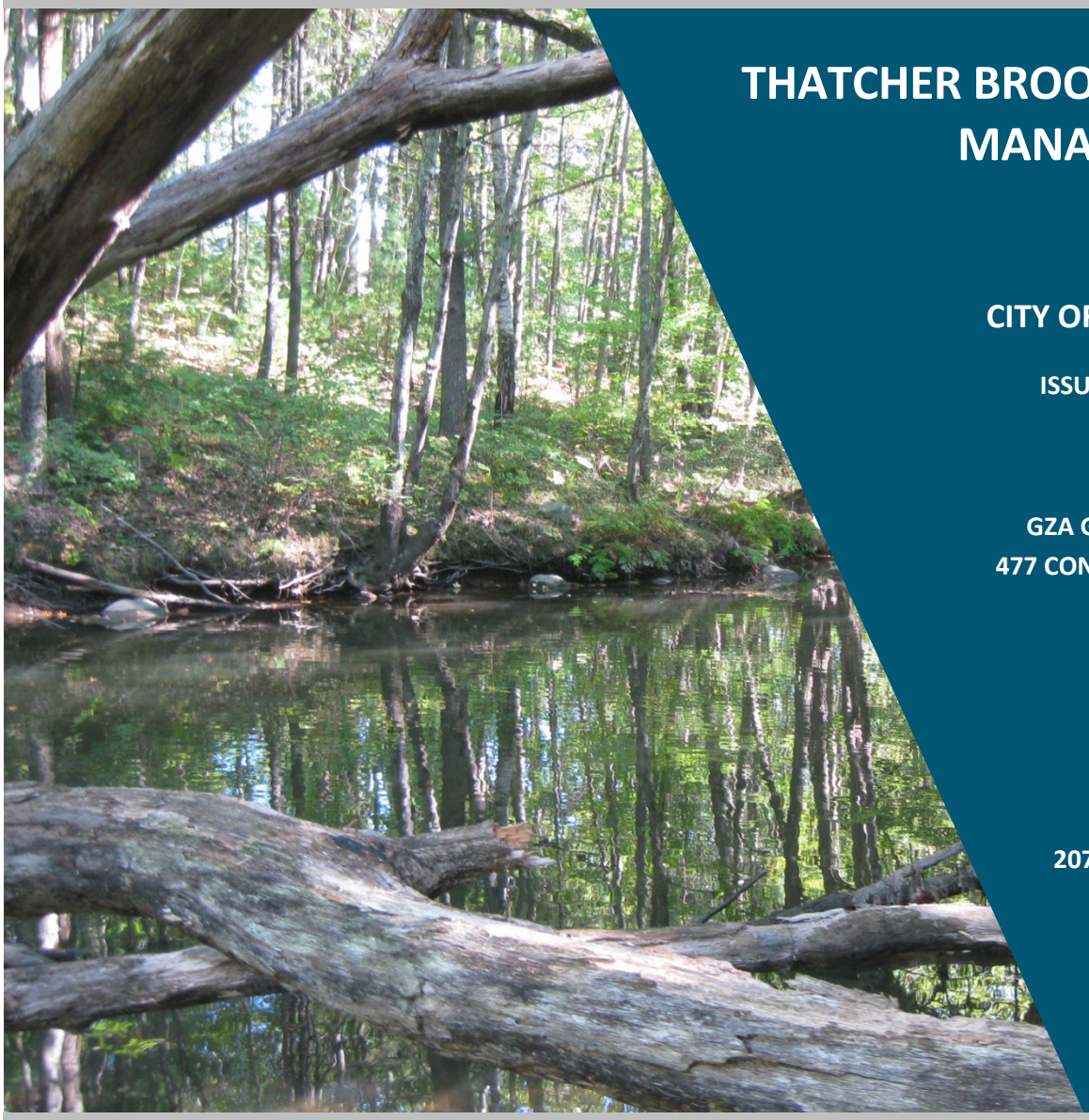

THATCHER BROOK WATERSHED MANAGEMENT PLAN

PREPARED FOR:

CITY OF BIDDEFORD, MAINE

ISSUED FOR PUBLIC COMMENT

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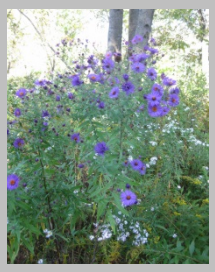

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1.0 EXECUTIVE SUMMARY

Thatcher Brook is a Class B fresh water stream located in the City of Biddeford and Town of Arundel, on the southern coast of the State of Maine in the northeastern corner of York County, the State's most southern county. The Thatcher Brook watershed encompasses approximately 5.59 square miles in Biddeford and approximately 1.52 square miles in Arundel (see **Figure 2**, Watershed Area by Municipality). Thatcher Brook drains into the Saco River just upstream of the Saco River Dam at Saco Falls before ultimately flowing into Saco Bay. The Thatcher Brook watershed is a complex mix of land uses that includes dense residential, commercial, industrial, agricultural, public and forested land. Approximately 2.75 square miles of the watershed is classified as a "regulated area" under the National Pollutant Discharge Elimination System (NPDES) Phase II Stormwater Program (see **Figure 3**, NPDES Phase II Regulated Area).

1.1 THREATS TO WATER QUALITY

Thatcher Brook is on Maine's 303(d) list, signifying that the stream is not meeting one or more of its designated uses. Stream habitat and biomonitoring assessments completed by the Maine Department of Environmental Protection (MDEP) found that Thatcher Brook did not support the aquatic macroinvertebrates that should be found in a Class B stream. Thatcher Brook is not yet listed as an Urban Impaired Stream in MDEP's Chapter 502. A stream is considered urban impaired if it fails to meet state and federal water quality classifications due to the effects of stormwater runoff from impervious surfaces such as rooftops, parking lots and roads. In August 2009, Thatcher Brook was included in MDEP's Statewide Bacteria Total Maximum Daily Load (TMDL) Report, which uses bacteria as an indicator for the presence of pathogens in water. This bacteria TMDL report provides documentation of impairment and information on pollutant sources that are intended to provide guidance for protection of the waterbody by watershed stakeholders. In September 2012, the United States Environmental Protection Agency (EPA) approved MDEP's Statewide Impervious Cover (IC) TMDL Assessment, in which Thatcher Brook is included as an impaired stream. This assessment provides a framework for addressing aquatic life and habitat impairments by using impervious cover as a surrogate for a suite of pollutants commonly found in urban stormwater runoff. This TMDL establishes the target percentage of IC for the watershed and provides guidance for efforts to improve water quality in Thatcher Brook.

During the development of this Plan, the following threats to water quality (a.k.a. stressors) were identified:

- Stream channel alteration and the resulting stream bank erosion and degraded habitat;
- Elevated phosphorus and decreased dissolved oxygen [DO] (in part due to naturally-occurring conditions in associated wetlands); and,
- Elevated bacteria and specific conductance.

The following Watershed Management Plan (WMP) was developed to specifically address the aquatic life use impairment of Thatcher Brook. Efforts to reduce bacteria source areas are being addressed primarily through MS4 requirements and the efforts of City Departments.

1.2 PLAN DEVELOPMENT AND COMMUNITY OUTREACH

Restoration is necessary because Thatcher Brook has impaired water quality and the health of the stream is important to the health of the Saco River and ultimately, Saco Bay. The goal of the Thatcher Brook WMP is to develop a locally-supported watershed-based plan that clearly outlines a strategy to restore and protect the water quality of Thatcher Brook in order for it to attain its Class B water quality criteria. The long-term goal is to enhance quality of life, minimize impacts to the environment and manage an identified growth area of the City in a comprehensive and responsible manner.

The City of Biddeford partnered with the York County Soil and Water Conservation District (YCSWCD), GZA GeoEnvironmental, Inc. (GZA), and MDEP to develop this Plan, which is intended to serve as a roadmap for restoring and protecting Thatcher Brook. Incorporating input from stakeholders, this Plan identifies the top threats in Thatcher Brook and establishes goals, objectives, and actions for reducing those threats. The Plan also contains a set of criteria that can be used to monitor progress towards attaining water quality standards and financing implementation.

1.3 RECOMMENDED MANAGEMENT STRATEGIES

An adaptive management approach is widely recommended for restoring urban watersheds (Center for Watershed Protection 2003). Adaptive management, which is the process by which new information about the health of the watershed is incorporated in the WMP, provides the flexibility needed to ensure efficient and successful Plan implementation. The adaptive management approach recognizes that an entire watershed cannot be restored with a single restoration action or within a short timeframe. As new data/information and/or technology become available, this management approach allows restoration efforts to be adjusted over time to meet the current needs of the watershed.

1.4 THATCHER BROOK ACTION PLAN

The Thatcher Brook action plan incorporates comments recommended by watershed stakeholders at public meetings. The City of Biddeford intends to establish a Thatcher Brook Workgroup to implement the following goals and objectives that were established by the project partners and stakeholders during development of this plan:

Goal #1 – Improve the water quality of Thatcher Brook to meet State water quality standards.

- Work towards Thatcher Brook meeting its designated Class B water quality standards for aquatic life.
- Continue to monitor water quality parameters (e.g. DO, specific conductance, temperature and macroinvertebrates) to assess whether the goal is being achieved.

Goal #2 – Once attained, protect and maintain water quality and habitat conditions to ensure the brook continues to meet State water quality standards.

- Improve the management of stormwater runoff from existing development in an effort to improve the treatment and water quality of stormwater.
- Protect the brook through zoning and ordinances changes for new and re-development projects.

- For future development, limit impacts to streams and wetlands associated with Thatcher Brook.
- Coordinate efforts with other conservation and preservation groups in the watershed to maximize protection opportunities.

Goal #3 – Increase community support for the preservation and enhancement of natural resources within the Thatcher Brook watershed.

- Develop an outreach and education program for residents and local businesses to promote and implement the WMP.
- Strengthen ties with the local schools and the University of New England to enhance education and participation in community action opportunities.
- Establish a Thatcher Brook Workgroup to oversee implementation of the goals and objectives in the Plan and realize long term health in the stream and watershed.

1.5 FUNDING STRATEGIES

Implementation of the Plan is expected to occur in phases for many of the projects identified in the Action Plan (see Section 8 of this document). Pending receipt of funding, several of the highest priority actions listed will be further refined and implemented by the City of Biddeford and interested landowners during Phase 1, from approximately 2015 to 2020. It is anticipated that monitoring and medium to low priority items will be investigated and pursued during Phase 2 (2020 to 2025). The City of Biddeford intends to apply for MDEP NPS funds ("319 Grant Funds") for a number of the restoration efforts identified in this Plan. The Thatcher Brook Workgroup will be organized as a first step in Phase 1 to review and further prioritize overall objectives of the Plan during each phase.

Watershed stakeholders recognize that grants alone are not the complete solution to restoring Thatcher Brook. Therefore, alternative private and public funding sources will continue to be explored by project partners and stakeholders to fund the implementation of large structural retrofits and stream crossing work. The estimated cost to implement all items outlined in the following Plan is $1,274,700 over the next ten years (2015 to 2025). Although the Plan is developed based on a 10-year cycle with two major phases, it is expected that additional efforts may be needed in following phases after 2025 to maintain a proactive approach to improving water quality in Thatcher Brook.

2.0 INTRODUCTION

The Thatcher Brook Watershed Management Plan was pursued by the City of Biddeford to proactively address the documented impairments of Thatcher Brook. The purpose of a Watershed Management Plan (WMP or Plan) is to document the potential sources of water pollution for the surface waterbody and identify opportunities to improve water quality within an impaired watershed. A watershed is comprised of all the land that drains to a single point on the landscape, typically a body of water such as a river, stream, lake, or estuary. Management is generally more successful at the watershed level, as all activities within a watershed have the potential to influence or affect the quality of the receiving water. The WMP provides a roadmap to restore the impaired waterbody to its designated uses and meet water quality standards. Community stakeholders perform a critical role in developing a locally-supported WMP, and the final plan reflects the community's goals for their watershed.

Thatcher Brook is a Class B stream located in the City of Biddeford and Town of Arundel that that drains into the Saco River and ultimately to Saco Bay. Thatcher Brook is approximately 7.7 miles in length and has a total watershed area of 4,525 acres, or 7.12 square miles (see **Figure 1**, Major Subwatersheds by Stream Segments). It is classified by the EPA as an "impaired waterbody".

The EPA defines impaired waterbodies as any waterbody that does not meet water quality criteria that support its designated use. Impaired waterbodies are then placed on the MDEP Section 303(d) list. Thatcher Brook was placed on Maine's 303(d) list for failing to meet its statutory water quality classification designation of Class B, primarily due to impairments related to bacteria and aquatic life.

This Plan incorporates and summarizes studies conducted on Thatcher Brook since 2000 to describe Thatcher Brook's impairments and identify opportunities and recommended actions needed to attain water quality standards. Furthermore, the unique conditions within the watershed have been investigated and considered by project partners throughout development of this Plan so that appropriate methods are proposed to minimize future impacts to the Brook due to land uses and human activities within the watershed.

2.1 HOW WAS THE PLAN DEVELOPED?

The plan was developed using a collaborative approach, which aimed to actively involve local stakeholders and community members in selecting management strategies that may be implemented over time to address issues in the watershed. On July 18, 2013, approximately 20 persons attended a community public meeting to learn about Thatcher Brook and provide input on stream and watershed issues. In addition, several technical and stakeholder subcommittee meetings were held over the following 15 months to develop and refine management strategies. This Plan incorporates this work and also follows EPA guidelines for watershed based management plans to restore impaired waters. Alignment with EPA requirements will enable project partners to seek future EPA and MDEP funding to assist in the implementation of the recommended actions identified in the Plan.

2.2 WHO ARE THE PROJECT PARTNERS?

The City of Biddeford, GZA, MDEP, and the YCSWCD partnered to develop the work plan for this project. The Town of Arundel, Maine Turnpike Authority, Maine Department of Transportation, watershed residents, business owners, and others also participated in the process.

2.3 WHO SHOULD READ THIS PLAN?

The targeted audience for this Plan includes any person or group that is interested in restoring and protecting the water quality of Thatcher Brook, as well as anyone that influences or is affected by its water quality, habitat management, and land use decisions within the watershed. Municipalities and local groups in and around the Thatcher Brook watershed should utilize this plan as the basis for local action and stream restoration. State and federal agencies can also use this plan to enhance their understanding of local watershed conditions and as a foundation for coordinating planning, permitting and regulatory decisions.

3.0 WATERSHED CHARACTERISTICS

3.1 LOCATION

The Thatcher Brook 7.11± square mile watershed includes 5.59± square miles in Biddeford and 1.52± square miles in Arundel (see **Figure 2**, Watershed Area by Municipality). A tributary to the Saco River, Thatcher Brook is comprised of three distinct segments, Upper Thatcher Brook, Lower Thatcher Brook, and Richardson Brook.

- **Upper Thatcher Brook** begins in a wetland area west of Andrews Road in Biddeford then flows southeast across Route 111 into the Town of Arundel and then passes under the Maine Turnpike before heading northwest back into Biddeford and crossing Route 111 a second time just east of the northbound exit ramp for Exit 32 off Interstate 95 (the Maine Turnpike). A relatively small tributary to Upper Thatcher Brook begins southeast of Terry Lane in Arundel and joins Upper Thatcher Brook just south of Old Alfred Road near the Biddeford town line.
- **Richardson Brook** connects with Upper and Lower Thatcher Brooks to the east of the Maine Turnpike near Exit 32. One tributary to Richardson Brook begins in a large wetland complex in the southeastern portion of the watershed and crosses US Route 1 and several commercial/industrial areas prior to meeting with Richardson Brook in the vicinity of the Eastern Trail west of Morin Street. Several small tributaries to Richardson Brook begin in the developed area around the Biddeford Municipal Airport and traverse several commercial/industrial areas before converging into a single tributary that crosses US Route 1 before meeting the other tributary and forming Richardson Brook.
- **Lower Thatcher Brook** crosses the Maine Turnpike twice before finally passing under Main Street near Biddeford High School before joining the Saco River just upstream of the Saco River Dam at Saco Falls before ultimately flowing into Saco Bay. One relatively small tributary to Lower Thatcher Brook begins at Biddeford Crossing and crosses Route 111 before joining Lower Thatcher Brook just west of the Maine Turnpike. Another small tributary to Lower Thatcher Brook begins in a developed area south of Route 111 and flows northwest crossing Route 111 and the Maine Turnpike before joining with Lower Thatcher Brook just prior to its final crossing of the Maine Turnpike. Two other small tributaries to Lower Thatcher Brook begin in a developed area near the railroad crossing north of Route 111 and flow northwest through a forested area before joining Lower Thatcher Brook just south of Glaude Avenue.

The Thatcher Brook watershed includes a diverse and complex mix of land uses that is comprised of dense residential, commercial, industrial, agricultural, public/non-profit and forested land. Approximately 2.75 square miles of the watershed is classified as a “regulated area” under the NPDES Phase II Stormwater Program (see **Figure 3**, NPDES Phase II Regulated Area).

3.2 POPULATION & DEMOGRAPHICS

Table 1. Population Demographics of Thatcher Brook's Watershed Communities, at the 2010 Census.

Town	2010 Population	Population Aged 0-24	Population Aged 25-64	Population Aged 65+	Median Household Income	Per Capita Income
Biddeford	21,277	33%	51%	16%	$37,164	$18,214
Arundel	4,022	32%	60%	8%	$49,484	$20,538

Biddeford is a city that has slightly more than 21,000 residents, at the time of the 2010 census (see **Table 1**), which is a 1.6% increase from the 2000 census. The City encompasses approximately 30 square miles of land ranging from rural to urban in character. Biddeford is situated beside Saco Bay on the Gulf of Maine and is the sixth largest city in the state. The City has almost 15 miles of frontage along the Saco River and its Atlantic coastline on which the peninsula of Biddeford Pool is located. The former textile mill City is one of Maine's fastest-growing commercial centers and is home to large institutions including Southern Maine Health Care and the University of New England. Biddeford offers an array of recreational areas including public beaches, an ice arena, and the Eastern Trail (a network of trails that will ultimately connect the East Coast Greenway from Calais, Maine with Key West, Florida). The City is also home to endangered species and significant habitat areas, including New England Cottontail (i.e., a State of Maine endangered species and a Federal Petitioned Candidate Species with a Listing Priority Number of 2[1]) sites, a highly threatened brook trout fishery, threatened plant communities (swamp saxifrage) and vernal pool areas.

Arundel is a town that has approximately 4,000 residents, at the time of the 2010 census, which is a 12.6% increase from the 2000 census. The Town encompasses slightly less than 24 square miles of land area and is bordered by the City of Biddeford, and the towns of Kennebunkport, Kennebunk, Lyman, and Dayton. Three major routes, Interstate 95 (Maine Turnpike), Route 1 (Portland Road) and Route 111 (Alfred Road), run through Arundel connecting Biddeford to Sanford, Kennebunk, and Kennebunkport.

