CAPEHART BROOK

Capehart Brook Watershed-Based Management Plan

Bangor, Maine

June 2015

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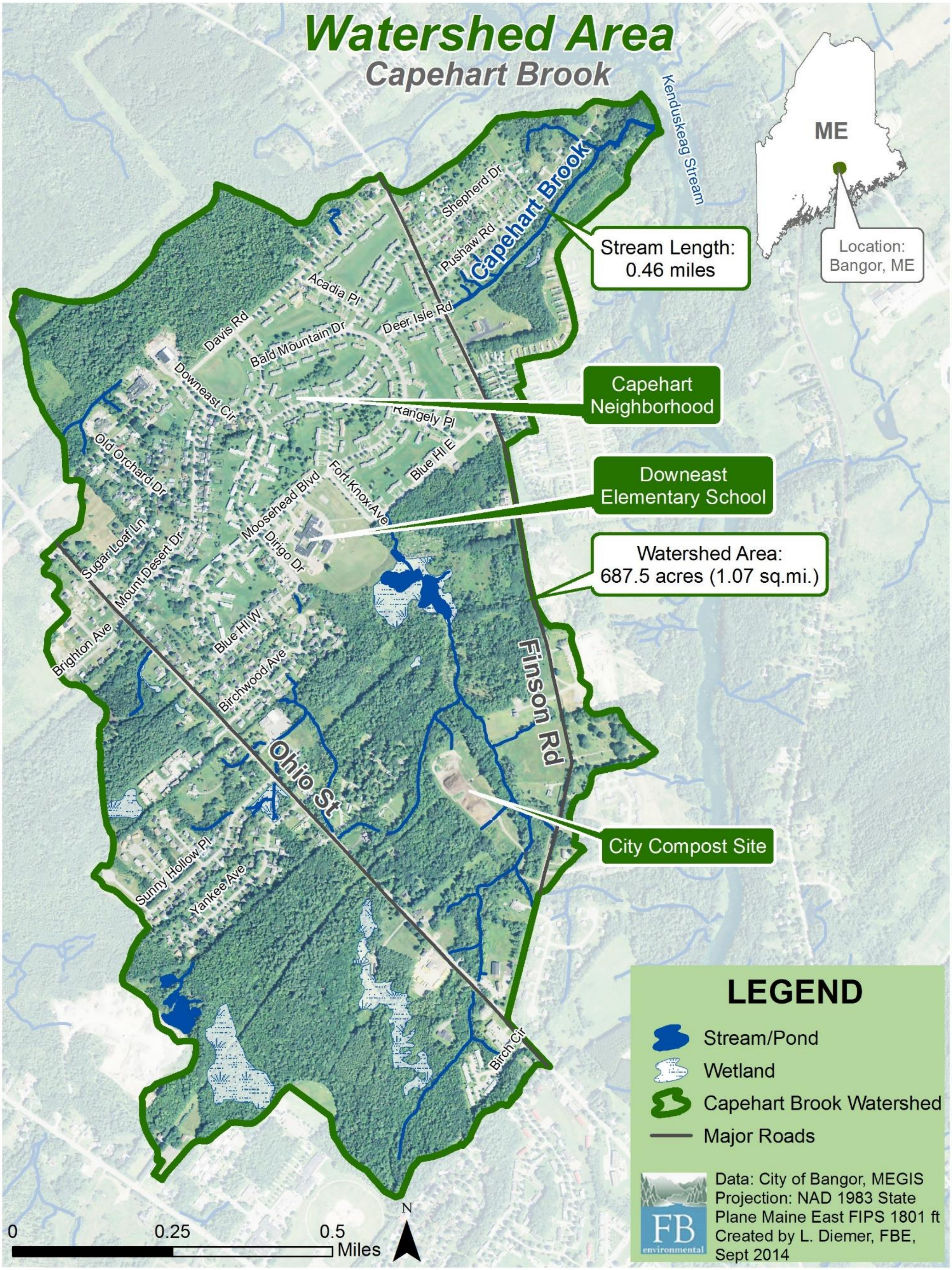
Watershed Area
Capehart Brook
Kenduskeag Stream
ME
Location: Bangor, ME
Stream Length: 0.46 miles
Capehart Brook
Capehart Neighborhood
Downeast Elementary School
Watershed Area: 687.5 acres (1.07 sq.mi.)
City Compost Site
Finson Rd
Ohio St
Shepherd Dr
Pushaw Rd
Acadia Pl
Deer Isle Rd
Davis Rd
Bald Mountain Dr
Downeast Cir
Rangely Pl
Blue Hl E
Fort Knox Ave
Moosehead Blvd
Dirigo Dr
Old Orchard Dr
Sugar Loaf Ln
Mount Desert Dr
Blue Hl W
Brighton Ave
Birchwood Ave
Sunny Hollow Pl
Yankee Ave
Birch Cir
LEGEND
Stream/Pond
Wetland
Capehart Brook Watershed
Major Roads
Data: City of Bangor, MEGIS
Projection: NAD 1983 State Plane Maine East FIPS 1801 ft
Created by L. Diemer, FBE, Sept 2014
0
0.25
0.5
Miles
N

CAPEHART BROOK

WATERSHED-BASED MANAGEMENT PLAN

Prepared for and funded by:

City of Bangor, Maine

Prepared by:

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June 2015

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EXECUTIVE SUMMARY

CAPEHART BROOK WATERSHED-BASED MANAGEMENT PLAN

PROJECT OVERVIEW

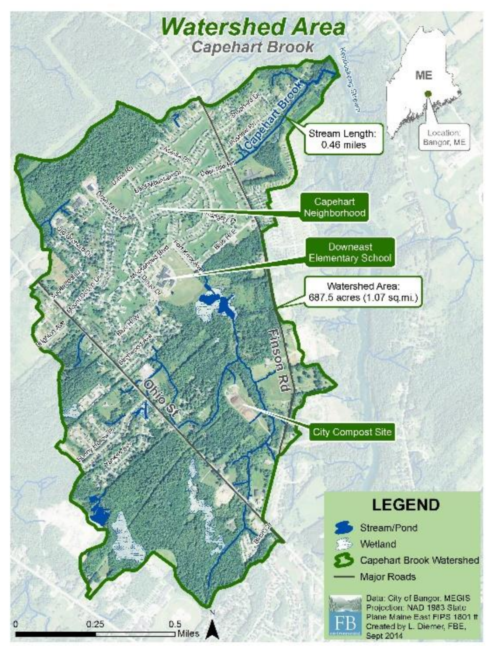
The Capehart Brook Watershed-Based Management Plan serves as an update to the 2011 watershed management plan completed by SMRT, Inc. FB Environmental Associates (FBE) was contracted by the City of Bangor to update the original management plan and to provide recommendations for restoration initiatives within the watershed. The goal of the plan is to improve the aquatic habitat and water quality conditions in Capehart Brook so that it attains Class B water quality standards. This will be achieved using a combination of on-the-ground stormwater retrofits, municipal maintenance, community education and outreach, and monitoring activities that focus on treating, and where possible, disconnecting impervious cover (IC) that contributes to the stream's impairment.

View of Capehart Brook just upstream of its confluence with the Kenduskeag Stream.

Development of the plan included conducting a rapid habitat and geomorphic stream assessment, compiling and analyzing historical water quality data, updating the existing GIS land cover data, and creating a simple pollutant loading model for the Capehart Brook watershed. This information was used to identify water quality problems, define management objectives, and prioritize restoration strategies in the watershed.

GOAL:
Restore watershed conditions in Capehart Brook so that the stream attains State water quality classification standards for Class B surface waters.

THE CAPEHART BROOK WATERSHED



Capehart Brook is a small urban stream that originates under Finson Road through a 66" culvert and flows 0.46 miles before emptying into the Kenduskeag Stream. The stream is fed by a series of underground pipe and open drainage ditches from the City stormwater system. This stream was dredged by the Army Corps of Engineers in the 1950's, but has since become a "naturalized" stream that flows parallel to residential homes on Pushaw Road to the northwest and a utility access road to the southeast.

The Capehart Brook watershed covers approximately 688 acres and is located entirely within the City of Bangor. The majority of the watershed's development between Finson Road and Ohio Street contains former military base housing, now mostly owned by the Bangor Housing Authority for low-income housing.

THE PROBLEM

As one of Maine's 31 "urban impaired streams," Capehart Brook is impaired for aquatic life use as a result of urbanization from high-density residential neighborhoods (and some commercial development) within the watershed. According to the Watershed Science Institute's Watershed Condition Series, Technical Note 3 on the EPT Index, Capehart Brook is classified as having a "poor" water quality rating since the majority of macroinvertebrates found are associated with degraded water quality (WSI 2012). According to the 2012 *State-wide Impervious Cover Total Maximum Daily Load* (IC TMDL) report, the primary culprit to the current impairment is the increased volume of stormwater runoff and associated pollutants flowing into the stream from IC, which was estimated at 15% for the Capehart Brook watershed (Maine DEP 2012b). Recent land cover analyses estimate that 14.4% (99.3 acres) of the Capehart Brook watershed is covered by IC, with roads and buildings (e.g. rooftops) making up a significant portion (62%).

Stormwater runoff from the Capehart Brook neighborhood flows directly into Capehart Brook.

Stormwater carrying dirt, metals, and other pollutants is conveyed directly from IC, such as parking lots, roads, and rooftops, to Capehart Brook with minimal pre-treatment, causing increased erosion, sedimentation, increased temperature, and habitat degradation in the stream (CWP 2003). Research shows that watersheds with IC greater than 12% often exceed criteria for aquatic life use (Stanfield and Kilgour 2006), and even lower levels of IC (4-6%) can significantly inhibit the abundance and diversity of fish and macroinvertebrate species (Wenger et al. 2008). Maine DEP currently establishes a target of 8% IC to meet aquatic life use criteria in Class B waters (Maine DEP 2012b). Based on the Maine DEP's target goal of 8% IC, a 44% effective IC reduction (equivalent to 44 acres) is needed to offset the effects that IC has on Capehart Brook. Maine DEP considers Capehart Brook to be a "highly restorable" stream, and therefore, of great interest for future mitigation and monitoring efforts by the City of Bangor.

Management measures described in this Plan will reduce effective IC in the Capehart Brook watershed by 44%. The Maine DEP target should be viewed as a guideline for achieving attainment. Every stream and its aquatic communities will respond differently to restoration activities, and Capehart Brook may or may not reach attainment before or after a full 44% effective IC reduction is achieved.

> **OBJECTIVE*:***
> *Based on the Maine DEP's target goal of 8% IC, a 44% effective IC reduction (equivalent to about 44 acres) may be needed to offset the effects that IC has on Capehart Brook.*

WHY DEVELOP A WATERSHED-BASED MANAGEMENT PLAN?

A watershed-based management plan helps identify problems, priorities, and actions that are needed to improve the water quality of a waterbody. Since each watershed is unique, the Capehart Brook Watershed-Based Management Plan is also unique to address the major issues and concerns of both the community and the stream.

A good restoration plan acts as a road map pointing out where to start, what visits to make in the watershed, how long it will take to get there, how much it will cost, and how you know you've arrived.

Reductions from Proposed Stormwater Retrofits:

44% Impervious Cover (IC)
40% Total Suspended Sediments (TSS)
22% Total Phosphorus (TP)
19% Total Nitrogen (TN)

The Capehart Brook Watershed-Based Management Plan builds upon the goal of reducing polluted stormwater runoff from reaching Capehart Brook and describes restoration objectives to meet this challenge. An Action Plan (Section 4) was developed based on feedback from the City of Bangor and the Stormwater Citizen Review Panel. These stakeholders discussed what they perceived to be the greatest threats to stream's water quality, and developed practical solutions to address them. Implementing all the recommended structural BMPs in the Capehart Brook watershed will likely disconnect 44 acres of effective IC in the watershed out of the 44 acres needed to reach the 8% effective IC target. Non-structural management measures may also reduce pollutants in the watershed by an additional 10% (Law et al. 2008, FBE 2011).

KEY RESTORATION CATEGORIES
Capehart Brook

- ☆ **Stormwater Best Management Practices (BMPs)-** *Reducing the volume of stormwater and the pollutants it carries to Capehart Brook is a priority that can be accomplished through a variety of innovative conservation practices that capture, filter, cool, and slow runoff from paved areas, rooftops, and other impervious surfaces.*
- ☆ **Stream Restoration-** *Improve habitat conditions in the stream using in-stream restoration efforts such as restoring riparian buffers and stabilizing eroding stream banks.*
- ☆ **Education & Outreach-** *Garner the support and cooperation from community groups while educating business owners, school children, and watershed residents about the need for and importance of clean water.*
- ☆ **Municipal Maintenance Practices-** *Work with municipal employees to improve existing stormwater infrastructure, catch basin cleaning, winter sand/salt spreading, snow storage, and street sweeping.*
- ☆ **Land Conservation & Land Use Planning-** *Coordinate local efforts to increase the amount of land in permanent conservation while working with City officials* to *expand riparian buffer zoning and improve City stormwater rules to protect impaired streams.*
- ☆ **Source Control-** *Identify and remedy known and unknown sources of illicit discharge to the stream.*
- ☆ **Water Quality-** *Continue and/or improve the water quality and macroinvertebrate monitoring.*

Successful development of the Plan, including final selection of key restoration strategies, requires an integrative and adaptive approach and depends primarily on the involvement of the City, its partners, and the watershed community. These partnerships help strengthen the Plan by increasing both public awareness of the problems and public commitment to the solutions. A community-based plan also provides other benefits such as attracting private, state, and federal dollars for green jobs and green infrastructure, and provides opportunities for both recreational and aesthetic improvements. This Plan will help to foster further thinking about long-term strategies for improving the water quality and related natural resources within the Capehart

Brook watershed, and help to promote communication among citizens, municipalities, and state agencies. This Plan is contingent on landowner cooperation since most of the land is privately-owned by individuals (69%) or the Bangor Housing Authority (13%) (Appendix A, Map 14).

What the Plan Includes

The City of Bangor has helped guide the watershed planning process since the initiative began in 2010, and will continue to guide efforts to implement the Plan over the next 10 or more years. The Plan is divided into six major sections based on the USEPA's nine key planning elements for watershed management plans:

Section 1 describes the purpose of the Plan, provides background information about Capehart Brook, a description of the planning process, and a brief description of recent efforts in the watershed.

Section 2 describes the watershed, including climate, population statistics, growth trends, land cover, topography, land conservation, soils and geology, water resources, and stormwater/sewer infrastructure.

Section 3 provides an IC assessment of the watershed, describes applicable water quality standards, summarizes water quality and biological assessment data collected from the stream, and summarizes the results of a Stream Corridor Survey which included a habitat assessment, rapid geomorphic assessment, culvert inventory, and documentation of nonpoint source (NPS) pollution hotspots.

Section 4 describes watershed restoration goals and objectives. Both structural and non-structural restoration opportunities and recommendations are discussed. Action strategies are presented in tables describing what needs to be done, how it will be done, who will help get it done, when it will be done, and how much it will cost. Restoration strategies are divided into several primary categories (shown below). Section 4.4 provides the results of a pollutant loading reduction analysis for the recommended structural retrofits.

Section 5 describes who is in charge of administering the Plan, and summarizes actions, costs, and technical assistance needed to ensure progress.

Section 6 describes specific recommendations for monitoring and evaluating the effectiveness of restoration efforts. This includes criteria for measuring progress and measurable milestones along the way.

Funding The Plan

The total new cost for implementing the Capehart Brook Watershed-Based Management Plan is estimated at $**560,000 or $56,000/year over the next 10 years**, including all structural and non-structural recommendations described in this Plan. The City has already taken the initiative to obtain funding for Phase I and II BMP implementation work within the Capehart Brook watershed. A long-term sustainable funding source has already been established through the Stormwater Utility fund, but additional strategies can and should be developed by the City of Bangor, particularly for monitoring efforts.

Administering The Plan

The City of Bangor will administer the Capehart Brook Watershed-Based Management Plan. The City will convene at least annually to provide periodic updates to the Plan, track and record progress made toward restoration, maintain and sustain action items, and make the Plan relevant on an ongoing basis by adding new tasks as they develop. The City will track achievements, press coverage, outreach activities, number of retrofits sites repaired, number of volunteers, and amount of funding received.

10-Year Cost Estimate for Restoring Capehart Brook				
	Category	**Costs covered by existing City programs for six impaired streams**	**New Costs to the City for Capehart Bk**	**New Costs to Other Stakeholders**
Structural BMPS				
	Stormwater Retrofit Sites	$150,000	$362,833	--
	Retrofit Maintenance	$30,000	$250,000**	--
Non-Structural BMPs				
	Administrative & Funding	$60,000	--	--
	Education & Outreach	$5,000	$6,750	$3,500
	Municipal Maintenance	$60,000	$283	--
	Land-Use Planning	$1,500	$500	--
	Source Control/Other	--	$83,500	--
	TOTAL	**$306,500**	**$91,033**	**$3,500**
Monitoring Program				
	Monitoring	$25,000	$107,000	--
GRAND TOTAL (10-yr)		**$331,500**	**$560,866**	**$3,500**

***not included in grand total due to high cost estimate variability*

NEXT STEPS

The success of this Plan can be measured in several ways, as outlined in Section 6.3 on Measurable Milestones. These milestones fall under three categories: environmental, programmatic, and social indicators. These indicators can be used as performance measures to determine how well implementation activities are working and provides a means to track progress toward established goals and objectives. Key milestones identified in this Plan are provided in the table below.

Successful implementation of the Capehart Brook Watershed-Based Management Plan depends primarily on the commitment and involvement of community members. Therefore, the success of this Plan will weigh heavily on the support and cooperation of the City and key stakeholders. The City will need to enthusiastically engage the community in restoration activities, work together to maintain the sustainable funding plan, and acquire additional funds to implement the suggested Phase III work. The City should officially adopt the Plan, thereby raising awareness about the importance of restoration efforts and the need for immediate action.

Measurable Milestones			
Indicators	**Benchmarks***		
	2017	*2020*	*2025*
Environmental			
Enhance macroinvertebrate type, abundance, and distribution (meet Class B standards)	5%	50%	90%
Reduce peak flows, temperature, and pollutants in water coming out of the Finson Road culvert (reduce % IC)	5%	25%	44%
Programmatic			
Number of areas installed with structural BMPs	5	10	20
Number of culverts stabilized	2	4	8
Social			
Number of volunteers for stream clean-ups and plantings	10	20	30
Number of people participating in educational events	10	20	30

**Benchmark figures are cumulative from 2017 to 2020 to 2025*

ACKNOWLEDGEMENTS

The following individuals contributed their time, knowledge, and forethought to help develop the Capehart Brook Watershed-Based Management Plan:

Wynne Guglielmo, City of Bangor Environmental Coordinator
Peralie Burbank, City of Bangor Civil Engineer
Scott Gorneau, FABCO Industries, Inc. Regional Vice President
Brad Moore, City of Bangor Superintendent of the Wastewater Treatment Plant
Paul Nicklas, City of Bangor Assistant City Solicitor

FB Environmental technical support & report writing provided by:

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Jennifer Jespersen, Senior Project Manager
Laura Diemer, Project Scientist
Whitney Baker, Project Scientist
Logan Cline, Project Assistant

Stormwater Citizen Review Panel members provided project support through Plan reviews:

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Elizabeth Rettenmaier
Julie Green
Redington R Robbins III
James M Taylor
Valerie J Carter
Brian J Ross
Patrick Quinn, Jr.
Lovern Stockwell

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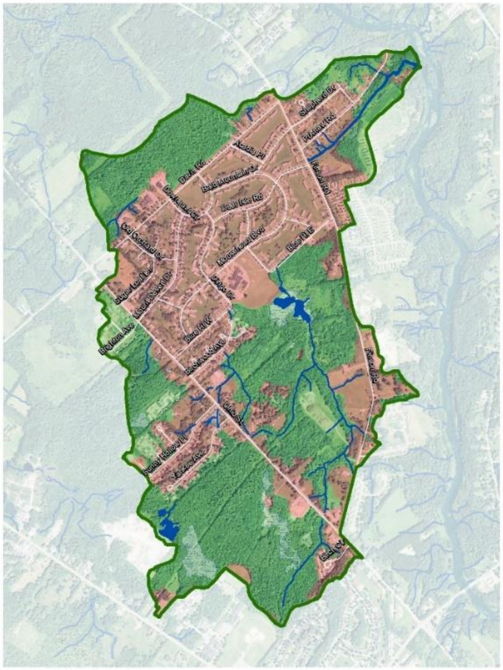
1.1 Purpose and Background

Small (1st and 2nd order or headwater) streams and their associated network of wetlands help sustain the biological productivity of downstream rivers, lakes, and estuaries. These small streams recycle nutrients, create habitat, and maintain biological diversity for plants and animals, including fish species such as salmon and trout (Meyer et al. 2007). Small streams also provide natural flood control, recharge the groundwater, and maintain water quality by trapping sediments and pollution from fertilizers and other contaminants (Allan and Castillo 2007). Streams also offer intrinsic benefits to our communities by providing a sense of place for the people who live near them and a place for children to grow and explore the natural world around them.

The numerous benefits afforded by small stream networks are being threatened by human activities that lead to increases in urban runoff, such as land clearing and development. Poorly planned development most often results in riparian vegetation and watershed hydrology alterations, water quality degradation, and invasive species introduction. These consequences not only impact the health of aquatic life, but also our physical, social, and economic health. Conservation efforts, including protection of the riparian zone, preservation of undeveloped forest buffers, and implementation of low-impact development techniques that prevent stormwater runoff from developed areas will help protect these small streams for future generations.

Capehart Brook is an interesting example of the impact that human activities can have on the landscape. According to historical records, Capehart Brook was created as a sewage ditch draining former base housing built circa 1958 and was dredged to maintain the channel. As a result, the "naturalized" portion of Capehart Brook is fed by a series of underground stormwater pipes and open ditches, part of the City's Municipal Separate Storm Sewer System (MS4), that converge under Finson Road. Today, the former base housing is a high-density residential neighborhood, complete with roads, driveways, and sidewalks that cannot filter stormwater. The network of open and closed drainage ditches throughout the watershed results in overland flow of stormwater runoff to stormwater pipes that eventually empty into Capehart Brook. The water quality in Capehart Brook is not meeting State Class B standards, and is threatening the health of downstream waterbodies, such as Kenduskeag Stream.



This map of the Capehart Brook watershed highlights developed (red) and undeveloped (green) land.

Impervious cover *refers to any surface that will not allow water to soak into the ground. Examples include paved roads, driveways, parking lots, and roofs.*

Development of the former base housing (a.k.a Capehart Neighborhood) was completed without any stormwater mitigation strategies put in place to reduce runoff from residential areas. The installation of drainage ditches altered the hydrologic cycle and movement of water through the landscape. The high percentage of developed land (mostly residential, but some commercial land uses) in the Capehart Brook watershed has increased overland flow during storm conditions. Overland flow picks up a variety of pollutants from **impervious cover (IC)** before reaching Capehart Brook.

