvertebrates beyond fine-sediment burrowers. This was observed at two locations where taxa were observed (Limnephilidae and Hydropsychidae, respectively) that are indicative of stream habitats with greater flow than what was observed in the majority of this section of Goodall Brook.

Bacteria

Bacteria in streams can pose health risks for people coming into contact with the water, and it can also introduce excess nutrients to streams, which can in turn impact the health of aquatic life. The bacteria, *E. coli*, is commonly used to assess bacteria levels in freshwater streams. There are two water quality standards for *E. coli* in Class B streams. The instantaneous criteria for individual samples must be below 236 colonies/100 mL. The geometric mean of at least six samples collected between May and September must be below 64 colonies/100 mL.

Maine DEP collected bacteria data from five stations on Goodall Brook in 2012 and 2013 (Table 4-3). No exceedances of the instantaneous water quality standard were found on the 2012 sampling date. However, numerous bacteria problems were found in samples collected between June and September 2013. The 2013 geometric mean of each site was greater than the geometric mean water quality standard, and ten of the 26 samples collected in 2013 surpassed the instantaneous standard for Class B streams. Four of these exceedances followed rainfall events and the other six were during low flow conditions in the stream. The sampling locations at G3 (Emerson St.) and Prescott had the most instantaneous *E. coli* violations, but every site had at least one exceedance.

Table 4-3: ME DEP *E.coli* results from 10/17/2012 and six sampling events in 2013.

Location	Location Description	10/17/2012 *E. coli* Instantaneous (colonies/100mL)	2013 *E. coli* Instantaneous (colonies/100 mL)	2013 *E.coli* Geo Mean (colonies/100mL)
G2	Berwick Road	16	187, 93, 70, 261, 214, 308	166
G3	Emerson Street	29	276, 104, 58, 411, 387, 157	186
G4	Roberts Street	21	345, 133, 101, 150, 105, 172	153
Prescott St.	Prescott Street	39	179, 249, 248, 261, 131, 173	201
G5	Lebanon Street	3	131, 285	NA

ME State Water Quality Standards for E. coli: Geometric mean: 64 colonies/100 mL; Instantaneous: 236 colonies/100 mL. Exceedances are indicated in red. Note that G5 did not have enough samples to calculate a geometric mean.

Volunteers with the Great Works River Watershed Coalition (GWRWC) collected water quality samples at

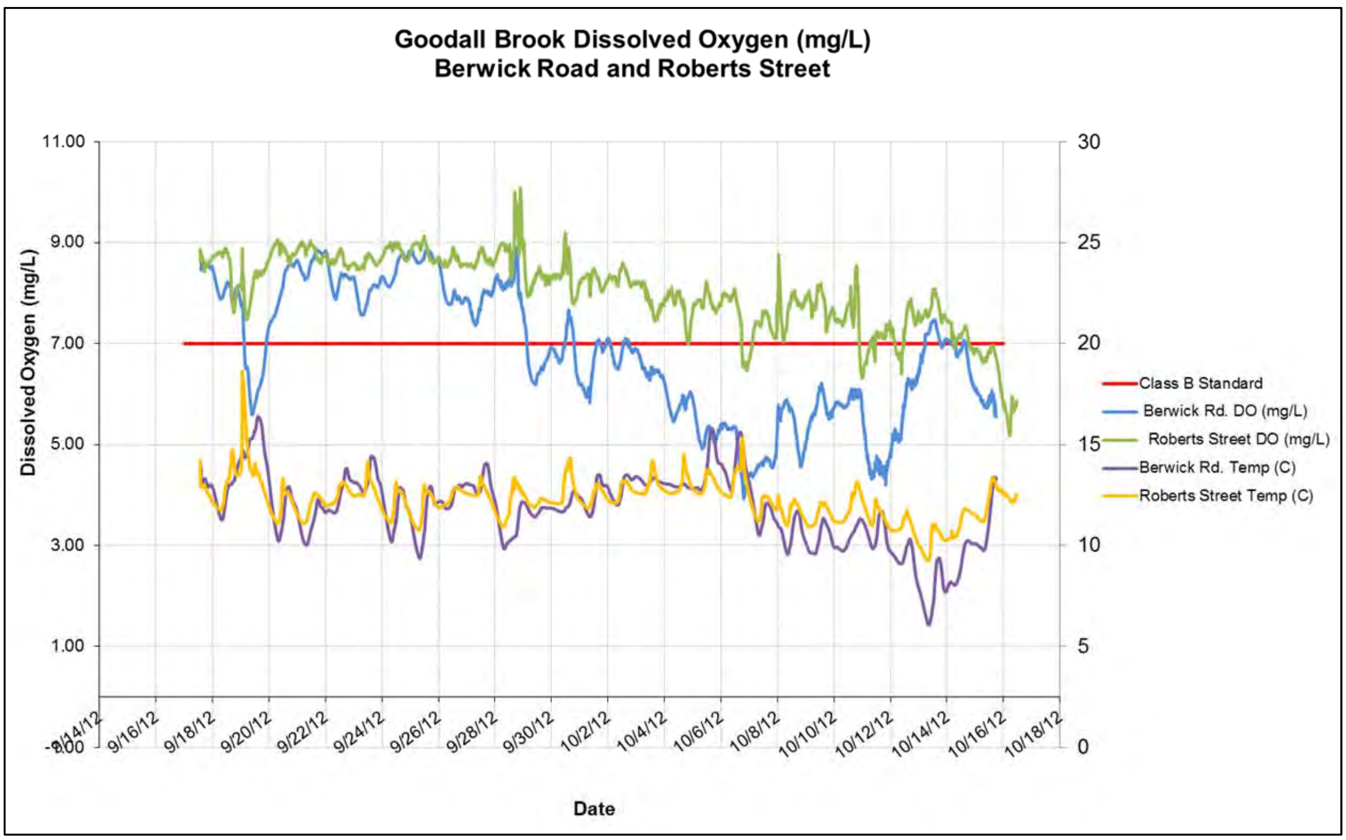
Roberts Street in 2004 and 2006 to assess the extent of pollutant contribution from Goodall Brook to Bauneg Beg Lake and the main stem of the Great Works River. A total of 15 of the samples were analyzed for *E. coli*. One third of the samples exceeded the instantaneous mean for Class B. Three of these five exceedances followed a storm event.

Dissolved Oxygen

The amount of dissolved oxygen (DO) in the water helps determine what lives in a stream with more sensitive organisms requiring higher levels of dissolved oxygen. The Class B standard for dissolved oxygen is 7.0 mg/L and 75% saturation. Stream DO is typically lowest in summer months when temperatures are highest and flows are lowest. DO is typically lowest during early morning hours (before 8:00 a.m.) because plants are using up, not producing, oxygen throughout the night. The amount of change in DO levels during the course of a summer day is also informative. While some DO change is normal, large swings (greater than 2 mg/L) is typical of streams with excess nutrients such as phosphorus.

The concentration of DO observed in Goodall Brook is of concern. In 2012 and 2013, Maine DEP collected continuous dissolved oxygen data at G4 (Roberts Street) and G2 (Berwick Rd.). (See Figure 4-1 for monitoring locations.) DO levels fell below Class B standards at both sites each year. Dissolved oxygen at the upstream location (Roberts St.) exceeded the water quality standard for most of the sampling period. However, dissolved oxygen at the downstream location (Berwick Rd.) was consistently below the water quality standard of 7 mg/L. (Figure 4-2).

Figure 4-2: ***ME DEP Continuous DO Monitoring Data in 2012.***



YCSWD also monitored six stations on four days in September 2012 and nine summer days in 2013. Sites were monitored for temperature, dissolved oxygen (DO) and specific conductivity twice daily, in the morning

(7:00 to 8:00 a.m.) and late afternoons (1:00 to 3:00 p.m.) to observe diurnal patterns. G3 (Emerson) had an average early morning DO of 5 mg/L and was the only station that fell below Class B standards. G5 (Lebanon) and G2 (Berwick) had a few readings below Class B standards, but their average early morning DO was 9 mg/L and 7 mg/L, respectively.

Diurnal DO swings were similar to the findings above, with only G3 (Emerson) experiencing problems. G3 had diurnal DO swings greater than 2 mg/L on nine of the 13 sampling dates. G2 (Berwick) experienced a diurnal DO swing of this magnitude on just one of the 13 sampling dates, while the other sites had no significant swings.

Table 4-4: Dissolved oxygen summary for Goodall Brook monitoring stations.

Sampling Station	Early Morning DO	Diurnal DO
G1 – Daylight Ave.	Good	No
G2 – Berwick Rd.	Fair	Possible
G3 – Emerson St.	**Poor**	**Large Swings**
G4 – Roberts St.	Good	No
G5 – Lebanon St.	Good	No
G6 - Headwaters	Good	No

Dissolved oxygen measurements were also collected by the GWRWC in 2004 and 2006 at Roberts Street. All samples were well above DO standards. However, sampling times were not available, so it is assumed that much of the sampling took place after 8:00 a.m.

Specific Conductivity

Specific conductivity (SpC) measures the amount of dissolved ions in the water. In urban streams, this measurement often reflects the amount of chloride from road salt present in the water. Specific conductance was measured by Maine DEP through continuous monitoring at sites G2 (Berwick) and G4 (Roberts) in 2012 and 2013. York County SWCD also measured specific conductance at six sites in 2012 and 2013.