3.3 CLIMATE

Arundel and Biddeford have an average low temperature of 12 degrees Fahrenheit in January to an average high of 76 degrees Fahrenheit in July. The annual average rainfall is 47.6 inches and 42 inches per year, for Arundel and Biddeford respectively, and the average yearly snowfall is approximately 44.1 inches.

3.4 SOILS & SURFICIAL GEOLOGY

3.4.1 SOILS

There is a variety of soil types in the watershed with four dominant major soil series: Lyman (~25% of total watershed area); Scantic (~21% of total watershed area); Naumburg (~13% of total watershed area); and Buxton (~9% of total watershed area). The Lyman series consists of shallow, somewhat excessively drained, gently sloping to steep, fine sandy loam to gravelly fine sandy loam. These soils are the result of glacial melt out and are generally found on summits, shoulders, and back slopes within the region. Areas of rock outcrops are common on the tops and sides of hills, ridges and mountains. Depth

[1] *Federal Register* Vol. 76 No. 207 (26 October 2011): 66370-66439

to bedrock in Lyman soils is generally 10 to 20 inches. The Scantic series consists of very deep, poorly drained, gentle sloping, water laid sediment of silt and clay that were formed in glaciomarine deposits. They are found on marine terraces, coastal lowlands and river valleys within the region. The Naumburg series consists of deep, poorly drained and somewhat poorly drained, nearly level, sandy glaciofluvial deposits found on low-lying outwash plains and deltas. The Buxton series consists of very deep, moderately drained, gently sloping to steep, glaciolacustrine deposits of silty loam and silty clay. They are found on coastal plains and river valleys. Both the Scantic and Naumburg soils are considered wetland (hydric) soils. Therefore, about 33% of the total watershed consists of wetland soils.

Soils are classified into Hydrologic Soil Groups (HSGs), which range from A through D. HSGs are an indication of infiltration rates, or the rate at which water enters the soil at the soil surface. Soils with high infiltration rates (i.e., HSG A) allow water to soak into the ground and permit groundwater recharge, while soils with low infiltration rates (i.e., HSG D) allow water to runoff the soil surface and erode the area. Approximately 70% of the Thatcher Brook watershed is comprised of HSG D soils that have high runoff potential with very low infiltration rates, while approximately 16% of the watershed is comprised of HSG type A soils that have low runoff potential and high infiltration rates even when thoroughly wetted (see **Figure 4**, Soil Hydrologic Group). Soils with high runoff potential tend to erode faster than what is considered tolerable, and therefore have a higher potential to negatively impact water quality.

Watershed soil types have a strong influence on the stream environment and its ability to support its designated uses. Thatcher Brook watershed soils tend to be highly erodible and are more likely to enter the stream channel under disturbed conditions. Also, the watershed soils do not typically allow for groundwater recharge into the stream, nor do the soils easily support stabilizing vegetation along the stream and within the floodplain where erosion is occurring.

3.4.2 SURFICIAL GEOLOGY

The surficial geology (see **Figure 5,** Surficial Geology) in the watershed area is the result of the advance and retreat of glaciers at the end of the last glacial period. The major geological formation types in the watershed are the Presumpscot Formation, Marine shoreline deposits, Marine regressive sand deposits, and Till.

The Presumpscot Formation is a fine-grained glaciomarine deposit with minor deposits of coarse-grained glaciomarine and till soils. The fine-grained glaciomarine sediments accumulated on the ocean floor when the lowland area of Southern Maine was submerged. The coarse-grained glaciomarine sediments, Marine shoreline and regressive sand deposits, were deposited where glacial meltwater streams and currents entered the sea. These sediments formed deltas, fans and kames and locally covered earlier glaciomarine deposits of silts and clays. Marine shoreline deposits were formed as stillstands, remaining stationary with respect to sea level during the regressive phase of marine submergence. Glacial moraine/till sediments are a sorted mixture of silt, sand, pebbles, cobbles, and boulders deposited over bedrock. These sediments underlie the glaciomarine sediments previously described where not exposed at the surface, and were deposited beneath the ice sheet during glacial retreat.

Depending on their source rock, glacial deposits may contain higher levels of metals (including iron and copper) and anions such as chloride, sulfide/sulfate, phosphate, and nitrate/nitrite than the surrounding deposits. These compounds may enter stream system when the deposits are disturbed by erosion or anthropogenic means.

Glaciomarine fans are deposits of sand, gravel, and till that are formed when runoff from a glacier contacts standing water. The Thatcher Brook watershed area generally transitions from shallow till sediments to glaciomarine deposits from west to east across the watershed. There are known mining/gravel pit operations near the headwaters of Upper Thatcher Brook (Andrews Road) and on the eastern edge of the watershed (Cole Road). Based on the surficial geology of the area, most groundwater recharge appears to be occurring outside and on the outer edges of the watershed.

As expected with this range in surficial geology, Thatcher Brook's stream bottom has both fine-grained and coarser (gravel and cobble) sediments. Under undisturbed conditions, the fine-grained (silt and clay) portions of the stream channel tend to be stable while the stream segments that flow through the coarser (sand and gravel) formations tend to be dynamic systems characterized by shifting banks and meanders.

3.5 LAND USE

3.5.1 HISTORICAL LAND USES

Prior to the European settlement in the 17th and 18th centuries, land cover in the Thatcher Brook watershed consisted mostly of forested areas. As settlers moved to the area in the early 17th century, forested land was converted to small farms and villages. Biddeford's first sawmill was built circa 1653 and lumber and fish became the community's major exports at that time. Biddeford was incorporated as a city in 1855, by which time major textile manufacturing facilities had been constructed along the Saco River bank. The developing mill town also had granite quarries and brickyards, in addition to lumber and grain mills. The mills remained prevalent throughout the 19th and 20th centuries, with the City's last remaining textile company closing in 2009.

Land use in the Thatcher Brook watershed continued to change throughout the 20th century, resulting in further conversion of forested areas to residential development and larger farms. By the middle of the 20th century farming was prevalent, as evidenced by aerial photos from the period which show large expanses of open fields with relatively sparse residential development in the central part of the watershed and denser development along the US Route 1 corridor (see **Figure 6**, Aerial Photography Circa 1990). However, by the latter part of the 20th century and early part of the 21st century nearly all the farm land in the Biddeford portion of the watershed had been converted to either residential or commercial development (see **Figure 7**, Aerial Photography Circa 2012). A similar conversion of farm land to residential development occurred in Arundel, though to a lesser extent since there is less residential development in the watershed and there are still several agricultural operations.

3.5.2 CURRENT LAND USES

Thatcher Brook watershed land use remains predominantly undeveloped (see **Figure 8**, Land Use Types), even with the development experienced in the latter 20th and 21st centuries. Forested areas in both Biddeford and Arundel are the most prevalent land cover type and comprise approximately 1,729 acres (or 38%) of the watershed. Wetlands interspersed throughout both communities cover approximately

782 acres (or 17%) of the watershed, based on hydrologic soil group classifications obtained from the NRSC Web Soil Survey. Scrub-shrub/grass and agricultural land uses occupy about 180 acres (4%) and 114 acres (2%) of the watershed, respectfully. The remaining 36 acres (1%) of undeveloped land area is occupied by various other uses (capped landfill, gravel pits, etc.).

The majority of the developed areas are located in Biddeford with the low and medium density development consisting mainly of residences and the open space development consisting of recreational facilities, cemeteries, and schools (see **Table 2**). The high intensity development consists mainly of public roads, including Interstate 95 (Maine Turnpike), US Route 1 (Portland Road), and State Route 111 (Alfred Road), as well as several commercial and institutional land uses.

Table 2. Development Summary.

Development Type	Percent Impervious	Acreage	Percentage of Watershed
Developed, Low Intensity	20-49%	533	12%
Developed, Open Space	<20%	522	11%
Developed, Medium Intensity	50-79%	395	9%
Developed, High Intensity	80-100%	272	6%
Undeveloped			62%

3.5.3 FUTURE LAND USE

Both watershed communities have zoning ordinances which provide specific guidance for reasonable development, encourage growth in the most appropriate areas, and conserve natural resources. In general, the Thatcher Brook watershed consists of approximately 54% residential and rural farm municipal zoning districts, with the remainder of the land area being comprised of industrial, business, and commercial/medical municipal zoning districts (see **Figure 9**, Municipal Zoning).

The Biddeford portion of the Thatcher Brook watershed is predominantly rural farm and residential uses with a variety of industrial and commercial uses clustered around the major roads that traverse the watershed (see **Figure 9**, Municipal Zoning). **Table 3** summarizes the municipal zoning present in Biddeford's portion of the watershed.

Table 3. Biddeford Zoning Summary.

Zoning District Name	Zoning Code	General Description	Acreage	Percentage of Biddeford's Watershed
Rural-Farm	RF	Allows for agricultural and residential uses, and under special circumstances some commercial uses	1156	32%
Industrial 1	I1	Allows for general commercial and industrial uses	623	17%
Residential 1A	R1A	Limited to small lot size single-family residential areas served by water and sewer; best characterized as in-town single-family neighborhoods	486	14%
Business 2	B2	Highway-oriented commercial areas; residential development is prohibited from this zone	422	12%
Industrial 3	I3	A gateway zone for a major entrance to the City; allows a mixture of commercial and industrial uses	400	11%
Industrial 2	I2	A more defined industrial zone that allows for selected industrial uses	192	5%
Residential 3	R3	Allows for a mixture of housing types on varying lot sizes	122	3%
Limited Rural-Farm	LRF	Area limited to nonresidential uses, such as recycling, open space, some agricultural uses, extractive operations	101	3%
Medical	M	Allows for hospitals and medical offices or other uses associated with medical facilities or occupations	68	2%

Thatcher Brook is protected by Biddeford's Stream Protection (SP) overlay district (a portion of the City's Shoreland Zone) which includes all land area within 100 feet, horizontal distance, of the normal high-water line of a stream.

The City of Biddeford has an Open Space Committee that seeks ways to protect prime open space for the benefit of all current and future Biddeford citizens. The City recognizes that open space land often contains important wildlife habitat, is adjacent to a waterbody, or is inland with maturing-growth forest or grasslands. Several large undeveloped parcels in the Thatcher Brook watershed are open, conserved, or designated for a current use such as tree growth (see **Figure 10**, Open Space and Conserved Land).

The Arundel portion of the Thatcher Brook watershed is located along the Town's northeastern boundary. This area consists of the Suburban Residential (R-2) district; the Business-Office Park-Industrial (BI) district, the Rural Residential (R-3) district, and the Community Commercial North (CCN) district (see **Figure 9**, Municipal Zoning). Both the R-2 and R-3 district have a 2-acre minimum lot size

and account for 49% and 9%, respectively, of the town's watershed land area. The R-2 and R-3 zones are the medium density residential districts in Arundel.

The BI district is comprised of the area around the northeastern portion of US Route 1. The BI district accounts for 36% of the Town's watershed land area and is currently made up of 1-acre lots. The remaining 5% of Arundel's portion of the Thatcher Brook watershed is zoned as Community Commercial North which also has a 1-acre minimum lot size and is located in the area around Route 111 at the Biddeford Town line.

Thatcher Brook is protected by Arundel's Shoreland Zone which includes all land area within 100 feet of the high-water line of a stream, or within 50 feet of the high water line of a tributary stream.

3.5.4 LAND USE EFFECTS ON THATCHER BROOK

New development typically converts the natural landscape to impervious surfaces (such as roads, sidewalks, parking lots, driveways and rooftops) that prevent rain water or snow melt from soaking into the ground. Pollutants such as petroleum products, herbicides, pesticides, fertilizers, bacteria and sediment can be mobilized from impervious surfaces during rain and snow melt events and carried to the nearest surface water without receiving any treatment to remove the toxins. Increasing the percentage of impervious cover (%IC) in a watershed is linked to decreasing stream health (Center for Watershed Protection 2003). DEP's Statewide IC TMDL Assessment uses IC as a surrogate for a measure of human disturbance as it relates to aquatic communities in streams, and to the overall health of watersheds.

As stated in DEP's Statewide IC TMDL Assessment:

- *Stormwater runoff from IC is the largest likely source of pollution and stream channel alteration to Thatcher Brook. Stormwater falling on roads, roofs and parking lots in developed areas flows quickly off impervious surfaces, and when untreated, can carry dirt, oils, metals, and other pollutants. When natural infiltration does not occur, high volumes of stormwater flow to the nearest section of the stream.*
- *Commercial development has expanded rapidly in the watershed over the last 10 years, adding acres of impervious cover which can increase the stress on the stream.*
- *Wetland and woodlands in the center of the Thatcher Brook watershed absorb and filter stormwater pollutants, and assist in the protection of both water quality in the stream and stream channel stability.*

Watersheds exceeding approximately 10-12% IC often fail to meet aquatic life criteria and narrative standards (Stanfield and Kilgore 2006; see review in MDEP 2012). The current IC for Thatcher Brook is 14%, based on impervious cover data updated in 2013 by MDEP and further refined by GZA (see **Figure 11**, Impervious Cover); however, DEP's Statewide IC TMDL Assessment concluded that in order to support Class B aquatic life use, the Thatcher Brook watershed may require the characteristics of a watershed with 8% impervious cover. Because Thatcher Brook is an impaired stream, DEP's Statewide IC TMDL Assessment recommends that the specific sources of stormwater runoff in the watershed should be investigated during the development of a watershed management plan in order to achieve the following goals:

- *Encourage greater citizen and stakeholder (such as the Maine Turnpike Authority) involvement to ensure the long term protection of Thatcher Brook;*
- *Address existing stormwater problems in the Thatcher Brook watershed by installing structural and applying non-structural best management practices (BMPs); and*
- *Prevent future degradation of Thatcher Brook through the development and/or strengthening of local stormwater control ordinances.*

3.5.5 TRANSPORTATION INFRASTRUCTURE

Roads represent approximately 27% of the total impervious cover currently within the Thatcher Brook watershed (see **Figure 11**, Impervious Cover). Public roads are an essential component of the built environment and are closely linked to adjacent land use development patterns. A significant amount of the polluted stormwater runoff generated in the watershed is conveyed along transportation corridors, either through underground stormwater conveyances or road side ditches. The vehicles that travel public roads can also be a source of pollutants (e.g., petroleum products, heavy metals, etc.) as well as winter maintenance activities (e.g., road salt and sand). Higher traffic volumes potentially increase the amount of pollutants generated from public roads and also increase the likelihood of pollutants from vehicles and winter maintenance activities (e.g., plowing, sanding/salting). A particular concern in freshwater streams is road salt, due to its adverse impacts on aquatic organisms. Winter road salt application is typically higher on arterial roads to meet public expectations for travelling conditions. The Biddeford Municipal Airport is also within the watershed. However, airport surfaces are not treated with salt and do not generate the automotive associated contaminants typical of highway runoff, because plane traffic on the runways is minimal compared to automotive traffic on the roadways.

There are approximately 30 miles of public roads within the Thatcher Brook watershed (see **Figure 12**, Traffic Volumes) and just under half of them (47%) have relatively low traffic volumes (less than 10,000 vehicles per day). These less traveled roads are not as likely to generate stormwater pollutants as the two most heavily traveled roads in the watershed. Interstate 95 (The Maine Turnpike) and Route 111 have traffic volumes well in excess of 20,000 vehicles per day with sections of these roads approaching, and at times reaching, an annual average traffic count of 35,000 vehicles per day. While a traffic count of 30,000 vehicles per day is generally recognized as the threshold at which pollutants from public roads become problematic, lower traffic volumes can still contribute to water resource degradation (ODOT 2006). The Portland Area Comprehensive Transportation System (PACTS) and local transportation plans do not anticipate the addition of new public roads over the next couple decades (PACTS 2010). However, new development and redevelopment will likely occur within the region and have the potential to increase the amount of traffic on the public roads located in the watershed.

In addition to winter maintenance activities, the City of Biddeford, Town of Arundel, Maine Department of Transportation (MaineDOT) and the Maine Turnpike Authority (MTA) are responsible for maintaining the public roads that traverse the watershed. These maintenance activities include:

- Street sweeping and catch basin cleaning
- Road surface maintenance
- Underground stormwater infrastructure repair
- Surface drainage (ditching) maintenance

- Road-side grass and weed control
- Litter and road kill removal

These maintenance activities can help reduce and control the amount of pollutants that are carried in stormwater. Routine street sweeping and catch basin cleaning are particularly important maintenance activities that remove pollutants that accumulate on public roads and in the stormwater conveyance systems before reaching nearby surface waters.

3.6 SURFACE WATER HYDROLOGY

Thatcher Brook emerges from large wetland areas in Arundel and Biddeford, beginning as two narrow tributaries to Upper Thatcher Brook in Arundel and three small tributaries to Richardson Brook in Biddeford. In the upper watershed in Arundel, Upper Thatcher Brook flows through large emergent and scrub-shrub wetlands, primarily associated with rural residential and agricultural properties. Tributaries to Richardson Brook in Biddeford originate from emergent and scrub-shrub wetlands and border the Biddeford Municipal Airport. Richardson Brook then flows northwesterly under Route 1, railroads, the Biddeford Connector Road, and Route 111 before converging with Upper Thatcher Brook. At the confluence of Upper Thatcher Brook and Richardson just south of Route 95, the stream is referred to as Lower Thatcher Brook. In Lower Thatcher Brook, the stream transitions into a wide riparian system and is a tributary to the Saco River. The Thatcher Brook watershed totals approximately 4,525 acres in the City of Biddeford and Town of Arundel.

3.7 GROUNDWATER RESOURCES

In order to properly evaluate and protect surface water within the Thatcher Brook watershed, groundwater and subsurface hydraulic conditions must be considered. Groundwater and surface water interact in both recharge and discharge areas within the watershed. Groundwater recharge area protection is critical to restoring and maintaining water quality within Thatcher Brook and its tributaries because the process of infiltration purifies the surface water and contributes to the stream base flow during dry weather conditions.

In general, the “watershed” for groundwater is the same as the surface watershed, meaning that surface water infiltrated within the watershed contributes to stream baseflow within the same watershed. Typically, infiltration/groundwater recharge areas are located in uplands and often within the topographically higher areas on the periphery of a watershed. In watersheds where the boundary is affected by anthropogenic activities, groundwater recharge areas may be situated outside of the watershed boundary. Permeable geologic strata that do not follow local topography will also impact a watershed’s groundwater recharge.

In the case of the Thatcher Brook watershed, groundwater recharge areas are assumed to be located along the watershed boundary. The Maine Geological Survey has not identified any significant sand and gravel aquifers within the Thatcher Brook watershed, and there is no anticipated future drinking water exploration within the watershed. Biddeford residents receive drinking water from The Maine Water Company, which sources its water from Saco River.