Capehart Brook was listed as impaired for aquatic life use by the Maine DEP beginning in 2006. The most recent listing in the 2012 *Integrated and Water Quality Monitoring and Assessment Report* by the Maine DEP places Capehart Brook under Category 4A for TMDL approval (Maine DEP 2012a). This listing was based on the non-attaining and indeterminate Class B determinations of 1997 and 2001 macroinvertebrate monitoring by the Maine DEP. Capehart Brook was also listed in the Maine DEP's Stormwater Management Law, Chapter 502 List of Urban Impaired Streams. The aquatic life violation prompted the inclusion of Capehart Brook in a *Statewide Impervious Cover Total Maximum Daily Load (IC TMDL) Report*, which was drafted in 2011 and published in 2012, and followed immediately by a watershed management plan by SMRT, Inc. in 2011 (Maine DEP 2012b, SMRT 2011). The IC TMDL set a target of 8% effective IC to help reduce current pollutant loads from the watershed and mimic natural watershed conditions (Maine DEP 2012b). Achieving this target will help restore habitat conditions in Capehart Brook so that it will attain Class B water quality standards. The Maine DEP considers Capehart Brook to be a "highly restorable" stream, and therefore, the Capehart Brook watershed is of great interest for future mitigation and monitoring efforts by the City of Bangor.

GOAL

The goal of the Capehart Brook Watershed-Based Management Plan is to provide management recommendations that will help improve aquatic habitat and water quality in Capehart Brook so that it meets Class B water quality standards.

This goal can be accomplished with the commitment of a coordinated group of local community leaders, conservation groups, city, state and federal partners, and citizens of the watershed working together to implement a 10-year plan to restore Capehart Brook. The Capehart Brook Watershed-Based Management Plan provides key actions needed to restore the stream, the timing of these actions, and the mechanisms by which they will be accomplished.

1.2 Developing a Community-Driven Watershed-Based Management Plan

A watershed-based management plan helps identify problems, list priorities, and outline actions that are needed to improve the water quality of a stream (EPA 2008). A good plan acts as a road map pointing out where to start, how long it will take to get there, how much it will cost, and how you know you've arrived. Since each watershed is unique, the watershed-based management plan should also be unique to address the major issues and concerns of the community.

Successful development of a watershed restoration plan depends primarily on the commitment and involvement of community members. These partnerships help strengthen the Plan by increasing both public awareness of the problems and public commitment to the solutions. Many of the recommendations of this Plan will require landowner cooperation with the City to implement retrofits on private or non-City-owned land. As such, it will be important to develop a strong education and outreach program that targets residents of the Capehart Brook neighborhood in an effective and trusting way; once landowners understand the importance of restoring Capehart Brook, they may be more likely to participate in the restoration process.

The following groups or individuals have been identified as potential public participants to help finalize the Plan, and implement recommended actions to restore Capehart Brook:

- Church volunteers
- Bangor Housing Authority (BHA)
- Penobscot Christian School Board
- Downeast Elementary School
- Cyr Bus Lines
- Bangor Land Trust (BLT)
- Bangor Area Storm Water Group (BASWG)
- Maine DEP
- UMaine Cooperative Extension
- Penobscot Job Corps
- Bangor High School
- City of Bangor Dept. of Community & Economic Development

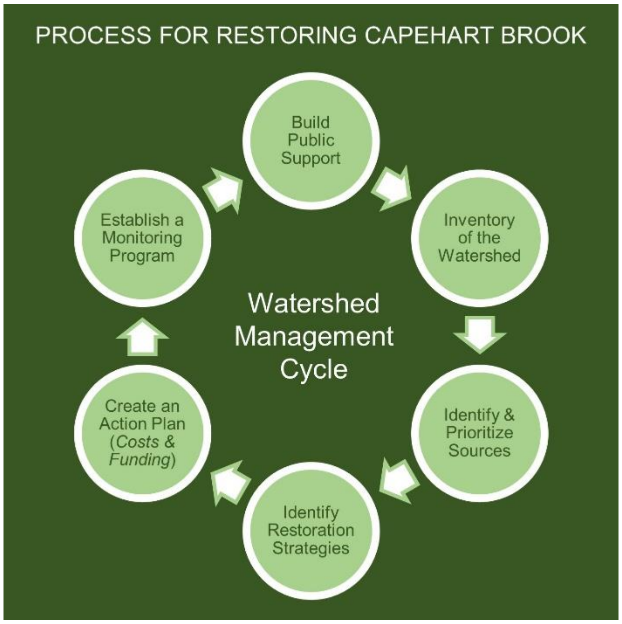


Figure 1. *Watershed Management Cycle. The City of Bangor has embraced the watershed management cycle and should ensure that this Plan is a "living document."*

The City of Bangor has shown a strong commitment to improving conditions at Capehart Brook. Several key recommendations from the 2011 Capehart Brook Watershed Management Plan have been or will be implemented by the City in the first two phases of restoration. Information about the Capehart Brook Watershed-Based Management Plan update was presented to the Stormwater Citizen Review Panel on June 4, 2014 to review the goals for restoring Capehart Brook. A meeting was also held with key City of Bangor staff on November 18, 2014 to review the draft Action Plan and make necessary revisions. A final presentation to the Review Panel on December 3, 2014 was designed to summarize the Plan content and solicit feedback on the Action Plan. The involvement of watershed stakeholders was encouraged through public access television to ensure that as many interests were considered. The Stormwater Citizen Review Panel comprises community members representing a variety of interests from local businesses, private landowners, municipal government, and education. The community-based approach will continue through the implementation of the Plan. An illustration of the structure needed to harness community involvement and provide community oversight for Plan development and implementation is shown in Figure 1. To ensure that restoration goals are achieved, the community should consider this Plan a "living document." In other words, the goals and objectives of the Capehart Brook Watershed-Based Management Plan should be revisited and revised on an annual basis by the City of Bangor.

1.3 Recent Efforts in the Watershed

The City of Bangor has an ongoing interest in restoring Capehart Brook and has been actively involved in the watershed since 2009 when the City contracted the James W. Sewall Company to conduct annual water quality and flow monitoring. This was in response to the listing of Capehart Brook on the Maine 303(d) list of impaired waters beginning in 2006. Both the City and the Maine DEP consider Capehart Brook to be a priority watershed for restoration due to its high potential for success. An aerial map highlighting current efforts in the Capehart Brook watershed is provided in Figure 2.

Capehart Brook Water Quality Assessment - Macroinvertebrate, physical habitat, and water chemistry data were collected by the Maine DEP in 1997 and 2001. Results were compared to Maine's statutory Class B water quality standards and the stream was listed as impaired due to non-attainment of aquatic life criteria. The Maine DEP also conducted continuous water quality monitoring of temperature, dissolved oxygen, and conductivity from March to September 2011 and provided a water quality summary to the City.

From 2009 to 2011, the City of Bangor contracted the James W. Sewall Company to conduct continuous flow monitoring and discrete sampling of dissolved oxygen, conductivity, temperature, pH, and chloride. The data for Capehart Brook were included in the *Summary Water Quality Data Report for Five Impaired Streams* (James W. Sewall Company 2012). In 2012, the James W. Sewall Company was contracted only for discrete sampling of dissolved oxygen, conductivity, temperature, color, and pH. The results were included in the *Bangor Interim Report* (Kahl and Bigelow 2012). In 2013, the City of Bangor collected discrete samples for dissolved oxygen, conductivity, temperature, and pH. These efforts were funded in part by American Recovery and Reinvestment Act (ARRA) and the City of Bangor stormwater budget. Water quality results are discussed in Section 3. The City of Bangor has also recently collaborated with FBE to monitor benthic macroinvertebrates in summer of 2014.

Capehart Brook Total Maximum Daily Load (TMDL) - To address the aquatic life impairment, Capehart Brook was included in a Statewide IC TMDL using an IC target of 8% (Maine DEP 2012b). The IC TMDL for Capehart Brook identified the high percentage of developed land (primarily residential) in the Capehart Brook watershed as the primary cause of impairment.

Capehart Brook Stream Corridor Survey - An AmeriCorps team conducted a Level 1 Stream Corridor Survey, including a Rapid Habitat Assessment and Rapid Geomorphic Assessment of Capehart Brook in 2010. The results were reviewed by the Maine DEP (Dennis 2010), and the findings were helpful for the development of the 2011 Watershed Management Plan (SMRT 2011).

Capehart Brook Watershed Management Plan - The 2011 Watershed Management Plan for Capehart Brook was developed for the City of Bangor by SMRT, Inc. (SMRT 2011). The plan recommended installation of bio-retention cells in the open space area ditches, reduction of road width with porous sidewalks, retrofit of an existing wet pond at Sunny Hollow Place, and installation of residential rain gardens and barrels, among others. Two of these major recommendations have already taken place (see below); the retrofit of Sunny Hollow Place is currently being pursued by the City in Phase II.

Capehart Brook Restoration Project Phase I - Following the completion of the 2011 Capehart Brook Watershed Management Plan, the City of Bangor was awarded a Maine DEP 319 grant to implement some of the recommendations made in the plan. With this funding, the City installed two bio-retention cell systems at Rangeley Place South (in 2012) and the Downeast Elementary School (in 2013), as well as several residential rain barrels and rain gardens in 2012. More detailed descriptions of the Phase I projects is provided in the final report submitted by the City of Bangor to the Maine DEP (City of Bangor 2013).

Bio-retention cell retrofit at Rangeley South. Photo credit: City of Bangor.

Bio-retention Cells at Rangeley Place South and the Downeast Elementary School: The network of drainage ditches in the open space areas throughout the residential neighborhoods of the Capehart Brook watershed were targeted for bio-retention cell retrofits. The goal of the biocells is to reduce flow volume and filter pollutants by replacing portions of the existing open ditch network. These two bio-retention cell systems treat stormwater from 6.29 acres of lawn and 1.34 acres of IC (including a parking lot, rooftops, driveways, and two streets)[1]. The bio-retention cell at the Downeast Elementary School was installed in the lawn area adjacent to a ditch and serves as an educational example of low-impact development. An estimated 5.7 tons of sediment, 6.6 lbs. of phosphorus, and 9.1 lbs. of nitrogen are kept from entering Capehart Brook annually as a result of the improvements.

Sidewalk Bridge: A sidewalk bridge was constructed along Blue Hill East Road near the Rangeley Place South area just upstream of existing catch basins to divert stormwater from the street to the sidewalk bridges where water can flow under and into the bio-retention cells for treatment. This was done to address concerns about the flat topography, which made it difficult to find effective locations for the bio-retention cells without major alteration to the landscape for drainage. This sidewalk bridge treats approximately 0.61 acres of IC[2].

[1] *These figures were provided in the Phase I final report by the City of Bangor to the Maine DEP based on STEPL model results (City of Bangor 2013). Actual area of disconnected IC from these retrofits varies slightly using the NHDES Simple Method.*

[2] *The estimated IC disconnections for the Phase I BMP implementations were provided by the City using STEPL. Estimates of IC disconnections using the NHDES Simple Method vary slightly from these figures and are noted in Section 4.4.*

Residential Rain Barrels and Rain Gardens: Penobscot Job Corps (PJC) volunteers installed 21 rain barrels and 3 rain gardens in the residential neighborhoods of the Capehart Brook watershed in 2012. Rain barrels were only given to residents upon request and after a brief training of proper use and maintenance was given to interested residents by PJC volunteers. As a result, an estimated 0.83 acres of IC was disconnected from Capehart Brook. The rain barrels and rain gardens remove an estimated 0.21 lbs. of phosphorus and 1.2 lbs. of nitrogen from the water flowing to Capehart Brook.

Willow Stake Plantings – In the spring of 2014, willow wattles, willow stakes, and dogwood stakes were planted along Capehart Brook just downstream of the Finson Road crossing. The City of Bangor purchased the wattles and stakes from Norpine Landscaping in Kingfield, ME. Willows and dogwoods are fast-growing species that can quickly and effectively stabilize and revegetate stream banks.

Willow and dogwood stake plantings at the Finson Road crossing. Photo credit: City of Bangor.

Capehart Brook Stream Clean-Up – On April 26, 2014, the City organized a stream clean-up for six urban impaired streams, including Capehart Brook, utilizing 350 volunteers from the Church of Jesus Christ of Latter Day Saints. A significant amount of debris was removed from Capehart Brook between the Finson Road crossing and the outlet to the Kenduskeag Stream.

Conservation Efforts in the Capehart Brook Watershed - Acquisition of land for conservation in the watershed has resulted in the long-term preservation of undeveloped forestland in the watershed. The City of Bangor owns a 28-acre parcel off Ohio Street, also known as Brown Woods (Appendix A, Map 5).

NPDES MS4 Stormwater Program – To meet permit regulations under the Municipal Separate Storm Sewer System (MS4) program, the City of Bangor conducts Best Management Practices (BMPs) and Standard Operating Procedures (SOPs) to better regulate stormwater quality within the City, including the Capehart Brook watershed. These ongoing efforts include revised construction ordinances, City vehicle spill kits and reporting protocols, road salt/sand storage, street sweeping, and catch basin cleaning.

Bangor Area Storm Water Group – The Bangor Area Storm Water Group (BASWG) is an active group comprised of individuals from the City of Bangor, City of Brewer, Town of Hampden, Town of Milford, City of Old Town, Town of Orono, Town of Veazie, the University of Maine at Orono, University of Maine at Augusta, Eastern Maine Community College, the Dorothea Dix Psychiatric Center, and the Maine Air National Guard. The purpose of this group is help municipalities comply with the education, outreach, and public involvement requirements that are part of the six Minimum Control Measures mandated by the NPDES Stormwater Program for MS4 communities. The BASWG uses a variety of techniques to promote better stormwater management and awareness, such as hosting public events, staff trainings, workshops, and stream clean-ups. Refer to their website for more information on current activities (www.baswg.org).

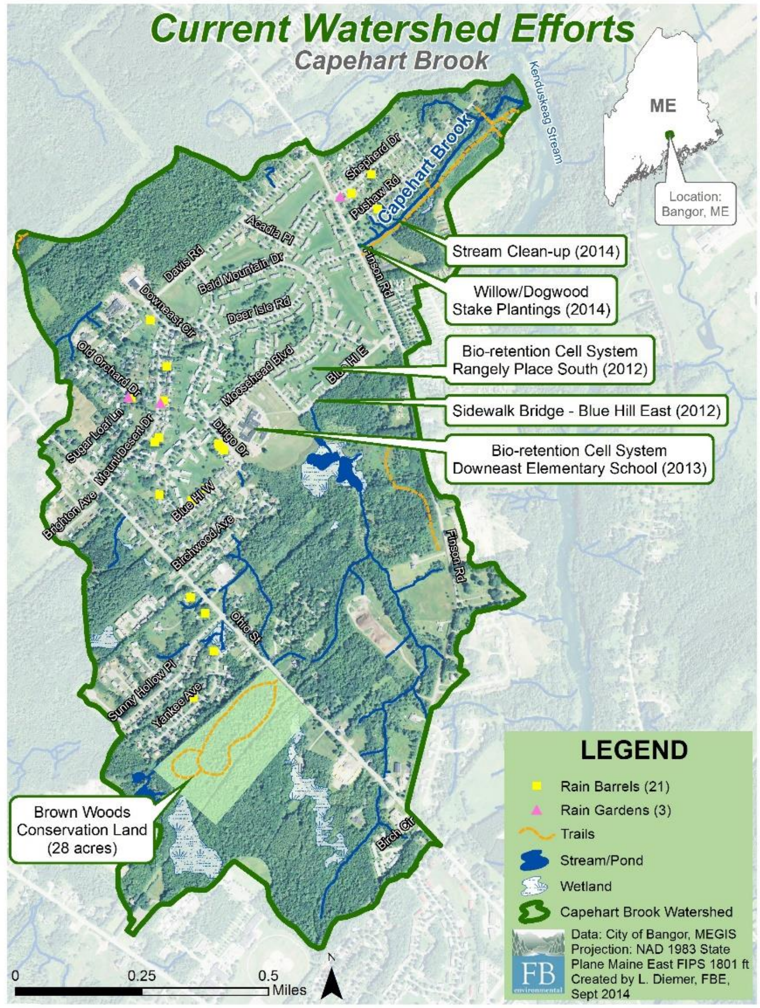


Figure 2. *Aerial map highlighting current efforts in the Capehart Brook watershed. Appendix A, Map 2.*

City of Bangor Stormwater Utility – In 2012, the City of Bangor established a stormwater utility, which generates funds through pro-rated fees from citizens. These funds can be used on various stormwater-related projects throughout the City, including the Capehart Brook watershed. The Stormwater Citizen Review Panel is comprised of a variety of stakeholders who review proposed uses of the stormwater utility fee funds.

Capehart Brook Restoration Project Phase II – The City of Bangor was recently awarded a 319 grant for $150,000 (with $125,000 in non-federal match) to continue restoration activities within the Capehart Brook watershed. The funds support the repair of the failing Sunny Hollow Place detention pond, installation of 155 catch basin inserts, and placement of four compact biofilter systems. This project will span two years beginning May 1, 2015. These retrofits will help remove suspended sediment from the stormwater that flows to Capehart Brook.

Oil Loading Decrease along Ohio Street – In October 2014, an underground drainage system/cesspool was discovered by City staff on a property within the Capehart Brook watershed. This system carried illicit connections from the various buildings to the City's Municipal Separate Storm Sewer System (MS4). The property managers, City Staff, the Maine DEP, and Clean Harbors worked in cooperation to fully disconnect the illicit discharge and prevent oils, greases, sink discharge, and parts washer discharge from reaching Capehart Brook. FBE staff noted oily and milky sheens on the surface water of Capehart Brook during the 2014 Stream Corridor Survey in August; removal of this

Cesspool removal. Photo credit: City of Bangor.

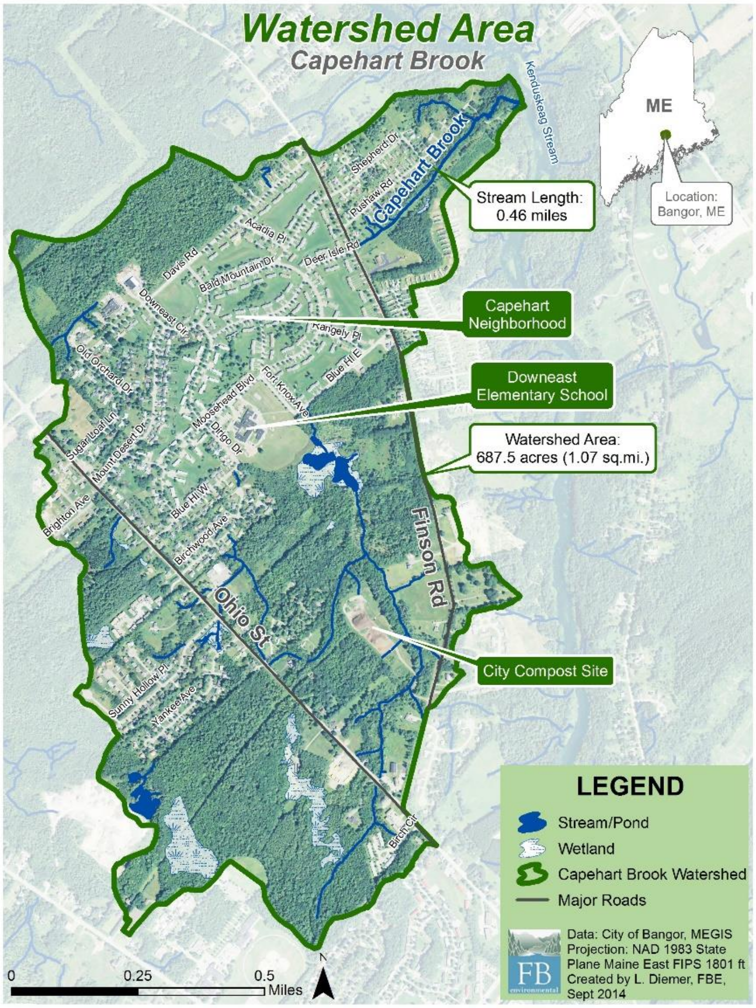
illicit discharge may help to alleviate these observed contaminations.

Other Efforts in the City - The City of Bangor has also installed stormwater placards at catch basins throughout the watershed to raise local awareness of the connection between what goes in storm drains and what ends up in nearby streams. A Stormwater Pollution Prevention Fact Sheet was also sent out to over 400 households in 2012 (City of Bangor 2013).

2. Watershed Characterization

A watershed is a geographic area in which all water drains to a given stream, river, lake, wetland, or coastal water. Large watersheds, such as the Kenduskeag Stream or Penobscot River watersheds, are comprised of many smaller or subwatersheds. Capehart Brook is a subwatershed of Kenduskeag Stream because all of the water that flows overland to Capehart Brook eventually makes its way to the Kenduskeag Stream.

The Capehart Brook watershed covers approximately 688 acres and is located entirely within the City of Bangor, Maine just west of the Kenduskeag Stream. Capehart Brook originates under Finson Road through a 66" culvert and flows 0.46 miles before emptying into the Kenduskeag Stream. The stream is fed by a series of underground pipelines and open drainage ditches from the City stormwater system. This stream was dredged by the Army Corps of Engineers in the 1950's, but has since become a "naturalized" stream that flows parallel to residential homes on Pushaw Road to the northwest and a utility access road to the southeast.



Aerial map of the Capehart Brook watershed area. Appendix A, Map 1.

2.1 Location & Climate

The City of Bangor is centrally located in the State of Maine, nestled in the Maine highlands about 30 miles from the coastal outlet of the Penobscot River. As Maine's third largest city and once the lumber capital of the world, the City of Bangor offers a variety of activities to those living in and visiting the area. The City is a cultural and entertainment center to the region and home to over 33,000 residents.

Over the last three decades (1981-2010), climate in the Bangor region has seen normal annual temperatures of 66.3 °F in summer, 20.8 °F in winter, and 44.3 °F overall, as well as a mean annual precipitation of 41.93 inches (NCDC 2014). Mean monthly air temperature and precipitation data have remained relatively consistent from 1953-2014 (Figure 3).