All values for specific conductance were elevated above natural conditions but significantly lower than levels correlated with chloride levels high enough to be toxic to aquatic organizations (~860 mg/L Cl). SpC was relatively uniform throughout the stream and ranged between 400 and 550 us/cm. The specific conductance at Berwick Rd. was consistently higher than that at Roberts St. (Figure 4-3).

Other Water Quality Parameters

Unlike other water quality parameters measured, temperature does not appear to be an issue anywhere in the stream. Temperatures for all stations were relatively cold, even during the summer months. Average temperatures were below 15° Celsius at all six monitoring sites. Roberts Street had the coldest temperatures (13.6° C), which indicates that there are springs entering the stream above this location. This is further corroborated by the observation of one spring adjacent to the stream in Soldiers and Sailors Park. The continuous cold temperatures throughout the length of the stream indicate that there are likely many springs feeding the stream and also suggests the existing riparian zone along the stream provides shading to help keep the stream cool.

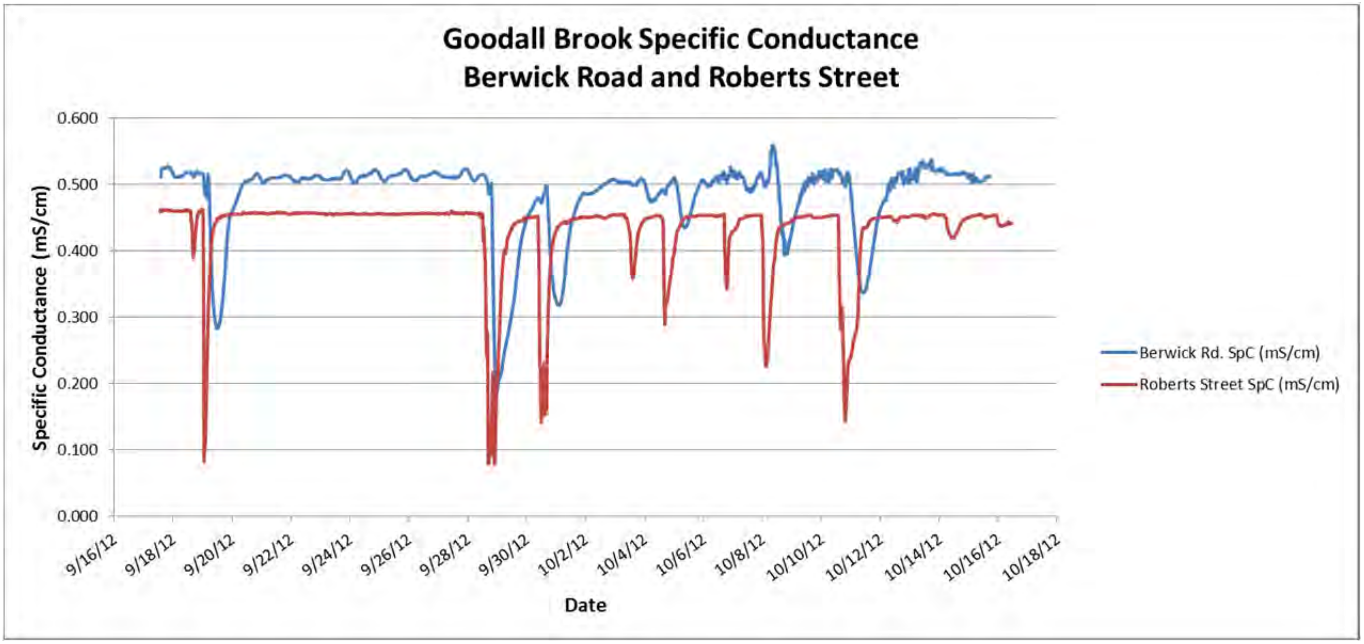


Figure 4-3: Goodall Brook Specific Conductance (mS/cm) Data for Berwick Road and Roberts Street Sampling Locations (September – October 2012).

The GWRWC and DEP have analyzed a few water samples for the nutrient, phosphorus, in 2004. Although there is not a water quality standard for phosphorus in Maine, the EPA provides the value of 30 mg/L as a suggested threshold. The GWRWC analyzed six samples for total phosphorus and found two of them had levels above 30 mg/L. One stormflow sample was 75 mg/L, and one baseflow sample was 40 mg/L. DEP's sample at Daylight Ave. was 48 mg/L. While it is difficult to draw conclusions from the limited data set, it does appear that there are elevated phosphorus levels in the stream. As discussed earlier in this section, diurnal DO data further supports this finding.

4.3 Summary of Goodall Brook Water Quality Data

Several aspects of Goodall Brook's water quality are encouraging. Water temperatures throughout the stream are cool, even during low flow and summer months. The lower portions of Goodall Brook appear to be in very good condition. Maine DEP's biomonitoring station below Daylight Ave. met Class B standards for aquatic life. Recent water quality monitoring indicates that this area also exceeds Class B standards for dissolved oxygen.

The upper portions of the stream, however, have several problems. As mentioned previously, Goodall Brook is listed as impaired due to a violation of aquatic life standards at the Roberts Street site. In addition, recent monitoring indicates that the stream has water quality problems. Dissolved oxygen levels are also severely low at Emerson Street and moderately low at Berwick Rd. Diurnal dissolved oxygen swings are also high at Emerson Street, which indicates phosphorus enrichment problems. Limited phosphorus data also supports the likelihood of excess nutrients in the stream.

Bacteria levels are elevated above Class B standards throughout much of the stream, both during low flow and storm conditions. Specific conductance, which typically indicates road salt/chloride, is also elevated throughout the stream. While it does not appear to reach levels that would be toxic to aquatic life, these elevated levels might combine with other stressors to make the aquatic organisms in the stream less resilient.

5.0 Pollution Sources and Threats to Water Quality

5.1 Stream Alterations and Habitat Impacts

Class B streams must provide habitat for fish and other aquatic life. To do so, streams habitat should include a wide variety of pools, faster-flowing riffles, large pieces of wood or logs, overhead tree canopy and a stable stream bottom (Maine DEP, 2010). These features create diverse conditions required by different aquatic organisms for survival and reproduction. Riffles help add oxygen to the water. Pools and wood in streams help trap food and provide cover and refuge for creatures. Stable stream bottoms covered with gravels provide spawning areas and homes to diverse macroinvertebrates. Canopy trees shade streams, and fallen leaves provide food for aquatic organisms.

As watersheds become more urbanized, these natural features often become degraded. Logs are removed from streams in misguided efforts to keep the streams 'clean'. Flashy stormwater flows disrupt stream bottoms and make it difficult for organisms to find refuge. The stream channel itself can be widened, straightened or dredged, and floodplain areas can be filled. In addition, culverts or other man-made structures can restrict flow, which can have many adverse effects on water quality and biological communities. Slow-flowing stream water is often warmer, contains less dissolved oxygen, and does not support the natural habitat structures that stream life has evolved to depend on.

2013 Geomorphic Assessment

A reconnaissance-level ***fluvial geomorphology*** study was conducted by John Field of Field Geological Services in the spring of 2013 to investigate stream channel conditions and the impact of past stream alterations on Goodall Brook (Appendix C). There are many geomorphological issues with the channel of Goodall Brook described in the report:

> ***Fluvial Geomorphology*** *is the science that studies the shape of streams and how they respond to human-induced changes.*

- **Past Channelization and Dredging.** Engineering plans from the City of Sanford ("Goodall Brook Channel Improvement") describes construction work in Goodall Brook in the 1970s, when the channel was deepened and widened. The 1970s document shows plans to remove wood planking along the stream bottom, which were likely installed in the 1930s or perhaps even earlier; these planks were never removed. This work was likely done as part of a wetland drainage project. Remnants of the natural channels may be seen along the location of the current channel in recent aerial photographs.
- **Floodplain Fill and Channel Constraints** (Figure 5-1)**.** The straightened channel mostly has banks about two feet high, but the left bank by Goodall Park is five feet or higher. These banks are artificially high, as it seems that material removed from the channel was placed along the stream as a safeguard against flooding. These berms not only restrict stream access to the floodplain, which is necessary for natural flow regimes, but high banks increase velocity in the channel and can lead to the scouring that is evident by Goodall Park.
- **Inadequate Culverts.** The culverts in Goodall Brook are narrower than the streams' width, leading to clogging and stagnant flow conditions on their upstream sides (Figure 5-1b). The lack of flow velocity creates sediment deposits in the channel, with soft sediment thickness being two feet or more in most locations upstream of these culverts. *Note that further investigations by project staff found that culverts did not seem to be significant stressor for Goodall Brook. As mentioned in Section 6.2, additional study may be warranted to help assess the impact of culvert size and condition on the stream.*

- **Impervious Cover.** Impervious cover in a watershed generally increases runoff and peak discharge that lead to channel incision and bank erosion. Despite 23.7% impervious cover in the Goodall Brook watershed, incision was not observed in the channel, which is likely an artifact of the low gradient channel sandy, well-drained soils in the watershed, and wide floodplain that prevent excess stream power from being generated by the increased runoff. However, urbanization in the watershed is likely having an increasing effect on the amount of sediment being delivered to the channel, as evident by the large volume of fine sediment present in the widened portions of Goodall Brook.