4.0 WATERSHED CONDITIONS

4.1 STREAM CLASS & CRITERIA

The State of Maine has had a water classification system since the 1950s. The current classification system identifies four classes for freshwater rivers and streams including Class AA, A, B, and C. The Maine Legislature (Title 38 MRSA 464-468) has enacted water quality classification standards for all surface waters, which establishes water quality goals for surface waters of each classification. This classification system is used to direct the State in its management of surface waters, to protect the quality of these waters for their intended purposes, and to direct the state to enhance the quality of waters where standards are not being achieved. All four classes of freshwater rivers and streams must attain minimum fishable-swimmable standards established by the federal Clean Water Act. However, the four classes represent a hierarchy of risk. This hierarchy ranges from Class AA streams, which are in the most natural condition and have the highest water quality criteria, to Class C streams, which are considered good quality but have a higher risk of degradation.

Thatcher Brook, including the Richardson Brook, Upper Thatcher Brook, and Lower Thatcher Brook segments) are designated as Class B by the MDEP (MRSA Title 38, Chapter 3). Class B streams must support aquatic life and be of such quality as to be suitable for other designated uses including drinking water, agriculture, industrial process and cooling water supply, hydroelectric power generation, navigation, fishing, and recreation. Class B streams must also be of sufficient quality to support all aquatic life indigenous to the receiving water without causing detrimental changes in the resident biological community. In addition, Class B streams must meet specific criteria for dissolved oxygen, bacteria, habitat and aquatic life. The following table summarizes the Water Quality standards that are applicable to Thatcher Brook:

Table 4. Maine Streams Classifications, Designated Uses, and Criteria.

	Designated Uses	Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria
Class B	Aquatic Life; Drinking Water after treatment; Fishing; Agriculture; Recreation; Navigation, Hydropower; Industrial Discharge	Dissolved Oxygen 7 ppm and 75% saturation E. coli bacteria 64/100 millileter (g.m.*) or 236/100 milliliter (inst.*)	Unimpaired	Discharges shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes to the resident biological community. **

* "g.m." means geometric mean and "inst." means instantaneous level

**Determined using numeric biocriteria through MDEP's Biological Monitoring Program

According to the current Integrated Water Quality Monitoring and Assessment Report, Thatcher Brook does not meet Class B designated uses and criteria for bacteria or aquatic life. Specifically, it is listed as impaired because they do not provide for aquatic life based on benthic macroinvertebrate assessments.

4.2 STREAM ASSESSMENTS

For the last 14 years, a number of water quality and biological assessments have been conducted in the Thatcher Brook watershed (see **Table 5**). **Figure 13** depicts the approximate locations of the monitoring sites used for these assessments. The following subsections summarize the available data, highlight the areas of and potential causes of the impairment, and identify possible future problems.

Table 5. Assessments in the Thatcher Brook Watershed.

Assessment Type	Completed By	Date
Macroinvertebrate Monitoring	MDEP and GZA*	2000, 2004, 2005, 2010, 2012, 2013*
Hydrologic and Hydraulic	HNTB Corporation	2011, revised May 2014
Rapid Geomorphic Assessment	GZA in association with MDEP and the City of Biddeford	2013
TMDL Assessment Summary	MDEP	
Fish Barrier Assessment Stream Crossing Inventory	Maine Stream Habitat Viewer GZA	2009 and 2010 2014 (to supplement data available through the Maine Stream Habitat Viewer)
Stream Survey Data (to supplement RGA)	City of Biddeford	2013
Water Quality Data Collection	MDEP, City of Biddeford, and GZA	2000, 2001, 2004, 2005, 2010, 2012, 2013, 2014

4.2.1 BIOLOGICAL ASSESSMENTS

Based upon the various Biological Assessments conducted within Thatcher Brook systems since the year 2000, the brook has consistently met aquatic life standards only within a portion of Lower Thatcher Brook based on samples collected during 2000, 2005, and 2010. Other portions of Thatcher Brook do not meet Class B standards for aquatic life. As a result, conditions for aquatic life are more favorable in the lower portion of the watershed. The following sections detail the biological assessments completed in the Thatcher Brook Watershed since 2000.

4.2.1.1 AQUATIC MACROINVERTEBRATE ASSESSMENTS

MDEP Rock Bag Assessments

The MDEP's Biological Monitoring Program (also known as the Biomonitoring Program) collects and analyzes aquatic macroinvertebrate samples from Maine's rivers, streams, and wetlands on an ongoing basis. The benthic macroinvertebrate community is used as an indicator of the general state of aquatic life and samples are collected to determine if water bodies are attaining aquatic life use criteria. The Biomonitoring Program uses a linear discriminate statistical model to determine if rivers and streams are meeting the aquatic life criteria associated with the assigned legislative water quality classification (AA, A, B, or C) of individual water bodies.

The standard protocols employed by MDEP in streams and rivers include installing three substrate samplers (e.g. rock bags) at each station for a period of 28 +/- four days between July 1 and September 30. Over the course of the sampling period, the rocks in the samplers become colonized by macroinvertebrates. At the end of the 28 +/- sampling period, macroinvertebrates from the samplers

are removed and sent to a qualified laboratory for identification. The data set is then run through one four-way and three two-way statistical decision models for water quality classification. Variables evaluated in the four-way model include total mean abundance, generic richness (number of insect genera), Plecoptera (stonefly) mean abundance, ephemeroptera (mayfly) mean abundance, Shannon-Wiener generic diversity, Hilsenhoff Biotic Index, relative Chironomidae (midge) abundance, relative Diptera (fly) richness, and *Hydropsyche* (spotted caddisfly) mean abundance (see Davies and Tsomides 2002).

Between the years of 2000 and 2013, the Biomonitoring Program collected samples from five different stations (i.e. locations) in Thatcher Brook and associated wetlands (see **Table 6**). Due to budgetary constraints, individual stations cannot be assessed every year. However, samples collected during 2004, 2012, and 2013 in Upper and Lower Thatcher Brook indicate that the brook is not meeting Class B standards for aquatic life use criteria. Specifically, samples did not meet standards at station TH1 (near Kohl's) and within a wetland near Walmart. However, samples in a downstream reach of Lower Thatcher Brook have consistently met Class B standards since 2000.

Table 6. Summary of MDEP Macroinvertebrate Assessments within the Thatcher Brook Watershed (see Data in Appendix A).

Year	Station ID: TH3, B1 Sterling Rope *Richardson Brook*	Station ID: TH2, B2 Medical Center Dr. *Richardson Brook*	Station ID: W-43 Walmart Wetland *Upper Thatcher*	Station ID: TH1 Below Kohl's *Lower Thatcher*	Station ID: S-451 Downstream of C2 *Lower Thatcher*
2000	N/A	N/A	N/A	N/A	Attained class
2004	N/A	N/A	N/A	Non-attainment	N/A
2005	N/A	N/A	N/A	N/A	Attained class
2010	N/A	N/A	N/A	N/A	Attained class
2012	Indeterminate	Indeterminate	N/A	Non-attainment	N/A
2013	Indeterminate	N/A	Met Class C (not B)	N/A	N/A

Macroinvertebrate samples collected in Richardson Brook during 2012 and 2013 were rated as "Indeterminate" by MDEP due to low numbers of macroinvertebrates collected in the samples. Mean abundance (average per bag) must be at least 50 individuals and generic richness (number of genera or insect groups) must be at least 15 to make a determination relative to aquatic life use.

To provide supplemental data, GZA, in consultation and cooperation with the City of Biddeford and MDEP, collected additional macroinvertebrate samples during 2013. The previously sampled MDEP stations were selected for long-term comparative purposes within Thatcher Brook. In addition, one representative station was chosen in Upper Thatcher Brook to complete macroinvertebrate sampling in all three subwatersheds. Due to the "Indeterminate" status within Richardson Brook, GZA recommended d-frame net sampling to augment the existing MDEP data. In situations where habitats of a stream vary from higher-gradient cobble dominated habitats to low-gradient silty substrates, the Mid-Atlantic Coastal Streams Workgroup recommends d-frame net sampling within streams to properly assess multi-habitats (Barbour et al. 1999). D-frame net sampling is not intended to be directly compared to rock bag data, but is useful in generating macroinvertebrate metrics (i.e. measurements of community structure and diversity) where rock bags may poorly sample stream habitats. Individual

macroinvertebrate metrics can then be compared over time to supplement rock bag data. D-frame net sampling also provides an active way for communities and schools to investigate and monitor the health of their streams.

GZA completed d-frame net macroinvertebrate sampling according to EPA's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999) and the EPA Wadeable Streams Assessment Quality Assurance Project Plan (USEPA August 2004). At each station, 20 dipnet "sweeps" were distributed throughout the microhabitats of a reach and combined into one sample for analysis purposes. Samples were then preserved, sorted, and identified to the lowest possible taxonomic level according to EPA RBP protocols and quality measures. Raw metric scores for EPAs "best candidate metrics" were calculated (see **Table 7**).

View of macroinvertebrate sampling and larval dragonfly (*Hagenius* spp).
This species (right photo) is adapted to utilize leaf litter microhabitats in woodland streams.

Table 7. Summary of Macroinvertebrate Metrics from the 2013 D-frame Net Sampling within the Thatcher Brook Watershed.

Metric	Predicted Response to Increasing Degradation	Station ID: TH3, B1 Morin St *Richardson*	Station ID: TH2, B2 Medical Center Dr. *Richardson Brook*	Station ID: A2 Easy Street *Upper Thatcher Brook*	Station ID: A3, TH1 Below Kohl's *Lower Thatcher*	Station ID: C2 near S-451 *Lower Thatcher* [1]
Total No. Taxa	Decrease	34	32	21	27	33
No. Mayfly Taxa	Decrease	0	3	3	5	6
No. Stonefly Taxa	Decrease	0	0	0	0	0
No. Caddisfly Taxa	Decrease	6	3	2	2	4
% EPT* Taxa	Decrease	21.2	28.2%	6%	28.2%	41.6%
No. Intolerant Taxa	Decrease	7	5	3	3	4
% Tolerant Organisms	Increase	11.5%	23.9%	38.5	38.5%	28.3
% Dominant Taxon	Increase	27-47%	23.9%	26.5%	12%	16.8%
% Grazers and Scrapers	Decrease	45.10%	20.5%	14%	9.4%	29.2%
No. of Clinger Taxa	Decrease	15	18	7	8	18
% Clingers	Decrease	70.8%	64.1%	20%	35.9%	47.8%
Hilsenhoff Index (for organic pollution)	Increase	3.81	2.44	1.63	2.14	3.51

*EPT – refers to the total number (or percentage of taxa) of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) within a sample. This group of organisms is considered sensitive to pollution and habitat conditions as a whole, although individual taxa vary in their responses.

1. Surrogate Reference or Passing Condition in Stream Based on MDEP samples.

Based on the d-frame net sampling, Station C2 in Lower Thatcher Brook (similar to the nearby MDEP station S-451) contains a well-balanced macroinvertebrate community. Compared to the other stations, Station C2 has a relatively high diversity of macroinvertebrates and contains the highest percentage of mayflies and caddisflies, which are considered sensitive to environmental conditions as a group. The station also has a relatively balanced macroinvertebrate community based on the percentage of the dominant taxon (i.e. dominant macroinvertebrate group).

Of the stations that have been previously coded as Indeterminate for meeting aquatic life use criteria for Class B standards (i.e. stations B1 and B2), Station B1 (Morin Street) had relatively high diversity based on total number of taxa. However, this station had a lower percentage of mayflies, suggesting that environmental conditions are not as conducive to this sensitive macroinvertebrate group, compared to other assessed reaches.

Station B2 near Medical Center Drive (an "Indeterminate" ranked station) exhibited high diversity (total number of taxa), a high percentage of clinger taxa, as well as moderate diversity in mayfly and stonefly diversity. During site evaluations, the team noted significantly higher numbers of macroinvertebrates, including mayflies, within the small narrow sections of the stream containing rocky substrates or wood. Very few macroinvertebrates were observed in the silty/clay pools of the reach. For this reason, in-stream habitat restoration is likely important in this reach to improve aquatic life use scores.

View of fishfly observed in Station B2.

Station B2 has an excellent buffer but poor instream features.

Station A3 (near TH1) has failed to meet MDEP attainment criteria for macroinvertebrates in both 2004 and 2012. During 2013, based on d-frame net sampling, station TH1 had moderate values for diversity and percent EPT taxa. It also had the highest numbers for percent of tolerant organisms and lowest percentages for percent grazers and scrapers, as well as a very low number of clinger taxa. This suggests that environmental conditions are not ideal for macroinvertebrates. Based on the RGA evaluation (see Section 4.2.2.2), this station is highly altered and has impaired habitat conditions. As a result, this station is a high priority site for habitat restoration.

4.2.1.2 FISHERIES AND BROOK TROUT POPULATION

The aquatic life criterion requires that all stream classes support native indigenous fish species, and brook trout (*Salvelinus fontinalis*) are considered indigenous to Maine streams. Brook trout historically were considered the most abundant and ubiquitous coldwater game fish in Maine. Brook trout also represent a good surrogate of general fisheries health as their local distribution is limited primarily by high water temperature, and other factors such as stream connectivity, which are generally impacted by watersheds with increasing impervious cover. However, it is also recognized that natural unimpaired streams also have variable habitat conditions, some of which may be less conducive and supportive of brook trout, so it is important to factor out natural variability from anthropogenically induced habitat changes. The Maine Department of Inland Fisheries & Wildlife have routinely stocked Thatcher Brook with brook trout and stocking has occurred recently in 2010, 2011, 2012, 2013, and 2014.

Brook trout require clean, cool, well-oxygenated water and appropriate spawning, nursery, and adult habitat to thrive. From a broad landscape scale, they are habitat generalists and utilize lake, stream, and marine/estuarine habitats. However, this species has very specific in-stream habitat preferences. Adults generally spawn in gravelly substrate over areas of upwelling ground water in the fall (approximately late September to November). As part of spawning, females dig shallow pits and cover their eggs with gravel after fertilization. The eggs remain in the pits over the winter, and the action of water moving through the gravel prevents eggs from becoming buried and smothered in fine sediments. The action of stream currents over the eggs also prevents the eggs from freezing, and provides the eggs the necessary dissolved oxygen for survival. The eggs hatch in early spring. Although brook trout are opportunistic feeders, they rely heavily on aquatic and terrestrial insects for food.

Threats to brook trout and other native species include habitat degradation, habitat fragmentation (e.g. via dams or hanging culverts), unauthorized introduction of native fish, and poor water quality. Brook trout require waters with average temperatures up to approximately 68˚ F (20 ˚C) and can inhabit waters with temperatures up to approximately 75 ˚F (24 ˚C). According to the Maine Department of Inland Fisheries & Wildlife, brook trout will decline in waters that have temperatures in excess of 20 ˚C or dissolved oxygen levels under 5 ppm for extended periods. Water temperatures of 25 ˚C or greater are considered harmful.

Based on the data to date, although portions of the stream corridor lack gravelly substrates and are slow moving, the majority of Thatcher Brook has water temperatures favorable to brook trout (see **Table 8**). The favorable temperatures observed throughout a majority of the watershed are likely due to the favorable vegetated areas (e.g. buffers) that provide stream shading currently present throughout much of the watershed. The presence of vegetated corridors is a positive attribute of the watershed, and should be maintained in the future to protect fisheries habitat, and serve to maintain and improve dissolved oxygen values for fish and other aquatic life. It should be noted that much of the water temperature data was taken opportunistically, and does not necessary represent a persistent condition in the sample location. Brook trout can and do adjust their location based upon environmental barriers. As a result, an episodic exceedance of 25 C does not necessarily impact trout if cooler water is located nearby.

Table 8. Stream Temperature Data.

Station	Location	Subwatershed	Mean Water Temperature (˚C) >25 = trout impacts	Max Water Temperature (˚C) >25 = trout impacts	Exceedance?
TH8A	Eastern Trail Trib	Richardson	19.90	25.3	No/Yes
S-978, TH3	Sterling Rope	Richardson	18.6	21.7	No
TH4	Biddeford Spur	Richardson	18	21.85	Yes
S-979, TH2	Medical Center Dr.	Richardson	17.17	21.56	---
TH8	Route 111	Richardson		21.3	No
TH8A	Ditch (near Route 111)	Richardson		19.8	No
TH9	Biddeford Spur	Richardson		20.9	No
TH10	Route 1	Richardson	18.5	19.6	No
TH11	Iron Trail Road	Richardson		21.6	No
TH12	Above Landry	Richardson	21.1	21.5	No
RPR	Park n' Ride	Richardson	20.5	25	No
S-450	Old Alfred Rd.	Upper	20.83	26.6	No/Yes
Bacteria Site 2	Mountain Rd.	Upper	19.08	22.5	No
A2	Easy Street	Upper	20.45	20.8	No
W-43	Walmart wetland	Upper	20.46	24.5	No
TH6	Route 111	Upper	16.54	23.08	No
S-746, TH1	Below Kohls	Lower	19.88	21.8	No
TH5A	Kohls Trib	Lower	17.64	23.65	No
TH5B, A3	Above Kohls Trib	Lower	16.53	22.04	No

Station	Location	Subwatershed	Mean Water Temperature (˚C) >25 = trout impacts	Max Water Temperature (˚C) >25 = trout impacts	Exceedance?
TH5C	Below Kohls Trib	Lower	18.10	22.8	No
Bacteria Site 6	Springbrook Dr.	Lower	19.86	24.2	No
C2	Off Barra Road	Lower	21.25	22.4	No
S-451	Downstream of C2	Lower	20.88	23.6	No
TH7	South Street	Lower	16.86	21.84	No

4.2.2 STREAM HABITAT AND GEOMORPHIC ASSESSMENTS

Summaries of the stream habitat and geomorphic assessments that have been completed in the Thatcher Brook watershed are presented in the following sections. Detailed discussion, links to other reports (where available), and detailed assessment methodologies are presented in Appendix A.

4.2.2.1 FISH BARRIER ASSESSMENT

The Maine Department of Agriculture, Conservation, and Forestry maintains data on public road, trail, and railroad crossings and this information is available through the Maine Stream Habitat Viewer. The data set provides information on stream crossings including culvert/bridge material and size. In addition, the data set classifies crossings as one of three categories (i.e. barrier, potential barrier, or no barrier) based on whether the structure is perched (barrier), blocked greater than 50% of the channel (barrier), or shows signs of scour and erosion (e.g. potential barrier). GZA completed a survey of 40 stream crossings in the watershed during September 2014 to supplement and enlarge the Habitat Viewer data set. Recent aerial photography was reviewed to target areas for assessment and identify potential stream crossings. During site evaluations, culvert size and stream width was approximated, and crossings were photographed to assess general habitat conditions across the watershed. This data set does not include small trail crossings and private property areas not easily visible on aerial photographs.