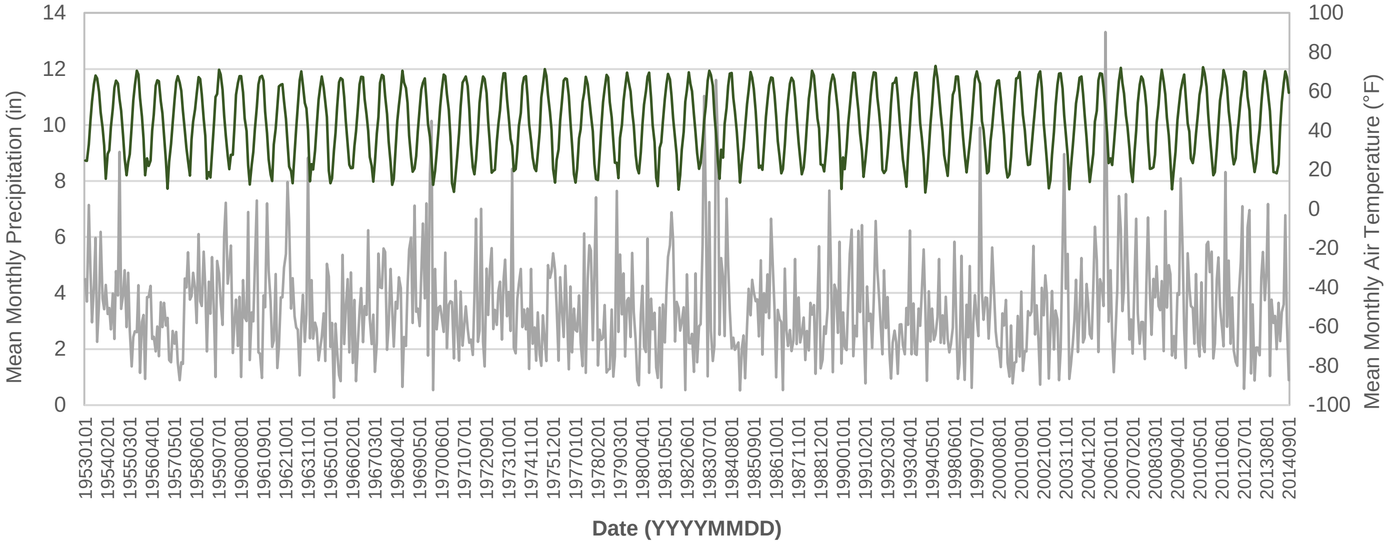


Figure 3. *Mean monthly air temperature (dark green) and precipitation (gray) from 1953 to 2014. Data were obtained from the NOAA National Climatic Data Center (NCDC) from the Bangor International Airport station (GHCND:USW00014606).*

2.2 Population, Growth Trends, and Land Use

Understanding population growth, demographics, and watershed development patterns provides critical insight to watershed management, particularly as it pertains to water quality.

2.2.1 Population and Growth Trends

The population of the City of Bangor has fluctuated over the past century, ranging from 24,803 in 1910 to its peak population of 38,912 in 1960 (Figure 4). The population decreased by 17% between 1960 and 1970 before stabilizing around 32,000 from 1970 to 2010. More recent population estimates for the City of Bangor show a 5% increase in the total population from 2000 to 2010 (Maine Office of Policy and Management 2010). Overall population growth since 1910 (past 100 years) shows increasing population.

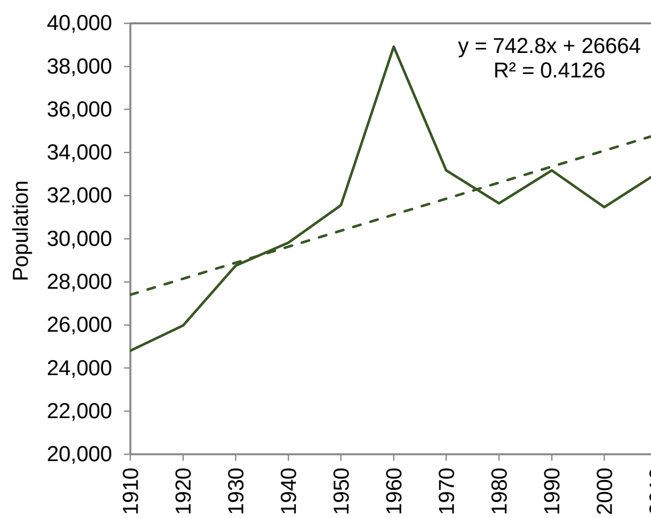


Figure 4. *Population and growth trends for Bangor, Maine. Note scale on y axis.*

Demographics within the City of Bangor show that the majority of the population is between the ages of 20-64 years old, and the number of people less than 20 years old exceeds the number of retirement age people (65+). The largest age group is 20-30 years old and comprises nearly 20% of the total population (Table 1, US Census American Fact Finder 2010).

Table 1. *2010 population demographics for Bangor, Maine.*

CITY	TOTAL POPULATION	POPULATION AGED 0-19	POPULATION AGED 20-64	POPULATION AGED 65+
BANGOR, MAINE	33,039	7,409	20,876	4,754

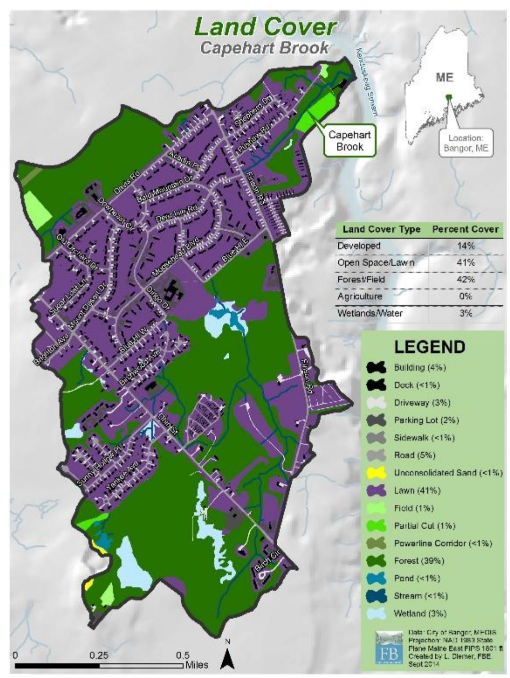
In more recent decades, slower growth has been documented in the State of Maine compared to the national average. Despite this trend, the State of Maine has seen greater growth in the State's metropolitan or urban areas compared to rural areas. Bangor and other large urban service centers (Portland, Lewiston/Auburn, Augusta, Rockland, Sanford, Ellsworth, and Farmington) account for 87% of total population growth in Maine between 2000 and 2010 (Muskie School of Public Service 2012).

"Low-impact development (LID) is an approach to land development that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainages that treat stormwater as a resource rather than a waste product." – USEPA (http://water.epa.gov/polwaste/green/)

Growth figures and estimates suggest that the City of Bangor should consider the effects of current land-use regulations on local water resources. As the region's watersheds are developed, erosion from disturbed and developed areas increases the potential for water quality decline. Therefore, it is imperative that watershed communities incorporate **low-impact development (LID) techniques** into new development projects to minimize the effects of developed areas, allowing water to soak into the ground rather than flow into the storm drain system and Capehart Brook.

2.2.2 Land Cover

Characterizing land cover within a watershed can highlight potential sources of nonpoint source (NPS) pollution that would otherwise go unnoticed in a field survey of the watershed. For instance, a watershed with large areas of developed land and minimal forestland will likely be more at risk from NPS pollution than a watershed with well-managed development and large tracts of undisturbed forest, particularly along headwater streams.



Land cover in the Capehart Brook watershed. Refer to Appendix A, Map 3.

Comparing land cover within a watershed over time can also highlight significant changes. Over the past 100 years, the Capehart Brook watershed has experienced significant changes in land cover, largely as a result of new development. Land cover is an essential element in watershed modeling because it can help estimate the contribution of nutrients, sediment, and other pollutants from the watershed to the stream via stormwater runoff. Unmanaged forested land, for example, tends to deliver very little phosphorus downstream when it rains, while high density urban land exports significantly more phosphorus from fertilizers, soil erosion, car exhaust, pet and human waste, failing municipal sewers, and many other sources. Excess nutrients, sediments, and other pollutants can stimulate algal blooms and embed critical habitat, both of which can alter the physical and chemical habitat within the stream.

As part of the watershed planning process, digital land cover data was updated by FB Environmental. A new data file was created that integrated IC (e.g. buildings, driveways, sidewalks, paved surfaces, decks, patios, parking lots, etc.) delineated by the City of Bangor, and water resources (e.g. wetlands, ponds, streams, etc.) provided by the Maine Office of GIS (MEGIS) online database (www.maine.gov/megis). The remaining land cover (e.g. fields, forests, lawns, partial cuts, powerlines, sandpits, etc.) was carefully reviewed by cross-referencing the National Agriculture Imagery Program (NAIP) 2013 imagery from the MEGIS online database and Google Maps 2014 imagery. This land cover update provided more accurate representation of the distribution of land cover categories throughout the watershed, particularly when compared to the MELCD raster data file based on 5-30 m resolution, SPOT 5 panchromatic imagery from 2004 (MEGIS online database).

Developed, impervious land (including buildings, driveways, sidewalks, roads, decks, patios, and parking lots) accounts for approximately 15% (99 acres) of the watershed, open space lawn accounts for approximately 41% (283 acres) of the watershed, and forested areas of primarily mixed hardwood/softwood species comprise 42% (284 acres) of the watershed (this includes partial cuts, powerline corridors, and fields; Figure 5). Wetlands and open water (e.g. streams and ponds) account for 3% (21 acres) of the watershed area. There is no active agriculture in the watershed.

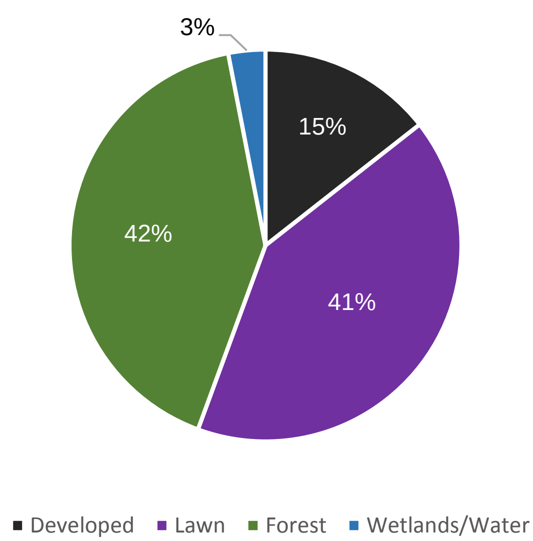


Figure 5. *Land cover in the Capehart Brook watershed. Numbers represent approximate acres for each land cover category.*

The extent of impervious cover in the Capehart Brook watershed is considered the primary cause of water quality impairment in the stream. Developed, impervious land replaces naturally vegetated areas and results in overland flow during rain and snow events. The stormwater picks up a variety of pollutants, and deposits them into the nearest ditch, catchbasin, stream or wetland. A more detailed discussion of the impact of IC on water quality is discussed in Section 3.

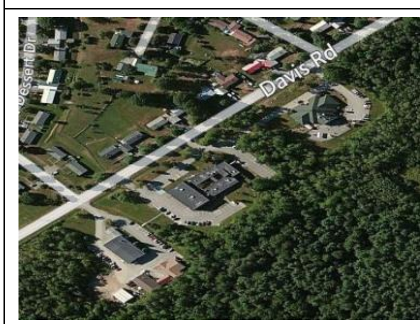
There are several commercial and residential developments within the Capehart Brook watershed, including a large residential development west of Finson Road and east of Ohio Street, the Downeast Elementary School along Moosehead Boulevard, the residential areas surrounding Shepherd Drive, Pushaw Road, Sunny Hollow Place, and Yankee Avenue, Bangor Housing Authority maintenance facilities located on the north side of Davis Road, two mobile home parks, and the City Compost Site.

Capehart Neighborhood: The Capehart neighborhood is a prominent feature in the watershed covering approximately 145 acres of land area that drains directly to Capehart Brook via the storm drain system. This area has been targeted for BMP implementation for both Phase I and II restoration efforts. Phase I included installation of bioretention cells at the Downeast Elementary School and Rangely Place South.

Downeast Elementary School: Within the Capehart neighborhood system and covering approximately 10 acres of land off Moosehead Boulevard, Downeast Elementary School has a considerable amount of IC that directs stormwater to the storm drain system. A bioretention cell was installed in the lawn area adjacent to one of the open ditches to help slow down flow and filter pollutants before reaching Capehart Brook.

Shepherd Drive and Pushaw Road Neighborhood: This neighborhood borders the northern side of Capehart Brook before its convergence with Kenduskeag Stream. Portions of the neighborhood within the Capehart Brook watershed consist of 72 housing lots, most of which are connected to City sewer. The City's stormwater infrastructure also drains IC throughout these neighborhoods directly to Capehart Brook.

Cedar Falls Mobile Home Park: The northwest portion of the Cedar Falls Trailer Park is located within the Capehart Brook Watershed. Currently 54 mobile home lots are located within the watershed boundary. This park has a private collection system that is connected to the City sanitary sewer system.



BHA Development on Davis Road: Bangor Housing Authority (BHA) owns development along the north side of Davis Road that covers approximately 6 acres within the watershed, and includes IC such as rooftops and parking lots that drain to the storm system and ultimately into Capehart Brook. These building include maintenance facilities and administrative offices for BHA.

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<td>**Sunny Hollow Place and Yankee Avenue:** Located on the outer edge of the Capehart Brook watershed, these neighborhoods are also serviced by Bangor’s storm drain and sewer network, and include 90 lots covering an area of approximately 40 acres. This detention pond was identified as failing and prioritized for retrofit as part of Phase II implementation work by the City of Bangor.</td>
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<td>**Colonial Pines Mobile Home Park:** Located within a forested area in the southwest portion of the watershed off Ohio Street, Colonial Pines Mobile Home Park has a private collection system that is connected to the City sanitary sewer system. This park covers approximately 8 acres of the watershed. According to Beginning with Habitat data from the Maine Department of Inland Fisheries & Wildlife, this park has a public drinking well on site.</td>
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<td>**Municipal Composting Facility**: The City of Bangor Leaf Compost Site is located on Finson Road approximately 1,300 ft from its intersection with Ohio Street. This 17-acre site consists of 2.99 acres of IC. The facility is set up to process about 7,000 cubic yards of Type 1A Solid Waste consisting of leaf and yard waste, such as lawn/grass clippings. The site is adjacent to several small tributaries that flow to Capehart Brook. Stormwater controls are in place at the site, including two gravel compost pads underlain by GeoTech Fabric, a level lip spreader, two DHP culverts, a sediment trap, outlet, stone check dams, bark filter berming, and riprap outlet protection. The natural vegetated buffer also captures additional runoff and sediment from sheet flow excess. The City of Bangor has a Compost Operation & Maintenance Plan for PERMIT # S-022380-CB-A-E.</td>
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There are approximately 32.9 acres of roadway within the Capehart Brook watershed. The watershed has three primary roads: Finson Road, Davis Road, and Ohio Street. These primary roadways and their arterial streets are largely City-owned and maintained and provide the network for the City’s sewer and stormwater infrastructure.

2.3 Physical Features

2.3.1 Topography

Capehart Brook is situated in the Penobscot River basin in the Maine highlands about 30 linear stream miles from Penobscot Bay and the Atlantic Ocean. The lowest point within the watershed (64 feet above sea level) is located at its convergence with Kenduskeag Stream. The highest point within the watershed (230 feet above sea level) is located to the southwest in the forested areas of the watershed. Refer to Appendix A, Map 4.

2.3.2 Land Conservation

Land conservation can provide significant benefits for the long-term protection of the water quality in Capehart Brook. Critical wildlife habitat and other environmentally sensitive land, and water resources, including riparian corridors, are just a few examples of areas targeted for conservation. In addition, land conservation provides low-impact, public recreational opportunities, such as hiking, to experience these natural resources.

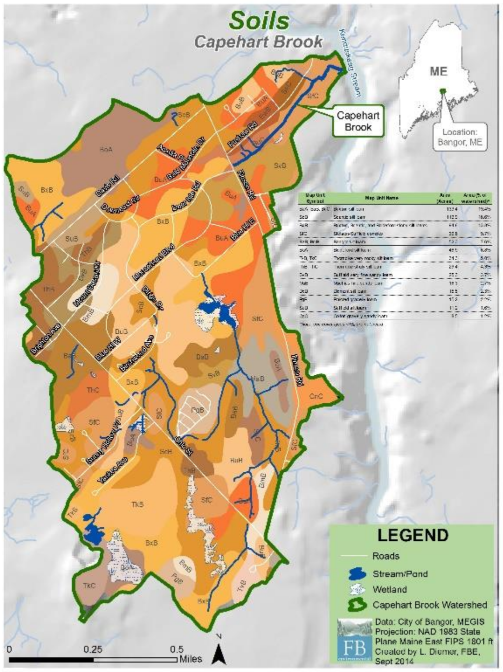
Brown Woods is the only parcel of conserved land located within the Capehart Brook watershed. This parcel covers approximately 28 acres in the forested area south of Ohio Street and just west of Yankee Avenue (Appendix A, Map 5). Owned by the City of Bangor and maintained by the Bangor Parks & Recreation Department, this preserve offers walking trails and a picnic area to Bangor residents. There may be additional opportunities for conserving undeveloped land in the watershed. The City will coordinate with the Bangor Land Trust to secure potential parcels for conservation in the future.

2.3.3 Soils and Geology

The composition of soils surrounding Capehart Brook reflects the dynamic geological processes that have shaped the landscape over millions of years. About 30,000 years ago, the region was covered by a slow-moving continental glacier that scraped over mountains and valleys, whittling the landscape to the form we recognize today.

As the glacier began to recede, the sea flooded coastal river basins, including the Penobscot River Valley in which the Capehart Brook watershed is situated. Immense deposits of sediment (glacial till and finer glacio-marine silts and clays) washed out of the melting ice sheet. Sand and gravel accumulated in meltwater streams within the glacier and deposited as ridges, also known as eskers.

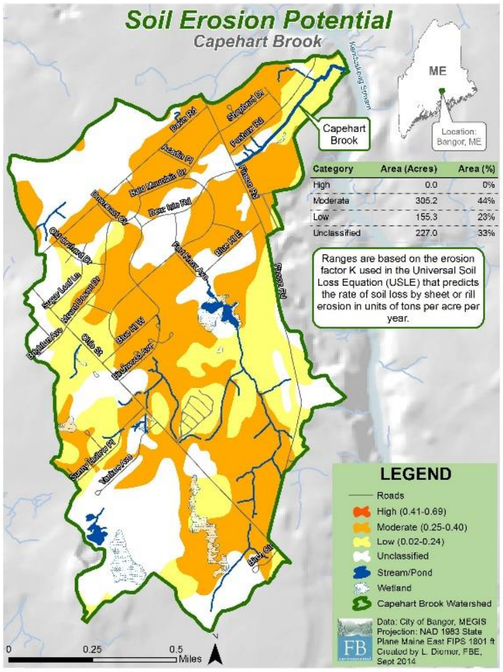
The local surficial geology along Capehart Brook is primarily eskers. Eskers are composed of gravel and sand, and may include glacial till deposits. The Capehart Brook watershed is comprised of glacial till and fine-grained, glacio-moraine deposits (Appendix A, Map 6).



Soil types in the Capehart Brook watershed are diverse and numerous. Appendix A, Map 7.

The Capehart Brook watershed is characterized by multiple soil series. Over 125 acres of the watershed is underlain by the Buxton soil series, which consists of very deep, moderately well-drained soils formed in glacio-marine deposits on coastal lowlands and river valleys. Buxton silt loam has a firm clay subsoil, high water-holding capacity, and slow permeability. Approximately 114 acres of the watershed is characterized by Scantic soil series. This soil series was also formed in glacio-marine deposits found in coastal lowlands and river valleys. Scantic soil is very deep and poorly-drained. It most commonly appears as a silt loam on a 1 percent slope with a clay subsoil, moderate water-holding capacity, and very slow permeability. Buxton Scantic and Biddeford stony silt loam soils comprise about 95 acres in the Capehart Brook watershed. These soils are moderately-well to very poorly-drained with a silty surface and a silt clay subsoil. The poorly-drained Scantic soil is dominant in this series. Water-holding capacity is high and permeability is very slow. The Stetson-Suffield Complex accounts for about 65 acres in the Capehart Brook watershed. This soil is characterized by mixed soil areas of well-drained sediments covering gravel and silts, which are underlain by clay. These soils are too complex to separate and have moderately-variable moisture-holding capacities and moderately-variable permeability.

Soils that characterize smaller portions of the watershed include the Bangor silt loam (~52 acres), Biddeford silt loam (~37 acres), Thorndike very rocky silt loam (~34 acres), Thorndike shaly silt loam (~29 acres), and Suffield very fine sandy loam (~25 acres). Bangor silt loam is characterized by deep, well-drained glacial till located in upland areas and have good water-holding capacity and moderate permeability. Biddeford silt loam is a very poorly-drained soil formed in very deep deposits of silt and clay. This soil has a very high water table and slow permeability. Thorndike very rocky silt loam is shallow, well-drained glacial till. This soil has moderate to low water-holding capacity and moderate permeability with 0 to 20 inches to shale bedrock with outcroppings common. Thorndike shaly silt loam is a moderately-deep, well-drained glacial till with moderate permeability. Bedrock occurs less than 20 inches from the surface. Suffield very fine sandy loam is characterized by deep, well-drained fine sandy loam over silt clay. This soil has high water-holding capacity and slow permeability (Penobscot County SWCD).



Most of the soils in the Capehart Brook watershed are categorized as having moderate soil erosion potential. Appendix A, Map 8.

<u>Other soils within the Capehart Brook watershed (accounting for <3% watershed area):</u>

Machias fine sandy loam (~18 acres)
Dixmont silt loam (~16 acres)
Plaisted gravelly loam (~15 acres)
Suffield silt loam (~11 acres)
Colton gravelly sandy loam (~9 acres)

Soil erosion potential is dependent on a combination of factors, including land contours, climate conditions, soil texture, soil composition, permeability, and soil structure (O'Geen et al. 2006). Soil erosion potential should be a primary factor in determining the rate and placement of development within a watershed. Soils with negligible soil erosion potential are primarily low-lying wetland areas near abutting streams.

The soil erosion potential for the Capehart Brook watershed was determined from the associated erosion factor K used in the Universal Soil Loss Equation (USLE) that predicts rate of soil loss by sheet or rill erosion in units of tons per acre per year. This information was obtained from the U.S. Department of Agriculture National Resources Conservation Service's online Web Soil Survey for Penobscot County (http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). The scores are rated from low to high, depending on the soil texture, structure, and organic matter content. Lower K values (and thus low soil erosion potential) are typically associated with clay-dominated soils. Sandy and silt loam soils range from low to moderate soil erosion potential, and silt-dominated soils typically exhibit a high soil erosion potential. High organic matter content can also help stabilize soils and reduce the erosion potential. Given that the erosion factor K is based on natural conditions, caution should be used when interpreting these ratings since they may be higher in areas that were disturbed by human activities (e.g. additions or depletions of organic matter, exposed or compacted surface materials from construction or development, etc.). Based on areas with a calculated K value, there are no high soil erosion potential areas located within the Capehart Brook watershed. However, moderate soil erosion potential is prevalent, accounting for 305 acres (44%) of land within the Capehart Brook watershed. Low soil erosion potential is less common in the watershed, comprising 155 acres (23%) of the watershed, and is concentrated in three major areas: the outlet of Capehart Brook, the eastern edge of the watershed, and the western area of the watershed along Ohio Street north of Birchwood Avenue.

Areas of moderate soil erosion potential should be monitored closely for erosion during and after any development projects to ensure that eroding soil is not degrading downstream water quality.