The historical channelization, dredging, filling of the floodplain, berms and other structures along Goodall Brook have altered the channel's morphology (shape), reduced connectivity to the floodplain, and impaired natural flow patterns and channel function. The survey found that these alterations are more detrimental to water quality and habitat availability than the amount of impervious cover in the watershed, because the channel morphology prevents excess stream power from being generated in the channel.

Human activity has resulted in stream channelization in many places along Goodall Brook. This condition leads to habitat degradation for aquatic life.

The geomorphic study of Goodall Brook suggests that log jams placed along the edges of the straightened and widened channel would help to restore natural channel dimensions and sinuosity in the long term. Wood that has naturally fallen into the channel from the riparian area has had this effect in scattered locations in Goodall Brook, which suggests that this approach would be effective.

Stream Channel Survey

The City of Sanford conducted a topographic survey of the stream channel from Roberts Street to below Berwick Road to evaluate stream gradient and provide additional information for stream restoration. Although additional surveying may be needed, the City's survey indicated that the stream has almost no gradient through this section of stream. The survey also found that there appears to be a slightly higher point in the streambed and extensive plant growth in the stream behind Seneca Ave. that backs up. Surveying by the City and DEP also determined that the culverts do not appear to be the cause of the lack of flowing water.

Figure 5-1. Channel restrictions along Goodall Brook: a) berms consisting of material dredged from channel, now restricting access of stream to floodplain; b) undersized or clogged culverts at the Robert St. crossing; c) remnants of an earthen dam; d) a sewer pipe across the channel. Photos and evaluation from Goodall Brook Geomorphic Study (Appendix B) by John Field.

5.2 Stormwater Runoff from Impervious Surfaces

In addition to the impacts associated with physical alterations to Goodall Brook, stormwater from watershed development can also impact stream health. Impervious cover (IC) is the term used to categorize all surfaces that do not allow stormwater to infiltrate naturally into soils. The combination of pollutants in stormwater contributes to the impairment of aquatic life in streams. Additionally, there can be substantial habitat loss and degradation associated with increased sedimentation carried by stormwater runoff. Several assessments have been conducted in the Goodall Brook watershed to evaluate potential stormwater impacts associated with residential areas, businesses, streets and other impervious areas in the watershed.

Neighborhood and Hotspots Inventory

In 2009, the DEP, BBLA, Great Works River Watershed Coalition, and the City of Sanford worked together to complete the Goodall Brook Neighborhood Source Assessment and Hotspots Inventory[1]. This rapid field survey evaluated potential pollution sources and restoration opportunities within urban subwatersheds. The resulting report provided a comprehensive overview of residential and commercial sources of stormwater pollution by evaluating pollutant producing behaviors in individual neighborhoods and assigning a pollutant severity index for screening purposes.

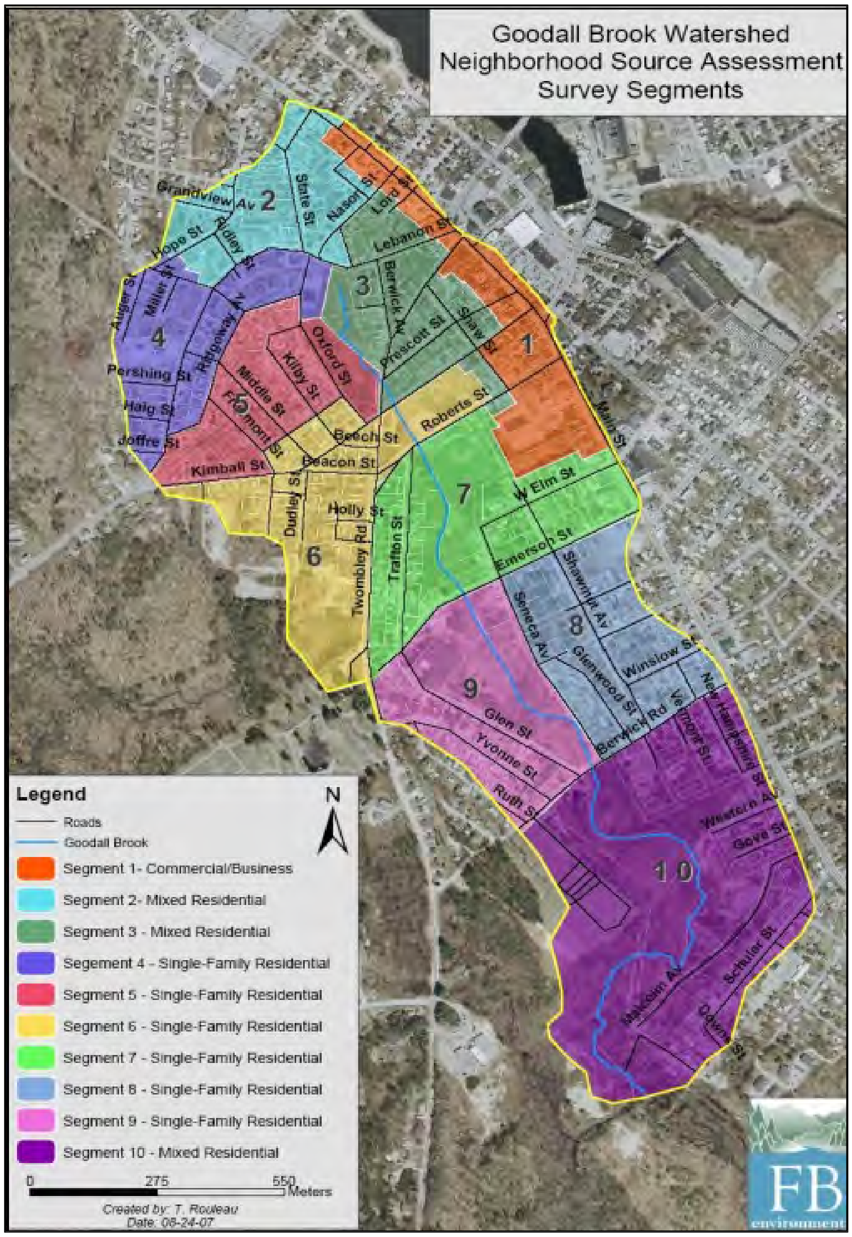


Figure 5-2: Goodall Brook 2009 Neighborhood Source Assessment Sectors.

For the **Neighborhood Source Assessment**, Goodall Brook watershed was divided into ten sectors (Figure 5-2). Yard and lawn conditions, driveways, sidewalks and curbs, rooftop runoff, common areas and streets in each neighborhood were rated for pollutant-producing behaviors and overall restoration potential. Specific recommendations including pollution prevention, structural retrofits, ordinance adjustments, and education were also identified.

Nine of the ten sectors were mixed or

[1] Methods described in the Center for Watershed Protection's Urban Subwatershed Restoration Manual Series #11.

single family residential. Although seven of the residential sectors ranked “high” in terms of pollution severity, all residential sectors were ranked “moderate” in terms of restoration. In all of the neighborhood sectors, there was a lack of adequate tree canopy and landscaped vegetation and a high percentage of impervious and semi-pervious areas of lawn. If landscaping and tree canopy increased, more rainfall and runoff would be intercepted and infiltrated. Infiltration Best Management Practices (BMPs) such as downspout drywells and rain gardens could catch stormwater and reduce the amount ending up in the stream and sewer system. Although highly manicured lawns were not widely observed, nutrient and pesticide impacts from lawn care could be issues. With the proper public education, homeowners could reduce the impact to water quality by practicing low impact landscaping techniques.

The **Hotspots Inventory** evaluated and documented businesses, public facilities and other properties with vehicle operations and parking, storage of materials outside, turf management, waste management and stormwater infrastructure. Potential hotpots were listed and rated with regard to their potential to generate stormwater. Nine confirmed or potential hotspot sites were identified and ranked in the watershed. The hotspots included three commercial businesses, five municipal properties and one housing complex. The ranking is based on observations related to vehicle operations, poor housekeeping (spills and leaks), waste management issues, a severe lack of vegetation and stormwater drainage issues. No severe hotspots were identified in any of the other sectors. The majority of the hotspot sites (8 out of 9) were rated as potential hotspots.

Table 5-1: Potential and Confirmed Hotspot Locations from the 2009 Hotspot Inventory[2].

Business/Location	Potential Hotspot	Confirmed Hotspot	Follow-Up Actions
Emerson School	X		Pervious area restoration, rain garden installation
Goodall Park	X		Pervious area restoration
Roberts/Kimball St (recreational facility)	X		Onsite retrofit, site inspection
ROW off 109 (Twombley Rd.)	X		Onsite retrofit
Edison School Apartments	X		Rain garden installation
Sanford Tire and Brake	X		Review of SWPP
Ballenger Auto		X	Review of SWPP, onsite retrofit
Dunkin Donuts	X		Pervious area restoration, onsite retrofit
City Hall/Police fleet storage	X		Pervious area restoration

Impervious Cover TMDL

The Clean Water Act requires that all impaired waters undergo a TMDL assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

To help meet this goal, Goodall Brook was included in the Maine DEP Impervious Cover (IC) **TMDL (Total Maximum Daily Load)** assessment for urban streams in Maine (ME DEP 2012; Appendix D). IC increases the amount of stormwater runoff that carries dirt, oils, metals and other pollutants to the stream. Geographic analyses found that the Goodall Brook watershed was 37% impervious cover, which is a very high percentage

[2] Note that two additional Hotspots were originally identified. However, one business changed from a gas station to a jewelry shop and another was mapped outside the watershed.

since stream degradation is found to be detrimental to aquatic life at 9% IC (ME DEP, 2012).