Based on the combined data sets, there are over 51 stream crossings in the Thatcher Brook watershed (see **Table 9** and **Figure 14**, Fish Barrier Assessment). Of these, 40 were rated using the barrier criteria developed by the State of Maine. Of the 40 assessed crossings, six (15%) are rated as barriers to aquatic life and 31 (78%) are rated as potential barriers.

Table 9. Fish Barriers in Thatcher Brook.

Culvert ID	Location	Comments	Approx. Channel Width	Barrier Class
1	Jeffs Way	48" CMP, hanging culvert	8-10'	Barrier
2	Cote Dr	24" CMP	4' wetland	Barrier
3	I-95	60" Concrete	6-11'	Barrier
4	Old Alfred Rd	60" CMP; Eroded inlet	~3'	Potential Barrier
5	Old Alfred Rd	72" CMP	Wetland	Potential Barrier
6	Mountain Rd	36" plastic with outer CMP	8'	Potential Barrier
7	Briar Ln	5 culverts: 1x18" RCP, 3 x 2' Corr plastic, 1 x 2' plastic	Obscured	Barrier
8	Bass Ln	48" CMP	6'	Potential Barrier
9	Terry Ln	2 x 24" CMP	6'	Potential Barrier
10	Alfred St (Rte 111)	36" CMP	5-6'	Potential Barrier
11	Alfred St (Rte 111)	36" concrete	No real channel	Potential Barrier
12	Alfred St (Rte 111)	48" concrete	4-5'	Potential Barrier
13	I-95	Twin 8' wide x 5' tall metal arch	12' upstream	Potential Barrier
14	Alfred St (Rte 111)	5.5' wide x 7' tall metal arch	~12'	Potential Barrier
15	Biddeford Spur	86" CMP	17'	Potential Barrier
16	Biddeford Spur	7' metal arch	12'	Potential Barrier
17	Railroad	5' tall x 4' wide granite box w/ concrete bottom	14'	Potential Barrier

Culvert ID	Location	Comments	Approx. Channel Width	Barrier Class
18	Portland Rd (US Rte 1)	4' concrete box	-10'	Potential Barrier
19	Railroad	5' tall x 3' wide concrete box	3'	Potential Barrier
20	Proctor Rd	48" CMP	3'	Potential Barrier
21	Roxanes Way	18" plastic, 36" metal	3'	Potential Barrier
22	Proctor Rd	36" plastic	5'	Potential Barrier
23	Elm St (US Rte 1)	6.5" tall x 5.5' wide concrete box	10'	Potential Barrier
24	Landry St	36" x 22" arch	3'	Barrier Potential
25	Hill St	2x3' CMP	3' ditched	Potential Barrier
27	Hill St	36" CMP	3'	Barrier
28	Grayson St	36" RCP	2'	Potential Barrier
29	Alfred St	18" plastic	3'	Potential Barrier
30	SMMC Entrance	36" CMP	Wetland	Potential Barrier
31	South St	15' wide x 10' tall metal arch	18'	Potential Barrier
32	Main St	12' tall x 26' wide granite block bridge	28'	Not a Barrier
33	Jessie Ln	6' plastic and 4' plastic	15' – no flow	Potential Barrier
34	Easy St	22' wide x 7' tall	22'	Not a Barrier
35	Medical Center Dr.	17' CMP	17'	Potential Barrier
41	Landry St.	16" CMP	Not available	Potential Barrier
42	Marcel Ave	24"	Not available	Potential Barrier

Culvert ID	Location	Comments	Approx. Channel Width	Barrier Class
43	Marcel Ave	24”	Not available	Potential Barrier
45	Hill St	Not Available	Not available	Potential Barrier
46	Hill St	RCP	Not available	Potential Barrier
47	Granite St Ext	Not Available	Not available	Potential Barrier
48	I-95	Not Available	Not available	Potential Barrier
49	I-95	Not Available	Not available	Potential Barrier
50	Trail	Not Available	Not available	Potential Barrier
51	Hill St	18” plastic corrugated	3’ wide	Potential Barrier

Note: The hydrography layer was recently updated, which influences and increases the number of stream crossings in the watershed.

View of Stream Crossing 7, which contains five different culverts.

4.2.2.2 RAPID GEOMORPHIC ASSESSMENT

Fluvial geomorphology is the science that assesses the shape and form of watercourses through an evaluation of the physical processes that relate to water and sediment transport. Although all streams change over time, human alteration of channels can destabilize the natural equilibrium in stream systems and cause excessive stream and bank erosion. In addition, increases in impervious surface can cause significant increases in peak runoff or increases in the amount of sediment reaching a stream.

Stream instability also directly affects stream habitat conditions by filling in important interstitial spaces between rocks, which serve as microhabitats to fish and other aquatic life. While sediment transport is a normal and important action of all streams which preserves aquatic habitat characteristics, sedimentation caused from excessive erosion and anthropogenic sources can alter water chemistry through the addition of pollutants and alteration of flow regimes. Historic alterations to stream channels (e.g., straightening and widening) can also slow down stream flow, which can also impact stream habitat and dissolved oxygen levels.

Applying Rapid Geomorphic Assessments (RGA) to stream reaches in watershed planning provides important information on channel stability, stream condition, and flow dynamics. Basic geomorphic information informs restoration efforts, and provides important baseline information on restoring and rehabilitating stream channel reaches. The RGA employed in this study provides a screening tool for the general stability and overall condition of assessed reaches, identifies areas of excessive bank erosion within assessed areas, and provides baseline data to target areas for more detailed assessments.

During July and August 2013, GZA, MDEP, and the City of Biddeford completed a RGA assessment of the stream reaches in the watershed utilizing the protocols outlined in "Stream Survey Manual: A Citizen's Guide to Basic Watershed, Habitat, and Geomorphology Surveys in Stream and River Watersheds – Volume I" published by the Maine Department of Environmental Protection. The RGA included an assessment of five key reaches (i.e. at Stations A2, A3, B1, B2, and C2) which were intentionally distributed within all three subwatersheds to provide basic geomorphic information on Upper Thatcher Brook, Richardson Brook, and Lower Thatcher Brook. Within each station, a Rapid Geomorphic Assessment data sheet was completed to assess four components of stream instability including: aggradation, degradation, widening, and planimetric form adjustment. The assessment yields a stability index score which provides a rating of the general condition of the assessed stream reach (see **Table 10**).

Table 10. Summary of Rapid Geomorphic Assessment Results.

RGA Parameter	A2 Easy Street *Upper Thatcher*	B1 Sterling Rope *Richardson Brook*	B2 Medical Center Dr. *Richardson Brook*	A3 Kohls *Lower Thatcher*	C2 Behind Barra Rd *Lower Thatcher*
Evidence of Aggradation	0.22	0.22	0.45	0.56	0.11
Evidence of Degradation	0.29	0.43	0	0.57	0
Evidence of Widening	0.13	0.38	0.63	0.88	0.63
Evidence of Planimetric Form Adjustment	0	0.14	0.57	0.14	0
Overall Stability Index Score	0.16	0.29	0.41	0.54	0.19
Condition Assessment	"in regime"	"in transition or stressed"	"in adjustment"	"in adjustment"	"in regime"

Note: The stability index is calculated to assess overall reach stability. Reaches identified as "in regime" ($\leq$ 0.20) are considered to be in reference or "good" condition. Reaches identified as "in adjustment" are considered to be in fair condition that have experienced changes in channel form and provide riparian habitat that may lack certain bed features and channel forms due to increases or decreases in the rate of erosion and deposition-related processes. Reaches identifies as "in transition or stressed" are considered to be in poor condition that are experiencing adjustment outside the expected range of natural variability and contains habitat that may be frequently disturbed beyond the range of many species adaptability (from Vermont Agency of Natural Resources 2004 In Maine Department of Environmental Protection 2009).

View of Thatcher Brook team completing stream measurements.

Based on the results of the RGA, the stream reaches within the watershed vary from "in regime" to "in transition or stressed" and the subwatersheds contain stream reaches with varying levels of alteration and overall stability. Station C2 (Lower Thatcher Brook), which has met attainment for aquatic use, is considered in regime. Station A3, which has failed to meet attainment, was rated as "in transition." Stations B1 and B2, which have been classified as "Indeterminate" for aquatic life were rated as "in transition or stressed" and "in transition," respectively. As a result, all stations with poor macroinvertebrate scores show signs of stream instability including aggradation, degradation, widening, and/or planimetric form adjustment.

View of Station A3.

4.2.2.3 STREAM HABITAT SURVEY

To meet water quality standards, Class B streams must provide habitat for fish and other aquatic life. To support fish and other aquatic life, stream habitat should include a diversity of benthic (i.e. stream bed) habitats including a wide variety of pools, fast flowing riffles, large woody debris, overhead tree canopy and a stable stream bottom. As watersheds become more urbanized, stream habitat is often degraded and destabilized. Habitat assessments provide valuable information on possible areas requiring habitat restoration, and serve to identify the specific habitat parameters that may need to be addressed to support a diverse natural aquatic community.

During July and August 2013, GZA, MDEP, and the City of Biddeford completed a Stream Rapid BioAssessment (RBA) habitat assessment of various stream reaches within the watershed utilizing the protocols outlined in the EPA, Rapid BioAssessment Protocols (Barbour et al., 1999.). The habitat assessment, like the RGA, included an assessment of five key reaches (i.e. at Stations A2, A3, B1, B2, and C2) which were intentionally distributed within all three subwatersheds to provide basic geomorphic information on Upper Thatcher Brook, Richardson Brook, and Lower Thatcher Brook. Within each station, a Habitat Assessment Field data sheet was completed to assess 10 habitat components including epifaunal or stream substrate, pool substrate, pool variability, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, vegetative protection, and riparian zone width. The assessment yields a score for each habitat parameter, as well as a total score for each reach and provides a straightforward method of evaluating reaches over time (see **Table 11a** for classification of scores and **Table 11b** for the results of this study).

Table 11a. Rapid BioAssessment Habitat Scoring Ranges.

Scoring	Poor	Marginal	Suboptimal	Optimal
Score for each Habitat Parameter	0 - 5	6 - 10	11 - 15	16 - 20
Total Score (sum of all parameters)	< 50	51 - 100	101 - 160	161 – 200

Table 11b. Rapid BioAssessment Results for Thatcher Brook System.

EPA Habitat Parameter	A2 Easy Street *Upper Thatcher*	B1 Sterling Rope *Richardson Brook*	B2 Medical Center Dr. *Richardson Brook*	A3 Kohls *Lower Thatcher*	C2 Behind Barra Rd *Lower Thatcher*
Stream substrate/Available Cover	Poor	Optimal	Marginal	Suboptimal	Marginal
Pool Substrate	Suboptimal	Marginal	Marginal	Suboptimal	Marginal
Pool Variability	Poor	Suboptimal	Suboptimal	Marginal	Suboptimal
Sediment Deposition	Optimal	Optimal	Suboptimal	Marginal	Suboptimal
Channel Flow Status	Suboptimal	Suboptimal	Suboptimal	Suboptimal	Suboptimal
Channel Alteration	Optimal	Suboptimal	Suboptimal	Suboptimal	Suboptimal
Channel Sinuosity	Marginal	Optimal	Marginal	Poor	Marginal
Bank Stability	Optimal	Suboptimal	Marginal	Poor	Suboptimal
Vegetative Protection	Optimal	Suboptimal	Suboptimal	Suboptimal	Suboptimal
Riparian Vegetative Zone Width	Optimal	Marginal	Optimal	Suboptimal	Optimal
Total Habitat Score*	Suboptimal	Suboptimal	Marginal	Poor	Marginal

*Stations with overall habitat scores within 10 points of a lower category are listed as the lower category if they have two or more categories with individual scores of less than 10 (i.e. marginal to poor scores)**.**

The stream habitat assessment revealed that overall habitat conditions range from poor to suboptimal in the assessed portions of the watershed. The specific parameters responsible for these ratings vary widely within the reaches (see **Table 11a and Table 11b**). Thatcher Brook currently has areas of optimal riparian vegetation zone width in all three sub-watersheds. Riparian vegetation is necessary to moderate stream temperatures, maintain dissolved oxygen, provide habitat and dispersal routes for adult semi-

aquatic organisms, and provide both structure and natural nutrient inputs to a stream. Like all watersheds, specific portions of the watershed contain reduced vegetation widths and these areas could be targeted for plantings or natural re-vegetation.

From a larger landscape perspective, in-stream habitat conditions (e.g. characteristics of the stream bed) within Thatcher Brook are compromised or altered in areas with seemingly good buffers (e.g. riparian vegetation width). For instance, Station B2 (near Medical Center Drive) has an optimal riparian vegetative zone, but marginal pool and epifaunal substrate (i.e. substrates available for colonization for macroinvertebrate), as well as marginal bank stability. Stations like B2 represent potential candidates for in-stream restoration. D-frame net sampling from this reach revealed that the reach has high diversity (total number of taxa), a high percentage of clinger taxa, as well as moderate diversity in mayfly and stonefly diversity. As a result, this stream segment is connected to areas with existing macroinvertebrate communities that may benefit from in-stream habitat restoration.

Station A3 (near Kohl's) exhibited the most impaired habitat conditions of all the assessed reaches. The station received the lowest score based on part on poor scores for bank stability and channel sinuosity, as well as a poor score for pool variability, and suboptimal scores for stream and pool substrate. Based on review of old topographic maps, this station is part of a larger reach that appears to have been rerouted between 1940 and 2012. As a result, the channel at Station A3 appears to have been created from past anthropogenic activities. The Station has clear ongoing erosion and poor substrates. Habitat condition is likely a major factor in poor macroinvertebrate scores/ratings identified by both MDEP in rock bags and by GZA in d-frame net samples.

Station B1 (near Morin Ave) is unique in that this station exhibited optimal stream substrates and stream sinuosity, but marginal riparian vegetation and suboptimal bank stability. This reach does not appear to require in-stream restoration but would benefit from streamside restoration in the form of bank stabilization and a wider vegetated buffer.

Station A2 (bordering Easy Street) had the highest scores for most parameters but was the only station to receive poor scores for stream substrate and pool variability. This area has a small narrow channel with a community dominated by crayfish. This area represents another possible candidate for in-stream restoration.

In addition to completing a habitat survey at rapid geomorphic sites, GZA also completed a buffer analysis of the entire watershed according to riparian vegetation zone width criteria outlined in EPA's Rapid BioAssessment Protocols (Barbour et al., 1999). Riparian vegetation zone widths were estimated using landcover data from MEGIS. Riparian vegetation zone widths were then classified as optimal (> 18 m), suboptimal (12-18 m), marginal (6-12 m) or poor (< 6 m). Approximation locations of zone widths were then calculated and totaled for the entire watershed (see **Table 12** and **Figure 15**, Vegetated Buffer Analysis). Based on the analysis, approximately 65.6% of the watershed has an optimal riparian vegetative zone width while approximately 30.7% of the watershed contains a poor riparian vegetative zone width. On the subwatershed level, the highest percentage of poor riparian vegetation zone widths is located in Thatcher Brook while Upper Thatcher Brook has the highest percentage of optimal riparian vegetation zone widths. This data set provides important information on where buffer restoration might improve water quality, and where conservation efforts might protect large unfragmented riparian zones. The data also provides a tool for assessing upland habitat connectivity in the stream corridor. In

general, habitat restoration efforts are more likely to be successful in areas that connect high quality habitats.

Table 12. Rapid BioAssessment Protocol Result for Riparian Vegetative Zone.

Riparian Vegetated Zone Width	Entire Watershed (%)	Within Upper Thatcher Brook (%)	Within Richardson Brook (%)	Within Lower Thatcher Brook (%)
Poor (< 6 m)	30.7%	49%	54%	68%
Marginal (6-12 m)	2%	3%	1%	1%
Suboptimal (12-18 m)	1.7%	3%	1%	0%
Optimal (>18 m)	65.6%	46%	44%	30%

4.2.3 WATER QUALITY ASSESSMENTS

The following sections summarize the data that has been collected in the Thatcher Brook Watershed and made available as part of the Plan. As recognized by the State of Maine, the Criterion Chronic Concentration (CCC) and Criteria Maximum Concentration (CMC) are used as comparative criteria for contaminant concentrations in surface waters. The CCC, or chronic criterion, is the highest in-stream concentration to which organisms can be exposed indefinitely without causing unacceptable effect (generally represented in the regulations as a maximum duration of 4 days every 3 years), and the CMC, or acute criterion, is the highest concentration to which organisms can be exposed for a brief period of time without causing an acute effect (represented in the regulations as a maximum duration of 1 hour every 3 years) (U.S. Environmental Protection Agency, 2012). The CCC and CMC for each constituent are provided on the applicable data tables.

4.2.3.1 DISSOLVED OXYGEN

Aquatic organisms (e.g. species with gills) respire under water and require dissolved oxygen to breath. Like fish, many larval forms of aquatic macroinvertebrates rely on dissolved oxygen for respiration. Stream ecosystems gain dissolved oxygen from the air, rainfall and runoff, through water movement over stream riffles and vertical drops which entrain air into the water, and from plant photosynthesis which produces oxygen as a byproduct. Due to photsynthesis, dissolved oxygen levels fluctuate throughout the course of the day, as well as seasonally. Warmer water is able to hold less oxygen and, therefore, oxygen levels tend to be most critical during the hottest portions of the summer. Decomposition, animal respiration, and chemical reactions consume dissolved oxygen. Lakes and streams tend to have lower dissolved oxygen levels in the early morning before the onset of daily photosynthesis since animal, plant and microbial metabolism depletes the oxygen during darkness without the benefit any new photosynthetic addition. Significantly depressed dissolved oxygen levels can affect aquatic use and lead to animal stress, mortality, or dispersal. The state criterion for Class B waters is 7 parts per million (75% saturation) to support a balanced community. Small differences below this amount (e.g. temporary values down to 5 parts per million) are not cause for concern, but frequent values below this criterion are considered detrimental for desirable aquatic stream health.

The development of this Plan has included an assessment of dissolved oxygen data from multiple sources. Opportunistic measurements were taken by MDEP from 2000 to 2010 at various stations. In addition, MDEP collected Sonde (automated sensor probe) data from July 26, 2012 to August 15, 2012. GZA collected additional dissolved oxygen samples during August and September 2012. Follow-up dissolved oxygen measurements were collected by MDEP during August 2014. Diurnal measurements

collected during 2012 were analyzed to determine the diurnal change in dissolved oxygen concentrations within stations located in each subwatershed. The data have been combined to yield minimum, maximum, and average dissolved oxygen measurements for the assessed stations (see Appendix B for complete data set).

The combined data set reveals that certain portions of the watershed routinely fail to meet Class B dissolved oxygen criteria (i.e. 7 parts per million [ppm]). Upper Thatcher Brook has a high percentage of stations that have failed to meet criteria. Station TH6 (Route 111) has had dissolved oxygen concentrations below five ppm on six separate sampling days. Additionally, none of the readings have met dissolved oxygen criteria.