2.3.4 Wetlands, Streams, and Riparian Habitat

Wetlands provide many values to the local community, including *flood protection* by trapping and slowly releasing rainwater; *shoreline protection* along lakes, rivers, and streams by stabilizing soil through plant roots and absorbing the energy of waves; *groundwater recharge* by maintaining baseline conditions; *water quality* by acting as natural filters to remove, retain, or transform pollutants and sediments from nonpoint sources; and *habitat* by providing a niche for species to breed, nest, and raise their young, and acting as wildlife corridors (USEPA 2013). In addition, wetlands provide scenic beauty, recreational activities, and educational opportunities for the local community. Wetlands and riparian habitat in the Capehart Brook watershed are home to communities of fish, birds, mammals, and plants that depend on clean water to survive and flourish.

The Capehart Brook watershed drains 687.5 acres of land, and is host to 19.6 acres (2.9%) of National Wetland Inventory (NWI) mapped wetlands. There are 2.9 acres (0.4%) of open water, 3.5 miles of major open drainages or stormwater ditches, and 0.46 miles of naturalized stream. An assessment of riparian habitat within 75 feet of Capehart Brook indicates that there are approximately 5.8 acres (62%) of intact riparian buffer habitat present. The remaining 3.6 acres (38%) has a limited buffer with partial clearings leading either to the utility access road to the south (1,522 linear ft) or the residential development along Pushaw Road to the north (542 linear ft). In addition, the U.S. Fish & Wildlife Service (USFWS) identified 9.6 acres of high value habitat within the Capehart Brook watershed, primarily located east of Finson Road and south of Pushaw Road. This high value habitat contains either rare, threatened, or endangered species or unique natural habitats. Refer to Appendix A, Map 9.

2.3.5 Stormwater and Sewer Infrastructure

The Capehart Brook watershed is considered a single catchment area where all water collected in the City's stormwater infrastructure is carried through a series of ditches (7.9 miles), underground pipes (5.9 miles), and catch basins (237) that empty the stormwater to Capehart Brook through a large culvert crossing at Finson Road. There are eight additional stormwater outfalls or discharges located east of the Finson Road culvert, and four outfalls or discharges located west of the Finson Road culvert. Stormwater outfalls are locations in which stormwater is delivered directly to the stream via a ditch or pipe. There are 12 documented stormwater outfalls in the Capehart Brook watershed. A list of outfalls with descriptions is provided in Appendix E.

The stormwater system is largely concentrated within the residential development between Finson Road and Ohio Street. The majority of stormwater runoff from parking areas, roads, private residences, and commercial areas in the watershed flows directly to the stream with minimal pre-treatment of pollutants or means to slow water flow during large storm events. As described previously, recent efforts in the watershed have attempted to treat a portion of this stormwater in a series of bio-retention cells at Rangeley Place South and the Downeast Elementary School. While the large expanse of grassy lawns provides some pre-treatment filtration of stormwater runoff, the shallow root structure of the grass makes it ineffective during large storm events.

The Capehart Brook watershed hosts a large network of stormwater and sewer lines for the Capehart Neighborhood. Appendix A, Map 10.

<u>Capehart Brook Watershed Sewer System</u>

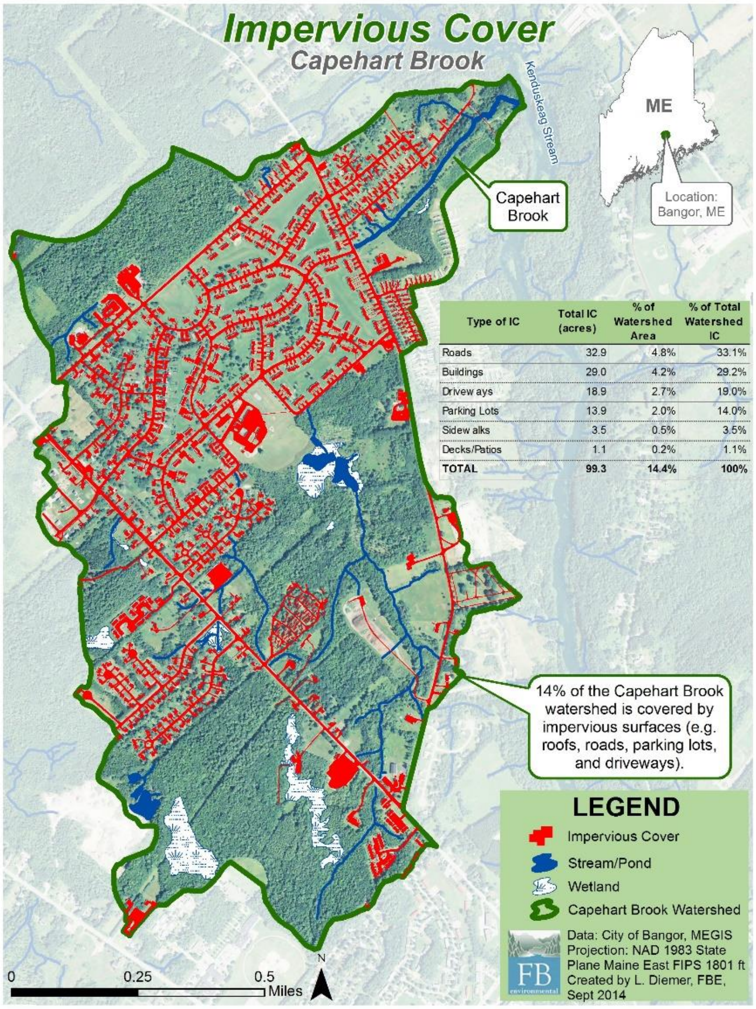
The majority of the Capehart Brook watershed, particularly in the residential complex between Finson Road and Ohio Street, is serviced by City sewer as a means of human waste disposal. There are currently 162 manholes and 6.95 miles of sanitary pipes in the watershed. An old sewer treatment facility, known as the Dow Air Force Base Wastewater Treatment Plant, was built in the 1950's at the downstream terminus of Capehart Brook, specifically for collecting waste from the military housing. Only primary treatment (settling) was done to the waste before it was dumped directly into the Kenduskeag Stream. In an effort to clean up the Kenduskeag, the City reconnected the facility's sewer to the rest of the City by 1973. The treatment plant was sold in 1980, and many of the structures still remain.

Capehart Brook Watershed Septic Systems

While the majority of buildings within the Capehart Brook watershed are connected to the City sanitary sewer system, a portion of lots are not, and rely on private septic systems for their waste collection and disposal. These lots are concentrated in the southern end of the watershed along Ohio Street. It may be beneficial to conduct a septic system survey of the watershed and identify systems that may not be maintained properly or need to be replaced.

3. Causes of Impairment

Urban watersheds have a disproportionate amount of IC from paved roads, sidewalks, parking lots, driveways, and rooftops that prevent rain from percolating into the soil. These hard surfaces force rainwater to flow overland where it can collect a variety of pollutants, such as metals, winter sand and salt, pesticides, petroleum products, animal and human waste, fertilizers, and sediment. These pollutants are delivered to nearby waterbodies, bringing with them excess limiting nutrients, such as nitrogen and phosphorus, which can stimulate potentially harmful algal blooms. Boom and bust populations of algae can rapidly deplete oxygen in the water and potentially release more phosphorous bound to benthic sediments. Additionally, heavy precipitation events in urban watersheds can result in large water surges to receiving streams, which may be unable to accommodate the excess water. This can scour out streambeds and undercut banks, sending eroded sediment downstream to deposit as sand plumes and embed critical benthic habitat for aquatic macroinvertebrate communities. These disturbances to stream habitat and geomorphic structure pose a significant threat to the health and function of streams (Allan and Castillo 2007).



Type of IC	Total IC (acres)	% of Watershed Area	% of Total Watershed IC
Roads	32.9	4.8%	33.1%
Buildings	29.0	4.2%	29.2%
Drivew ays	18.9	2.7%	19.0%
Parking Lots	13.9	2.0%	14.0%
Sidew alks	3.5	0.5%	3.5%
Decks/Patios	1.1	0.2%	1.1%
TOTAL	**99.3**	**14.4%**	**100%**

Figure 6. *Impervious cover in the Capehart Brook watershed. Appendix A, Map 11.*

Capehart Brook was listed in 2006 as impaired for aquatic life use and was most recently listed in the *2012 Integrated Water Quality Monitoring and Assessment Report* (Section 303(d) list), as well as the Maine DEP's Stormwater Management Law, Chapter 502 list of Urban Impaired Streams (Maine DEP 2012b). As required by federal and state regulations under the Clean Water Act, the stream was included in the 2012 *Impervious Cover Total Maximum Daily Load (IC TMDL) Report* (Maine DEP 2012b). Capehart Brook was found to be impaired for aquatic life use as a result of stream habitat assessments showing macroinvertebrates not meeting Class B water quality criteria. Percent IC was used as a surrogate measure for the unspecified pollutants in stormwater likely contributing to the stream's degraded status.

3.1 Impacts of Development: Impervious Cover Assessment

Increases in the extent of impervious cover (IC) pose significant risks to streams (CWP 2003). Research shows that watersheds with IC greater than 12% often exceed criteria for aquatic life use (Stanfield and Kilgour 2006), and even lower levels of IC (4-6%) can significantly inhibit the abundance and diversity of fish and macroinvertebrate species (Wenger et al. 2008). Maine DEP currently establishes a target of 8% IC to meet aquatic life use criteria in Class B waters (Maine DEP 2012b). Approximately 14% (99 acres) of the Capehart Brook watershed is covered by IC (Figure 6). This estimate is based on updated digital land cover files of roads, driveways, buildings, decks/patios, parking lots, and sidewalks provided by the City of Bangor.

Roads and buildings (e.g. rooftops) make up a significant portion of the total watershed IC (62%; Table 2). This is followed closely by driveways (19%) and parking lots (14%). Decks and sidewalks serve as only a minor portion of the total watershed IC (3.6%). Based on the Maine DEP's target goal of 8% IC, a 44% IC reduction (equivalent to 44 acres) is needed to offset the effects that IC has on Capehart Brook.

Table 2. *Types and percent coverages of impervious cover (IC) in the Capehart Brook watershed.*

TYPE OF IC	TOTAL IC (ACRES)	% OF WATERSHED AREA	% OF TOTAL WATERSHED IC
ROADS	32.9	4.8%	33.1%
BUILDINGS	29.0	4.2%	29.2%
DRIVEWAYS	18.9	2.7%	19.0%
PARKING LOTS	13.9	2.0%	14.0%
SIDEWALKS	3.5	0.5%	3.5%
DECKS/PATIOS	1.1	0.2%	1.1%
TOTAL	**99.3**	**14.4%**	**100%**

Efforts to reduce in-stream impacts from IC should focus on areas within the watershed that exhibit the highest levels of IC with a direct connection to the stream. For Capehart Brook, the high-density residential area with a ditch network that drains directly to Capehart Brook should be the highest priority for treating stormwater.

3.2 Applicable Water Quality Standards and Criteria

Capehart Brook is designated as a Class B freshwater stream. According to Maine's Water Classification Program under the Maine Legislature (Title 38 MRSA 464-468), "Class B waters shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, Section 403; and navigation; and as habitat for fish and other aquatic life." A summary of the narrative and numeric water quality standards for Class B freshwaters is provided in Table 3.

Table 3. *Maine water quality criteria for Class B waters (38 MRSA § 465).*

PARAMETER	CRITERIA FOR COMPLIANCE
DISSOLVED OXYGEN (YEAR-ROUND)	May not be less than 7 ppm or 75% saturation, whichever is higher.
DISSOLVED OXYGEN (OCTOBER 1ST-MAY 15TH)	In order to ensure spawning and egg incubation of indigenous fish species, the 7-day mean dissolved oxygen concentration may not be less than 9.5 ppm and the 1-day minimum dissolved oxygen concentration may not be less than 8 ppm in identified fish spawning areas.
DISCHARGES	Must not cause adverse impact to aquatic life, and the receiving waters must be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.

3.3 Water Quality and Biological Assessments

Water quality data have been collected in the Capehart Brook watershed since 1997 by the Maine DEP, AmeriCorps, James W. Sewall Company, and the City of Bangor for multiple water quality parameters and physical site characterizations (Table 4). Refer to Appendix A, Map 15 for sample site locations and descriptions and Appendix B for raw water quality data.

Table 4. *List of available water quality monitoring data for Capehart Brook by year collected and agency the data was collected by.*

YEAR COLLECTED	AGENCY COLLECTED BY	PUBLISHED DATA SOURCE	DATA COLLECTED
1997	Maine DEP	Biomonitoring Program	Macroinvertebrates, physical description, temperature, conductivity
2001	Maine DEP	Biomonitoring Program	Macroinvertebrates, physical description, dissolved oxygen, temperature, conductivity
2010	AmeriCorps	Bangor Streams Survey Report	Stream habitat & geomorphic survey
2011	Maine DEP	Water Quality Summary	Temperature, dissolved oxygen, conductivity, chloride
2009-2011	James W. Sewall, City of Bangor	Summary Water Quality Data Report for Five Impaired Streams	Flow, dissolved oxygen, conductivity, temperature, pH, chloride
2012	James W. Sewall, City of Bangor	Bangor Interim Report, raw data	Dissolved oxygen, conductivity, temperature, color, pH, benthic macroinvertebrates
2013	City of Bangor/Lotic	Raw data	Dissolved oxygen, conductivity, temperature, pH, macroinvertebrates
2014	FBE	Memo to City of Bangor	Macroinvertebrates

The following provides a description of water quality results for Capehart Brook. Analyses of these data will provide a baseline of comparison for future changes in the stream's water quality and provide the information necessary to assess the health and function of the stream.

3.3.1 Biological Assessment

Macroinvertebrates are aquatic insects, including mayflies, dragonfly larvae, caddisfly larvae, aquatic worms, amphipods, leeches, clams, and snails, that live on stream bottom substrates, such as rocks, logs, sediment, and plants. They serve as excellent indicators of water quality, depending on the amount and type of species present and their associated pollutant tolerances. EPT is an index of three orders of aquatic insects: Ephemeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies). These taxa are generally intolerant of pollutants and are found in less impacted, **oligotrophic** streams. Chironomidae (midges) are more tolerant of pollutants and are found in greater abundances in **eutrophic** streams.

> ***Oligotrophic*** *– waterbodies exhibiting low productivity as a result of low nutrient and organic matter input.*
>
> ***Eutrophic*** *– waterbodies exhibiting high productivity as a result of high nutrient and organic matter input. These surface waters are prone to harmful algal blooms.*

Protocol for sampling and analysis of macroinvertebrate surveys include deploying rock bags on the stream bottom for approximately four weeks, which allows macroinvertebrates enough time to colonize the rocks (Maine DEP 2011a). Bags are collected along with physical data (water velocity, dissolved oxygen, temperature, conductivity, description of substrate and site). The macroinvertebrate communities within the rock bags are separated and identified by lowest taxonomic group (genus or species). This generates data on the abundance and generic richness of the macroinvertebrate community present within the stream.

A macroinvertebrate survey was conducted in 1997 and 2001 by the Maine DEP Biomonitoring Program. A summary of results are provided in Table 5. According to the Watershed Science Institute's Watershed Condition Series, Technical Note 3 on the EPT Index, ***Capehart Brook would be classified as having a "poor" water***

Definitions

Total Mean Abundance: a count of all individuals in all replicate samples from a single site divided by the number of replicates.

Generic Richness: a count of the number of different genera found in all replicates from one site.

Relative Chironomidae Abundance: a count of all individuals from the order Chironomidae in all replicate samples from a single site divided by the number of replicates, and then divided again by the total mean abundance.

EPT Generic Richness: a count of the number of different genera from the order Ephemeroptera (E), Plecoptera (P), and Trichoptera (T) in all replicate samples.

Definitions extracted directly from Appendix C-1: Methods for the Calculation of Indices and Measures of Community Structure Used in the Linear Discriminant Models from *Methods for Biological Sampling and Analysis of Maine's Rivers and Streams* (ME DEP LW0387-B2002).

quality rating since EPT generic richness values were less than 6 (WSI 2012). Additionally, 25-50% of the total mean species abundance were classified as Chironomidae, which is a taxonomic order ***associated with degraded water quality.*** Total mean abundance and generic richness for all species were generally lower than required for assessment purposes (total mean abundance > 50, generic richness > 15) by the Maine DEP. This was reflected in the final determination of “indeterminate” in 2001 when not enough organisms were collected to meet the minimum requirements for the model. The initial survey in 1997 found Capehart Brook to be not attaining for aquatic life use standards for Class B freshwater streams based on professional judgment by the Maine DEP.

Biomonitoring by the Maine DEP is conducted on a five-year rotation schedule. Capehart Brook was resampled by the City of Bangor and the Maine DEP in 2013 and the stream did not attain Class B status due to an insufficient population of mayflies. Macroinvertebrate sampling completed by Lotic, Inc. in 2013 showed that Capehart Brook may meet Class B or C standards. According to the Maine DEP Biomonitoring Protocols, the macroinvertebrate communities must meet water quality standards for two consecutive sampling events within a 10-year period for the stream to be considered attaining for aquatic life. The City of Bangor conducted follow-up biomonitoring in 2014, but results are not yet available. The City plans to continue a biomonitoring program at Capehart Brook at two locations along the stream.

Table 5. *Summary of biomonitoring surveys at Capehart Brook by the Maine DEP.*

SAMPLE DATE	TOTAL ABUNDANCE	GENERIC RICHNESS	RELATIVE CHIRONOMIDAE ABUNDANCE	EPT GENERIC RICHNESS	GENERA PRESENT	FINAL DETERMINATION
9/10/1997	18	12	0.22	4	Caddisfly, dragonfly, damselfly, fishfly, cranefly, midges, snails	Not Attaining
8/17/2001	30	14	0.50	1	Beetle, Dobsonfly, Cranefly, midges, mayfly, planaria, snails	Indeterminate
9/30/2013	U	U	U	U	U	Not Attaining

U = unavailable

3.3.2 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the concentration of oxygen dissolved in the water that is available for aquatic organisms and macrophytes. DO facilitates critical chemical reactions within the channel and benthic sediments that support life processes and functions. Depletion of available oxygen (known as hypoxia or anoxia) inhibits physiological functioning of aquatic life and its persistence can reduce the diversity and abundance of biota. DO fluctuates naturally on a diurnal basis depending on a suite of interactions and resource availability (e.g. light, nutrients, organic matter, temperature, etc.). DO is often highest during the day when sunlight drives photosynthesis (produces oxygen), while DO is often lowest at night when autotrophic respiration and decomposition of organic matter dominates (consumes oxygen). The State of Maine and EPA set numeric criteria for DO at 7 ppm from May 15 to September 30. From October 1 to May 14, daily mean DO must be greater than 8 mg/L and the 7-day mean must be at least 9.5 mg/L.

DO was collected monthly using a YSI 85 multi-meter probe by the James W. Sewall Company and the City of Bangor from 2009 to 2013 (Table 6). DO readings conducted during the Maine DEP macroinvertebrate surveys in 2001 and 2013 were also included (Appendix B). These instantaneous DO readings ranged from 7.2 to 15.4 mg/L and 75 to 109% saturation with means of 10.7 mg/L and 93% saturation, respectively. These data show acceptable ranges for DO (mg/L and percent saturation) with the lowest DO occurring in summer. In the early spring and fall sampling months, Capehart Brook tended to be supersaturated with oxygen when respiration processes were slower and water temperatures cooler.

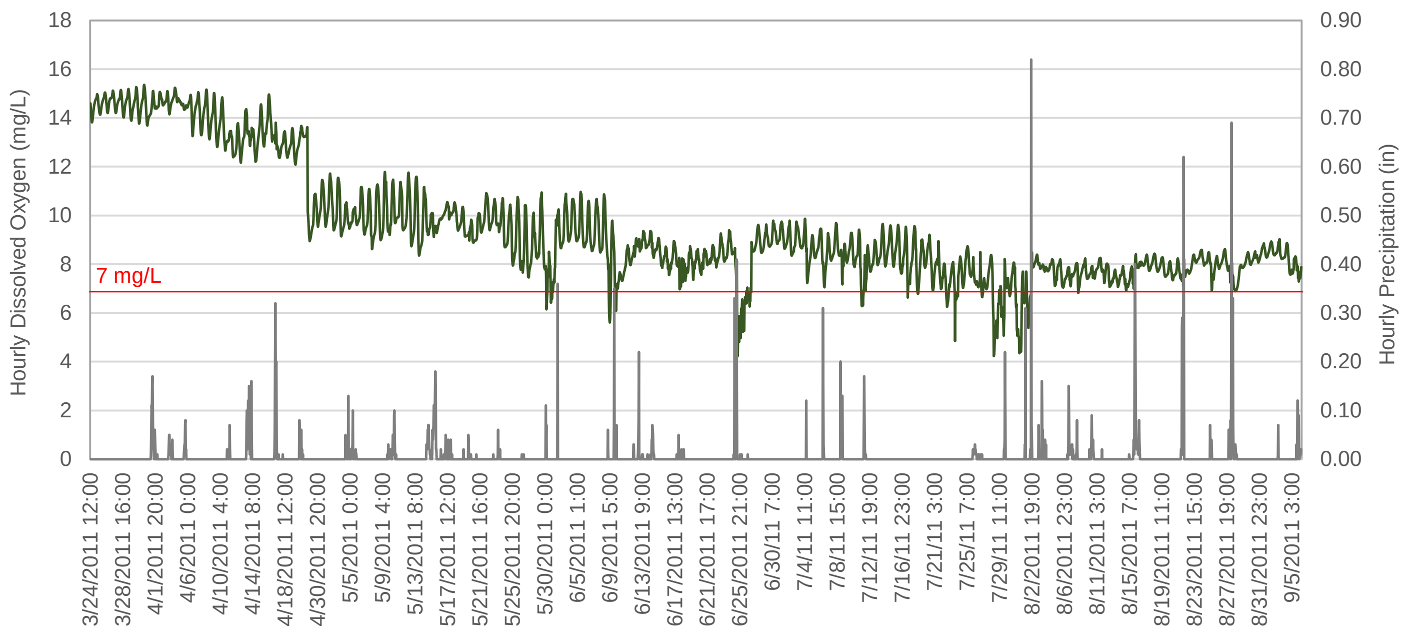


Figure 7. *Hourly dissolved oxygen concentration (dark green) for Capehart Brook from March to September 2011. Data were collected as part of the Bangor Stream Monitoring Project with assistance from the Maine DEP. Daily precipitation (gray) values were obtained from the NOAA National Climatic Data Center (NCDC) from the Bangor International Airport station (GHCND:USW00014606). Red line indicates a dissolved oxygen threshold of 7 mg/L, below which is considered hypoxic and detrimental to aquatic life.*

Continuous water quality logging by the Maine DEP in summer 2011 showed DO concentrations ranging from 7-10 mg/L in June with a few days approaching 4 mg/L (Figure 7). These low DO events occurred in conjunction with 0.5-1" summer rain events. Since rain events often increase water turbulence and the exchange of oxygen between water and the atmosphere, the Maine DEP suggested that these rain events may have flushed low DO water from a wetland upstream near Ohio Street. DO concentrations in July were at or below 7 mg/L with many days in late July having DO around 4-5 mg/L. These low DO events did not consistently correspond to significant rainfall. DO concentrations in August held above 7 mg/L with only one low DO reading on August 2. The final conclusion by the Maine DEP was that Capehart Brook is impaired by low DO likely due to anthropogenic nutrient loading that causes large diurnal fluctuations in DO (> 2 mg/L; Maine DEP 2011b). An alternative explanation for low DO may be that the failing detention pond at Sunny Hollow adjacent to Ohio Street is flushing low DO water to downstream portions of Capehart Brook.