The TMDL report estimates that to mitigate the effects of IC in the Goodall Brook watershed, and help the stream meet water quality standards, that the watershed must have the characteristics of a watershed with only 9% impervious cover. ME DEP (2012) estimates that, to attain Class B standards, the Goodall Brook watershed would need reduce the stormwater runoff volume and existing stormwater-associated pollutant loads by 76%.

***TMDL** is an acronym for Total Maximum Daily Load, representing the total amount of a pollutant that a water body can receive and still meet water quality standards.*

Note that the TMDL was completed prior to the detailed mapping of the Goodall Brook watershed, which refined the watershed boundary and percentage of impervious cover. The current IC estimate of 23.7% would shift the target IC lower than that recommended in the TMDL. Regardless of the specific target, IC reductions may be achieved through adequate treatment of stormwater with Best Management Practices (BMP) and Green Infrastructure techniques that reduce the *effect* of impervious cover.

5.3 Bacteria Contamination

Elevated levels of *E. coli* in surface water is an indication of contamination from the fecal waste of humans, domesticated animals or wildlife. High concentrations of these coliform bacteria during baseflow conditions suggest that the contamination originates from illicit discharges, such as leaky sewer pipes. If the high concentrations are observed only during storm events, the contamination is likely occurring from runoff that carries the bacteria from the land into the stream.

Since observed *E. coli* concentrations exceeded the state water quality standards during both baseflow and storm conditions (Table 4.3), it is likely that bacteria is entering Goodall Brook from a variety of sources. Since the sewer infrastructure is several decades old and the pipes cross or lie close to the stream in several areas, there is potential for leaking sewer lines to be a source of bacteria. Pet waste is also a potential issue, especially since there are several popular parks and trails next to the stream where waste could easily reach Goodall Brook. Although there do not appear to be large wildlife gathering areas in the stream, wildlife could also be a potential source of bacteria. In addition to these more discrete sources, stormwater runoff itself can be high in bacteria. Private septic systems are not likely a significant issue since almost the entire watershed is serviced by public sewer.

5.4 Identification of Critical Areas

Stream Habitat Restoration

As discussed previously, stream habitat problems are distinctly different above and below Roberts Street. Habitat conditions in both areas of the stream should be addressed so that the stream meets water quality standards.

Above Roberts Street

- **Flows from Stormwater Outfalls Cause Shifting Sediments.** This is of particular note for the large storm drain above the Roberts St. crossing that drains the hill that rises from Goodall Brook to the Sanford City Hall at the Corner of Main St. This outfall has created a plunge-pool effect, as the drain hangs 3-5 feet above the stream. The substrate below this outfall is sandy and loose, and there is evidence of shifting sediments below the pipe to the culverts at Roberts St. The substrate above this outfall is firmer, more stable, and consists largely of gravel and sand. Notably, this drain at Roberts St. is the location of DEP Biomonitoring site S-747, which fails to attain water quality standards for aquatic life (macroinvertebrates).

- **Invasive Plants and Lack of Riparian Vegetation.** Riparian areas containing native vegetation helps to reduce erosion, filter pollutants from runoff, and keep stream waters cool with shade. They also provide the critical habitat for the adult life stages of aquatic macroinvertebrates. When aquatic macroinvertebrates emerge from the streams and rivers where they spend their juvenile life stage, they need protective vegetation to facilitate the adult stage of their life cycle. It is here that they find a mate, lay eggs, and feed (in some taxa). Without adequate riparian vegetation, the adults will not utilize the stream nearby and the communities of aquatic macroinvertebrates will not propagate. Invasive plants can move into disturbed areas (such as places where vegetation has been cleared), and out-compete the native vegetation that is important to stream health. Invasive plants, like Japanese knotweed (*Fallopia japonica*), do not have the same erosion-preventing quality, pollutant filtering capacity or habitat values of native vegetation.

  Although much of Goodall Brook has an intact riparian buffer, the section between Roberts Street and Lebanon Street is compromised. In Soldiers and Sailors Park, there is a good tree canopy, but understory shrubs and groundcover plants have been removed in places. Just above Roberts Street, some restoration work has taken place in recent years. However, the buffer remains very minimal and is overrun by invasive plants.

Between Roberts Street and Berwick Road

- **Flow velocity is of particular concern in this section of Goodall Brook.** There is very little elevation change over this stretch of stream, which leads to low-flow velocity conditions. This issue has likely been exacerbated by previous dredging and channelization (straightening) of the stream in this section. The stream is wide and shallow, and the substrate consists of very deep mud and muck, at times two feet thick or greater. This activity has reduced any variability in flow velocity, which is also important for sustaining habitat. There is very little suitable habitat in this section of the stream, but some can be found in scattered locations where debris or vegetation has created a narrowing of the channel. In these locations, where flow has been weakly restored (either where vegetation or placed rocks have restricted the channel), macroinvertebrates found there suggest that the water quality is not suppressing the aquatic community as much as absence of suitable habitat.

Stormwater Mapping, Retrofit Survey and Prioritization

Goodall Brook's watershed boundary was field checked and refined by Maine DEP and City of Sanford staff as part of this project. The developed areas of the watershed that drain directly into the stream via stormwater outfall pipes, ditches or other concentrated runoff were investigated, and areas draining to each of these catchments were also mapped for the watershed (Appendix E). Maine DEP staff created detailed IC delineations in tandem with the field mapping. Together, this work allowed for an IC analysis for the entire watershed and helped prioritize areas for future work based on potential water quality impacts and retrofit options.

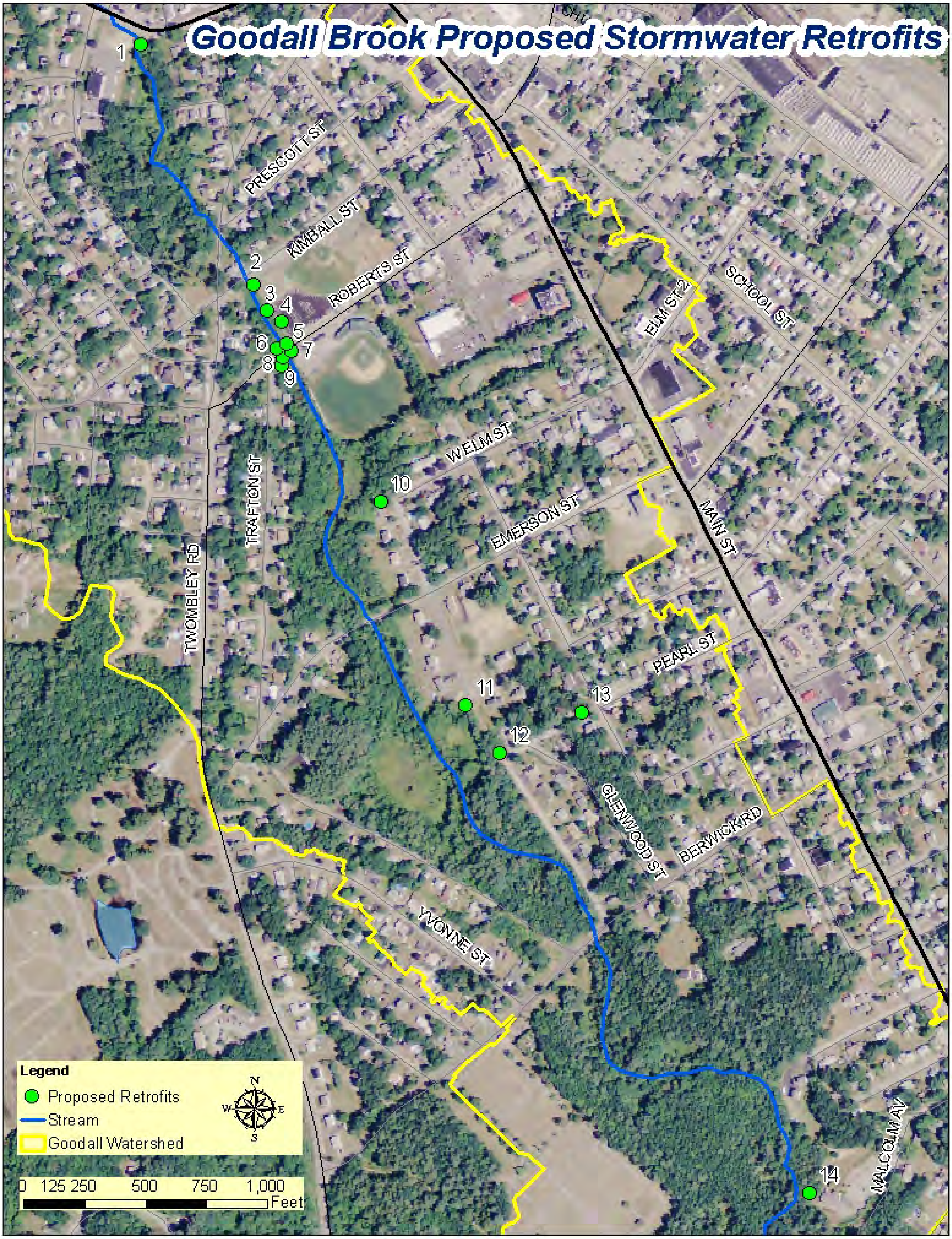


Figure 5-3. Map of Proposed Stormwater Retrofit Projects.