Richardson Brook has average dissolved oxygen readings ranging from 2.31 ppm at Bacteria Site 1 (Eastern Trail tributary) to 8.72 ppm at TH11 (Iron Trail Road). Although a few specific sites have low dissolved oxygen readings (e.g. Bacteria Site 1 and TH10), other sites (e.g. S-979/TH2; Medical Center Drive) have consistently high dissolved oxygen readings. Further, average dissolved oxygen values within Lower Thatcher Brook are generally high with mean values ranging from 6.4 to 8.5 ppm and mean low values ranging from 4.9 to 7.38 ppm. As a result, low dissolved oxygen levels do not appear to be a consistent stressor throughout the watershed.

In certain developed reaches of the Brook, it is likely that phosphorus from stormwater contributes to low dissolved readings. High nutrients have the potential to increase photosynthetic activity, which increases the magnitude of diel fluctuations in oxygen, with more production during daylight and increased respiration and oxygen depletion during darkness. Therefore, higher productivity systems can have oxygen concentrations in water with higher maximum concentrations and lower minimum concentrations. Additional phosphorus sampling may be needed in the future in this subwatershed to determine if there are other current or historical (i.e., legacy) sources of nutrients (e.g. from agriculture).

Stormwater runoff containing higher loads of organic matter such as leaf litter can also cause additional depletion of oxygen levels by providing additional organic substrate for degradation and respiration by microbial populations, and also secondarily adding released nutrients into the system.

However, natural characteristics of the watershed may also be an important contributor to low dissolved oxygen values for portions of the Thatcher Brook system. Upper Thatcher Brook, which has the least amount of impervious surface (6%) and associated development, has the highest amount of stations regularly failing to meet dissolved oxygen criteria, which suggests that impervious surfaces and stormwater runoff may not be directly responsible. As previously noted, there are a significant amount of wetlands and hydric soils within the watershed, and this subwatershed has a very low gradient and large emergent marsh and scrub-shrub wetland areas that contain shallow standing water for much of the growing season. Such systems may well contribute to observed low dissolved oxygen values via the normal functioning of these wetland systems. While the emergent vegetation photosynthetically produces oxygen during daylight, such oxygen is released into the atmosphere through the above-water leaf structure and not into the water or stream, as performed by algae or aquatic macrophytes. However, the below water portion of the same wetlands are primarily heterotrophic (i.e., involving the respiratory depletion of oxygen via organic decomposition). Below the flooded surface soil levels, the system is anaerobic. Such heterotrophic systems would be expected to naturally deplete oxygen from

any waters passing through these wetlands. Given the high percentage presence of these flooded wetland systems in the upper watershed, it would be expected that they might have an influence on local oxygen levels.

View of wetlands bordering Thatcher Brook.

4.2.3.2 CHLORIDE AND SPECIFIC CONDUCTANCE

Chloride ion is a natural element and part of sodium and calcium chloride salts that are used in road-deicing. In high enough concentration, it is a pollutant that can alter plant communities resulting in changes in habitat, as well as creating conditions favorable for the proliferation of certain invasive species (e.g., *Phragmites*). At high enough concentrations, chloride ion can result in direct mortality of aquatic organisms. It is soluble in water. Unlike nutrients and other contaminants, chloride cannot be removed using best management practices. Elimination from the environment is principally a result of dilution. However, while it is typically diluted from surface waters, it can become a longer-term resident in groundwater when contaminated surface waters infiltrate. Effective management measures and best management practices for chloride generally involve techniques to reduce the use of chloride.

Specific conductivity, or specific conductance, is the ability of water to conduct an electrical current at 25 degrees Celsius. Because chloride ion affects water conductivity, the measurement of conductivity in the field can be an indicator of chloride when this contaminant provides the highest local signal in the field measurements. The specific conductivity measures the ionic content of water, and, in a stream with certain water chemistry, can be used as a surrogate for chloride measurements. However, sediment and other natural ions also contribute to water conductivity. To better correlate the measure of conductivity with actual chloride presence, both chloride and specific conductance data were collected during the summer of 2012 and 2014 in Thatcher Brook and analyzed with a regression analysis originally developed for Trout Brook in South Portland, Maine. Thatcher Brook and Trout Brook have similar surficial geology and soils, and the data for Thatcher Brook correlates well with the regression analysis performed for Trout Brook. As a result, the Trout Brook regression analysis was utilized to estimate chloride measurements in Thatcher Brook based upon the field measurement of specific conductance, to supplement the field samples of chloride. Additional information on the chloride regression analysis is provided in Appendix C.

Based on conductivity measurements taken within Thatcher Brook, chloride does not appear to be a widespread stressor at this point. However, during August 2014, an elevated level of chloride (260 milligrams per liter [mg/l]) was confirmed by MDEP in Lower Thatcher Brook, in a small tributary located between Kohls and Route 111 (See **Table 13**). This station is located in close vicinity to major routes and parking lots, which all function as potential sources of chloride. Salt management will become increasingly important in this area, as well as other portions of the watershed, as additional chloride is utilized on local roads and parking lots.

Table 13. 2014 Chloride Samples and Sample Locations.

Sample Location	Sample Date	Chloride mg/l
TH5C	8/6/2014	150
TH10	8/6/2014	140
Kohls Trib	8/6/2014	260*

*230 mg/l is the exceedance criterion of MDEP for surface waters.

Table 14 presents the range of maximum chloride values estimated from the chloride/conductivity regression curve). Based on the regression curve, conductivity measurements of 1000 microsiemens per centimeter [µS/cm] or greater are assumed to represent potential chloride exceedances. Assumed chloride exceedances have been noted in Lower Thatcher Brook in multiple locations near Route 111 and in the Richardson subwatershed near Route 1. Although chloride exceedances haven't been observed throughout the watershed, conductivity and chloride will be important to monitor in the future as chloride accumulates over time and can become a more widespread stressor.

Table 14. Predicted maximum chloride concentrations based on conductivity measurements.

Station	Location	Subwatershed	Date	Specific Conductance (µS/cm)	Estimated Chloride Exceedance from the Specific Conductance/Chloride Regression*
Spec. Cond. Exceedance based on Regression (µS/cm) = 1000					**230 (MDEP Criterion)**
TH8A	Eastern Trail Trib	Richardson	8/21/13	74	No
S-978, TH3	Sterling Rope	Richardson	8/6/14	546	No
TH4	Biddeford Spur	Richardson	8/6/14	471	No
S-979, TH2	Medical Center Dr.	Richardson	8/21/12	438	No
TH8	Route 111	Richardson	8/6/14	450	No
TH8A	Ditch (near Route 111)	Richardson	8/6/14	1900	Yes
TH9	Biddeford Spur	Richardson	8/6/14	447	No
TH10	Route 1	Richardson	7/1/14	**2470**	**Yes**
TH11	Iron Trail Road	Richardson	8/6/14	534	No
TH12	Above Landry	Richardson	8/6/14	878	No
RPR	Park n' Ride	Richardson	8/6/14	532	No
S-450	Old Alfred Rd.	Upper	8/21/13	538	No
Bacteria Site 2	Mountain Rd.	Upper	8/21/13	141	No
A2	Easy Street	Upper	8/15/13	186	No
W-43	Walmart wetland	Upper	6/14/01	246	No

Station	Location	Subwatershed	Date	Specific Conductance (µS/cm)	Estimated Chloride Exceedance from the Specific Conductance/Chloride Regression*
TH6	Route 111	Upper	9/13/12	541	No
S-746, TH1	Below Kohls	Lower	8/12/04	**1410**	**Yes**
TH5A	Kohls Trib	Lower	9/25/12	**1377**	**Yes**
TH5B, A3	Above Kohls Trib	Lower	8/13/14	678	No
TH5C	Below Kohls Trib	Lower	8/13/14	830	No
TH5D	Aroma Joe's	Lower	7/1/14	**1245**	**Yes**
Bacteria Site 6	Springbrook Dr.	Lower	8/21/13	459	No
C2	Off Barra Road	Lower	8/1/13	413	No
S-451	Downstream of C2	Lower	8/15/05	279	No
TH7	South Street	Lower	9/25/12	406	No

Note: Conductivity measurements have been taken during both dry and wet weather events, which may influence readings. In addition, although maximum values are presented here, measuring average conditions over a longer time period can provide valuable insight on "typical" conditions (see Appendix B for additional data).

4.2.3.3 PHOSPHORUS

Total phosphorus was collected in all three subwatersheds during 2014 in order to evaluate potential nutrient impacts to Thatcher Brook. Although phosphorus is a vital nutrient, it is typically not abundant in natural waters. Phosphorus may impact stream health through the proliferation of algae, cyanobacteria, and aquatic macrophytes. The die off and decomposition of vegetation as well as respiration during the night can reduce dissolved oxygen and cause stress and mortality in fish and other aquatic organisms. The EPA suggested criterion for phosphorus is 30 parts per billion (30 ug/L). MDEP currently does not have a formal water quality criterion for phosphorus but utilizes the EPA guidance for assessments of potential nutrient impacts on dissolved oxygen.

Phosphorus occurs in dissolved organic and inorganic forms, and attaches to sediment particles. Excess phosphorus found in runoff can be attributed to a variety of activities including over fertilization of yards and agricultural fields, sewage discharge, and construction activities. Phosphorus is also present in vehicle exhaust.

View of heavy traffic on the Interstate.

The majority of the total phosphorus data included in this plan was collected before and during storm events on May 17, 2014, July 1, 2014, July 29, 2014, August 6, 2014, and October 16, 2014. Focused sampling was also collected to help identify and bracket areas suspected of contributing excess nutrients to the stream. Data was collected by MDEP and the City of Biddeford during baseflow (pre-storm) conditions and during storm events. Phosphorus concentrations can be highest during peak "flush" events where stormwater is a primary contributor. Concentrations may also be higher during baseflow conditions, if there are baseflow sources of phosphorus. As a result, it is important to obtain phosphorus data from a range of flow conditions. Exceedances observed during baseflow conditions may be attributed to sewer leaks and illicit discharges while exceedances observed during stormflow may be attributed to stormwater. Data from various flow conditions serves to assess potential point sources of phosphorus, and focus retrofit design efforts. In 2014, the total phosphorus concentrations ranged from 10 to 300 ug/L (see **Table 15**). Each site that was assessed during storm events in 2014 had at least one sample that exceeded the EPA phosphorus criterion of 30 ug/L. As a result, stormwater was considered to be one source of observed phosphorus in the watershed.

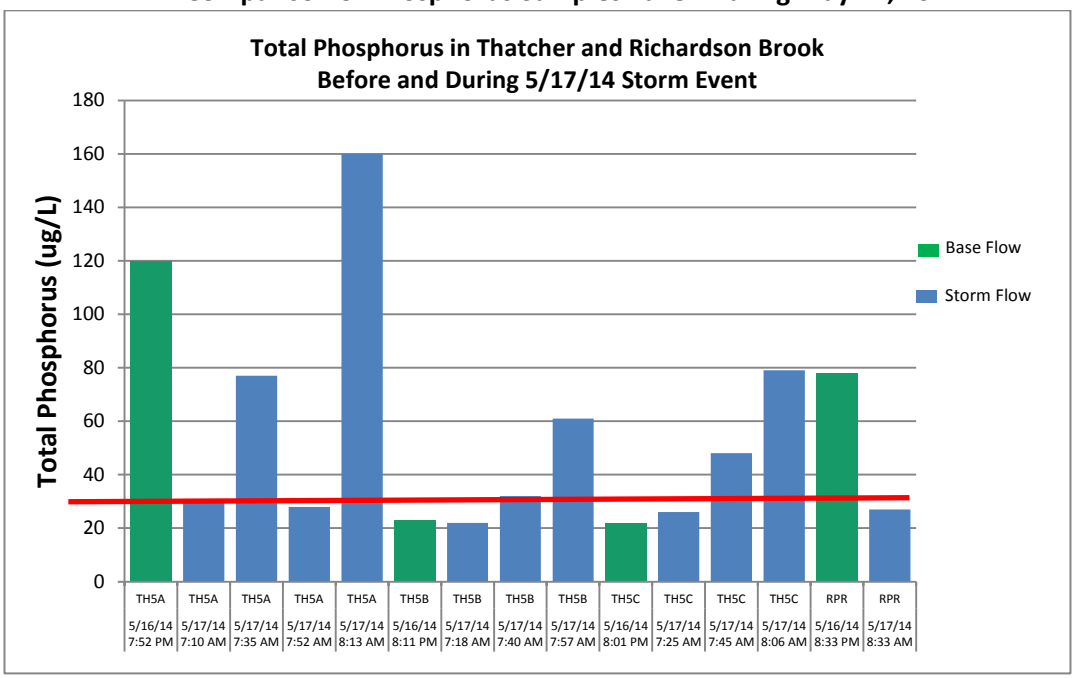
Table 15. Total Phosphorus Data Summary.

Station	Location	Subwatershed	Maximum Storm Concentration Of Phosphorus (ppb)	Maximum Baseflow Concentration of Phosphorus (ppb)	Exceedance?
Criterion =			**30**	**30**	
S-978, TH3	Sterling Rope	Richardson	220	21	No
TH4	Biddeford Spur	Richardson	140	36	Yes
TH4A	Small tributary	Richardson	300	18	Yes
TH10	Route 1	Richardson	230	24	No
TH11	Iron Trail Road	Richardson		13	No
TH12	Above Landry	Richardson		12	No
RPR	Park n' Ride	Richardson	220	78	Yes
W-43	Walmart wetland	Upper		51	Yes
TH5A	Kohls Trib	Lower	160	120	Yes
TH5B, A3	Above Kohls Trib	Lower	61	22	Yes
TH5C	Below Kohls Trib	Lower	79	22	Yes
TH5D	Aroma Joe's	Lower		18	No
Bacteria Site 6	Springbrook Dr.	Lower		36	Yes
S-451	Downstream of C2	Lower		33	Yes

Note: Phosphorus measurements have been taken during both dry and wet weather events, which influences readings. In addition, although maximum values are presented here, measuring average conditions over a longer time period can provide valuable insight on "average" conditions and can provide insight on whether exceedances are regularly occurring (see Appendix B for complete data set).

The May 17, 2014 phosphorus sampling was focused at the junction of Richardson Brook and confluence with Lower Thatcher Brook. Focused sampling within one portion of a watershed is often required during storms due to the limited amount of time available to repeatedly visit stations during storm events. The May 17, 2014 storm sampling included two to five samples at each station (over the course of approximately one hour, and revealed that total phosphorus exceedances were occurring during baseflow conditions at Stations TH5A and RPR, as well as during stormflow at TH5A, TH5B, and TH5C. This sampling identified the need for potential retrofits draining from Richardson Brook into Lower Thatcher Brook.

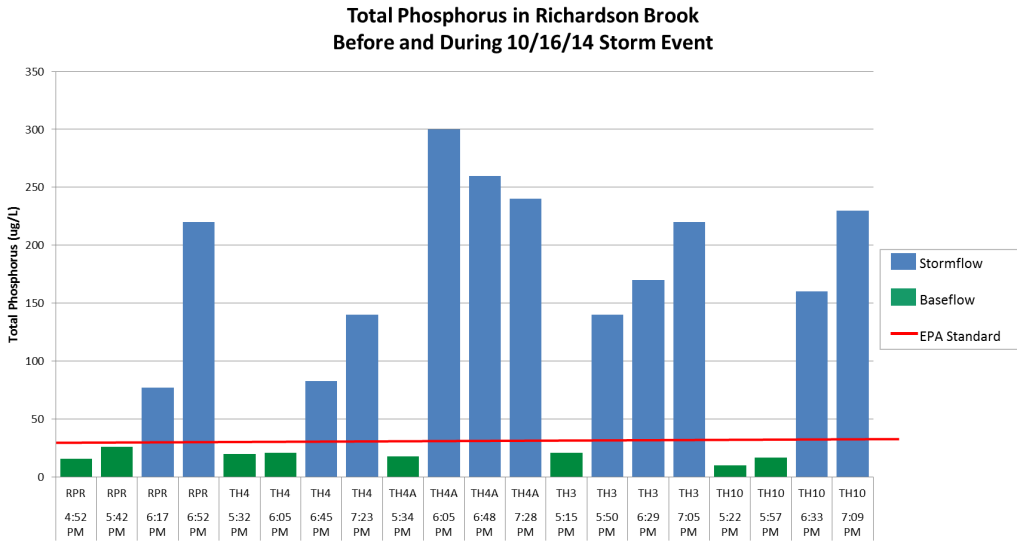
GRAPH 1
Comparison of Phosphorus Samples Taken During May 17, 2014.



Note: Graph provided courtesy of MDEP.

Sampling conducted during October 16, 2014 was focused within Richardson Brook. During the October 16, 2014 storm, total phosphorus was relatively low during baseflow conditions at all stations. However, total phosphorus exceeded the criterion at all five assessed locations in Richardson Brook during storm samples. The highest levels of phosphorus were observed at Stations TH4A, TH3, and TH10. Station TH4 located downstream of TH3 had lower peaks of phosphorus, but still witnessed phosphorus exceedances. These data point to the need for prioritizing potential stormwater retrofits at locations draining toward Sites TH3 and TH10 in Richardson Brook.

GRAPH 2
Comparison of Phosphorus Samples Taken During October 16, 2014.



Note: Graph provided courtesy of MDEP.

4.2.3.4 METALS

Compared to other stressors, there is relatively little information on metals in the watershed. MDEP has sampled iron, lead, and/or zinc at Station S-450 (Old Alfred Road), at W-43 (near Walmart), and at S-451 (Lower Thatcher Brook) in water samples. An elevated level of iron was observed at S-450. However, there is not enough data to implicate metals as a likely stressor in the watershed. Further studies may be warranted to properly assess metals as potential stressors.

4.2.3.5 BACTERIA

Thatcher Brook is listed on the Maine Statewide Bacteria TMDL (Total Maximum Daily Load). The TMDL is designed to reduce public health risk from waterborne disease-causing organisms. *Escherichia coli* bacteria (i.e. E. coli) are used as indicator organisms of potential disease-causing organisms in freshwater systems. E. coli bacteria are found in the digestive tract of warm-blooded organisms and can cause infections and illness when they colonize organs outside the digestive tract. E. coli can enter surface waters from a variety of sources including failing septic systems, combined sewer overflows, livestock operations, recreational use, pet waste, and wildlife waste. Although E-coli are generally studied to protect human health and recreational uses, E. coli can also be indirect indicators of potential nutrient sources. The Class B criterion for E. coli is a geometric mean of 64 colonies/100 mL or an instantaneous level of 236 colonies/100 mL from May 15 to Sept 30 of a given year.