Table 6. *Summary of dissolved oxygen (mg/L and percent saturation) instantaneous readings using a YSI 85 multi-meter probe from 2001-2013 at Capehart Brook. Refer to Appendix B for the full data set.*

	DO (MG/L)			DO (% SATURATION)		
DATE RANGE	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*
2001-2013	10.7	7.2	15.4	93	75	109

3.3.3 Chloride / Specific Conductivity

Specific conductivity is used as a surrogate measure for chloride concentrations, but conductivity includes all elements within a parcel of water that have an ionic charge, whether positive (Ca^{2+}, Na^{+}, K^{+}, Mg^{2+}) or negative (Cl^{-}, NO_3^{-}, SO_4^{2-}). Many of these ions are weathering products and reflect differences in parent geology. Chloride is of primary interest to management because it represents a large anthropogenic source of pollutants from excess road salt. The concentration of chloride is directly linked to population density and percent IC and is thus linked to urban watersheds, where greater runoff from developed areas impacted by road salt application leads to high inputs of chloride (Daley et al. 2009). High chloride concentrations in streams and groundwater can be toxic to aquatic life and human health by disrupting extracellular function and osmotic activity.

The Maine DEP sets a standard of a mean 1-hour (acute) exposure of 860 mg/L for chloride and a mean 4-day (chronic) exposure of 230 mg/L for chloride (DEP 06-096 Chapter 584). Any chloride results greater than these standards are considered toxic to aquatic life. This standard does not directly apply to specific conductivity since it represents other elements in addition to chloride, but a relationship for converting specific conductivity to chloride can be easily done.

Data from discrete sampling by the Maine DEP, James W. Sewall Company, and the City of Bangor is provided in Table 7. Conductivity ranged from 90-545 µS/cm with a mean of 255 µS/cm. Chloride ranged from 50-150 mg/L with a mean of 83 mg/L. These are well within the numeric criteria for chloride established by the State. These data showed a poor relationship between specific conductivity and chloride, which Sewall suggests may have been due to the field kit method for measuring chloride and interferences of other charged elements in the water sample.

Continuous water quality logging by the Maine DEP in summer 2011 showed specific conductivity ranged from 200-400 µS/cm with maximum conductivity reaching 525 µS/cm on April 3rd, 2011 (Figure 8). Higher conductivity was observed in March and April during rain events when runoff from roads containing salt and sand were flushed to streams. Rain events later in the summer resulted in dilution. The final conclusion by the Maine DEP was that conductivity levels stayed below chronic levels and are likely not inhibiting aquatic life.

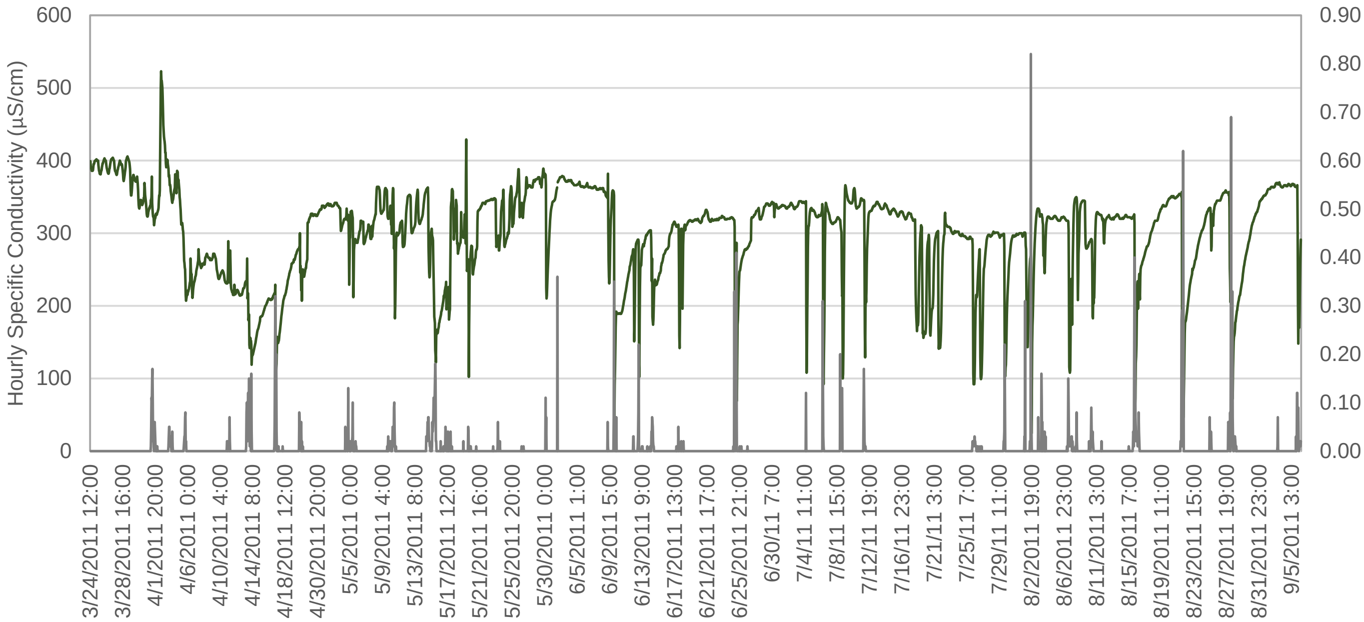


Figure 8. *Hourly specific conductivity (dark green) for Capehart Brook from March to September 2011. Data were collected as part of the Bangor Stream Monitoring Project with assistance from the Maine DEP. Daily precipitation (gray) values were obtained from the NOAA National Climatic Data Center (NCDC) from the Bangor International Airport station (GHCND:USW00014606).*

Table 7. *Specific conductivity (µS/cm) readings using a YSI 85 multi-meter probe and chloride (mg/L) measurements using a field kit from 1997-2013 at Capehart Brook. Refer to Appendix B for full data set.*

	SPECIFIC CONDUCTIVITY (*µS/cm*)			**CHLORIDE (*mg/L*)**		
DATE RANGE	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*
1997-2013	255	90	545	83	50	150

3.3.4 Water Temperature

Stream water temperature plays an important role in regulating chemical reactions (e.g. dissolvability of elements) within the water and can be adversely impacted by urban development. IC heat up quickly when exposed to direct sunlight. Stormwater runoff over these hot IC delivers unnaturally warm water to streams, also known as thermal pollution. High volumes of warm water from overland flow or groundwater mixes with cooler stream water, leading to increases in stream water temperature (UNHSC 2011). Stream temperature is also regulated by the amount of shading by riparian vegetation along stream banks. More open canopies allow sunlight to reach surface waters, which can heat up quickly during the day. Many fish species thrive under optimal water temperatures, which trigger reproductive functions and regulate growth of juvenile fish.

Maximum weekly and instantaneous temperature means of 19 °C (66.2 °F) and 24 °C (75.2 °F) were found to be the limit for juvenile brook trout survival (Brungs and Jones 1977). Capehart Brook, among many northern New England streams, should be able to support coldwater fish and other species.

Single reading temperature data collected by the James W. Sewall Company, the City of Bangor, and the Maine DEP from 1997-2013 is provided in Table 8. Temperature ranged from 0.9 °C (33.6 °F) to 19.7 °C (67.5 °F) with a mean of 10.4 °C (50.7 °F). These are well within acceptable and predictable limits of streams supporting coldwater fish species.

Continuous water quality logging by the Maine DEP in summer 2011 showed mean temperatures ranging from 16-18 °C (60.8-64.4 °F) in late summer (July and August) (Figure 9). Only one day reached 25 °C (77 °F) for a few hours during peak daylight hours. The conclusion by the Maine DEP was that temperature was not adversely affecting aquatic life in Capehart Brook.

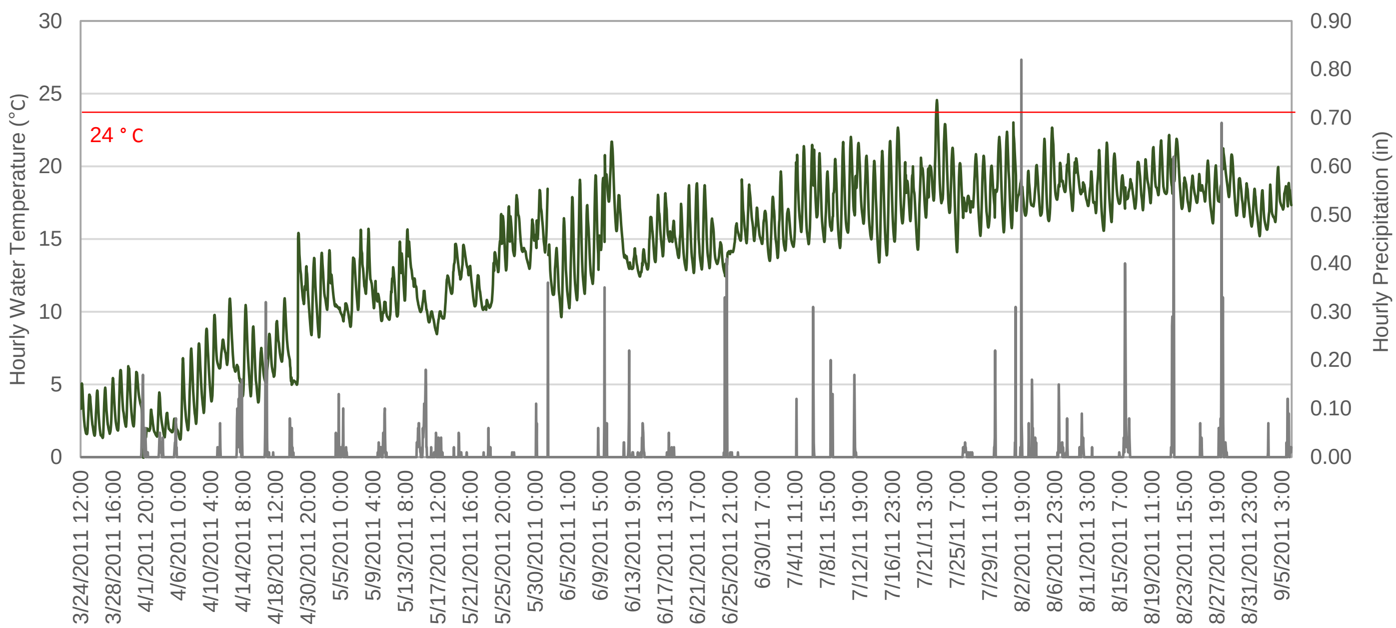


Figure 9. *Hourly water temperature (dark green) for Capehart Brook from March to September 2011. Data were collected as part of the Bangor Stream Monitoring Project with assistance from the Maine DEP. Daily precipitation (gray) values were obtained from the NOAA National Climatic Data Center (NCDC) from the Bangor International Airport station (GHCND:USW00014606). Red line indicates an instantaneous water temperature threshold of 24 °C, above which is considered detrimental to aquatic life.*

Table 8. *Temperature (°C) readings using a YSI 85 multi-meter probe from 1997-2013 at Capehart Brook. Refer to Appendix B for full data set.*

	TEMPERATURE (°C/°F)		
DATE RANGE	*Average*	*Minimum*	*Maximum*
1997-2013	10.4 / 50.7	0.9 / 33.6	19.7 / 67.5

3.3.5 pH

pH is a measure of the concentration of hydrogen ions in water on a logarithmic scale of 0 (acid) to 14 (basic). pH is determined by bedrock, acid rain deposition, wastewater discharge, and natural carbon dioxide fluctuations. pH regulates the solubility and biological availability of elements, including primary nutrients (phosphorus and nitrogen) and heavy metals. Low pH can release toxic metals and interfere with primary life functions. pH fluctuates naturally on a daily basis due to photosynthesis that consumes hydrogen ions for reaction processes. pH tends to be higher (more basic) during the day and be lower (more acidic) at night. These same daily patterns can be applied at the seasonal scale when photosynthesis becomes more prominent during the growing season. These fluctuations are typically very minor since there are buffering agents within the water (depending on contributing geology) that help protect against large swings in pH. Most aquatic organisms thrive under a pH environment of 6.5 to 8.5. Any values below or above this range can reduce the reproductive capacity of fish populations.

pH measurements collected by James W Sewall Company and the City of Bangor from 2009-2013 showed pH ranging from 7.0 to 8.3 with a mean of 7.8 (Table 9). These readings are within acceptable limits for aquatic life.

Table 9. *pH readings from 2009-2013 at Capehart Brook. Refer to Appendix B for full data set.*

	PH		
DATE RANGE	*Average*	*Minimum*	*Maximum*
2009-2013	7.8	7.0	8.3

3.3.6 Color

Color is the influence of suspended and dissolved particles in the water as measured by Standard Platinum Units (SPU). A higher color value indicates greater contribution of suspended particles that can make the water appear stained or dark. Sources of suspended and dissolved particles include organic (algae, decaying vegetation, tannins, lignins, etc) or inorganic (iron and manganese) forms and may depend on the dominant land use activities and contributing parent geology within the watershed. For instance, natural wetlands can be a significant source of organic matter that make the water appear brown from tannins, while anthropogenic disturbances can release eroded organic matter to streams and contribute to higher apparent color. Color values greater than 25 significantly reduce water clarity and the ability of sunlight to penetrate to the stream bottom, which can limit stream productivity.

Limited data are available for color since only two samples were collected in 2012 by the City of Bangor. These two readings were 10 and 30 SPU (Table 10). Because of this large range, it is difficult to make any conclusions about the condition of water clarity. The high color sample (30 SPU) taken in April 2012 may represent the spring freshet with high amounts of organic matter loading from the watershed. The lower color sample (10 SPU) taken in June 2012 is “clearer” and well below 25 SPU. This sample likely represents dry, summer conditions for Capehart Brook. From the minimal data collected and the assumptions made, color at Capehart Brook seems fairly typical for northern New England streams.

Table 10. *Color (SPU) measurements in 2012 at Capehart Brook.*

DATE	COLOR (SPU)
4/18/2012	30
6/12/2012	10

3.3.7 Discharge

Discharge is a measure of stream flow, typically in units of cubic feet per second (cfs), and is a function of stream width, stream depth, and water velocity. Although no numeric criteria exists for this parameter, discharge is an important component of stream health, and should be incorporated in any stream monitoring design. Streams in urban environments with high coverage of IC are most at risk for flashy responses to storm events. High volumes of water run off IC and empty into receiving streams. To accommodate these influxes of water, most streams often experience expansion of stream bank width at the high water line, scouring of stream beds, and erosion of sediment. Eroded sediment along stream banks are deposited downstream in sand plumes where bottom substrates often become embedded with silts and sands. These large-scale disturbances can reduce habitat diversity for aquatic communities and alter habitat structure and function.

There are a number of ways to measure discharge with varying levels of accuracy. For Capehart Brook, the James W. Sewall Company deployed a data logger (Global Logger™) to measure water depth (or stage height) continuously every 15 minutes from 2009-2011. Four flow measurements at varying discharges (low to high) were conducted in the field using a current meter. From this, a flow rating curve was developed between direct flow measurements and corresponding stage height. The regression equation was applied to the continuous stage height data, and the subsequent mean daily flow results are presented in Figure 10. Flows ranged from 0.7 to 8.6 cfs with a mean of 2.0 cfs. Capehart Brook experienced lowest flows in summer when precipitation was low. Flow tends to increase rapidly in response to rainfall and recede quickly, indicating that Capehart Brook experiences sudden surges in water level immediately following storm events and recedes quickly in a similar manner. This high disturbance environment may not be conducive for most biological communities and tends to scour out banks and deposit sediment downstream where the stream cannot accommodate the enhanced flow volume.

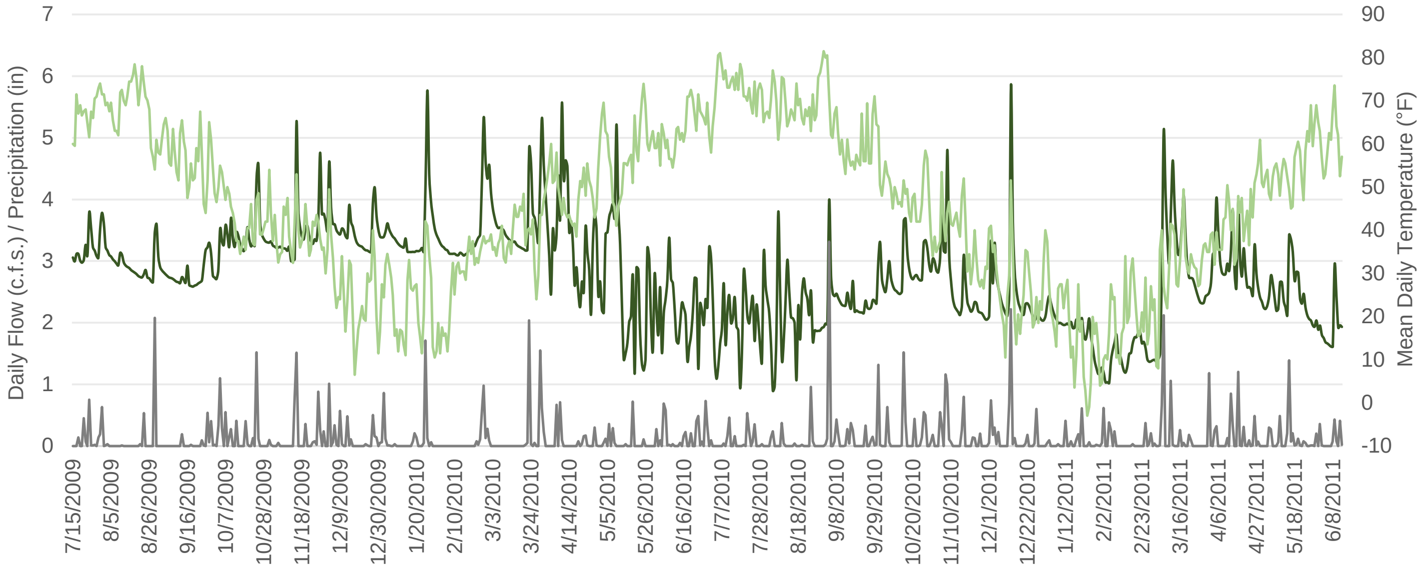


Figure 10. *Daily average flow (dark green) for Capehart Brook from July 2009 to June 2011. Data were collected as part of the Bangor Stream Monitoring Project with assistance from the James W. Sewall Company. Daily precipitation (gray) and temperature (light green) values were obtained from the NOAA National Climatic Data Center (NCDC) from the Bangor International Airport station (GHCND:USW00014606).*

3.4 Geomorphic, Riparian, and In-Stream Habitat Assessments

On August 28, 2014, a Level 1 Stream Corridor Survey was conducted by FBE staff and the City of Bangor for Capehart Brook based on methods described in the Maine DEP Stream Survey Manual (Maine DEP, 2009). The survey consists of two major types of evaluation: 1) a Rapid Habitat Assessment (RHA), and 2) a Rapid Geomorphic Assessment (RGA). The RHA relies primarily on visual observation of stream habitat characteristics, wildlife present, and gross physical attributes of the stream, as well as a simple in-stream macroinvertebrate evaluation. The primary use of the RHA is to identify high-quality coldwater habitat and any severe habitat or water quality problems. The reconnaissance-level RGA is focused on determining the impact that urbanization has on channel morphology. This type of survey is useful for identifying reaches receiving large volumes of stormwater that can cause channel instability, and identify reaches with signs of alteration from human activities. Information gathered from the RGA can be used to target specific stream reaches needing further assessment and restoration planning. Results of both surveys can also be used to raise public awareness and to help prioritize management objectives for stream restoration.

3.4.1 Rapid Habitat Assessment (RHA)

Capehart Brook was divided into six stream reaches (Reaches A1-A6). Reach lengths were based mainly on changes in physical characteristics of the stream, but in some cases were influenced by man-made structures such as road crossings and culverts. Survey results characterize the overall health of Capehart Brook as fair to poor (Figure 11).

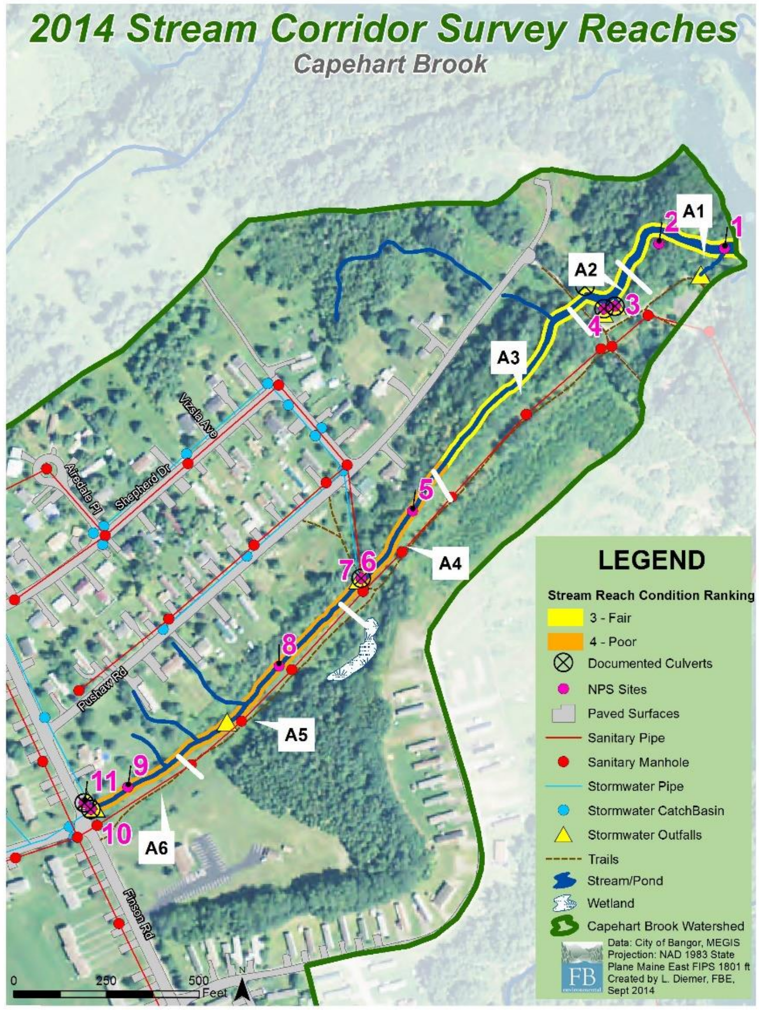


Figure 11. *Survey reaches for the Level 1 Stream Corridor Survey conducted by FBE staff in 2014. Appendix A, Map 12.*

<u>*Habitat*</u>- Typically, communities of coldwater fish (e.g., salmonids such as brook trout and Atlantic salmon) and other aquatic organisms (e.g., aquatic insects and other macroinvertebrates) are more robust in streams and rivers having a diverse array of habitats, especially those containing riffles with gravel and/or cobble substrates, and pools formed by scouring action behind boulders and downed pieces of large wood (e.g., tree trunks, logs) or other stream processes (Allan and Castillo, 2007). Examination of the in-stream characteristics of Capehart Brook indicates the presence of several different habitats across the six stream reaches. The most prevalent habitats include shallow pools, riffles, and runs.