Project staff performed a stormwater retrofit survey in November of 2013. Stormwater retrofits provide stormwater treatment in locations where existing stormwater management practices do not exist, or they can enhance existing stormwater management practices and provide a benefit to the receiving waterbody. The purpose of the survey was to examine the existing stormwater management infrastructure that drains to Goodall Brook, determine areas and facilities that could be improved upon to mitigate identified stream stressors, and estimate cost and priority for each.

Project staff identified 14 stormwater retrofit projects. Site locations are shown on Figure 5-3 and project descriptions are summarized in Appendix F. High and medium priority sites were assigned to nine stormwater sites located adjacent to or above Roberts Street (Sites 1-9). Work at these sites should help improve conditions for aquatic life at the DEP's biomonitoring station and would thereby be the most beneficial projects to help the stream meet Class B standards. Projects include stabilizing stormwater outfalls, adjusting/maintaining existing tree box filters to optimize stormwater treatment, installing stormwater BMPs and enhancing the stream buffer. The remaining five stormwater retrofits are located below Roberts Street and will help remove phosphorus and sediment sources to Goodall Brook, as well as Bauneg Beg Lake.

6.0 Watershed Plan Goals, Strategies and Action Plan

6.1 Watershed Plan Goals

The primary water quality goal for Goodall Brook is to improve the biotic community to attain Class B status at the Maine DEP biomonitoring site above Roberts St. Since Goodall Brook is also impacted by a variety of problems and potential stressors between Roberts St. and Berwick Rd., the plan also includes the goal of restoring downstream areas so that it could meet Class B standards as best possible. Long-term protection and stewardship goals were also included in the plan to guide future development and land use decisions that have the potential to create future problems in Goodall Brook. The issues in the watershed that are currently causing non-attainment are multi-faceted, and therefore the goals for the watershed are to address many sources of impairment to the quality of water and habitat in Goodall Brook. The goals include:

Improve conditions in Goodall Brook so that it meets Class B water quality standards.

- Restore the macroinvertebrate community to one that meets aquatic life use criteria
- Improve dissolved oxygen levels in the stream
- Reduce the levels of *E. coli* bacteria in the stream

Prevent future water quality impacts to Goodall Brook and downstream waters, including Bauneg Beg Lake.

- Provide improved stormwater treatment from new and existing development
- Implement municipal ordinances that guide new development and reduce stream impacts
- Coordinate with partners to protect important conservation lands and address future potential impacts

Build community awareness and support for the restoration and protection of Goodall Brook and the City's other water resources.

- Develop and carry out public outreach programs to raise awareness about pollution issues and individual actions to reduce impacts to water quality
- Involve local schools in stream monitoring and restoration activities
- Form a Goodall Brook committee to guide plan implementation

6.2 Management Strategies

A variety of management strategies will be pursued to achieve the goals outlined above. These include the following five strategies, which are described in further detail in this section.

- **In-Stream Habitat Restoration.** These action items focus on restoring habitat so the stream supports aquatic life and meets standards for Class B streams.
- **Stormwater Management and Phosphorus Reduction.** These action items prioritize the mitigation of stormwater runoff to reduce phosphorus loading to the stream and stabilize stormwater outfalls that are impacting stream stability. The items include both structural BMPs (e.g., stormwater retrofits and rain gardens and other green infrastructure) and non-structural BMPs (e.g., outreach about limiting fertilizer use).
- **Bacteria Reductions.** These actions aim to lower bacterial concentrations in Goodall Brook by replacing leaking sewer pipes and better managing pet waste in the watershed.
- **Education and Outreach.** Education and outreach tasks will help by informing watershed residents about good water quality practices, proper disposal of pet waste, utilizing Green Infrastructure practices on their properties and creating a business certification program.
- **Protection Strategies.** Ongoing planning and coordination will be needed to anticipate and prevent future threats to the stream. Specific strategies include ordinance development, continued reduced use of road salt on roads and long term maintenance of BMPs.

In-Stream Habitat Restoration

Flow velocity is of particular concern in Goodall Brook in the section between Roberts St. and Berwick Rd. There is very little elevation change over this stretch of stream, which leads to low-flow velocity conditions. This issue has likely been exacerbated by previous dredging and channelization (straightening) of the stream in this section. The stream is wide and shallow, and the substrate consists of very deep mud and muck, at times two feet thick or greater. This activity has reduced any variability in flow velocity, which is also important for sustaining habitat. Flow velocity can be promoted in the following ways, which should also address the rehabilitation of both in- stream and riparian habitat.

- **Stimulate channel narrowing and habitat creation with wood additions to stream**. Places in Goodall Brook where trees have fallen in exhibit the potential of this method to stimulate the development of natural stream function and habitat. In areas where the stream has been straightened and widened, the fallen wood causes the channel to narrow, which creates deposition, variation in flow patterns and restores natural channel sinuosity. Flow is accelerated around the woody habitat, which is good for aquatic macroinvertebrates. This would be the most inexpensive option that would have direct benefits to the flow regime of Goodall Brook.

Installation of tree root wads in Blanchette Brook in Westbrook.

- **Maintain and Improve Vegetated Riparian Zones.** Many sections of Goodall Brook retain intact vegetated buffer zones, which should be maintained and enhanced where possible. A relatively small section of stream between Lebanon Street and Roberts Street has an inadequate buffer dominated by invasive species and should be targeted for enhancement. Buffer plantings should be pursued and an invasive species removal program should be carried out in critical areas.

- **Address channel constraints that are impeding natural flow velocity**. There are many locations along Goodall Brook where flow is constricted due to structures that may be fixed or removed. Figure 5-1 shows four instances of this; berms along the channel that restrict floodplain access (5-1a), improperly sized or clogged culverts (5-1b), sewer pipes (5-1c) and remnants of an earthen dam (5-1d). It is unclear if larger or adjusted culverts would provide the increased flow velocity that would help restore aquatic habitat in Goodall Brook. A HEC-RAS survey is a hydrological model that predicts how water flows through systems based on energy loss. A HEC-RAS model may be useful in Goodall Brook to investigate the roles that elevation, culverts, and channel dimensions have on the current flow velocity situation. The results of the model may help to determine which restoration actions may be most successful in establishing flow velocity variations and habitat in Goodall Brook. The Goodall Brook Committee should further investigate the cost and benefits of having a HEC-RAS model completed for this stream. Similarly, the impact of earthen dams, sewer line crossing and the stream's extensive streamside berm are unclear. A geomorphologist could be consulted with to determine the effects on the stream from these features.

Stormwater Management

The high amount of impervious cover (IC) in the Goodall Brook watershed creates stormwater runoff that carries dirt, oil, grease, nutrients and other pollutants to the stream. Several structural stormwater BMPs are in place in the watershed that help treat this polluted runoff. Three tree box filters are in place at Roberts St., and an underdrained soil filter is located adjacent to the parking lot runoff at the Edison School Apartments. There are numerous opportunities for additional stormwater retrofits that will reduce the contaminants in stormwater before it enters the stream. Stormwater retrofits specific to watershed locations and their stormwater management needs are available in Appendix F.

Stormwater BMPs may provide water quality benefits on the residential scale as well. These BMPs, also called ***Green Infrastructure***, such as rain barrels, rain gardens and yardscaping practices can capture, store and utilize rainwater from roofs rather than diverting the runoff straight into storm drains. The use of these BMPs can be taught in workshops and classes targeted to watershed residents. Planting, enhancing and maintaining vegetated buffers of natural vegetation in the watershed also help to control erosion and absorb nutrients and pollutants from stormwater runoff.

Green Infrastructure

Green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water. Practices include rain gardens, permeable pavement, urban tree planting and green roofs. Also called Low Impact Development. For more information, go to http://water.epa.gov/infrastructure/greeninfrastructure

Tree boxes contain a special mix of soil that filters pollutants from stormwater.

E. coli Bacteria Reductions

E. coli is present in high concentrations throughout Goodall Brook from Lebanon St. to Berwick Rd. Given the land use patterns characteristic of the Goodall Brook watershed, it is likely that the source of fecal coliform in the water is either pet waste or leaking sewer pipes. It is essential that the source or sources of bacterial contamination be identified so that proper mitigation actions may be taken. For bacteria sources associated with sewer pipes, mitigation strategies will include inspecting sewer lines with cameras to detect leaking pipes or cross connections with follow up dye testing at key sites, flow monitoring or canine detection to pinpoint problems, replacing pipes in areas where problems are detected. In terms of pet waste sources, management strategies include investigating allowable disposal methods under City ordinances, conducting an outreach campaign about impacts of pet waste and proper disposal, installing signage at popular dog walking areas and providing pet composting and biodegradable bags for sale at transfer station.

Educational and Outreach

This plan includes an educational component that will be used to enhance public understanding of the plan and encourage community and business participation in watershed restoration and protection activities. Efforts will be made to encourage people to identify with the watershed and to promote stewardship of water resources.