During July and August 2014, the City of Biddeford and MDEP collected bacteria samples to supplement existing data available from MDEP. The samples were analyzed by the Biddeford Treatment Plant. The combined sampling found bacteria exceedances in all three subwatersheds of Thatcher Brook (see **Table 16**). Although bracketed sampling was conducted in an effort to identify possible sources, it is likely that additional sampling will be need to pin-point specific bacteria sources. A bacterial source tracking study may be warranted in the future to address bacteria (and any associated nutrient pollution) exceedances.

Table 16. Bacteria Data Summary.

Station	Location	Subwatershed	Instantaneous Level	Geometric Mean	Exceedance?
Exceedance Criteria (ME TMDL, 2009)			**(236/100mL)**	**(64/100 mL)**	
TH8A	Eastern Trail Trib	Richardson	159	99	Yes
S-978, TH3	Sterling Rope	Richardson	2419.6	762	Yes
TH4	Biddeford Spur	Richardson	579.4	---	Yes
S-979, TH2	Medical Center Dr.	Richardson	---	---	---
TH8	Route 111	Richardson	235.9	---	No (but borderline)
TH8A	Ditch (near Route	Richardson	1111.9	---	Yes
TH9	Biddeford Spur	Richardson	248.1	---	Yes
TH10	Route 1	Richardson	>2419.6	---	Yes
TH11	Iron Trail Road	Richardson	686.7	---	Yes
TH12	Above Landry	Richardson	2419.6	---	Yes
RPR	Park n' Ride	Richardson	1203.3	196	Yes
S-450	Old Alfred Rd.	Upper	186	35	No
Bacteria Site 2	Mountain Rd.	Upper	1011	240	Yes
A2	Easy Street	Upper	---	---	---
W-43	Walmart wetland	Upper	129	43	No
TH6	Route 111	Upper	---	---	---
S-746, TH1	Below Kohls	Lower	---	---	---
TH5A	Kohls Trib	Lower	579.4	---	Yes
TH5B, A3	Above Kohls Trib	Lower	1413.6	---	Yes
TH5C	Below Kohls Trib	Lower	1413.6	96	Yes
TH5D	Aroma Joe's	Lower	1046.2	---	Yes
Bacteria Site 6	Springbrook Dr.	Lower	649	165	Yes
C2	Off Barra Road	Lower	---	---	---
S-451	Downstream of C2	Lower	---	---	---
TH7	South Street	Lower	---	---	---
TB27	Main Street	Lower	1120	199	Yes

4.2.3.6 SUMMARY OF STRESSSORS

The above data was consolidated and ranked to identify the highest priority stressors in each subwatershed (see Tables 17 and 18). Each water quality parameter (i.e. DO, temperature, chloride conductivity, metals, nutrients, bacteria as a surrogate to potential nutrient sources) was ranked based on the number or percentage of failing scores at each representative station (see **Table 17**). A parameter is considered a stressor if it fails to meet state or EPA criteria. The stressors are further discussed in **Section 6** of this Plan.

Table 17. Criteria for Rankings of Stressors and Stream Health Metrics.

	Stressors – Causes of Impairment								Major Metric of Stream Health
Ranking of Stressors and Parameters	Dissolved Oxygen and Temp.	Chloride	Conductivity	Metals	Nutrients	Bacteria	Habitat*	Rapid Geomorphic Assessment	Macro-invertebrates
Indeterminate	Only one sample available.						N/A	N/A	Indeterminate as determined by ME DEP (too few macro-invertebrates collected in rock bags)
Red	Failed for more than 7 days	State/EPA criteria failed for > 50% of samples					EPA habitat score of < 50 (poor)	RGA score > 0.4 (stressed)	Nonattainment as determined by ME DEP model
Orange	Failed for 3 – 7 days or two or more samples are under 4 mg/L	State/EPA criteria failed for 30 – 50% of samples					EPA habitat score of 51 -100 (marginal)	RGA score of 0.31 – 0.4 (in transition, heading toward stressed category)	Macro-invertebrate scores have improved over consecutive years but still do not meet classification
Yellow	Failed for 1-3 days	State/EPA criteria failed for 25% of samples					EPA habitat score of 101-160 (suboptimal)	RGA score of 0.21 - 3 (in transition)	The most recent sample is borderline for meeting classification as determined by ME DEP
Green	Meets Classification (No failing scores with two or more samples)	Meets classification (No failing scores)					EPA habitat score of 161-200 (optimal)	RGA score of 0 – 0.2 (in regime)	Meets ME DEP classification

*Stations with overall habitat scores within 10 points of a lower category are listed as the lower category if they have two or more categories with individual scores of less than 10

Table 18. Thatcher Brook Data Summary (2000-2014).

Reach	Sta.	Landmark	Dissolved Oxygen	Temp	Chloride direct and estimated from conductivity	Nutrients Phosphorus	Bacteria	Habitat	Rapid Geomorphic Assessment	Macro-invertebrates (Aquatic Life Use)
Richardson	TH3, B1	Sterling Rope	Red	Green	Green	Indeterminate (one passing sample)	Red	Yellow	Yellow	Orange Indeterminant (2012)
Richardson	TH2, B2	Medical Center Drive	Yellow	Green	Green	No data	No data	Orange	Red	Orange Indeterminant (2012)
Richardson	RPR	Park and Ride	Orange	Green	Green	Red	Orange	No data	No data	No data
Upper Thatcher	A2	Easy Street	Yellow	Green	Green	No data	No data	Yellow	Green	
Upper Thatcher	W-43	Walmart Wetland	Orange	Green	Green	Red	Green	No data	No data	Red Nonattainment -2013
Lower Thatcher	TH1	Below Kohls	Red* (based on sonde data)	Green	Yellow	No data	No data	No data	No data	Red Nonattainment (2004 and 2012
Lower Thatcher	TH5B	Above Kohls Trib	Yellow	Green	Green	Orange	Indeterminate (one failing score)	Red	Red	
Lower Thatcher	TH5C	Below Kohls Trib	Orange	Green	Green	Red	Orange	No data	No data	
Lower Thatcher	C2	Off Barra Road	Yellow	Green	Green	No data	No data	Orange	Green	
Lower Thatcher	S-451	Down-stream of C2	Yellow	Green	Green	Orange	No data	No data	No data	Green Attained Class (2000, 2005, and 2010)

4.3 OTHER ASSESSMENTS

Other assessments have been completed in the Thatcher Brook Watershed for specific purposes not relating directly to watershed management. Data and recommendations provided by such assessments have been considered as part of this Plan. The following sections summarize other studies completed within the Thatcher Brook watershed that are relevant to this Plan.

4.3.1 HYDROLOGIC AND HYDRAULIC MODEL

During 2011, HNTB Corporation (HNTB) prepared an analysis of the 5-ft by 8-ft double box culvert crossing located at Interchange 32 on Route 95 in Biddeford, Maine (see Appendix A, HNTB Memorandum dated May 5, 2014). The analysis was prepared as a result of large rainfall events that caused the overtopping of flood water from Thatcher Brook onto the turnpike and Route 111/Precourt Street intersection. As part of the analysis, HNTB prepared a watershed hydrologic and hydraulic model ("drainage model") to provide additional information on the capacity of the culverts hydrologically tied to the turnpike culvert. HNTB characterized the area that includes the turnpike culvert/s, ramp, Route 11, and the Spur Road as very flat, and cautioned that conditions at and between structures can affect flooding conditions at upstream locations. HNTB observed that there is a general lack of vertical drop to the Saco River, and the downstream channels and crossings south of the study area have shallow slopes that limit capacity. HNTB linked these conditions to producing significant backwater during major storm events, and constraining the capacity of the study area by raising water levels downstream of the study area culverts. HNTB further cautioned that enlarging culverts may exacerbate flooding conditions at downstream structures and blockages of channels or culverts can impact multiple

upstream sites. Possible mitigating solutions identified by HNTB included clearing downstream debris from structures, increasing downstream channel capacity, adding additional 5 foot x 8 foot culverts (to reduce flooding at ramps), and/or raising the mainline and ramp profile.

This study provides key information on factors that contribute to flooding near Interchange 32. Any habitat restoration efforts proposed within the vicinity of this area should take into account the factors that limit and constrain stream crossings in this area.

5.0 POLLUTANT IDENTIFICATION METHODOLOGY

Section 4 above summarized the suspected pollutants and environmental factors that are preventing Thatcher Brook from meeting Class B standards. Municipal representatives also provided important information on the known historical extent of stressors within the watershed. The above data and information was utilized to develop the following recommendations for stream restoration and water quality improvement.

5.1 IDENTIFYING STREAM HABITAT IMPAIRMENTS

As outlined in Section 4, GZA, MDEP, and the City of Biddeford completed a habitat assessment in five key reaches of the watershed utilizing the protocols outlined in EPA "Rapid BioAssessment Protocols" (Barbour, 1999). In addition, GZA completed a watershed-wide evaluation of riparian vegetation condition using GIS. The combined data assessed key habitat attributes including bank stability, in-stream habitat condition, and riparian zone condition. The watershed wide riparian zone assessment also provided broadscale information on general habitat connectivity, to prioritize high priority areas for habitat restoration. Potential restoration sites were identified based on impact severity, expected benefit (related to improving aquatic life use), feasibility, and cost.

5.2 IDENTIFYING NONPOINT SOURCES

Nonpoint source pollution was identified as a likely cause of impairment in the watershed (see Section 4). Based on current land-use activity and water quality sampling, the primary source of nonpoint source pollution in the watershed is believed to be stormwater discharges from impervious surfaces.

5.2.1 STORMWATER INFRASTRUCTURE & IMPERVIOUS SURFACES

Stormwater from development can alter both the water quality of stream systems and the stability and physical traits of streams by affecting the water flow and contaminant level characteristics of the stream. Much of the residential, commercial and institutional development near the stream was completed after the 1940s. However, only development occurring over the past two decades has had any stormwater mitigation incorporated into the discharge design, and the degree of mitigation has evolved considerably over this period. As a result, the highly impervious areas in the lower part of the watershed have changed stream flows by directing large volumes of runoff directly to the stream. Some of the stormwater discharges directly into the stream by way of outfall pipes. Other outfalls flow into road ditches, which in turn flow into the stream.

Studies in Maine and around the country show a strong correlation between stream health and the amount of development in a watershed. Impervious cover is a measure of watershed development and includes all impervious surfaces including parking lots, roads, rooftops and other paved areas. Research has demonstrated that impervious cover increases above approximately 10-12% result in a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life (Stanfield and Kilgore 2006; see review in MDEP 2012).

Potential stormwater system retrofit locations in the Thatcher Brook watershed were identified based on an initial "desktop" study followed by field investigations. Based on the existing water quality data which indicates that there are elevated levels of phosphorus in Thatcher Brook and its tributaries, the Thatcher Brook Technical Committee elected to focus initially on the placement of structural stormwater best management practices (BMPs) that treat phosphorus and other nutrients. The

Committee prioritized locations where there are large expanses of impervious cover that receive little or no stormwater treatment prior to discharge, and which are subjected to high traffic levels. In addition, retrofits were prioritized for areas where sampling revealed elevated concentrations of phosphorus in stormwater and low dissolved oxygen values. This resulted in the identification of potential retrofit locations in the areas of the industrial park along Route 1 near the Biddeford Connector, the Route 111/Route 95/Biddeford Connector intersection, including the tollbooth plaza operated by Maine Turnpike Authority (MTA) and the 'park and ride' lot off of Route 111. The identified retrofits are described later in this WMP.

Sources of information for the desktop study included GIS data from the City of Biddeford, Maine Office of GIS (MEGIS), MDEP, and the MTA, soils data from the USDA Natural Resources Conservation Service Web Soil Survey, and Google Maps, including street view images.

The overall goals of the stormwater retrofit analysis were to identify structural stormwater retrofit opportunities that could be implemented:

- In areas with highest expected gain in water quality improvement (where phosphorus exceedances and/or low DO were documented);
- With limited impact on existing infrastructure;
- In a cost effective manner (i.e. BMPs that provide the highest level of treatment for the lowest installation cost per acre).

5.2.2 NUTRIENT CONTRIBUTIONS FROM OTHER LAND USES

Water samples collected from Thatcher Brook during 2014 revealed phosphorus exceedances in all three subwatersheds, with the highest exceedances observed in Richardson Brook. Due to the widespread nature of exceedances, it was not possible to identify particular properties with obvious point sources. Based on the 2014 data, it is likely that phosphorus is contributed from a variety of areas. As a result, the Thatcher Brook Technical Committee determined that any formal retrofits at this time should be targeted to "hot spots," areas with expected long-term larger contributions of phosphorus where the highest phosphorus exceedances were observed. However, long-term management and reduction of phosphorus will require smaller contributions of nutrients to be identified and addressed, and implemented on a small scale. In addition to large commercial properties and state-maintained roads, there are also numerous smaller residential and commercial areas adjacent to the stream, and these sources will also be important areas for future work.

The following are additional recommendations for reducing nutrient inputs in Thatcher Brook:

- Education and outreach to residential landowners to encourage proper fertilizer application techniques, appropriate yard and pet waste disposal, and alternatives to chemical fertilizers. Consider a recognition system for landowners that implement good practices.
- Outreach to agricultural landowners to ensure that they are receiving adequate support for nutrient management planning, livestock field rotation, manure storage, fertilizer BMPs, and farm conservation planning activities.

- Outreach to schools to provide education on watershed cycling and stormwater.
- Implement a nutrient loading program at the municipal level for new developments under one acre.
- Provide continued buffer protection and water quality protection in municipal ordinances.

6.0 IDENTIFYING AND PRIORITIZING POLLUTANTS, SOURCES, AND CAUSES

Like other streams in developed watersheds, Thatcher Brook is likely influenced by a variety of pollutants and stressors. There are a wide variety of potential restoration and storm water retrofit projects that could be pursued in the Thatcher Brook watershed. To create the most cost-effective and targeted restoration plan possible, the Thatcher Brook project partners reviewed data available to date and identified and prioritized the specific stressors to different parts of Thatcher Brook, to the greatest extent practicable based on available information. This stressor identification process (not the official EPA process) formed the basis of the current plan (Section 8) with the highest priority projects tied directly to sites believed to be affecting stream conditions.

6.1 UPPER THATCHER BROOK WATERSHED

Formal biomonitoring using MDEP rock bag protocols has only been completed by MDEP in the lowest segment of the watershed, in a wetland near Walmart. This station failed to meet attainment for Class B standards in 2013. GZA completed additional macroinvertebrate monitoring during 2013 according to EPA protocols for d-frame net sampling. This data revealed that the middle portion of Upper Thatcher Brook contains a moderate level of macroinvertebrate diversity, high percentage of dominant taxa, and a low percentage of clingers. These metrics suggest that the assessed reach does not represent an undisturbed "natural" or "reference" condition. This subwatershed has relatively low impervious surface coverage, but also has observed phosphorus exceedances. In addition, the subwatershed has the highest percentage of culverts that are rated as stream barriers. The central portion of the subwatershed contains long linear areas with poor buffers (e.g. riparian zone width). Due to the relatively low level of commercial uses, nutrient inputs are likely coming from agricultural uses and human and animal waste. "Legacy" residual nutrient sources from past land use practices (e.g., agriculture) also could be a factor. Remedial measures in the Upper Thatcher Brook should include nutrient management and buffer enhancement. In addition, where economically feasible, aging hanging culverts should be replaced with properly sized structures to reduce erosion and provide aquatic connectivity.

6.2 RICHARDSON BROOK WATERSHED

Formal MDEP biomonitoring evaluations conducted during 2012 and 2013 within the Richardson subwatershed (near Sterling Rope and Medical Center Drive) were categorized as "indeterminate," largely due to low sample size. D-frame net sampling conducted by GZA at both stations in 2013 revealed that both stations have high diversity and a high percentage of clingers, as expected from a natural stream, and compared to samples collected in Lower Thatcher Brook. However, both stations had relatively low percentages of EPT taxa, which are considered sensitive to disturbance.

The Richardson Brook subwatershed contains a variety of land uses, and appears to be impacted by a variety of stressors including in-stream habitat condition (in the lower portion of the watershed), buffer condition (in various portions of the subwatershed), and nutrient inputs. The WMP is specifically designed to address in-stream habitat and riparian habitat where feasible. In addition, the WMP seeks to provide a tool box of options for addressing possible nutrient inputs. Due to the presence of bacteria exceedances, bacterial source evaluation may need to be considered to address nutrient inputs in this subwatershed. In addition, because toxics have not been well-studied in the watershed, additional toxicity testing may be warranted if the recommended retrofits do not result in improving aquatic life use scores. Stream bioassays or bench toxicity tests could be conducted after the implementation of

high priority retrofits and restoration measures, if macroinvertebrates do not respond within approximately two years after implementation.

6.3 LOWER THATCHER BROOK WATERSHED

MDEP biomonitoring evaluations have revealed that the lowest portion of the subwatershed meets aquatic life use criteria, while the upper portion of the subwatershed has repeatedly failed to meet aquatic life use criteria. This suggests that water quality alone cannot explain macroinvertebrate impairments in Lower Thatcher Brook. In-stream habitat condition and riparian condition are considered major causes of impairment in this area. In addition, phosphorus exceedances and low dissolved oxygen likely contribute to impairment, and low dissolved oxygen is considered an important stressor. During 2012 sonde monitoring, dissolved oxygen values fell below Class B standards on a daily basis. Due to the presence of ongoing low dissolved oxygen values and phosphorus exceedances, it is presumed that low dissolved oxygen scores may be occurring due in part to anthropogenic causes. Chloride, although not considered a primary impairment in the watershed, has been observed in exceedance of the state standard in Lower Thatcher Brook. As a result, the WMP attempts to address multiple stressors in Lower Thatcher Brook through retrofit identification, habitat restoration, and BMP implementation.

7.0 WATERSHED RESTORATION GOALS & OBJECTIVES

There are both long and short term goals of the Thatcher Brook Watershed Based Management Plan. The goals are to restore the stream to its statutory classification, protect the values and uses of the stream for the long term, and involve stakeholders from the watershed to generate community support. The following goals and objectives were established by the project steering committee and stakeholders at several public workgroup meetings:

Goal #1 – Improve the water quality of Thatcher Brook to meet State water quality standards.

- Work towards Thatcher Brook meeting its designated Class B water quality standards for aquatic life.
- Continue to monitor water quality parameters (e.g. DO, specific conductance, and temperature) and macroinvertebrates to assess whether the goal is being achieved.

Goal #2 – Once attained, protect and maintain water quality and habitat conditions to ensure the brook continues to meet State water quality standards.

- Improve the management of stormwater runoff from existing development in an effort to improve the treatment and water quality of stormwater.
- Protect the brook through zoning and ordinances changes for new and re-development projects.
- For future development, limit impacts to streams and wetlands associated with Thatcher Brook.
- Coordinate efforts with other conservation and preservation groups in the watershed to maximize protection opportunities.