<u>*Nature of Particles in Stream Bottom and Embeddedness*</u>- Gravel and cobbles provide fairly stable anchoring/attachment sites for macroinvertebrates, algae, and aquatic plants. The non-embedded spaces found between gravel and cobbles provide well-oxygenated spawning (egg-laying) sites for salmonids and excellent habitat for macroinvertebrates to crawl through and cling to.

While all of the stream reaches contain a variety of substrate materials, some of the reaches in the upper portion of the stream (Reaches A4, A5, and A6) had more soft substrate (silt, sand, clay and mud) compared to the lower reaches (A1, A2, A3), which were dominated by hard substrates such as bedrock, rubble, cobble, and boulders. However, all of the reaches were found to have some degree of coarse gravel, rubble, or cobble at varying amounts.

Of particular concern is the extent of embeddedness in four of the six stream reaches (A3, A4, A5, and A6). Embeddedness refers to the extent to which rocks (gravel, cobble, and boulders) and snags are covered or sunken into the silt, sand, or mud on the stream bottom. Generally, as rocks become embedded, the surface area available to macroinvertebrates and fish (for shelter, spawning, and egg incubation) decreases. Embeddedness is a result of large-scale sediment movement and deposition. Overall, substrate in the stream reaches dominated by sand is continually moving, and therefore any salmonid habitat will be less resilient to withstanding high flow volumes, and may be virtually eliminated in these reaches.

Stream bottom conditions range from Good to Poor (Table A1, Appendix A). Reaches A1 and A2 represent Good stream bottom conditions, while A3, A4, and A6 score slightly lower with conditions characterized as Fair. Reach A5 stream bottom conditions rank as Poor due to a heavy accumulation of silt and sand (>75% embedded).

Woody Debris- Large pieces of wood in streams and small rivers help form pools and provide cover, which are important habitat needs of salmonids (Flebbe and Dolloff, 1995). Pools also trap leaves and twigs, which are an important food source for macroinvertebrates and for fish that eat the macroinvertebrates. Woody debris across the six stream reaches within Capehart Brook range from none (A6) to few (A1, A2, A3, A4, and A5).

The amount of large woody debris in rivers and streams in Maine may be significantly less than what existed prior to European settlement of North America (Magilligan et al. 2008). In addition, ongoing research in streams in the White Mountain National Forest region of New Hampshire and Maine suggests that additions of large woody debris to high-gradient, rocky-bottom streams has a positive impact on brook trout and macroinvertebrate communities.

Water Appearance/Odor- The water flowing in Capehart Brook during non-storm flow conditions is generally clear with a few notable exceptions. These include portions of reaches that were orange (Reach A6) due to iron oxidation, or had a milky surface sheen (Reach A5). A mild sewage odor was noted in one section in Reach A4, and a strong sewage odor was noted at the upstream end of Reach A6. No other unnatural odors were observed in the other reaches. It may be important to investigate potential cross-contaminations between the sewer and stormwater system upstream of the Finson Road crossing.

Streamside (Riparian) Vegetation and Water Temperature- Shading of streams is important to the health of coldwater fish species (e.g., brook trout and Atlantic salmon) and other aquatic organisms (e.g., aquatic insects and other macroinvertebrates) for a variety of reasons including the fact that cold water has the ability to retain more dissolved oxygen and create less physiological stress on aquatic organisms (Allan and Castillo 2007). A narrow stream like Capehart Brook (average wetted width ~ 7.5 feet) has a better chance of having good canopy cover compared to a larger stream or river. For Capehart Brook, three of the six stream reaches have good riparian cover (75% shaded; Reaches A1, A3, and A5). Two reaches exhibit 50% cover (Reaches A2 and A4), while the uppermost reach below Finson Rd. (Reach A6) has very little vegetative cover and is characterized as Poor. Areas with low percent cover are located near the highly developed residential areas and the Finson Road stream crossing. The City of Bangor has begun addressing this issue by planting willow stakes along the streambank in the spring of 2014.

Riparian cover is directly correlated with stream temperature. The greater the shading, the cooler the water temperature, and vice versa. Instantaneous temperatures collected within Capehart Brook range from 16.1 ˚C (Reach A6) to 20.4 ˚C (A4). Reaches A1 and A2 were 17 ˚C and 17.1 ˚C, respectively. Reach A5 and A3 had similar temperature readings at 19 ˚C and 19.3 ˚C, respectively. Reaches A1, A2, and A6 are below the reported maximum weekly average temperatures for growth, and short-term maximum temperatures for brook trout survival (juveniles) of 19 and 24 ˚C, respectively (Brungs and Jones, 1977). The temperature in Capehart Brook is Good, while riparian vegetation ranges from Good to Poor. Ironically, the lowest temperature was recorded below Finson Rd. at the Finson Rd. culvert crossing. It would be expected that the reach with the lowest amount of riparian cover, and one of the greatest threats from NPS pollution and the large extent of algae would result in higher temperatures compared to other reaches. However, several factors may relate to the lower temperatures: 1) water flows underground above this point, so any discharge under low flow conditions would be the result of flow from this underground source, and 2) this was the final monitoring point of the day which was collected close to 6 pm when air temperature is lower than earlier in the day. It is expected that a rain event on a sunny summer day would increase stream temperatures at this location dramatically as a result of the rainwater washing over warm roofs, driveways and roads.

Streambank and Channel Characteristics- Streambank and channel characteristics include bank shape (vertical or undercut, steeply sloping, gradual, or no slope), channel shape, and the extent of artificial bank modifications, such as rip-rap, retaining walls, etc. The nature of the soils and geology in the watershed, as well as within and adjacent to the stream, play a large role in the condition of the stream channel. Rocky streams lined with boulders and cobbles will tend to be more stable than a stream comprised of sand because sand is much lighter and can be picked up and moved downstream during high flow conditions.

Overall, Capehart Brook is a somewhat narrow (average wetted width of 7.5 ft.) and relatively shallow stream with the exception of one small pool greater than two feet deep. Three of the six reaches have at least one bank with steep, eroding slopes, and all reaches exhibit undercut banks at varying degrees of severity. Degradation of natural streamside plant cover and collapsed banks is common. Discharging pipes (including storm drain outfalls) and/or ditches are present in a majority of the reaches, carrying stormwater and attached sediment and pollutants, and causing erosion where the discharge meets the stream. Refer to Table 11 for more specifics.

Example of stream bank erosion (Reach A1).

Streambank and channel conditions within Capehart Brook range from Fair (A1, A2, A3, A4) to Poor (A5, A6). Undercut banks with steep slopes and bare soil, in addition to culverts/outfalls and road crossings has resulted in erosion and sedimentation in the stream. Protecting, restoring, and keeping riparian forests in good health and in a relatively undisturbed condition is vital for the long-term protection of Capehart Brook.

An obvious change in channel conditions occurs between Reaches 3 and 5, as the composition of the streambed changes from a rubble/bedrock/cobble dominated stream downstream, to a more gravel dominated stream upstream.

Visual Biological Survey- Benthic (stream bottom) communities act as continuous monitors of environmental quality over time, beyond individual water quality sampling events. The RHA utilized simple visual observations, including wildlife, fish, barriers, aquatic plants and algae, and presence and types of macroinvertebrates. The rock-rubbing method was used to collect macroinvertebrates.

Results of the visual survey indicate that green frogs (*Rana clamitans melanota*), a common frog species in Maine, are prevalent within the lower reaches of Capehart Brook. Small fish (1-2") were also documented in all of the six reaches, with slightly larger fish (3-4") documented in Reaches A2 and A6. Macroinvertebrates were found occasionally, but not in great abundance. Most notable were numerous small caddisfly larvae in Reaches A1 and A2. However, aquatic insects became less abundant upstream, and changed from a caddisfly-dominated stream to the more pollution-tolerant species, such as leaches, aquatic worms, and snails in the upstream reaches. This is largely due to the change in streambed composition (as described above), and an increase in stormwater inputs. A dead mole, squirrel, several frogs, and a baby bird were documented in the stream between Reaches A1 and A3. All of the animals appeared to be recently deceased, and the reason for the deaths are unknown. All the dead animals observed were intact, which does not suggest predation by wildlife or domestic cats.

A broken pipe in Reach A4 may be part of the old sewer system.

Water Quality and Potential Pollution Sources and Problems- Water quality and potential pollution sources are scored separately for each stream reach (Table 3, Appendix A). The most apparent problems stem from both known and unknown sources including eroding culverts, stormwater outfalls, ATV crossings, yard waste, trash, and undercut banks. Bank erosion is common, as well as trash and debris in most stream reaches. Despite a major volunteer trash clean-up in Capehart Brook in the spring of 2014, large quantities of trash were documented throughout the stream, indicating that more effort is needed to keep trash out of the stream (e.g. public education, installation of a trash guard(s) at outfalls, etc). The potential illicit discharge documented in Reach A4 has been addressed by the City. Water quality in Capehart Brook ranges from Fair (Reaches A1, A2, and A3) to Poor (Reaches A4, A5, and A6).

3.4.2 Rapid Geomorphic Assessment (RGA)

Geomorphic Condition of Capehart Brook:
"In Transition or Stressed"

Leaning trees, exposed roots, basal scour on the inside of meander bends, and steep bank angles are all indicators that the stream is widening, and were documented throughout the majority of Capehart Brook. The exception is Reach A6, where the major geomorphic process is aggradation. Indicators of aggradation include lateral bars, siltation in pools, mid-channel bars, poor lateral sorting of bed materials, and soft, unconsolidated bed. This is not entirely unexpected, as Reach A6 receives the largest volume of stormwater, which carries sediment from the developed areas in the watershed. While widening is the major geomorphic process in the downstream reaches, almost all of the reaches exhibited other geomorphic processes including degradation and planimetric form adjustment.

The upstream reaches have an "In Transition or Stressed" geomorphic position (A3, A4, A5, and A6). This illustrates that these reaches are in poor condition and experiencing adjustment outside the expected range of natural variability. An increase in stream volume and water velocity from stormwater outfalls are likely candidates for the current position. Reach A2 is the only reach that is considered "In Regime," meaning that the stream reach is in good condition and dynamic equilibrium, which involves localized changes to its shape or location while maintaining process and function within the range of natural variability. This is intricately tied to the greater percentage of bedrock in this reach compared with the other reaches. The bedrock provides a stable streambed and stream bank, protecting the stream from the forces of erosion. Reach A1 has an "In Adjustment" geomorphic position, meaning that the stream is in fair condition and has experienced changes in channel form and fluvial processes outside of the expected range of natural variability.

3.5 Non-Point Source Stormwater Assessment

During the August 28, 2014, Level 1 Stream Corridor Survey, FBE staff also assessed Capehart Brook for possible non-point source (NPS) issues and documented all culverts. Six culverts were identified along the reach, five of which were written up for NPS issues. Other NPS issues noted were severe bank erosion upstream from the confluence with the Kenduskeag Stream, seasonal bank instability from an ATV trail crossing, an unknown residential garden hose connection, and uncovered yard waste with cleared vegetation extending to the stream. Documented culverts and NPS sites are shown in Figure 11 and recommendations for NPS issues are provided in Table 11.

Table 11. *Non-point source (NPS) issues documented along Capehart Brook beginning at the confluence with the Kenduskeag Stream upstream to the Finson Road crossing.*

NPS #	SITE ID	PROBLEM	RECOMMENDATIONS	GPS LOCATION (UTM)	
				NORTHING	***EASTING***
1	NPS 1-01	Concentrated flow path of stormwater from trail and CH01 causing bare soil	Install turnout/runoff diverter on upper part of slope, plant/improve buffer to stabilize banks	515682.8	4964739.5
2	NPS 1-02	Severe streambank erosion/failure from down-cutting/incision at channel bend	Stabilize bank with cribbing	514999.8	4966162.5
3	NPS 2-02	CH03 – hanging pipe from old treatment plant along upper east bank	Armor drainage ditch with stone, identify source of outfall and remove	514964.0	4966111.0
4	NPS 2-03	Culvert at trail crossing off Pushaw Rd has severe streambank erosion and bank down-cutting/incision causing bare soil	Stabilize banks by installing a runoff diverter and improving buffer with plantings, pending landowner approval	514955.1	4966108.7
5	NPS 4-01	Possible corroded old sewer line along western bank of stream	Removed by the City	515640.3	4964703.2
6	NPS 4-02	ATV trail crossing with severe seasonal erosion problem	Construct an ATV bridge crossing and stabilize both banks, pending landowner approval	515633.3	4964694.0

NPS #	SITE ID	PROBLEM	RECOMMENDATIONS	GPS LOCATION (UTM)	
				NORTHING	***EASTING***
7	NPS 4-03	CH04 - culvert misaligned and depositing stormwater from Pushaw Rd in opposite direction of Capehart Brook flow	Treat with catchbasin inserts along Pushaw Rd	515633.3	4964694.0
8	NPS 5-01	Uncovered yard waste with cleared vegetation extending to stream; excessive build-up of sediment and milky sheen to surface water just downstream	Ask landowner to extend/improve buffer with plantings; compost yard waste	515622.2	4964681.9
9	NPS 6-01	Hose in stream with unknown connection to residential property	Check on source and remove	515601.6	4964665.2
10	NPS 6-02	CH05 – culvert outlet at Finson Rd crossing shows erosion from road due to lack of vegetation; observed heavy algae mats in stream and strong sewage odor	Stabilize banks with plantings or riprap armoring; investigate causes of odor and algae	515609.3	4964662.1
11	NPS 6-03	CH06/CH07 - concentrated flow path of stormwater from culvert	Armor ditch with stone or grass, improve buffer with plantings	514530.6	4965700.4

4. Restoration Strategies

The various studies conducted and reports completed for Capehart Brook, and feedback from three meetings with the Bangor Stormwater Citizen Review Panel and the City of Bangor staff in 2014 provided an excellent framework for identifying and understanding the sources of pollution and the problems that have resulted in poor water quality in Capehart Brook. This information has helped to develop locally-driven solutions and a prioritized list of actions that address the underlying causes of the stream's impairment. This section provides key actions needed to restore the stream, the timing of these actions, and the mechanisms by which these actions will be accomplished.

4.1 Goals and Objectives for Restoration

The purpose of the Capehart Brook Watershed-Based Management Plan is to provide recommendations that will restore habitat and improve water quality so that Capehart Brook meets Class B water quality standards for the State of Maine. This can only be achieved through the commitment of a coordinated group of local community leaders, conservation groups, city, state and federal partners, and watershed residents working together to accomplish common goals and objectives. The following recommendations are contingent on landowner cooperation since 69% and 13% of the watershed is owned by private individuals and the Bangor Housing Authority (BHA), respectively; the City owns less than 10% of the watershed (Appendix A, Map 14). General watershed restoration objectives are outlined in Table 12, and serve as the foundation for specific recommendations made in the Action Plan (Tables 13-14).

Table 12. *Capehart Brook watershed restoration objectives.*

GOALS	WATERSHED RESTORATION OBJECTIVES
IMPROVE WATER QUALITY	Manage sources and transport of urban stormwater pollutants and nutrients.
	Achieve applicable water quality standards to support diverse and healthy aquatic communities.
IMPROVE PHYSICAL HABITAT	Improve aquatic habitat extent and quality to support the return and persistence of diverse native fish and macroinvertebrate communities.
	Improve terrestrial habitat extent and quality to support the persistence of native terrestrial communities and connectivity to aquatic habitats.
IMPROVE HYDROLOGY	Increase runoff infiltration and detention areas to normalize stream hydrographs and reduce stormwater flow to the stream.
	Restore the extent, connectivity, and functions of streams, drainages, wetlands, riparian areas, and floodplains to improve bank stability and natural hydrologic function and reduce risk to the built environment and human safety.

Many of the recommendations to restore Capehart Brook are referred to as Best Management Practices (BMPs). BMPs are conservation practices that are designed to minimize the discharge of stormwater and associated pollutants to the stream from IC in the watershed. The EPA recommends that urban stormwater management plans include a combination of non-structural and structural BMPs for existing and new development to ensure long-term restoration success.

The 2011 Capehart Brook Watershed Management Plan provided over 60 recommendations that spanned a range from education, direct stream and riparian restoration, structural retrofits, and ordinance changes (SMRT 2011). Many of the suggestions were designed to address issues related to water quality of all surface water bodies in the City of Bangor. Some of these recommendations are included in the updated Plan with minor revisions, but several major recommendations have also been added.

4.2 Structural Management Opportunities and Recommendations

To achieve Class B standards in Capehart Brook, the *Statewide Impervious Cover Total Maximum Daily Load (IC TMDL) Report* set a target of 8% effective IC to help reduce current pollutant loads and flow volumes from the watershed (Maine DEP 2012b). Capehart Brook contains 99.3 acres (14.4%) of IC, with the largest and most connected IC in the residential development between Ohio Street and Finson Road; a 44% (~44 acres) reduction in effective IC is needed to achieve the State target of 8%. Using State 319 funds for the Capehart Brook Restoration Phase I Project, an estimated total of 2.17 acres of IC and 5.26 acres of lawn were disconnected from the stream through the installation of eight bioretention cells at Rangeley Place South, one bioretention cell at the Downeast Elementary School, and 21 rain barrels and 3 rain gardens scattered throughout the watershed[3].

Effective vs. Disconnected Impervious Cover
Effective IC is a developed area directly connected to a stormwater system that conveys water to nearby waterbodies. These areas can be "disconnected" with the implementation of Best Management Practices (BMPs) that slow and filter stormwater flow. For example, connecting a rain barrel or rain garden to a downspout can disconnect the contributing area of stormwater runoff from rooftops.

The majority of IC in the watershed has no existing stormwater treatment in place; therefore, large quantities of stormwater are discharged directly to Capehart Brook via one major outfall at the Finson Road crossing, and eight more outfalls or discharges along the downstream portion of the stream. Structural BMPs, or BMPs that are engineered to treat stormwater, will make up the majority of treatment options for the Capehart Brook watershed. Many of these structural BMP recommendations have already been designed and proposed by the City of Bangor as part of the Capehart Brook Restoration Phase II Project to be completed beginning May 2015 through May 2017. More detailed surveys of other proposed stormwater retrofit sites will be required, including some engineered designs, before these practices can be fully implemented.

An overall objective of structural stormwater retrofits is to reduce the effects of IC in the watershed by 44%.

[3] *The estimated IC disconnections for the Phase I BMP implementations were provided by the City using STEPL. Estimates of IC disconnections using the NHDES Simple Method vary slightly from these figures and are noted in Section 4.4.*

4.2.1 Structural Toolbox & Recommendations

As described in previous sections of this Plan, the 2011 Watershed Management Plan provided key structural recommendations that would achieve significant reductions in stormwater pollutants reaching Capehart Brook. The City has already begun implementation of these recommendations using 319 funding for Phase I (2012-2014) and now Phase II (2015-2017) work. Therefore, the recommendations in this Plan build on and improve current restoration objectives and actions. A description of recommended best management practices (BMPs) are described in Appendix C.

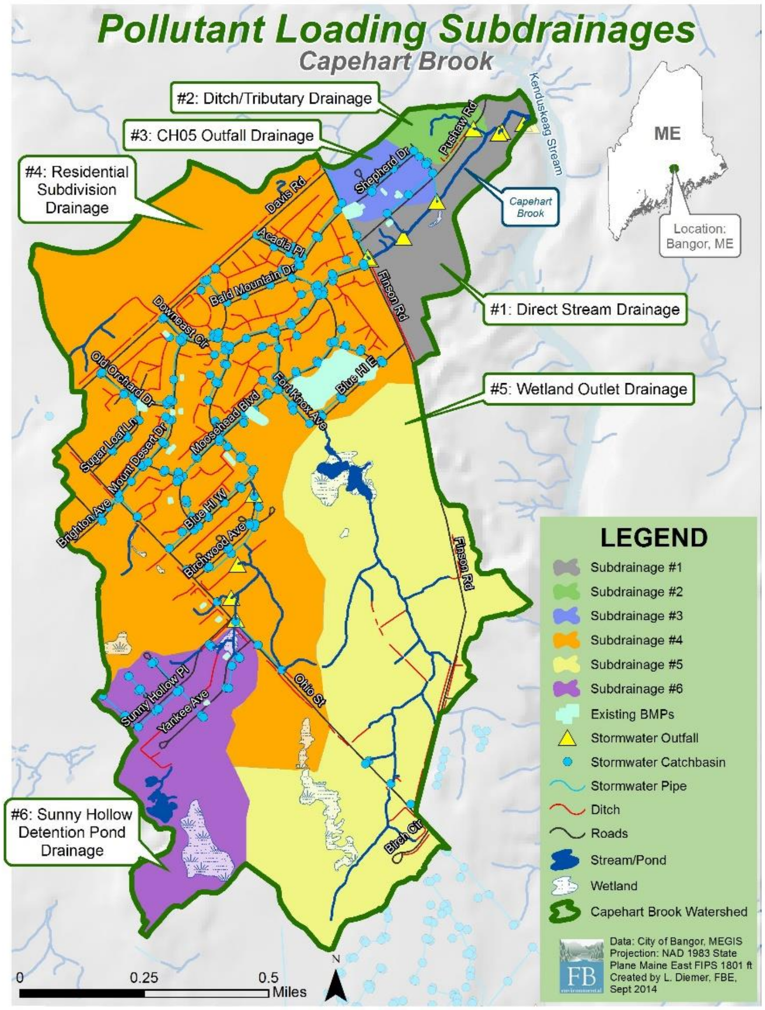


Figure 12. *Map of subdrainages for NHDES Simple Pollutant Loading Model. Appendix A, Map 13.*

A simple pollutant loading model was used to simulate TSS, TP, and TN loading reductions and resulting effective IC disconnections for the Capehart Brook watershed (refer to Section 4.4 and Appendix D for more details on methodology). For purposes of the model, the watershed was divided into subdrainages based on locations of major discharges or recommended BMP implementation sites (Figure 12). Specific BMP recommendations were applied to each subdrainage (Table 13). For instance, as part of the current Phase II project, retrofitting the existing detention pond at Sunny Hollow Place within Subdrainage 6 is a high priority recommendation. This retrofit will include a new outlet structure that will aerate flow to alleviate low dissolved oxygen water from impacting downstream reaches, particularly during large storm events. More details for these recommendations are provided in the Action Plan for stormwater retrofits and restoration strategies (Tables 14-15).