In November 2012, a group of Environmental Science students from Sanford HS successfully completed an Intercept Study with 357 Sanford residents on Election Day. An Intercept Study is used by groups to gauge the public's awareness of a certain issue. It involves intercepting a respondent in a high traffic area and conducting a brief survey. The Goodall Brook intercept survey included questions related to water quality and stormwater issues. The overall results of the survey revealed there is strong appreciation and support for clean water among Sanford residents. However, more effort needs to be focused on educating community members in order to make informed decisions concerning stormwater pollution issues in their town and on their private property. A follow up survey is recommended to assess changes in public awareness and project success.

Sanford High School students conduct intercept survey at 2012 elections.

As part of the Goodall Brook Watershed Plan, the following educational actions will be completed:

- Organize stream walk/cleanup events that serve to clean trash from the stream and riparian area, and raise awareness of water quality issues.
- Promote an existing green lawn care program such as YardScaping.
- Post "Stream Crossing" or "Entering Goodall Brook Watershed" signs to raise awareness of stream and water quality in community.
- Involve Sanford HS students with water quality monitoring and follow-up survey to 2012 Intercept Survey.
- Develop a guidance document, with accompanying website links, to help homeowners learn about Best Management Practices and Low Impact Development strategies.
- Enact a city-wide campaign to educate residents about where pet waste ends up, including signage at popular dog walking areas.
- Establish a "Friend of Goodall Book" business certification program where businesses can pledge to adopt practices that would protect stream.
- Publicize project activities via newspapers, websites and through partner organizations.

Protection and Prevention of Future Impacts

Even after implementing the management strategies described in previous sections, changing land use practices and ongoing development has the potential of further impacting Goodall Brook in future years. As such, additional strategies will need to be pursued to prevent future degradation or impacts from other pollutants.

- ***Reduction of Winter Road Salt Application*** - The City of Sanford has been proactive with road salt applications by limiting excessive use of salt on watershed roads. As a result, chloride toxicity does not appear to be a problem in Goodall Brook as it is in similar urban streams in southern Maine. The City should continue to limit chloride application and also look for new tools and opportunities to reduce salt use and further reduce water quality impacts.
- ***Creation of Goodall Brook Watershed Overlay Management Area*** - The City of Sanford has been in the process of adopting a Land Stewardship Plan, which is designed as a site specific review comparing the impact of a proposed development on a parcel which has predetermined capacity for development. That capacity is based on upon compliance with pre-existing standards/guidelines/regulations for a specific area such as a specific watershed overlay. The Land Stewardship Plan would provide for site specific review within a Goodall Brook Watershed Overlay Management Area. The establishment of a Goodall Brook Watershed Overlay Management Area would guide new development to follow BMPs identified in this plan.
- ***Long Term Maintenance*** **-** The Sanford Department of Public Works will actively maintain existing and new municipal retrofits installed as a result of this Plan on a regular basis. The Sanford DPW uses a Vacall E5 "All-Catch" Basin Cleaner, which utilizes wet-vac and dry-vac capability to thoroughly remove soils and impurities from the City's catch basin sumps. Sanford DPW will continue its ongoing program to suction and clean the City's stormwater basins on a regular basis, including a focus on those basins located in the Goodall Brook watershed.
- ***Conservation of Forested Headwaters*** **-** The City of Sanford has adopted a Conservation Plan as part of the City's Comprehensive Plan. Uplands in the Hansons Ridge Road area contain forested and open, undeveloped parcels that are the origins and upper reaches of the Goodall Brook watershed. These areas were part of a larger area identified by a focus group as providing the most benefit to the City in terms of conservation of natural resources. The City and partners will continue to reach out to landowners to obtain conservation easements in this area of the Goodall Brook watershed. As part of its Land Stewardship Plan (described above), this rural upper watershed area will be included as one of the various conservation areas identified in the City's Plan called "The Headwaters".
- ***Main Street Combined Sewer Separation*** - In the coming years, the City of Sanford is planning to reconstruct the portion of Route 109 (Main Street), including new underground utilities, in collaboration with the Sanford Sewerage District. Currently the storm drain system in Main Street between its intersections with Twombley Road and Washington Street is conveyed into the sanitary sewerage system, where it is ultimately treated at the wastewater treatment plant. (Conversely, there is no sewerage draining into a storm drain system.) As part of this roadway reconstruction project, the Sewerage District, in collaboration with the City of Sanford will be required to design and construct a separate municipal stormwater collection system to separate and remove the stormwater from the sanitary sewer system. By virtue of this Plan, the City's design intent will be to design a route for this new drainage system to an existing outfall in the Mousam River, and to not route it to Goodall Brook or its watershed. It should be noted that this separation project is the last of the significant separation projects that the Sewerage District is mandated to complete to comply with its Federal requirements.

6.3 Action Plan

An Action Plan (Table 6-1) was developed to reflect goals and strategies identified during the watershed planning process. This Action Plan outlines priority level, parties that may be responsible, possible funding sources, the estimated cost, and a tentative schedule for implementation. The implementation phase of this plan will take place over 10 years (2015-2025), and costs will be spread out over that time period.

Table 6-1. Goodall Brook Action Plan

Improve conditions in Goodall Brook so that it meets Class B water quality standards.				
Action	**Priority**	**Who**	**When**	**Cost**
Upper Watershed (above Roberts St.) – Improve stream habitat.				
Install high priority stormwater retrofits (4 sites)	H	City of Sanford-Public Works & Highway Depts.	2015-2018	$60,000
Design and install stream habitat enhancement projects between Kimball and Roberts St.	H	City of Sanford, YCSWCD, DEP, with geomorphologist	2019	$20,000
Enhance riparian buffer adjacent to stream between Roberts St. and Lebanon St.	M	City of Sanford, Sanford HS, YCSWCD, volunteers	2015-2020	$10,000
Promote use of rain barrels, rain gardens and other green infrastructure	M	City of Sanford, DEP, YCSWCD, volunteers	2016-2019	$10,000
Middle Watershed (Roberts St. to Berwick Rd.)- Improve stream habitat and DO levels. Reduce nutrients				
Install logs and habitat structures to narrow stream channel, create pockets of stream velocity and habitat and improve DO (7 projects)	H	City of Sanford, DEP, YCSWCD and oversight from geomorphologist	2016-2020	$40,000
Conduct HEC-RAS modeling to assess whether culverts adjustments will improve velocity	H	City of Sanford-Public Works and/or consultant	2015-2020	$35,000
Install medium priority stormwater retrofits (7 sites)	M	City of Sanford-Public Works & Highway Depts., BBLA, Sanford High School, DEP, landowners	2018-2023	$25,000
Conduct lawn care outreach to property owners to reduce fertilizer use	M	City of Sanford, YCSWCD, BBLA	2019-2021	$5,000
Investigate impacts of streamside berms, sewer line and earthen dams	L	City of Sanford, with fluvial geomorphologist	2020	$5,000
Watershed Wide – Reduce bacteria contamination to the stream.				
Inspect sewer lines with cameras to detect leaking pipes or cross connections	H	Sanford Sewer District	2015-2017	$5,000

Action	Priority	Who	When	Cost
Conduct follow up dye testing, flow monitoring or canine detection to pinpoint problems	H	Sanford Sewer District	2016-2019	$10,000
Replace pipes in areas where problems are detected	H	Sanford Sewer District	2016-2025	TBD
Investigate City's pet waste disposal ordinance and adjust if needed.	M	City of Sanford	2015-2016	$1,000
Conduct outreach about pet waste impacts and proper disposal.	M	YCSWCD, City of Sanford	2016-2019	$5,000
Install signage at popular dog walking areas to encourage pet waste cleanup.	M	YCSWCD, City of Sanford-Parks & Recreation Dept.	2016-2017	$2,000
Provide pet composting and biodegradable bags for sale at transfer station.	M	City of Sanford-Public Works	2016-2020	$2,000
Prevent future water quality impacts to Goodall Brook and downstream waters, including Bauneg Beg lake.				
Install low priority stormwater retrofits to reduce nutrient loading to stream and lake (4 sites)	M	City of Sanford-Public Works & Highway Depts., Sanford High School, YCSWCD, BBLA, landowners	2020-2025	$35,000
Conduct regular maintenance on stormwater BMPs	H	City of Sanford-High and Parks Depts.	2015-2025	$20,000
Coordinate with Planning Board to create municipal overlay zone for Goodall Brook to align with plan goals and recommended BMPs for each part of the watershed.	M	City of Sanford-Planning Board	2015-2018	$2,500
Continue with road salt management that minimizes application of winter road salt. Evaluate new strategies for further reductions for water quality and cost savings.	M	City of Sanford-Public Works & Highway Department	2015-2025	$3,000
Coordinate on Main Street combined sewer separation project to limit impacts and stormwater to Goodall Brook.	M	City of Sanford	2015-2018	$3,000
Coordinate with land trusts with the goal of protecting important conservation land in watershed, particularly forested headwaters.	L	City of Sanford and Three Rivers Land Trust	2015-2025	TBA
Identify additional stormwater retrofit opportunities from existing or new development	L	DEP, YCSWCD, City of Sanford- Public Works & Planning Dept.	2015-2025	$10,000

Build community awareness and support for the restoration and protection of Goodall Brook and the City's other water resources.				
Form a Goodall Brook committee to guide plan implementation and conduct regular meetings.	H	City of Sanford, Sanford High School, Sanford Sewer District, BBLA, YCSWCD, DEP, residents	2015-2025	$5,000
Conduct water quality and BMP monitoring to assess stream conditions and project success	H	Sanford HS, Sanford Sewer District, BBLA, DEP	2015-2025	$10,000
Install Goodall Brook signs at stream crossings	H	YCSWCD, City of Sanford	2016-2017	$5,000
Conduct stream cleanups to remove trash and identify problems (e.g., pet waste disposal areas)	H	Sanford High School, City of Sanford	2015-2020	$5,000
Publicize project activities through local newspapers, partner websites and mailings	H	YCSWCD, City of Sanford	2015-2025	$5,000
Implement Business Certification program	M	City of Sanford, YCSWCD	2015-2018	$5,000
Conduct intercept survey and compare assess change in public awareness, actions and project success	L	YCSWCD, Sanford High School	2024	$3,000

6.4 Plan Oversight

Designating an effective group to carry out the environmental restoration activities presented in this plan is a crucial step in achieving real success. The group must have authority and resources that are well matched to the job. Sustainable funding, a good administrative process, and collaboration with landowners, local businesses, and residents are all variables that will lead to the success of the plan. Formal adoption of the plan by the City of Sanford 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.