Goal #3 – Increase community support for the preservation and enhancement of natural resources within the Thatcher Brook watershed.

- Develop an outreach and education program for residents and local businesses to promote and implement the WMP. Include one-on-one outreach and signage to educate residents on their role and value in implementing the Plan.
- Strengthen ties with the local schools and the University of New England to enhance education and participation in community action opportunities. Provide opportunities for local schools to engage in restoration activities and monitoring.
- Establish a Thatcher Brook Workgroup to oversee implementation of the goals and objectives in the Plan and ensure the Plan goals are achieved.
- Develop incentives for residents, businesses, and contractors within the watershed to participate in WMP action items.

8.0 THATCHER BROOK ACTION PLAN

The goal of the Thatcher Brook WMP is to restore the health of the stream so that it supports a well-balanced community of aquatic organisms and habitat that meets water quality standards. There are several stressors affecting different parts of Thatcher Brook. The primary stressors include stream channel alteration, elevated phosphorus, depressed dissolved oxygen (likely exacerbated by natural conditions in some areas), and habitat alteration. Elevated chloride is a potential secondary stressor in the watershed. It is not known exactly what level of load reduction or habitat improvements will be required to allow the biological communities and habitat to recover. However, the following section outlines an action plan based on available data, and based on where recovery efforts are believed to be most critical.

8.1 ADAPTIVE MANAGEMENT & PROJECT PHASING

Adaptive management is the process by which new information about the health of the watershed and the proposed actions to address this new information are iteratively incorporated into the Plan. An adaptive management approach is widely recommended for restoring urban watersheds (Center for Watershed Protection 2003), and provides communities a mechanism to update plans as new information becomes available. This approach recognizes that the entire watershed cannot be restored with a single set of restoration actions, within a short time frame. It also recognizes that management plans require that various stakeholders work together to develop solutions. As new data/information and/or technology become available, this approach establishes a mechanism for restoration efforts that can be adjusted to meet the current needs of the watershed over time.

8.2 PLAN OVERSIGHT

It is important for local residents and stakeholders to take an active role in implementing and updating the plan. It is anticipated that the Thatcher Brook Watershed Based Management Plan will be executed by the City of Biddeford in concert with the Town of Arundel, and with extensive involvement from private landowners and stakeholders within the Watershed. It is envisioned that the plan will be reviewed annually and updated formally at least once every five years to incorporate new data and update management recommendations.

The City of Biddeford will take the lead role in the Thatcher Brook Workgroup. Other participants serving on the workgroup may include the YCSWCD, MDEP, Town of Arundel, and watershed landowners. The Workgroup stakeholders will meet at least three times a year as projects are implemented, and at least twice a year following implementation of high priority items. One of these meetings should be structured as a public meeting as a means of providing the community with updates about the brook and implementation efforts.

Additional subcommittees of the workgroup may be necessary to provide more efficient implementation of the Action Plan. All groups may require interaction with each other and collaborative participation is necessary for the successful implementation of the plan. Possible sub-committees could include: Water Quality Monitoring, Restoration and Retrofit Implementation, and Education and Outreach.

8.3 ACTION PLAN

The Thatcher Brook Action Plan identifies the contaminant reduction targets where applicable and recommended actions to achieve water quality objectives in the Thatcher Brook Watershed.

8.3.1 NUTRIENT REDUCTION

The sources of elevated nutrient levels in Thatcher Brook and its tributaries is most likely attributed to stormwater runoff emanating from impervious surfaces, particularly which are subjected to high levels of vehicular traffic. Phosphorus is deposited onto impervious surfaces and therefore is a source of this nutrient addition to surface waters. The treatment of stormwater runoff from paved surfaces with retrofit stormwater treatment measures that address phosphorus is projected to decrease the nutrient levels in Thatcher Brook and its tributaries. Specific retrofit measures that may be implemented to target areas of impervious surfaces that are subjected to high and moderate traffic are presented later in this WMP.

Areas in the Thatcher Brook watershed with large expanses of impervious surfaces under private ownership can be retrofitted with stormwater treatment measures as properties are re-developed or in an otherwise phased approach designed to fit in with planned site improvement projects. Re-development including parking lot and walkway reconfiguration or repaving, or drainage system upgrades is most amenable to the implementation of stormwater treatment practices that can reduce the discharge of nutrients and other pollutants from the site.

Retrofits that may potentially be implemented by this approach generally include the replacement of curb-side catch basins with tree box filters, the replacement of existing catch basins or drain manholes in paved parking lot areas with proprietary manhole units, the installation of open treatment systems in areas that are currently maintained as lawn, and the retrofit of existing detention basins to improve water quality treatment capacity. Other retrofits may include subsurface infiltration systems below parking lots, permeable pavement, and converting parking lot islands to rain gardens. In some cases, re-direction of existing storm drains may be necessary to implement these types of retrofits. There are also Phosphorus removal mechanisms such as absorptive layers that are being incorporated into various BMPs that may be applicable as retrofits in future applications.

Example rain gardens after construction.

A "tool box" of potential retrofit options is summarized below in **Table 19**. The stormwater treatment measures that may be implemented with redevelopment projects are categorized, listed and described in the following table. As these measures are implemented, additional studies will likely be underway to monitor the health of Thatcher Brook and its tributaries in support of an adaptive management approach to restoring the watershed.

Table 19. Retrofit Tool Box.

Category	Retrofit Measure*	Description	Estimated Pollutant Removal Efficiency
Infiltration: Storage of stormwater runoff until it exfiltrates through the native soils below the floor of the structure. Requires pre-treatment to remove sediments, oils & greases.	Infiltration basin	An open basin that can store and treat runoff from larger drainage areas (5-50 acres). May be installed in areas that are currently maintained as lawn.	80% TSS with pre-treatment 50-60% Total N 60-70% Total P 85-90% Metals 90% Pathogens (MA Stormwater Handbook)
	Infiltration trench	A stone-filled excavation for treating runoff from smaller drainage areas (less than 10 acres). Suitable for long linear applications, such as along the edges of parking lots or roads.	80% TSS with pre-treatment 40-70% Total N 40-70% Total P 85-90% Metals Up to 90% Pathogens (MA Stormwater Handbook)
	Dry well	Small, stone-filled structure for treating runoff from small contributing areas, typically roof runoff.	80% TSS (MA Stormwater Handbook)
	Subsurface infiltration	Infiltration trenches and dry wells may be designed as subsurface systems. In addition, there are a variety of proprietary chamber systems that may be used to provide subsurface storage of runoff for infiltration.	
Bioretention/Filtration: Stormwater runoff is treated via filtration, microbial activity, and/or plant uptake as it percolates through soil media.	Vegetated underdrained soil filter beds	A bed of specific soil media through which stormwater runoff is filtered before it reaches an underdrain and is discharged. Soil media is planted with grass. Suitable for long linear applications, such as along the edges of parking lots or roads.	80% TSS with pre-treatment 20-40% Total N 10-50% Total P 50-90% Metals (MA Stormwater Handbook)
	Tree box filter	Typically a concrete structure filled with porous soil media overlying crushed gravel containing an underdrain, with a tree planted in the soil media. Stormwater is directed to the tree box filter and percolates through the soil media to the underlying crushed gravel layer. Proprietary media that targets pollutants of concern may be used. The concrete container structure and curb	88% TSS 10% Total N 0% Total P 88% Zn (metals) (UNHSC***)

Category	Retrofit Measure*	Description	Estimated Pollutant Removal Efficiency
		inlet design may or may not be proprietary.	
	Rain garden	A shallow depression lined with a bed of specific soil media through which stormwater runoff is filtered before it reaches an underdrain and is discharged. Soil media is planted with dense native vegetation. May be installed in areas that are currently maintained as lawn.	90% TSS with vegetated filter strip (pre-treatment) 30-50% Total N 30-90% Total P 40-90% Metals (MA Stormwater Handbook) For bioretention: 92% TSS 29% Total N 27% Total P (Houle**)
Site modifications	Detention basin retrofit	Detention basin retrofits may include changes to outlet structures, installation of forebays, or converting the basin to other systems such as a subsurface gravel wetland.	For subsurface gravel wetland: 96% TSS 55% Total N 58% Total P 82% Zn (metals) (UNHSC***) For wet (retention) pond: 68% TSS 0% Total P 68% Zn (metals) For dry (detention) pond: 79% TSS 40% Total N 0% Total P 50% Zn (metals) (UNHSC***)
	Decrease amount of pavement or reconfigure to provide buffer distance between edge of pavement and receiving waters	As sites are redeveloped, opportunities to reduce the amount of pavement should be evaluated. Pavement may be reduced by eliminating unused parking spaces, narrowing drive lane widths, eliminating unnecessary sidewalks, and/or replacing paved medians with unpaved surfaces. In locations where the edge of pavement encroaches on the stream, reconfigure to allow space between edge of pavement and channel.	

Category	Retrofit Measure*	Description	Estimated Pollutant Removal Efficiency
	Permeable/ porous pavement	Alternative to traditional asphalt or concrete pavements that allows rainfall/ runoff to penetrate the surface and into the underlying soils. Types of permeable/porous pavement include porous asphalt/concrete, block pavers, and plastic grid pavers.	For porous asphalt: 99-100% TSS 45% Total N 60% Total P 75% Zn (metals) For pervious concrete: 85% TSS 0% Total N 0% Total P 75% Zn (metals) (UNHSC***)
Proprietary	Catch basin inserts	Designed to improve the efficiency of catch basins by providing additional removal of oil and grease, trash, debris, and sediment. (Example = "snout")	Varies
	Media/ membrane filtration	Proprietary stormwater filters are manufactured units, typically with underground chambers which contain filter cartridges that filter water to remove fine solids, nutrients, and other pollutants. The filters may be comprised of media, of which there are several types that may be targeted for removal of the pollutant of interest. Other filter technologies include membrane filtration, which involves the flow of water through a membrane to remove fine particulates and other pollutants. These units are recommended where catch basins are located in paved areas and collect stormwater that can't be directed to an alternative treatment system.	Varies

*Shall be designed in accordance with design criteria specified in Volume III of the *Maine Stormwater Best Management Practices Manual* (http://www.maine.gov/dep/land/stormwater/stormwaterbmps/index.html).
**Houle, J.J., et al. (2013). "Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management." *J. Environ. Eng., 139:932-938*.
***University of New Hampshire Stormwater Center (UNHSC). (2012). "2012 Biennial Report."

An example of how the Tool Box retrofit measures could be applied is during planned re-development of properties within the industrial park along Route 1 near the Biddeford Connector. The industrial park consists of an assortment of buildings and paved parking lots, connected by paved roads. Stormwater runoff is collected by a network of catch basins and pipes and discharged, apparently untreated, via outfalls primarily on the western side of the industrial park. In this campus-like setting, there are many potential opportunities for structural BMP retrofits to treat the water quality of stormwater discharges.

The current data suggests that contributing drainage from Route 1 and the properties along it may also be a contributor to stressors in Thatcher Brook and its tributaries. More data may be required to further evaluate this potential. However, in the meantime, if retrofits from the Tool Box are considered and implemented as this area is redeveloped in an adaptive management approach, improvements in the health of the streams may be realized sooner.

The minimum information required to design stormwater treatment retrofits on a given site includes:

- Existing drainage system layout, pipe sizes, and invert elevations,
- Catchment areas to drainage system inlets, including existing and proposed land cover, distribution within each catchment, and
- Existing and proposed topography.

Soil infiltration capacity and subsurface contamination potential should be reviewed when citing locations for infiltration systems. Locations where soils of Hydrologic Soil Group Type A or B are present, as defined by USDA NRCS Web Soil Survey mapping, are more amenable to infiltration practices. These soil types have high to moderate infiltration rates. Soil test pits to confirm infiltration rates and depth to groundwater is recommended in areas of proposed infiltration practices. Also, consideration should be given to the potential for chloride contamination of groundwater where infiltration systems are proposed. In areas where there is likelihood of high deicing salt use or sensitive receiving areas, caution should be used when deciding the suitability of infiltration practices.

8.3.2 STREAM HABITAT RESTORATION

This WMP has identified areas in all three subwatersheds with poor habitat conditions. Both riparian vegetation conditions (e.g. natural vegetated zone width) and in-stream habitat features (e.g. pool variability, substrate type, and stability) influence abundance and diversity of aquatic organisms. Habitat restoration is a key component for reaching attainment of aquatic life use standards in Thatcher Brook. The following restoration options are included in the plan (see **Figure 17**, Potential Restoration Sites):

- In-stream habitat restoration
- Buffer restoration/planting
- Culvert Replacement
- Bank Stabilization

8.3.2.1 IN-STREAM HABITAT RESTORATION

This WMP identified areas with poor in-stream habitat conditions in otherwise well-vegetated riparian corridors. Portions of Thatcher Brook contain long reaches of silty/clay dominated substrates, which are generally less favorable to colonization by macroinvertebrates, interspersed with shorter cobble riffles. In some cases, the silty/clay dominated reaches also lack other important habitat features including wood. These areas were targeted for restoration efforts due to the presence of macroinvertebrate communities observed nearby where in-stream habitat is more favorable.

Based on field work, Stations A3 and B2 were identified as high priority in-stream restoration sites and are important locations for long-term macroinvertebrate monitoring. Based on review of old aerial photographs, Site A3 was highly altered through historical channel rerouting. Site A3 (behind Kohls) has poor bank stability, marginal channel sinuosity, and marginal pool variability. In addition, the Hydrology and Hydraulic study prepared by HNTB indicates that Station A3 is subject to significant flooding during

storm events. As a result, the impaired geomorphic condition of the station needs to be considered during final restoration design. The design plans should be prepared by a fluvial geomorphologist, and reviewed by a Professional Engineer. This plan recommends in-stream restoration for at least 350 linear feet of stream channel and stream bank at Station A3. Restoration should include the addition of wood as a primary method for creating pool diversity and enhancing microhabitat diversity. The addition of rock substrate would temporarily improve channel habitat conditions. However, the high flows witnessed by the upstream culvert would likely washout material if wood is not used to provide "natural" anchoring and habitat complexity.

Station B2 (off Medical Center Drive) is a long-term macroinvertebrate monitoring station and has optimal buffer width, but marginal stream substrate conditions, channel sinuosity, and bank stability. This station is a high priority site for in-stream habitat restoration. Similar to Station A3, restoration at Station B2 should include the addition of wood as a primary method for creating pool diversity and enhancing microhabitat diversity. However, Station B2 would be an ideal candidate to include the addition of natural bank run materials to the restoration design, subsequent to formal review by a fluvial geomorphologist and/or engineer. The upstream portion of the station is characterized by boulders and a diverse macroinvertebrate community was observed in this boulder area, also known as "the falls."

8.3.2.2 BUFFER RESTORATION

The WMP identified that approximately 31% of the watershed is characterized by poor riparian buffers. Areas with poor, suboptimal, and marginal riparian zones represent potential buffer restoration sites (see Figure 17, **Potential Restoration Sites** and **Table 20**). In cases where natural vegetation is present nearby, buffer plantings are not often necessary. As an alternative, stream channel areas located within maintained fields may be appropriately designated as no mow zones. Simply avoiding cutting can benefit stream health by increasing shading, providing nutrient cycling, and by providing habitat for semiaquatic species associated with the brook. This plan recognizes that buffer restoration is not feasible in certain locations, including where public roads directly border drainages and where the presence of a road dictates clear lines of sight. However, in other cases, buffer plantings may be appropriate and beneficial. The plan identifies one high priority (Tier I) buffer restoration site and four moderate priority buffer restoration sites, based on expected benefit to aquatic life and expected project feasibility. In total, the Plan recommends approximately 2505 linear feet of buffer restoration activities, pending review and approval by relevant landowners. At least one potential buffer restoration site was targeted in each subwatershed. These areas were recommended based on buffer classification, expected consistency with current land use, and relative cost. Buffers in the "poor" or worse category were considered the highest priority targets. Buffers impacts by roads and other permanent features are expected to be impractical for buffer restoration. However, agricultural and athletic field edges were targeted as potential Tier II restoration areas as simply altering mowing practices may improve buffer characteristics, with minimal or very little formal planting involved. It is expected that the Thatcher Brook Workgroup would work with landowners to determine overall restoration feasibility, with a target of accomplishing at least one project per year in the first three years of plan implementation. If targeted sites become unavailable, it is expected that the Thatcher Brook workgroup could use the Vegetated Buffer Analysis to target additional areas with an overall project goal of restoring approximately 500 linear feet in each subwatershed in the areas with the poorest buffer condition. The Thatcher Brook Workgroup may wish to identify possible landowner incentives and recognition for project participants.

Table 20. Potential Buffer Restoration Sites.

ID	Location	Subwatershed	Approximate Length of Proposed Restoration	Current Buffer Classification
1	Wellspring Rd	Lower Thatcher Brook	400	Poor
2	Mountain Rd	Upper Thatcher Brook	1200	Poor
3	Mountain Road	Richardson	530	Poor
4	Elm St and Morin St	Richardson	375	Poor

8.3.2.3 CULVERT REPLACEMENT

The WMP identified 51 stream crossings within the watershed, excluding trails and pedestrian bridges. Major stream crossings can function as barriers to aquatic life during low flows and extremely high flood conditions. In addition, poorly sized structures generally contribute to erosion, scour, and stream instability, which impacts habitat conditions for a broad range of aquatic species. Of the identified stream crossings, Culverts 1, 2, and 7 are identified as high priority replacements subject to funding availability. These structures are rated as barriers to aquatic life and contribute to general stream instability.

View of Culvert #1. This structure only passes approximately 50% of the natural channel width.

8.3.2.4 BANK STABILIZATION

The RGA and habitat assessment components of the WMP identified unstable stream banks (i.e. non-optimal conditions) in four out of the five assessed reaches. Stream bank destabilization can be caused by erosion from alterations to stream channels, as well as from erosion caused from concentrated stormwater. Station B1 has favorable in-stream habitat, but significant bank and riparian erosion caused from concentrated roof runoff. To remedy this site condition, the WMP proposes a stormwater retrofit to slow and detain stormwater, as well as the development of bank stabilization plan for this important macroinvertebrate monitoring site. Station B1 was targeted for restoration because it has experienced historical erosion that is ongoing. Currently, there are three eroded bank areas that vary in length from

20 to 40 feet, two to six feet in depth. The WMP recommends that a naturalized bank stabilization and buffer enhancement plan be developed for this site, after the proposed stormwater retrofit is completed. The final plan, if implemented, should maintain the existing wooded buffer and focus on stabilizing the gullies in the existing forested buffer.

View of recommended bank stabilization area at Station B1.