Based on knowledge of the funded work completed or to be completed by the City in the watershed, several scenarios were modeled for Subdrainage 4, the Capehart Neighborhood between Finson Road and Ohio Street, based on the City’s current course of action (**Phase II - Option 1**), a suggested alternative course of action using existing allocated funding for Phase II (**Phase II - Option 2**), and a recommended next step for a potential Phase III project (**Phase III**). Phase II (Option 2) will satisfy the requirements outlined in the 319 grant workplan for treating a wide array of pollutants found in urban stormwater (nutrients, bacteria, and/or metals) and not just gross pollutants (sediment and litter).

<u>Phase II - Option 1</u>

The proposed design for the current Phase II project includes 155 catch basin inserts without filtration cartridges and 4 biofilter systems similar to the existing bioretention cell systems previously installed in the watershed at Rangeley Place South and the Downeast Elementary School. The catch basin inserts are designed to treat sediment and litter entering the storm drain system, and, by default, will also capture some nutrients and other attached pollutants in stormwater; however, they do not address flow volume and do not provide removal specifications for nutrients or other pollutants. The biofilter systems will address both stormwater quality and quantity for the broad range of stormwater pollutants, but the treatment area of only four biofilter systems is relatively small.

<u>Phase II - Option 2</u>

As an alternative to the proposed design for the Phase II project, it is recommended that catch basin inserts with filtration cartridges similar to the Fabco StormBasins are installed with underground storage chambers for infiltration of stormwater runoff. In addition to sediment, these alternative systems will also treat for nutrients, bacteria, and metals. This alternative option has long-term annual maintenance requirements that the City may deem too expensive (e.g. $470 per year per StormBasin), and therefore, the City may want to investigate alternative combinations of StormBasins and FocalPoints (bioretention systems) to suit their needs and sustainable maintenance capabilities. Also, consider redesigning or modifying the current retrofit at Sunny Hollow Place to treat stormwater quantity; this will allow the drainage area to be counted as an IC disconnection. This alternative option will satisfy all components of the 319 grant workplan goal of addressing the wide array of pollutants in urban stormwater.

<u>Phase III</u>

In an effort to reach the goal of 8% effective IC in the watershed, the following steps are recommended for a future Phase III project to address flow and pollutants in the stream:

1) Install gravel wetlands or similar (e.g. rain gardens may also be sufficient) at two locations in the watershed where stormwater retrofits were supposed to be put in place in the original design plans for the neighborhoods, including one location near the private Penobscot Christian School along Birchwood Avenue and the second location along Ohio Street near the Sable Ridge neighborhood; and

2) Plant a combination of trees and rain gardens to infiltrate runoff from the large expanse of residental lawns and driveways (Table 14). The City can coordinate with UMaine Cooperative Extension or local engineers to help with designs, reach out to the Arbor Day Foundation for donations, and work with local volunteers, such as the Penobscot Job Corps, for plantings.

Gravel wetlands are an effective way to treat several acres of IC by reducing flow volumes and allowing time for filtration of sediment and nutrients. A land feasibility and flow study should be conducted before a design plan is developed for the two sites described above. It may be determined that another type of retrofit (e.g. rain garden) is more appropriate for a particular site.

Trees are becoming a more popular method of stormwater management, particularly in urban areas because they treat both stormwater quality and quantity, while also beautifying an area, among numerous other benefits. When planting trees in the residential lawns areas in the Capehart Brook watershed, it will be important to coordinate with landowners for land access permission, which may become a limiting factor in final designs. The City should consult local foresters, engineers, or staff from the UMaine Cooperative Extension to determine tree species that will have the greatest impact on water storage and filtration, since water storage capacity varies by tree species. It was suggested that fruit tree species (e.g. apple trees) may be beneficial not only for stormwater infiltration, but also community interest. This will need to be weighed against other tree species (e.g. oak, pine, willow) that have much higher water storage capacities.

It is important to note that reduction estimates for tree plantings are based on mature trees with trunk diameters of more than 10 inches. As such, it will take several years for the trees to reach maturity and their full potential for stormwater infiltration. If time is an important factor to the City of Bangor, then they should select fast-growing tree species with a moderate to high water infiltration capacity.

Finally, the final cost of utilizing trees or rain gardens may also include the cost of installing curb drains or manipulating the landscape to direct stormwater to the planted trees or rain gardens. This cost was included in the Action Plan, but is a variable number depending on what the final designs will involve (e.g. type of tree species, size of tree species purchased, extent of stormwater flowpath manipulation to planted trees or gardens, etc.).

<u>Additional Priority Actions</u>

In addition, the following actions should be a priority for the City to pursue within the next year or so (as also described in Tables 14-15):

1) Address issues identified in the 2014 Stream Corridor Survey.
    a. Stabilize existing culverts/outfalls with direct discharge to Capehart Brook.
    b. Stabilize areas of stream bank erosion and replant sparsely-vegetated buffers.
    c. Conduct IDDE survey to identify and fix/eliminate potential illicit sources of discharge from multiple drainages along the stream.
2) Notify the Bangor Land Trust of lots for sale within the watershed and the need for expanding conservation areas within the Capehart Brook watershed.
3) Conduct fish and wetland surveys to identify potential areas for habitat improvement.

4) Develop a yearly fact sheet about restoration activities paid for by the Stormwater Utility fund to include in the Stormwater Utility bill to residents.

5) Conduct a fertilizer and septic survey within the watershed to determine potential sources of pollutants to Capehart Brook.

6) Work with City Council to expand rules on restricting or mitigating the impact of new development in impaired watersheds to better protect those streams.

Management measures described in this Plan will reduce effective IC in the Capehart Brook watershed by 44% and meet the restoration objective of having 8% effective IC in the Capehart Brook watershed. However, the Maine DEP target of 8% effective IC should be viewed as a guideline for achieving attainment. Every stream and its aquatic communities will respond differently to restoration activities, and Capehart Brook may or may not reach attainment before or after a full 44% effective IC reduction is achieved. Some retrofits, including the Sunny Hollow Place detention pond repair, cannot be counted toward the IC reduction because it will not reduce total flow volumes, but it will filter for pollutants and slow the rate of flow reaching downstream portions, thus reducing potential disturbances to aquatic habitat from stream surges. Restoration of in-stream and riparian habitat conditions can also be accelerated with riparian buffer plantings, addition of woody debris to upper reaches of the stream where it is lacking, and stream bank stabilization in areas of severe sediment erosion.

These recommendations were presented to the Stormwater Citizen Review Panel in December of 2014. The decision by the City to move forward with Phase II Option 1 or 2 using approved 319 Phase II funding will depend on the overall value of each retrofit to stream health (e.g., amount of IC treated and type of pollutant addressed), compared to the ease and cost of implementation of each retrofit. The recommendation of this Plan is to implement retrofits that treat the major pollutants of interest (sediment, nitrogen, and phosphorus) and reduce the volume of stormwater flow to Capehart Brook by disconnecting IC. Option 2 is a viable alternative to Option 1 that meets this recommendation, but more detailed analyses and designs should be conducted by a qualified engineering firm.

Table 13. *BMP recommendations and their sediment and nutrient loading reduction estimates by subdrainage.*

DRAINAGE DESCRIPTION	BMP RECOMMENDATIONS	TOTAL AREA (ACRES)	PRE-DEV EFFECTIVE IC AREA (ACRES)	POST-DEV EFFECTIVE IC AREA (ACRES)*	TSS LOAD REDUCT. (LBS/YR)	TP LOAD REDUCT. (LBS/YR)	TN LOAD REDUCT. (LBS/YR)
DIRECT STREAM	Vegetated buffers in riparian zones (2,064 linear ft of potential plantings)	39.74	4.67	4.67	3,321	11	61
DITCH/TRIBUTARY	Conserve land	10.10	0.78	0.78	0	0	0
CH05 OUTFALL	Install 6 rain gardens and 10 rain barrels	15.39	3.89	0.12	2,135	9	26
RESIDENTIAL NEIGHBORHOOD	**Phase II - Option 1**: Install 155 catchbasin inserts without filtration cartridges and 4 compact biofilter systems similar to the bioretention cells at Rangely Place South	345.52	65.91	64.71	15,066	3	16
	Phase II - Option 2: Install Fabco StormBasins and chamber rows			56.91	6,906	24	95
	Phase III: Combine recommendations of Option 2, gravel wetland installation at two locations, 324 mature tree plantings, and 25 rain garden installations (~272 sq.ft. each)			26.91	26,555	77	312
WETLAND OUTLET	Conduct wetland survey and functional assessment to determine appropriate remediation efforts	202.52	13.57	13.57	0	0	0
SUNNY HOLLOW DETENTION POND	Repair existing detention pond at Sunny Hollow Place	74.24	9.15	9.15	6,721	22	80
	Total % Reductions with Phase II - Option 1			**5%**	**28%**	**8%**	**7%**
	Total % Reductions with Phase II - Option 2			**13%**	**20%**	**12%**	**10%**
	Total % Reductions with Phase II - Option 2 plus Phase III			**44%**	**40%**	**22%**	**19%**

**Only recommendations that reduce runoff from impervious surfaces can be counted as disconnections from effective IC area*

***Table 14**. Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
STORMWATER				
#1: Alleviate upstream contribution of low dissolved oxygen from a failing detention pond	1) Repair detention pond at Sunny Hollow and install outlet structure using existing Phase II funding allocation from Maine DEP. Consider working with engineers to redesign or modify the Sunny Hollow Place retrofit so that it reduces flow volumes and the treated area of IC can be counted as disconnected.	City of Bangor	2015-2017	$50,000*
#2: Reduce gross pollutants in stormwater flowing out of the Finson Road crossing	1) Install catch basin inserts and biofilter systems throughout residential development using existing Phase II funding allocation from Maine DEP [Phase II - Option 1].	City of Bangor	2015-2017	$225,000*
	a) Consider replacing Option 1 with Fabco StormBasin and chamber row systems that filter more TSS, TP, and TN and reduce flow volumes [Phase II - Option 2].			
#3: Reduce stormwater volume and temperature of water reaching Capehart Brook	1) Install gravel wetlands at two key locations in the watershed to filter and slow down water from the stormwater system as part of a Phase III initiative. Cost does not include labor to install [Phase III].	City of Bangor	2017-2020	$45,000
	2) Work with BHA and private landowners to plant multiple trees and rain gardens in the Capehart neighborhood lawn areas to reduce flow reaching the stormwater system as part of Phase III initiative. Use local volunteers for planting. Consult engineers for tree/plant placement. May need to install additional retrofits to direct stormwater [Phase III].	City of Bangor (with help from BHA, landowners, church/school groups, PJC)	2017-2020	$250,000
#4: Improve and/or stabilize existing culverts/stormwater outfalls	1) Address NPS issues identified in the Level 1 Stream Corridor Survey related to culverts/stormwater outfalls that discharge directly to Capehart Brook.	City of Bangor	2015-2020	$10,000
#5: Maintain a record of BMP implementation work	1) Track BMPs using the Maine DEP NPS Site Tracker.	City of Bangor	2015-2025	$200/yr**
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

Table 14 (continued). *Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
STORMWATER				
#6 Maintain existing and future BMPs	1) Conduct annual maintenance as necessary on all existing and proposed BMPs (if selecting Option 2 for Phase II work). This cost does not include labor and equipment provided by the City.	City of Bangor	2015-2025	$25,000/yr
STREAM RESTORATION				
#1: Stabilize stream banks along the daylighted portion of Capehart Brook	1) Address NPS issues identified in the Level 1 Stream Corridor Survey related to stream bank erosion and lack of vegetated buffer. This is contingent on landowner cooperation and/or obtaining easements.	City of Bangor	2015-2020	$50,000
#2: Prevent warm water/invasive/exotic species from entering the stream from the Kenduskeag Stream	1) Conduct a fish/fish spawning survey to determine which fish species are using the stream.	City of Bangor (with help from MDIFW, Consultants)	2015-2020	$2,500
	2) Consult with MDIFW to determine if the existing thermal barrier is sufficient for the fish species desired, whether spawning areas for any sensitive fish species are active, and what actions can be taken to enhance fish habitat in the stream.	City of Bangor, MDIFW	2015-2020	N/A
#3: Protect and restore natural wetlands within the watershed	1) Survey major wetlands within the watershed for proper buffering and natural wetland functioning. This is contingent on landowner cooperation.	City of Bangor (with help from Consultants)	2015-2020	$5,000
	2) Place properties adjacent to the wetlands in conservation, if possible.	City of Bangor, BLT	2015-2025	TBD
	3) Work with landowners to revegetate degraded buffers around the wetlands. Contingent on landowner cooperation.	City of Bangor, Volunteers	2017-2025	TBD
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

4.3 Non-Structural Management Opportunities and Recommendations

Because structural BMPs are on the forefront of most watershed restoration projects, non-structural BMPs, which do not require extensive engineering or construction efforts, often receive little emphasis in watershed planning. However, these practices are extremely important components of overall restoration efforts (Clar, EPA 600/R-03/103) and can help reduce stormwater runoff and associated pollutants through operational actions such as prevention and good housekeeping practices, land use planning strategies, and targeted education and training.

4.3.1 Non-Structural Toolbox

Non-structural management measures were identified through a variety of sources, including adaptations from the original 2011 Watershed Management Plan (SMRT 2011), personal communications with City of Bangor staff, feedback from the Stormwater Citizen Review Panel and other local stakeholders over the course of several public and non-public planning meetings. Table 15 lists these recommendations, potential partners, timeframes, and costs in five categories:

Administrative & Funding action items are a vital part of bringing both structural and non-structural BMP recommendations to fruition. The City has already taken significant leadership in this category by obtaining two 319 grants from the Maine DEP for implementation work within the Capehart Brook watershed. In addition, the recent establishment of a Stormwater Utility fee has set up a long-term sustainable funding plan for the City to implement stormwater management projects and restoration activities throughout all the impaired watersheds in the City. Additional funding can always be secured, and the City should be aware of and apply for funding opportunties as they arise.

Education & Outreach action items will promote awareness of the connection between land use, water quality, and stream health. Therefore, efforts should focus on engaging communty groups, businesses, town maintenance crews, residents, and school groups. This will likely be the most difficult category to fulfill within the Capehart Brook watershed given the history of the stream and the low level of interest or awareness by residents.

Municipal Maintenance Practices are preventative measures that will reduce the amount of pollutants in stormwater runoff. The City of Bangor Public Works Department is already taking actions to better maintain roads in the watershed with water quality as a priority. Recommendations for future actions include re-evaluating the City maintenance schedule for storm drains, catchbasins, ditches, and culverts; re-evaluating and making improvements to sand/salt storage and spreading; and maintaining street sweeping. A regularly scheduled street sweeping and catch basin cleanout program will reduce the amount of sediment and nutrients that enter the stream.

Land Use Planning & Conservation are two popular tools for reducing pollutant loads from new development in the watershed. Conservation efforts can permanently preserve undeveloped land, while land use planning can help promote the design and construction of development that will minimize and/or eliminate the effects of stormwater on the stream. Zoning can be an effective tool and will require support from the City and the community. Recommendations include expanding City stormwater rules to incorporate standards that are more protective of State minimums for stormwater management and extending shoreland zoning rules to protect more riparian habitat adjacent to Capehart Brook and other impaired streams (currently at 75 ft).

Source Control action items are recommendations that manage known sources of pollutants within the watershed. The City of Bangor provides contact information and drop-off locations for various household hazardous wastes on their website (http://www.bangormaine.gov/hhw). The City also conducts curbside yard waste (e.g. leaves, branches, etc.) collection in the fall, and yard waste can be brought to the Public Works Department any day of the year (except Sundays) during normal business hours. It is important to advertise these resources to residents. Other recommendations are based on observations during the 2014 Stream Corridor Survey, and include some investigative work to determine the source of several unknown sources of discharge to the stream. A portion of the stream exhibited a milky sheen on the water surface and bright green algae located downstream of a recent hydro-seeding site (private parcel on south side of Pushaw Road) adjacent to the stream; it is recommended that the source of this be confirmed and remedied. Lastly, it is recommended that a fertilizer use survey be conducted to document the rate and extent of fertilizer application on lawns and gardens within the watershed. This will provide helpful insight regarding typical fertilizer use in watershed, increase public awareness of the effects of fertilizers on water quality, help inform future watershed nutrient modeling efforts, and help determine whether more stringent fertilizer limits need to be put in place by the City.

***Table 15**. Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
ADMINSTRATIVE & FUNDING				
#1: Apply for funding	1) Apply for state and federal grants and/or seek other funding to support implementation of planning recommendations, including Phase III work.	City of Bangor	Ongoing	In House
EDUCATION & OUTREACH				
#1: Garner support and cooperation from different community groups and agencies	1) Contact civic organizations within the City of Bangor and work with these groups to raise awareness about stream restoration.	BASWG	2015-2025	In House**
	2) Continue working with local volunteers on the annual stream clean-up.	City of Bangor, Local Volunteer Groups	Ongoing	$100/yr**
#2: Educate citizens about stormwater and engage them in stream restoration efforts	1) Organize an educational event for families that live in the impaired stream watersheds. This may include a hands-on outdoor event with water in the summer (e.g. identifying macroinvertebrates) or a walking tour down to the confluence with the Kenduskeag Stream.	BHA, BASWG, Maine DEP, Consultants, UMaine	2015-2020	$250/yr**
	2) Encourage citizens and school groups to “Adopt” a segment of stream or portion of the watershed to keep clean. This is contingent on landowner cooperation.	City of Bangor, BASWG	2015-2025	In House**
	3) Develop yearly one-page fact sheet to accompany the Stormwater Utility bill to update residents about restoration projects and educate residents on proper "housekeeping," including use of sand, salt, sealants, fertilizers, pesticides, trash, recycling, etc.	City of Bangor, Stormwater Utility budget	2015-2025	$500/yr**
	4) Establish BMP demonstration sites for residents to visit (aim for at least 1 site per impaired watershed).	City of Bangor (with help from BASWG, BHA)	2015-2020	$500**
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

Table 15 (continued). *Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
EDUCATION & OUTREACH (continued)				
#2: Educate citizens about stormwater and engage them in stream restoration efforts (continued)	5) Work with volunteers to install placards at high visibility catchbasins throughout the watershed.	City of Bangor	2015-2020	$500**
	6) Continue publication of annual press releases regarding proper use and maintenance of snowmobile and ATV trails.	City of Bangor	2015-2025	In House**
#3: Engage school groups from elementary through high school	1) Conduct watershed education at local schools.	Maine DEP, BASWG	2015-2025	$100/yr
	2) Work with Downeast Elementary School to establish a volunteer monitoring program at Site CB4. See Monitoring in Section 6 of the Plan.	Maine DEP	2015-2025	In House
#4: Design and install a nature trail along the stream to raise awareness of stream restoration and protection	1) Work with landowners and local partnerships to design a public trail along the stream. Contingent on landowner cooperation or land acquisition by BLT.	City of Bangor (with help from BLT, Consultants)	2015-2020	$1,000
	2) Utilize volunteers to help with installation of trail system. Contingent on landowner cooperation or land acquisition by BLT.	City of Bangor (with help from PJC, other Volunteers)	2015-2020	$5,000
	3) Install educational signs that focus on stewardship, stream-friendly landscaping practices, and proper trash disposal.	City of Bangor (with help from PJC, BASWG)	2015-2020	$1,500
#5: Educate business owners about the need and importance of stormwater control and retrofits	1) Contact list of high priority businesses and determine willingness to participate.	BASWG, City of Bangor	2015-2020	In House
	2) Develop a “Green Business” program encouraging and educating business owners on stormwater management, and recognize businesses that make changes.	City of Bangor	2015-2025	$1,000**
	3) Encourage business owners to “Adopt” a stream segment or portion of the watershed to keep clean.	BASWG, City of Bangor	2015-2025	In House**
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

Table 15 (continued). *Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
EDUCATION & OUTREACH (continued)				
#5: Educate business owners about the need and importance of stormwater control and retrofits (continued)	4) Work with commercial businesses, churches, and others with large impervious areas to reduce use of salt application.	City of Bangor, BASWG	2015-2025	In House**
MUNICIPAL MAINTENANCE PRACTICES				
#1: Re-evaluate the City's existing maintenance schedule	1) Work with Public Works to continue ongoing maintenance of catch basins, culverts, and ditches.	City of Bangor	Ongoing	In House**
	2) Continue annual sweeping schedule for roads.	City of Bangor	Ongoing	In House**
	3) Educate staff regarding connection between maintenance and water quality.	City of Bangor	Ongoing	In House**
#2: Re-assess and make improvements to City salt/sand spreading and storing	1) Work with Public Works to limit winter sand/salt spreading on road surfaces.	City of Bangor	2015-2025	In House**
	2) Ensure winter sand/salt is properly stored.	City of Bangor	2015-2025	In House**
#3: Review record of annual municipal maintenance practices by the City	1) Hire third party consultant to review record of annual municipal maintenance practices developed and maintained by the City.	City of Bangor (with help from Consultants)	2015-2025	$170/yr**
LAND USE PLANNING AND CONSERVATION				
#1: Increase the amount of land in permanent conservation	1) Work with BLT to expand the amount of land currently held in conservation, when opportunities arise.	BLT (with help from City of Bangor)	2015-2025	TBD**
#2: Expand City stormwater rules to incorporate standards that are more protective of State minimums for stormwater	1) Work with City Council to develop rules that protect water quality for all new commercial and residential development within impaired watersheds throughout the City.	City of Bangor	2015-2020	TBD**
#3: Incorporate the Capehart Brook Action Plan into the City Comprehensive Plan	1) Ensure that the Capehart Brook Action Plan is incorporated into the next City Comprehensive Plan, which was updated in 2012.	City of Bangor	2022	In House

*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined

**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)

MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps

Table 15 (continued). *Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
LAND USE PLANNING AND CONSERVATION (continued)				
#4: Work with landowners to designate trails for ATVs and snowmobiles where such activity is present.	1) Place signage to clearly mark out trails for ATVs and snowmobiles and install stream crossings. Contingent on landowner cooperation.	City of Bangor (with help from PCJ)	2015-2018	$500
#5: Extend shoreland zoning rules to protect more riparian habitat adjacent to impaired streams	1) Extend existing zoning rules from 75 ft to 100 ft or more from the high water line of impaired streams and their direct drainages.	City of Bangor	2015-2020	In House**
SOURCE CONTROL				
#1: Address unknown sources of discharge identified in the 2014 Stream Corridor Survey	1) Conduct an IDDE survey to identify unknown sources of discharge to the stream found during the 2014 Stream Corridor Survey.	City of Bangor	2015-2017	$5,000
	2) Utilize results from recent IDDE testing to determine if follow-up action is necessary.	City of Bangor	2014	In House
	3) Conduct stormwater and sewer line inspections using smoke or dye testing to identify potential cross-contaminations and determine where upgrades are needed.	City of Bangor	2015-2020	$5,000
	4) Utilize canine scent tracking to detect potential human sources of bacteria.	City of Bangor (with help from ECS)	2015-2020	$2,500
	5) Repair or eliminate unknown sources of discharge.	City of Bangor	2017-2020	$50,000
#2: Locate the source of the milky sheen and bright green algae in the middle reaches of Capehart Brook downstream of the Finson Road crossing	1) Conduct source tracking upstream of sheen and algae.	City of Bangor (with help from Volunteers, Maine DEP, Consultants)	2015-2017	$5,000
	2) Determine if sheen and algae is present under or after both base and storm flow conditions.		2015-2017	$1,000
	3) Work with Maine DEP to test sheen for type of pollutant.		2015-2017	$2,500
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps, ECS = Environmental Canine Services				

Table 15 (continued). *Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
SOURCE CONTROL (continued)				
#3: Expand and support ongoing source control programs	1) Support landscaping waste pick-up program as well as street sweeping on municipal roads and commercial parking areas.	City of Bangor	Ongoing	In House
#4: Determine fertilizer application rate within watershed	1) Conduct fertilizer survey of watershed to determine what portion of the residential lawns are fertilized and by how much on an annual basis.	City of Bangor (with help from Consultants)	2015-2017	$5,000
#5: Conduct a septic system survey	1) Identify lots that rely on septic systems by reviewing the City's sewer bill and comparing that list to all properties within the watershed.	City of Bangor (with help from Consultants)	2015-2017	$7,500
	2) Conduct a door-to-door survey of septic systems to identify the age and maintenance of each system.			
	3) Develop a list of priority properties to follow-up on.			
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

Table 15 (continued). *Non-Structural BMP recommendations for the Capehart Brook watershed.*

ACTION	HOW	WHO	WHEN	COST
MONITORING				
#1: Continue annual water quality monitoring program	1) Maintain or improve annual baseline water quality monitoring and assessment procedures, including stormwater monitoring at outfalls, annual benthic biomonitoring, and continuous data logging for multiple parameters (temperature, dissolved oxygen, conductivity, and discharge). Refer to Section 6 for more details.	City of Bangor, Maine DEP	Ongoing	$10,000/yr
#2 Utilize local volunteers or school groups to maintain or expand baseline water quality monitoring	1) Consider starting a volunteer monitoring program to collect discrete data on temperature, dissolved oxygen, and conductivity, and possibly expand monitoring to include pH and turbidity data collection on a regular basis. Volunteers may include students from the Downeast Elementary School.	City of Bangor, Maine DEP	2015-2025	$5,000
#3: Investigate contribution and sources of other pollutants	1) Collect water samples for analysis of other contributing pollutants, including heavy metals and bacteria, and determine if further action is necessary to mitigate their impact to the stream.	City of Bangor (with help from Consultants)	2015-2025	$2,000
*Funding already obtained by City through grants; In House = funding already part of City or other stakeholder budget; N/A = not applicable; TBD = to be determined				
**Costs that can be applied to City-wide efforts in restoring impaired streams (1/6 of total cost)				
MDIFW = ME Dept. Inland Fisheries & Wildlife; BLT = Bangor Land Trust; BASWG = Bangor Area Stormwater Group, PCJ = Penobscot Job Corps				

4.4 Pollutant Removal and Stormwater Flow Reduction

Implementation of recommended structural BMPs is expected to disconnect 44 acres (44%) of effective impervious cover in the watershed.