A Goodall Brook Committee will be formed to oversee and guide the implementation of the Goodall Brook Watershed Plan. The committee will be set up through the City Council and will include City staff, representatives from the Planning Board and City Council, BBLA and other interested stakeholders. Continued support will also be provided by Maine DEP and YCSWCD staff.

7.0 Water Quality Targets and Reductions

7.1 Pollutant Load Reduction Targets

Stream Habitat Restoration

The overarching goal of this watershed management plan is to restore the biological community to one that fully attains it Class B aquatic life use. Several stressors have been identified that likely impair the biological communities in Goodall Brook, including poor habitat, low dissolved oxygen, elevated nutrients and bacterial contamination. The most significant stressor has been identified as poor habitat, as much of the stream channel suffers from historical practices of widening, straightening and dredging of the natural stream channel. It is likely that the low DO mentioned above is also closely tied to the lack of flow, and that restoration of natural flow will ameliorate the conditions inhibiting the biological communities of Goodall Brook.

Some sections of Goodall Brook maintain a healthy vegetated riparian buffer, which helps to reduce land erosion, absorb nutrients in runoff, and keep stream water cool with shade.

It is therefore the determination of the Technical Advisory Committee that the water quality and habitat issues in Goodall Brook can be attributed primarily to a flow problem, rather than a pollution loading problem, and that conventional approaches of estimating pollutant loads and reductions in loading do not necessarily apply to this stream. Instead, the committee presents a plan to achieve restoration by addressing issues that are specific to Goodall Brook. Many of the recommended actions in this plan will, however, result in reduced pollutant loads, which will benefit Goodall Brook, Bauneg Beg Lake and other downstream waters. Although not a primary focus, the following sections provides ways to estimate loading reductions to meet secondary water quality targets.

Impervious Cover

As discussed in Section 5.2, ME DEP (2012; Appendix D) estimates that the ***effective amount of impervious cover*** in Goodall Brook should be reduced to 9%, which constitutes a reduction in stormwater runoff volume and existing stormwater-associated pollutant loads by 62%[3]. This may be achieved through adequate treatment of stormwater with BMPs and Green Infrastructure techniques that reduce the effect of impervious cover. Load reduction estimates for various BMPs are presented in Table 5-2.

> ***Effective Impervious Cover***
> *Adjusted measure of impervious cover that takes into account techniques used to reduce pollutant runoff. Reducing effective IC to 9% doesn't mean halting development or removing pavement, but instead treating runoff from paved areas to reduce the effects of polluted runoff.*

Bacteria Concentration

When enough data are available, reductions in the loading capacity necessary to meet water quality standards are calculated for a rough estimation of pollution abatement action [3] Note that this estimate was based on a much higher estimated IC for the watershed. As such, this target should be used only as a very rough estimate and target needed. For Goodall Brook, the estimate of percent reduction needed was calculated based on the difference between measured *E. coli* bacteria data from 2013 and the water quality criteria for Class B streams (geometric mean of 64 colonies/100 ml; instantaneous level of 236 colonies/100 ml). Water quality criteria were compared to both the geometric mean and the highest concentration level measured at each of the seven monitoring sites.

[3] Note that this estimate was based on a much higher estimated IC for the watershed than was determined through this more in-depth project. As such, this target IC should be used only as a very rough estimate.

To calculate the estimated % reduction necessary to achieve the *E. coli* water quality standard in Goodall Brook:

$$\frac{(\text{E. coli measured value} - \text{E. coli standard})}{(\text{E. coli measured value})} = * 100 = \text{Percent E. coli reduction needed}$$

Here, the percent reductions were calculated so that the target values were the 90th percentile of the state standards for *E. coli* (geometric mean of 64 colonies/100 ml; instantaneous level of 236 colonies/100 ml). Setting the goal at this threshold allows for a buffer from the state standard, so sample reading that may vary will still be under the threshold for Class B standards. To calculate the percent reduction in *E. coli* necessary for Goodall Brook to meet the state standard for geometric mean across all sites:

$$\frac{(178.8 - (64 * 0.9))}{(178.8)} * 100 = 67.8\% \text{ Reduction}^4$$

Table 7-1. Maximum measures and geometric means for fecal coliform in five sampling sites on Goodall Brook.

Site[5]	*E. coli*: Maximum Measure	*E. coli* : Geometric Mean	% Reduction Needed (Max)*	% Reduction Needed (Geometric mean)*
G2 - Berwick	260.9	166.0	8.9%	65.3%
G3 - Emerson	410.6	185.7	42.5%	69.0%
G4 - Roberts St.	344.8	152.7	31.6%	62.3%
G5 - Lebanon St.	285.0	193.6	17.2%	70.2%
Prescott	261.3	200.7	9.7%	71.3%
Overall	**410.6**	**178.8**	**42.5%**	**67.8%**

**The percent reduction needed is calculated using 90th percentile values as the target for both maximum values (236*0.9 = 212) and geometric mean (64*0.9 = 58).*

The *Overall* row calculates the maximum value observed, the overall geometric mean, and the percent reduction necessary for Goodall Brook to entirely meet state water quality standards for *E. coli*. There needs to be a 67.8% reduction in *E. coli* in Goodall Brook to meet the standard for the geometric mean.

7.2 Load Reduction Estimates

The management guidance provided in this plan is intended to support evaluation of BMP alternatives and identification of next steps in the process of mitigating water quality impairment in Goodall Brook. It is difficult to predict in detail the pollutant loading reduction that may be achieved using a management practice or BMP. Additional site-specific evaluation will be required to support precise quantification of the nature and extent of pollutant reductions that would be achieved through implementation of the mitigation measures described above. Table 7-2 provides estimates of pollutant removal efficiencies for various types of practices and BMPs. These estimates are the result of investigations conducted throughout the United States and were compiled by the US EPA. These removal efficiency values

BMP Selection Criteria

Since phosphorus is the stormwater pollutant of greatest concern for Goodall Brook and Bauneg Beg Lake, BMPs with the highest phosphorus removal should be selected.

[4] Calculation based on the draft MDEP methodology for developing bacteria TMDLs (ME DEP, 2009).

[5] Refer to Figure 4-1 for site location map.

are useful to support planning and selection of appropriate mitigation measures, but should be considered rough estimates of actual removal performance. Factors that can affect the reporting of BMP performance include:

- Number of storms sampled
- Manner in which pollutant removal efficiency is computed
- Monitoring technique employed
- Sediment/water column interactions
- Soil type
- Rainfall, flow rate, and particle sizes of the influent
- Size and land use of the contributing catchment
- Incoming pollutant concentrations

Table 7-2. Structural stormwater Best Management Practices and expected pollutant removal efficiency (EPA,1993).

BMP Type	Typical Pollutant Removal (percent)				
	Suspended Solids	Nitrogen	Phosphorous	Pathogens	Metals
Dry Detention Basins	30 – 65	15 – 45	15 – 45	< 30	15 – 45
Retention Basins	50 – 80	30 – 65	30 – 65	< 30	50 – 80
Constructed Wetlands	50 – 80	< 30	15 – 45	< 30	50 – 80
Infiltration Basins	50 – 80	50 – 80	50 – 80	65 – 100	50 – 80
Infiltration Trenches/Dry Wells	50 – 80	50 – 80	15 – 45	65 – 100	50 – 80
Porous Pavement	65 – 100	65 – 100	30 – 65	65 – 100	65 – 100
Grassed Swales	30 – 65	15 – 45	15 – 45	< 30	15 – 45
Vegetated Filter Strips	50 – 80	50 – 80	50 – 80	< 30	30 – 65
Surface Sand Filters	50 – 80	< 30	50 – 80	< 30	50 – 80
Other Media Filters	65 – 100	15 – 45	< 30	< 30	50 – 80

7.3 Indicators to Measure Progress

Successful restoration of Goodall Brook requires setting goals and developing objectives to help meet those goals. The participation of landowners, City of Sanford, YCSWCD, Maine DEP and other partners is vital to the implementation of the watershed plan. The action plan provides key actions and milestones toward stream restoration, but it is inevitable that new information, technology, and techniques will be developed in future years.