FB Environmental conducted a simple pollutant loading analysis to estimate the amount of total suspended sediments (TSS), total phosphorus (TP), and total nitrogen (TN) loading to the stream based on pre- and post-development conditions. Pre-development conditions included existing BMPs implemented in 2012 and 2013 by the City of Bangor. Post-development conditions included proposed BMPs with the estimated percent loading reduction for each pollutant by subdrainage (Table 13). The combination of Phase II - Option 2 and Phase III has the greatest impact on pollutant loading reduction in the Capehart Brook watershed. Caution should be used when interpreting the modeled pollutant loading values as these values may change with a more thorough evaluation of the site-specific runoff and soil infiltration rates by a qualified engineering firm. The pollutant loading values provided in this Plan have been estimated using references from multiple sources and personal communication with engineers, but should be used as guidelines in the planning and decision-making process. Refer to Appendix D for specific references.

Table 16. *Estimated total post-development areas disconnected as a result of BMP implementation options.*

	TOTAL POST-DEV DISCONNECTED IC AREA (ACRES)	TOTAL POST-DEV EFFECTIVE IC REDUCTION (%)
EXISTING BMPS	1.8	1.8%
PHASE II - OPTION 1	1.2	1.2%
PHASE II - OPTION 2	9.0	9.1%
PHASE III	30.0	30.2%
OTHER PROPOSED RETROFITS	3.8	3.8%
TOTAL	**44.6**	**44.9%**

In additon to the reductions that can be expected for TSS, TP, and TN, proposed retrofits are estimated to reduce the effective IC from 14.2% (after existing BMPs are factored in) to 8.0% (assuming Phase II - Option 2, Phase III, and other proposed retrofits are implemented; Table 16). This will likely disconnect approximately 44.6 acres of IC needed to reach the 8% effective IC target. Since effective IC disconnections are based on runoff reductions, certain BMPs could not be factored in as disconnections, despite their substantial contribution to pollutant loading reductions; only recommendations that reduce runoff from IC can be counted as disconnections from effective IC area (Horsley Witten Group, Inc. 2011). These BMPs include the vegetated buffers in Subdrainage 1 and the detention pond retrofit at Sunny Hollow Place in Subdrainage 6. While the current design has a new outlet structure that will regulate flow, this will only delay the flow volumes to reduce the impact of surge responses to storm events.

Implementation of non-structural BMPs will result in an estimated 10% reduction in pollutants to Capehart Brook.

Additional pollutant removal can be expected for recommended non-structural BMPs (Section 4.3) including municipal maintenance practices (street sweeping and catch basin cleaning) which have the most quantifiable reductions. Adequate street sweeping can significantly reduce sediment loads and play a major role in source reduction. However, reductions can vary depending on the type of equipment used (vaccuum vs. mechanical street sweeper), and the frequency of maintenance (monthly, annually, etc.) on the order of 10-20%. A conservative estimate for Capehart Brook would be a 10% reduction in pollutants watershed-wide as a result of planned non-structural management measures (Law et al. 2008, FBE 2011).

The City of Bangor has a street sweeping/catch basin cleaning/storm drain maintenance program. The program involves systematically sweeping every street to clear them of winter sand in the spring each year. Every catch basin in the City is also cleaned of sand and debris once a year after the street sweeping is complete. Certain catchbasins that are noted for high sediment and debris volumes are flagged for more frequent cleaning.

5. Implementing the Plan

5.1 Plan Oversight & Adoption

The Capehart Brook Watershed-Based Management Plan will be carried out by the City of Bangor with local participation from other stakeholders when needed. Key staff from the City of Bangor will need to meet regularly and be diligent in coordinating resources to implement practices that will reduce the effects of urbanization in the Capehart Brook watershed.

The Plan will take 10 years to implement, depending on funding sources and availability. Sustainable funding, a good administrative process, and cooperation by partners and landowners are all variables that will lead to the success of the Plan. If Capehart Brook meets Class B water quality standards before implementation of recommended actions are complete, then the goal of the Plan has been met.

This Plan was presented to the Stormwater Citizen Review Panel in December 2014 following review by the City of Bangor. Formal adoption of the Plan by the City 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.

Recommended actions to restore Capehart Brook to Class B water quality standards are presented in Sections 4.2, 4.3, and 6.2. These actions include 32 tasks in 8 different categories.

A diverse source of funding and a sustainable funding plan is needed to reach desired goals and objectives for restoration.

5.2 Estimated Costs and Technical Assistance Needed

The cost of successfully implementing the Capehart Brook Watershed-Based Management Plan is currently estimated at $560,000 over the course of the next 10 years (2015-2025) based on the recommended actions in Section 4. This includes structural BMPs (Section 4.2), non-structural BMPs (Section 4.3), and monitoring efforts (Section 6.2). This general ‘best guess’ estimate is based on the following assumptions:

10-Year Cost Estimate for Restoring Capehart Brook				
	Category	**Costs covered by existing City programs for six impaired streams***	**New Costs to the City for Capehart Bk***	**New Costs to Other Stakeholders***
Structural BMPS				
	Stormwater Retrofit Sites	$150,000	$362,833	--
	Retrofit Maintenance	$30,000	$250,000**	--
Non-Structural BMPs				
	Administrative & Funding	$60,000	--	--
	Education & Outreach	$5,000	$6,750	$3,500
	Municipal Maintenance	$60,000	$283	--
	Land-Use Planning	$1,500	$500	--
	Source Control/Other	--	$83,500	--
	TOTAL	**$306,500**	**$91,033**	**$3,500**
Monitoring Program				
	Monitoring	$25,000	$107,000	--
GRAND TOTAL (10-yr)		**$331,500**	**$560,866**	**$3,500**

**Note: These costs are estimates that may vary depending on actual costs of recommendations. The structural BMP cost estimate does not include funding already obtained by the City for Phase II work. This also does not include costs for future work that will be determined (TBD), such as restoring wetlands, purchasing land, etc.*

***This cost is not included in the total costs due to the high variability of the estimate, which is dependent on the final implementation of retrofits selected by the City. The cost presented here represents a conservatively high long-term operation and maintenance cost associated with 54 StormBasins.*

Restoration efforts should be funded by all aspects of the community, including local businesses and property owners, community groups, conservation groups, corporate sponsors, and the City.

Stormwater Retrofits: State and federal agencies such as the Maine DEP, Maine DOT, and USEPA 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 City has already pursued State 319 funding for Phase I and II work, and should apply again for Phase III funding in 2016. The City of Bangor Department of Community and Economic Development may also help with beautification projects. Planting trees can be largely accomplished with local volunteers, along with help from the UMaine Cooperative Extension, the Arbor Day Foundation, and the City of Bangor.

Municipal Maintenance: Actions such as culvert repair, enhanced storm drain cleanout and street sweeping programs, and ordinance revisions should be supported by the City through the Stormwater Utility fee, as well as other tax dollars, permit fees, or fees collected as a result of ordinance violations. Other funding sources such as local planning grants may help supplement these projects.

Land Conservation: Conserving undeveloped land in the Capehart Brook watershed is of great importance to protect the watershed from further development. The City of Bangor owns a 28-acre parcel west of Ohio Street, known as Brown Woods. The City should work with the Bangor Land Trust to obtain additional land for conservation with particular focus on large tracts of forest and land adjacent to wetlands. Long-term 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 of water quality in this watershed. Options such as obtaining easements within the riparian areas on the stream should also be considered in lieu of outright purchase. Utilizing conserved lands for public trail systems and educational kiosks are a good way to educate the public about watershed restoration efforts in the Capehart Brook watershed. There are currently two parcels for sale in the Capehart Brook watershed. One parcel is located near the stream itself and is owned by Vaughn Smith. The City may be able to work with the Bangor Land Trust and purchase the property with support from the Stormwater Utility fund.

Monitoring and Assessment: Future monitoring and assessment efforts will require a variety of sources of funding, including the City of Bangor, the Stormwater Utility fee, and private foundation grants.

6. Methodology for Measuring Success

While this Plan provides specific goals and key actions needed to restore Capehart Brook, it is inevitable that new information, technology, and techniques will be learned and developed in the years to come that may change the priorities of identified goals and actions. Therefore, the goals and priority of actions identified in this "living document" should be revisited and revised on an annual basis.

6.1 Adaptive Management Components

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

The adaptive management components of the Capehart Brook Watershed-Based Management Plan will include:

Creating an Organizational Structure for Implementation- Since watershed restoration will require a considerable effort, key personnel from the City of Bangor should be officially appointed and be responsible for administering and coordinating the implementation of this Plan.

Maintaining a Funding Mechanism- The City has already taken initiative in obtaining State 319 funding for Phase I and II work, and additional funding has been obtained through the City of Bangor's Stormwater Utility fund. The City of Bangor should evaluate other options for establishing long-term funding to support the actions in this Plan. Consideration should be given to the type and extent of technical assistance needed to design, inspect, and maintain suggested stormwater BMPs and the annual field monitoring program. Clearly, funding is a critical element of sustaining the restoration process and once it is established, the Plan can be fully vetted and restoration activities can move forward.

Determining Restoration Actions- This Plan provides a unified watershed restoration strategy with prioritized recommendations for restoration using a variety of methods, including structural, non-structural, in-stream, and riparian restoration actions. Since some of the recommended actions already have funding in place, an alternative option was given for current Phase II work as well as recommended next steps for future Phase III work with several smaller ventures that can be completed by the City at any time depending on funding and resource availability. The City should use the proposed designs in this Plan as a starting point for discussion with a qualified engineering firm that will design retrofits within the confine of the currently allocated funding for the Phase II work. The City should then move forward with applying for Phase III work, as outlined in this Plan. Other restoration activities should be prioritized by the City and scheduled accordingly.

Improving the Community Participation Process- Implementation of this Plan will require ongoing community outreach efforts to involve more stakeholders both in the watershed and in the larger community of Bangor. A sustained public awareness and outreach campaign is essential to secure the long-term community support that will be necessary to successfully implement this project. Much of the success of implementing the recommendations will be contingent on landowner cooperation since 69% of the watershed is privately-owned (Appendix A, Map 14).

Developing a Field Monitoring Program- A field monitoring program is necessary to track the anticipated improvements to aquatic health within the Capehart Brook watershed as restoration actions are implemented. The monitoring program will provide feedback on the effectiveness of restoration practices at the catchment and/or subwatershed level, and will support optimization of restoration actions through an adaptive management approach. The City of Bangor will maintain this program.

Establishing Measurable Milestones- A restoration schedule that includes milestones for measuring the implementation of restoration actions and monitoring activities in the Capehart Brook watershed is critically important. Once the level of funding has been established to determine the extent of recommended action strategies that can be implemented each year, a detailed schedule featuring iterative implementation and monitoring activities should be developed. Refer to Section 6.3 for more details.

6.2 Monitoring Program

A well-designed monitoring program is a critical component of the Plan since it will establish the relative effectiveness and success of restoration recommendations against pre-implementation (or "baseline") watershed conditions. The current monitoring program should be maintained or improved with two primary goals: monitoring should 1) support the assessment of overall aquatic health of Capehart Brook over time, and 2) provide an evaluation of the effectiveness of restoration practices for improving the aquatic habitat. Refer to the monitoring section of the Action Plan in Table 15.

The monitoring program will feature a two-tiered approach:

Ambient Capehart Brook Monitoring- An ambient stream monitoring program will support assessment of the overall health of the stream system;

Catchment Area and/or Subwatershed Monitoring- A set of specific monitoring programs will assess the performance of restoration actions.

Hydrologic, water quality, and aquatic biological measurements may be required to identify success of restoration efforts. It would also be useful to include annual stream walks to assess the condition of the riparian corridor in relation to adjacent land use change. Stream walks can be coordinated with annual stream clean-ups sponsored by local church groups.

6.2.1 Ambient Capehart Brook Monitoring Program

An overall goal of the ambient monitoring program is to track the improvement of the watershed's overall aquatic health over time. A representative set of aquatic health indicators should be measured and interpreted on a predetermined timeframe (Maine DEP collects data every 5 years and is due to sample again). The set of aquatic health indicators should include characteristics that have been degraded by the urbanization of the Capehart Brook watershed. Measuring these characteristics each year will support accurate assessment of the success of restoration actions. The ambient monitoring program should include the following components:

Hydrology: Continuous stream flow measurements

- Since Capehart Brook is a small urban stream with surge responses to storm events, it will be important to continue stream flow monitoring, since flow will be reduced significantly with each acre of IC disconnected from implemented retrofits. The City may want to purchase a few sondes to rotate among the impaired watersheds within the City and establish a point person or company to maintain them year-round.

Water Quality: Continuous in-situ measurements and laboratory analysis of synoptic grab sampling for key water quality parameters

- Dissolved oxygen (DO) was found to be the main culprit for water quality degradation and inhibition of aquatic life function in Capehart Brook. Using data loggers for continuous readings would provide the best information, but discrete sampling can also be useful if conducted in the early morning (before 9am) or during storm events when DO is typically lowest.

- Other key water quality parameters to continue collecting (either continuously with data loggers or discretely with grab sampling) are water temperature and specific conductivity.

    - Discrete readings of specific conductivity should be collected along with grab samples for more precise laboratory analysis of chloride concentrations since field kit methods for measuring chloride can be inaccurate.

- Future monitoring should include weekly to monthly grab samples for primary nutrients (nitrogen and phosphorus) and chlorophyll-a. This should be taken during both wet and dry weather events (in conjunction with upstream wetland connection sampling) to determine when and where nutrients are impacting the stream.
    - Combining turbidity sensors with stage loggers would provide important information about the flow-chemistry regime of Capehart Brook, particularly when paired with nutrient data during wet and dry weather events.

    - It would also be beneficial to conduct bacteria sampling at potential source hotspots within the watershed and along the stream. This can be conducted along with canine scent detection of human waste to identify any areas of illicit discharge (e.g. leaky sewer pipes).

- The City should also consider conducting spot sampling for nutrients and pesticides in the tributary downstream of the City Compost Site to ensure that runoff is not causing impacts to Capehart Brook.

Biology: Macroinvertebrate and fish surveys

- Continue City-funded macroinvertebrate monitoring. This will provide crucial information on stream health and help gauge the success of restoration efforts in the watershed.

The number of surveys, the locations and number of sampling sites, and the specific measurements collected will be determined by the City of Bangor as the goals of the monitoring program become clear based on available resources and funding.

The ambient monitoring program should build on and enhance previous monitoring efforts in the watershed. After each sampling event, data should be analyzed and compared to data collected during previous years. This data collection program and data analysis and interpretation protocol will support assessment of progress in restoring Capehart Brook.

6.2.2 Catchment Area Site-Specific Performance Monitoring

Restoration of Capehart Brook will require implementation of numerous catchment area best management practices (BMPs) to reduce the adverse impacts of these areas on the aquatic ecosystem. A goal of the catchment area performance monitoring program is to quantify the effects of each set of restoration actions. This monitoring program will serve to validate the positive impact of restoration and will support the process of optimizing effectiveness in future mitigation actions. For example, the types of BMPs that are observed to be highly effective will be used more in the future while less effective BMPs will be phased out.

A site-specific performance monitoring program for a stormwater BMP may include before and after measurements at the outlet of the catchment area for the following:

- Volumetric discharge rate through a series of storm events;
- Continuous recording of in-situ water quality parameters;

A more simplified version of these measurements can be established depending on the budget allocated for monitoring. Catchment area monitoring would be conducted prior to installation of BMPs in order to establish baseline conditions and following installation of BMPs to measure improvement in hydrologic and water quality conditions.

6.3 Measurable Milestones

Establishing indicators and numeric targets (benchmarks) to quantitatively measure the progress of the Capehart Brook Watershed-Based Management Plan will provide both short and long-term input about how successful the Plan has been in meeting the established goals and objectives for the watershed.

Indicators are derived from tasks identified in the Action Plan. While the Action Plan provided a description of tasks, responsible parties, schedule, and estimated annual costs associated with each task, the indicators are developed to reflect how well implementation activities are working, and provides a means by which to track progress toward established goals and objectives.

The following environmental, programmatic, and social indicators and associated benchmarks will help measure the progress of the Capehart Brook Watershed-Based Management Plan. These benchmarks represent short-term (2017), mid-term (2020), and long-term (2025) targets for improving water quality in Capehart Brook. Setting benchmarks allows for periodic updates to the Plan, maintains and sustains the action items, and makes the Plan relevant to ongoing activities. The City of Bangor will review the benchmarks for each indicator on an ongoing basis to determine if progress is being made, and then determine if the Plan needs to be revised if the targets are not being met.

Environmental Indicators are a direct measure of environmental conditions. They are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. They include:

Environmental Indicators			
Indicators	**Benchmarks***		
	2017	*2020*	*2025*
Improvement of in-stream water quality & habitat			
a) Enhance macroinvertebrate type, abundance, and distribution *GOAL: Meet Class B standards (based on probabilities of meeting)*	5%	50%	90%
b) Reduce peak flows coming out of the Finson Road crossing culvert *GOAL: Disconnect 44% of IC within watershed*	10%	25%	44%
c) Reduce maximum stream water temperatures *GOAL: Disconnect 44% of IC within watershed*	10%	25%	44%
d) Reduce in-stream pollutants (TSS, TN, TP) *GOAL: Disconnect 44% of IC within watershed*	10%	25%	44%
Improvement of riparian habitat			
a) Revegetate riparian habitat adjacent to Capehart Brook** *GOAL: Plant 2,064 linear feet of riparian buffer*	10%	50%	100%
b) Protect vegetative buffer around wetlands** *GOAL: Revegetate all limited buffer areas*	10%	50%	100%

**Benchmark figures are cumulative from 2017 to 2020 to 2025*
***Contingent on landowner cooperation*

Programmatic Indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic measurements list actions intended to meet the water quality goal. They include:

Programmatic Indicators			
Indicators	**Benchmarks***		
	2017	*2020*	*2025*
Amount of funding secured for Plan implementation	$200,000	$400,000	$700,000
Number of areas installed with structural BMPs	5	10	20
Number of structural BMPs inspected and maintained	10	20	50
Acres of IC treated and disconnected by BMPs	10	25	44
Number of residential BMP demonstration project completed	1	2	3
Number of culverts stabilized	2	4	8
Number of voluntary septic system inspections	1	2	5
Number of lateral wastewater or septic system upgrades	1	5	10
Number of acres of new land in conservation	1	5	10
Number of watershed-based educational materials distributed	250	500	1,000
Number of non-structural restoration activities completed	5	10	15
Number of municipal ordinance changes that relate to watershed protection	1	2	3

**Benchmark figures are cumulative from 2017 to 2020 to 2025*

Social Indicators measure changes in social or cultural practices and behavior that lead to implementation of management measures and water quality improvement. These indicators can be used to estimate impact of restoration activities on public perception and awareness of water quality issues. They include:

Programmatic Indicators

Indicators	Benchmarks*		
	2017	*2020*	*2025*
Number of volunteers for stream clean-ups and plantings	10	20	30
Number of certified contractors completing a BMP or LID training and certification program	1	3	5
Number of landowners with >10 acre lots participating in land conservation programs	1	2	5
Number of people participating in educational events	10	20	30
Number of stakeholders adopting a stream segment to keep clean**	1	5	10
Number of businesses participating in restoration activities	1	2	3

**Benchmark figures are cumulative from 2017 to 2020 to 2025*
***Contingent on landowner cooperation*

6.4 Conclusion

Watershed residents, landowners, business owners, and recreationalists alike should have a vested interest in improving the long-term water quality of Capehart Brook so that everyone can have access to clean water. The objective of the Capehart Brook Watershed-Based Management Plan is to reduce the effective IC in the watershed, moving toward the IC TMDL target of 44% effective IC reduction; this will reduce the volume and temperature of stormwater entering Capehart Brook as well as the amount of pollutants associated with developed areas. Reducing effective IC by 44% in the Capehart Brook watershed will cost approximately $56,000 per year over the next 10 years. Cost estimates are based on tasks identified in the Action Plan, which will need to be updated as the Plan is implemented and new action items are added. Implementation of this Plan over the next 10 years will require the dedication and hard work of state and municipal employees, watershed groups, and volunteers to ensure that the actions identified in this Plan are carried out accordingly.

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