Adaptive Management

An adaptive management approach is widely recommended when implementing environmental restoration programs. Adaptive management refers to an approach which incorporates a systematic re-evaluation of action items as new information continues to be gathered, and when necessary, adjusting the order, timing, or other aspects of the restoration program to achieve the ultimate goal of water quality attainment. This approach, which will be led by the Goodall Brook Committee, requires several elements:

- An initial schedule for implementing restoration actions;
- Periodic re-evaluation of the plan;
- A program to collect and analyze new data, especially regarding the stream's response to the restoration actions taken; and
- Expertise and the authority to adjust the plan in response to that information.

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 adequate funding, stakeholder guidance, and an efficient coordination of restoration activities. This approach will ensure that restoration actions are effective over the long term.

Interim Goals

The ultimate success of this plan and the strategies identified in the action plan will be the full attainment of all water quality standards in Goodall Brook. However, establishing indicators to measure progress towards that goal provides short term input on the success of the plan and work completed. These indicators will help create periodic updates to the plan and provide a mechanism to reevaluate the original action items. In addition to water quality monitoring, the following environmental, social, and programmatic indicators may be used to measure the progress of the ***Goodall Brook Watershed Management Plan***:

- **Programmatic indicators** are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic indicators will indicate actions intended to meet the water quality goal.
  - Establishment and formation of the Goodall Brook Committee
  - Amount of funding secured for plan implementation
  - Number of BMPs installed
  - Number of acres of impervious surface treated
  - Feet of sewer line inspected
  - Linear feet of riparian habitat improved
  - Feet of leaking sewer lines replaced
  - Number of illicit discharges identified and removed from the watershed
  - Number of stream cleanups conducted
  - Number of flow velocity enhancements sites established

- **Social Indicators** measure changes in social or cultural practices and behavior changes that lead to implementation of management measures and water quality improvement.
  - Number of students who participate in stream cleanups
  - Number of homeowners who participate in residential stormwater educational programs (green infrastructure, rain garden, or rain barrel workshops)
  - Number of people that purchase pet waste bags

- **Environmental Indicators** are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions.
  - Number of monitoring stations meeting water quality standards
  - Number of sites where flow velocity and in-stream habitat has been restored
  - Removal from DEP's list of impaired waters

8.0 Plan Implementation

8.1 Estimated Costs and Technical Assistance Needed

Total cost to implement the Goodall Brook Plan between 2015-2025 is estimated to range between $300,000 and $450,000. Estimated costs for each action item are listed in Table 6-1. Developing a funding plan that garners the approval of the community is essential to success. A community restoration effort should include the collaboration and support of the entire community including local businesses and property owners, community groups, conservation groups, and the City. State or federal grants will also be pursued to help implement the Action Plan. Broad community support is a major strength when applying for such funding.

> ***Potential Funding Sources***
>
> ***State and Federal Grants and Loans***
> - DEP Section 319 Grants
> - US EPA Five Star Grants
> - Stormwater Compensation Funds
> - State Revolving Fund
> - Piscataqua Region Estuaries Partnership (PREP) Grants
>
> ***Local Sources***
> - City of Sanford in-kind labor for maintenance and construction
> - Landowner, student and volunteer time
> - Business donations

- **Stormwater Retrofits**: State and federal agencies such as Maine DEP, Maine DOT, and EPA offer competitive grant programs to implement high priority stormwater retrofits in the watershed and in-stream restoration efforts, as well as select education and outreach activities. The Maine DEP's 319 grant program, in particular, is a good potential funding source for plan implementation. Stormwater Compensation Funds for Bauneg Beg lake may also be pursued to help fund stormwater retrofits that target phosphorus removal that would benefit downstream lake water quality. The Maine State Revolving Fund is also a potential source of low interest loans. Funding may come from a stormwater utility or a management district, if one is created in the future.
- **Municipal Maintenance**: Actions such as stormwater BMP maintenance, enhanced storm drain cleanout and street sweeping programs, and ordinance revisions should be supported by the City through tax dollars, permit fees. The City may also consider additional funding from fees collected as a result of ordinance violations. Other funding sources such as local planning grants may help supplement these projects.
- **Land Conservation**: Conserving land in the relatively undeveloped upper Goodall Brook watershed is a priority given the high levels of development in the lower watershed. Ongoing land conservation efforts will need the support of local conservation groups, conservation enthusiasts, and individual donors in order to prevent poorly planned development and long-term degradation in this portion of the watershed. Options such as obtaining easements within the buffer areas along the brook should also be considered in lieu of outright purchase.
- **Monitoring and Assessment**: Future monitoring and assessment efforts will require a variety of sources of funding. Maine DEP will conduct some of the monitoring through its existing programs. The Maine Volunteer River Monitoring Program, Sanford High School and Sanford Sewer District will assist with general stream monitoring. Federal Clean Water Act Section 319 money may be used to monitor the impact of stormwater retrofits or other restoration implementation. Other funding such as municipal government, and private foundation grants, should be considered.

8.2 Monitoring Plan

The development of a sound monitoring plan is critical to measure the success of restoration efforts. Monitoring key water quality parameters will help ensure that watershed issues adversely affecting water quality and aquatic habitat are being addressed. An adaptive management approach to implementation will allow for updates to monitoring activities deemed necessary by the Goodall Brook Committee in the future.

Water Quality Monitoring

Sanford High School, in partnership with Sanford Sewer District and BBLA, will conduct stream water quality monitoring as part of the Maine DEP's Volunteer River Monitoring Program (VRMP). Currently, Sanford High School conducts monitoring on the Mousam River through the VRMP, but additional stations will be added in Goodall Brook.

Students will conduct regular monitoring of dissolved oxygen at established sites using field meters. Early morning DO readings taken in summer should be targeted for sampling events in order to determine the lowest likely dissolved oxygen concentrations. In addition, students will collect water samples for bacteria analysis. Sanford Sewer District will analyze bacteria samples at their lab and assist with monitoring as needed.

Macroinvertebrates

Two stations on Goodall Brook are monitored by the Maine DEP for macroinvertebrates on a five year rotation schedule, with the next visit planned for 2015. Additional biomonitoring stations or a more frequent schedule will be pursued as needed to assess restoration efforts.

In-stream Habitat Structures

A critical component of habitat restoration for the aquatic communities in Goodall Brook is generating an increase in the diversity of flow velocities in the stream.

All stream habitat restoration projects will be closely monitored. Logs placed in the stream will be regularly inspected to make sure the structures are stable, providing habitat and increasing localized flow velocity. Kicknetting or rock bags could also be used below habitat construction sites to assess resulting improvements in aquatic life. Dissolved oxygen readings will be measured above and below structures to assess resulting improvements. Photo points will also be established at each restoration site. Photos will be taken at the same locations before and after construction and regularly over time to assess changes over time.

8.3 Evaluation Plan

The effectiveness of this Management Plan should be made public as work progresses. The Goodall Brook Committee could consider releasing an annual report (or updating a webpage) that highlights the progress and activities in comparison to the timeline set forth in the Action Plan (Table 6-1). Tasks listed in the Action Plan should be tracked and recorded as they occur, and new tasks should be added to the plan as needed. All achievements, such as press releases, outreach activities, number of sites repaired, number of volunteers, amount of funding received, number of sites documented, will be tracked. The committee may use the plan’s goals to evaluate the progress of the plan.

References

Center for Watershed Protection (CWP). 2003. Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph No. 1. Center for Watershed Protection, Ellicott

Maine DEP, 2004a. Maine DEP Biomonitoring Program stream assessment. "Goodall Brook - Station 747" http://www.maine.gov/dep/gis/datamaps/lawb_biomonitoring/station_web/S-747M.htm

Maine DEP, 2004b. Maine DEP Biomonitoring Program stream assessment. "Goodall Brook - Station 748" http://www.maine.gov/dep/gis/datamaps/lawb_biomonitoring/station_web/S-748M.htm

Maine DEP, 2009. Maine Statewide Bacteria TMDL (Total Maximum Daily Loads). August 2009. Report # DEPLW-1002http://www.maine.gov/dep/water/monitoring/tmdl/2009/bacteria_report.pdf

Maine DEP, 2010. Maine Stream Survey Manual Volume II – A Citizen's Primer on Stream Ecology, Water Quality, Hydrology and Fluvial Geomorphology. Publication DEPLW-0965.

Maine DEP, 2012. Maine Impervious Cover Total Maximum Daily Load Assessment (TMDL) for Impaired Streams. http://www.maine.gov/dep/water/monitoring/tmdl/2012/IC%20TMDL_Sept_2012.pdf

Maine DEP, 2012. Integrated Water Quality Monitoring and Assessment Report. http://www.maine.gov/dep/water/monitoring/305b/2012/report-final.pdf.

MRSA Title 38 § 465: Maine Revised Statutes, Title 38: Waters And Navigation, Chapter 3: Protection And Improvement Of Waters, Subchapter 1: Environmental Protection Board, Article 4-A: Water Classification Program. http://www.mainelegislature.org/legis/statutes/38/title38sec464.html

SMRPC. (2013). Southern Maine Regional Planning Commission. Population estimates by Town. SMRPC. http://www.smrpc.org/index.php/programs/land-use-plainning/community-profiles

US Census Bureau, 2010. http://www.census.gov/2010census/

USDA/NRCS, 2013. Web Soil Survey. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

US EPA, 1993. Urban Runoff Pollution Prevention and Control Planning. U.S. Environmental Protection Agency. EPA-625/R-93-004. http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=30004LY0.txt