8.3.3 CHLORIDE REDUCTION

Although chloride was not identified as a significant stressor throughout the watershed, chloride exceedances were documented in a few instances. The restoration target is to have chloride levels in Thatcher Brook below the CCC action level of 230 mg/L. Chloride exceedances have been observed near Route 111, and chloride is likely entering the stream from roadway and parking lot applications of road salt during the winter months. Chloride may also enter groundwater where soil infiltration is occurring.

To prevent chloride from becoming a larger stressor in the watershed, the WMP recommends the following salt management recommendations:

1. Research salt application practices in the watershed to assess current salt blends and application rates. A chloride source study could be conducted to identify areas with high application rates that might benefit from low application alternatives.
2. Educate landowners, snow removal contractors, and municipal workers on appropriate salt application processes. This education component should encourage reduced use and targeted application where appropriate. General guidelines are provided by the University of New Hampshire's Green SnowPro program. The Thatcher Brook Workgroup should work towards identifying possible incentives for encouraging creative, low salt application alternatives.
3. Assess salt application practices and subsurface geology in areas where infiltration BMPs are proposed. Avoid infiltrating chloride-laden stormwater (from roadways, parking lots, and driveways) in areas where the water table is close to the surface.
4. Identify possible partnerships and incentives for encouraging creative, low salt application alternatives and salt alternatives (i.e. non-chloride salts). Liability concerns are often cited as

reasons for excessive salt application rates. For instance, the Thatcher Brook Workgroup could work with local commercial businesses to identify portions of parking lot areas that are used rarely during non-peak shopping seasons. Reduced salt plowing and salt application in these areas could limit chloride load in the watershed. Landowners participating in these initiatives could be rewarded with incentives and public recognition.

5. Identify locations where excess salt use may be attributed to frequent re-freezing of melted snow, such as shaded areas downgradient of melting snow piles, and prioritize these areas for possible implementation of permeable pavement. It has been noted in existing applications of permeable pavement in New England that the more rapid infiltration of melted snow into the permeable pavement reduces puddling and the potential for black ice to form.

8.3.4 STORMWATER TREATMENT AND IMPERVIOUS COVER REDUCTION

Research has demonstrated that IC increases above approximately 10-12% result in a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life (Stanfield and Kilgore 2006; see review in MDEP 2012). The current IC for Thatcher Brook is 14%, based on impervious cover data updated in 2013 by MDEP and further refined by GZA (see **Figure 11**, Impervious Cover); however, DEP's Statewide IC TMDL Assessment concluded that in order to support Class B aquatic life use, the Thatcher Brook watershed may require the characteristics of a watershed with 8% impervious cover. To meet this goal, the objective is to decrease the adverse effects of IC by installing stormwater treatment measures to capture and treat runoff near its source, and reduce flows and velocities. The removal of pavement may also be considered where feasible, but is not required when stormwater is managed appropriately. Both existing and new development should incorporate stormwater management approaches that reduce or minimize effective impervious cover.

Approximately 270 acres of existing effective IC would need to be retrofitted with stormwater treatment measures that reduce the impacts of IC to reach the target of 8% effective IC in the Thatcher Brook watershed. The following summarizes stormwater retrofit recommendations that may be implemented as the initial steps towards achieving this goal.

Stormwater Retrofit Recommendations

Potential stormwater system retrofit locations in the Thatcher Brook watershed were identified within the areas of the Route 111/Route 95/Biddeford Connector intersection, including the tollbooth plaza operated by Maine Turnpike Authority (MTA) and the 'park and ride' lot off of Route 111. The potential stormwater retrofits for these areas are described below.

<u>Park 'n' Ride Lot</u>

The park and ride area, owned by MTA, consists of two parking lots that are connected by an access road from Route 111. The lower lot is located adjacent to Route 111 and is separated from the upper lot by a steep slope and an unpaved strip which together are about 30 feet wide. The upper lot is higher in elevation than the lower lot. Located within the unpaved strip, to the west of the upper lot, and to the west of the access road are drainage swales that are either grass- or riprap-lined. It appears that stormwater runoff from the lower lot is captured by catch basins and discharged to a drainage system in Route 111. Runoff from the upper lot sheet flows to the edges of the lot and generally towards the southwestern corner of the lot. It appears that the intent of the stormwater management design was for runoff to sheet flow from the edges of the lot and into the bordering swales; however, the

concentration of flow at the southwestern corner of the lot is evident from the repaired erosion scar along the slope from the upper lot to the swales below. Runoff which enters the swales is directed to wetlands located west of the access road, and/or a catch basin which discharges to the catch basin in Route 111.

There are two potential alternatives for retrofits at the park and ride lot. The first potential retrofit (PR) alternative "1" would include the construction of an underdrained bioretention system located in the southwestern corner of the upper lot, at the low point where much of the runoff from the upper parking lot collects before it flows over the slope into the swales between the upper and lower lots (see **Figure 18A**). Placement of a retrofit at the southwestern corner of the upper lot would necessitate the loss of approximately two (2) parking spaces. The proposed bioretention system would have a discharge outlet for overflows and underdrained flows that would discharge to the existing downstream end of the swale before it is conveyed under the access driveway.

The process of bioretention treats stormwater runoff via filtration, microbial activity, and/or plant uptake as it percolates through soil media. A bioretention system is typically a shallow depression lined with a bed of specific soil media through which stormwater runoff is filtered before it reaches an underdrain and is discharged. The soil media is planted at the surface with dense native vegetation. These types of bioretention systems are often referred to as rain gardens. The soil media mix must be specified and may consist of proprietary media with tested infiltration capacity and treatment capability, such as the proprietary media offered by Filterra.

The second retrofit alternative # "2" would include the construction of an underdrained grassed soil filter bed to replace the downstream section of swale that is located between the upper and lower lots (Figure 18B). Curbing would be installed near the southwestern corner of the upper lot to collect runoff from the upper lot and convey it to PR-2. The existing catch basin would likely be elevated to serve as an overflow structure. The installation of curb cuts or regrading along the northern edge of the lower lot to allow some runoff from the lower lot to enter the filter bed may be considered.

An underdrained grassed soil filter bed is also a type of bioretention system, similar to a rain garden, but the soil media is planted with grass. It is suitable for long linear applications, such as along the edges of parking lots or roads.

The following table summarizes the dimensions and cost estimates of each potential retrofit. The cost estimates are based on an installed unit cost per square foot for a bioretention system or grassed soil filter bed which includes an underdrain, gravel, soil media, mulch and plantings. The installed unit cost was estimated based on literature values and GZA's prior experience. These cost estimates are for preliminary planning purposes only and should be updated when more detailed designs have been developed.

Table 21. Summary of Potential Park n' Ride Retrofits.

Potential Retrofit	Surface Area, square feet	Estimated Storage Volume, cubic feet[1]	2014 Planning Level Cost Estimate[2]
1	250	250	$4,000
2	1920	1920	$33,000

[1]Assumes surface depression with average depth of 1 ft.
[2]Based on $17/square foot of underdrained bioretention system/underdrained grassed soil filter bed and rounded to the nearest thousand dollars. These are estimated costs for general planning purposes.

Route 111/Route 95 Intersection/Tollbooth

The roadways within this intersection, including Route 111, the Biddeford Connector, and the tollbooth area are mostly without curbs; thus, stormwater is able to sheet flow from the paved roadway shoulder towards vegetated areas. However, in many areas, the existing grading and soil/vegetated lip at the edge of the pavement promotes gutter flow and does not allow runoff to flow into the adjacent vegetated areas.

Proposed retrofits on MTA property include those numbered 3, 4 and 5 (see **Figure 18C**). Proposed retrofit "3" is a bioretention system located in the current lawn area southeast of the toll booth plaza. In order for stormwater runoff from the paved connector road to reach the bioretention area, the shoulder and area surrounding the bioretention system would need to be regraded towards the bioretention system. A drain manhole may be necessary to direct the underdrain outlet from the bioretention system to the existing downgradient catch basin to avoid an existing utility pole.

Proposed retrofit "4" is an underdrained grassed filter bed located along the western edge of the collector road to intercept runoff from the road which currently flows towards the shoulder. Curbing may be installed at the intersection with Route 111 to convey additional runoff towards the filter bed.

Proposed retrofit "5" is also an underdrained grassed filter bed located along the eastern edge of the collector road, with curbing at the intersection with Route 111, similar to PR-4.

The following table summarizes the dimensions and cost estimates of each potential retrofit. The cost estimates were developed as described above.

Table 22. Summary of Potential Tollbooth Retrofits.

Potential Retrofit	Surface Area, square feet	Estimated Storage Volume, cubic feet[1]	2014 Planning Level Cost Estimate[2]
3	1600	1600	$27,000
4	1200	1200	$20,000
5	1150	1150	$20,000

[1]Assumes surface depression with average depth of 1 ft.
[2]Based on $17/square foot of underdrained bioretention system/underdrained grassed soil filter bed and rounded to the nearest thousand dollars. These are estimated costs for general planning purposes.

Along Route 111 near the intersection with the tollbooth access road/Precourt Street, there are a few opportunities for retrofits within or adjacent to the roadway shoulder (see **Figure 18D**). Proposed retrofit "6" does not involve the installation of a specific retrofit measure, but instead is recommended maintenance for the roadway shoulder. This is an example of where the existing grading and soil/vegetated lip at the edge of the pavement promotes gutter flow and does not allow runoff to flow into the adjacent vegetated areas. At this location, there is an existing vegetated buffer which could provide some natural treatment if stormwater runoff from Route 111 could access the buffer. Proposed retrofit "6" includes the removal of buildup at the pavement edge to encourage runoff to sheet flow into the adjacent buffer.

Across the street, on the eastbound side of Route 111 to the west of the Precourt Street intersection, proposed retrofit "7" is the installation of a narrow strip of permeable concrete to allow some infiltration and treatment of runoff. The use of media that provides a higher level of treatment for phosphorus should be evaluated. Some curbing or regrading may be necessary to manage the flow of runoff for maximum effectiveness of this measure.

Proposed retrofit "8" on the eastbound side of Route 111 east of Precourt Street is a proposed underdrained grassed soil filter bed which would accept runoff from Route 111 and a catch basin in the parking lot of the nearby gas station.

Table 23. Summary of Potential Route 111 Retrofits.

Potential Retrofit	Surface Area, square feet	Estimated Storage Volume, cubic feet[1]	2014 Planning Level Cost Estimate
6	1300	N/A	$1,300[2]
7	400	N/A	$6,000[3]
8	2100	2100	$36,000[4]

[1]Assumes surface depression with average depth of 1 ft.
[2]Based on $1/square foot. These are estimated costs for general planning purposes.
[3]Based on $15/square foot.
[4]Based on $17/square foot of underdrained bioretention system/underdrained grassed soil filter bed and rounded to the nearest thousand dollars.

It is recommended that existing catch basins at the Park 'n' Ride area and the Route 111/Route 95 Intersection/Tollbooth intersection be retrofitted to be equipped with oil and grease protection, such as a "snout", if not already present.

The retrofits described herein have been identified as potentially viable options based on preliminary "desktop" and field investigations. It is possible that further investigations, advancement of conceptual designs and more detailed cost-benefit analyses will result in the determination that one or more of these retrofits is not feasible, or the measure proposed here will be altered to a different measure. The retrofits in these areas can generally be prioritized by traffic volume in the following order:

1. Retrofits that treat runoff from collecting roads with the highest moving traffic volume should be given first priority.

2. Retrofits that treat runoff from areas that have frequent stop and go traffic, such as gas station/convenience stores should be given medium priority.
3. Retrofits that treat runoff from locations where cars are parked for extended periods of time, such as the Park n' Ride area, should be given lesser priority.

Thus, priorities for each of the retrofits described above are as follows:

Table 24. Priority Level of Proposed Route 111/Route 95/Toll Booth Retrofits.

Potential Retrofit	Priority
1	3 - low
2	3 - low
3	1 – high
4	1 – high
5	1 – high
6	1 - high
7	2 - medium
8	2 - medium

Industrial Park

As described below, the installation of retrofit measures in the industrial park along Route 1 near the Biddeford Connector should be considered as properties are redeveloped using the "Tool Box" included in this WMP. However, specific retrofits to manage runoff from a property within the industrial park that is closest to Thatcher Brook have been identified and are described here. The edge of the parking lot behind the building at 26 Morin Street is approximately less than 50 feet from Thatcher Brook at its closest location. Much of the runoff from the parking lot and building roof sheet flows to the edge of the parking lot and has caused large erosion rills and gullies as it travels downslope to Thatcher Brook. It is recommended that a grassed swale be installed parallel to the edge of the parking lot to capture the runoff before it has the opportunity to cause erosion on the slope and convey it south to existing wetlands (potential retrofit "9", Figure 18E). A portion of the parking lot edge may be curbed to capture the runoff and direct it into the swale. After the runoff is managed, the existing rills and gullies should be repaired.

Table 25. Proposed Industrial Park Retrofit.

Potential Retrofit	Length, feet	2014 Planning Level Cost Estimate[1]
9	400	$50,000

[1]Based on $100/linear foot of grassed swale with average depth of 4 feet, width of 4 feet and side slopes of 3 horizontal: 1 vertical, and rounded to the nearest thousand dollars. Assumed approximately 300' of curbing.

This retrofit should be given high priority to stop continued erosion and potential undercutting of the bank, which could eventually result in loss of property.

Estimation of Pollutant Load Reduction

Structural stormwater retrofits for phosphorus were targeted for areas with high vehicle use, such as areas with high traffic and turnover of parking. Based on review by MDEP, it was decided that evaluating the net reduction in annual phosphorus load would be an appropriate method for estimating

the contributions of retrofits within the watershed for pollutant load reduction estimation. The pollutant load analysis focused on the net reduction in pounds per year of algal-available phosphorus that would result from the implementation of the structural stormwater retrofits presented in the Thatcher Brook Action Plan. The analysis uses a generalized approach by defining the pollutant load as a function of land use area. To estimate the net reduction in phosphorus, the first step of the analysis was to determine the pretreatment export by multiplying the treated area (in acres) by the export coefficient for the landuse under consideration (expressed as pounds of phosphorus exported per acre per year). Once the pretreatment export was assessed, the net reduction achieved was estimated by multiplying the removal efficiency by the pretreatment export value. Both the reduction efficiencies and area export coefficients were developed using guidance provided by MDEP. As presented in Table 26, the structural stormwater retrofits result in an estimated reduction of phosphorus export of approximately 47%.

Table 26. Pollutant Load Reduction Analysis

Potential Retrofit ID	BMP Type	Est. Removal Efficiency	Total Drainage Area, Acres	Impervious Drainage Area, Acres	Roads/ Driveways, Acres	Export Coefficient, lb/acre/yr	Parking, Acres	Export Coefficient, lb/acre/yr	Roofs/ Other, Acres	Export Coefficient, lb/acre/yr	Pervious Drainage Area*, Acres	Export Coefficient, lb/acre/yr	Pre-treatment Export (lb/yr)	Net Reduction (lb/yr)
1	Underdrained bioretention system	0.6	0.24	0.24	0	1.75	0.24	1.25	0	0.5	0	0.8	0.3	0.18
2	Underdrained grassed soil filter bed	0.6	0.74	0.56	0	1.75	0.56	1.25	0	0.5	0.17	0.8	0.84	0.51
3	Underdrained bioretention system	0.6	0.42	0.33	0.33	2	0	1.25	0	0.5	0.09	0.8	0.73	0.44
4	Underdrained grassed soil filter bed	0.6	0.67	0.65	0.65	2	0	1.25	0	0.5	0.02	0.8	1.32	0.79
5	Underdrained grassed soil filter bed	0.6	0.53	0.52	0.52	2	0	1.25	0	0.5	0.01	0.8	1.05	0.63
6	Natual buffer	0.3	0.35	0.24	0.24	2	0	1.25	0	0.5	0.11	0.8	0.56	0.17
7	Permeable Pavement	0.6	0.2	0.2	0.2	2	0	1.25	0	0.5	0	0.8	0.4	0.24
8	Underdrained grassed soil filter bed	0.6	2.41	1.56	0.45	1.75	0.97	1.25	0.14	0.5	0.85	0.8	2.75	1.65
9	Grassed Swale	0.2	3.14	3.01	0	1.75	1.94	1.25	1.07	0.5	0.14	0.8	3.06	0.61
												TOTAL	11.03	5.23
												PERCENT REDUCTION		47%

8.3.5 SUMMARY OF POTENTIAL ACTION ITEMS

The Thatcher Brook Action Plan includes a retrofit tool box to enhance stormwater treatment opportunistically as properties are redeveloped in the watershed. This approach allows municipalities and landowners in the watershed to develop creative and cost-effective solutions to address stormwater during the design phase of a project. In addition, the Action Plan includes recommendations for restoration and retrofit measures at specific sites (see **Table 27**). The recommendations include measures to address the priority stressors in the watershed including stormwater inputs (including phosphorus), habitat alteration, and riparian buffer conditions. Each recommendation was categorized as a high, medium, or low priority based on expected benefit to the stream, overall feasibility, anticipated interest of the current landowner, and total cost. Projects that have higher expected benefit to the resource and greater opportunity for multiple funding sources were considered higher priorities. During Year 1, Thatcher Brook high priority projects will be reviewed with the appropriate stakeholders to determine cost share/match availability, to then use in applying for grants. An important task of the Thatcher Brook Workgroup will be to develop Requests for Bids/Quotes on each item to be used for grant purposes. The estimated costs in this plan are provided as approximate rough numbers for general project scoping. Each task will require additional review and design to prepare construction plans and more refined cost estimates. However, it is anticipated that high priority retrofits will be pursued in Phase 1 of the project from approximately 2015 to 2020. Medium to low priority retrofits and restoration projects will likely pursued in Phase 2 (2020-2025) and Phase 3 (2025 – 2030, and beyond if needed). All measures will be ultimately reviewed and prioritized by the Thatcher Brook Workgroup based on available funds and current information (see Table 27 for details on project phasing).

The implementation of the Plan will require the input and participation of a variety of stakeholders. MTA, MDOT, and private landowners have been contacted as part of the project, and have provided input on retrofit recommendations. The final approval of these stakeholders is required for successful completion of the project. The implementation of the tool box will also require participation by landowners/applicants of future development projects. The Thatcher Brook Workgroup should include and establish relationships with a variety of stakeholders, including business owners, to refine and

implement the tool box. The Town of Arundel is also an important stakeholder for recommendations (e.g. culvert replacements) that occur in their municipality.

In addition to retrofit and restoration recommendations, the Action Plan includes recommendations for workgroup establishment, monitoring, outreach, and ordinance development, which will likely be conducted in part by Biddeford staff. It is anticipated that these items will be further refined and developed by the Thatcher Brook Workgroup, and certain items may be conducted with assistance from specialists. However, approximate potential costs are presented in Table 27 for initial planning purposes. The total estimated cost to implement all aspects of the Plan is $1,274,700 over the course of 15 to 20 years.

TABLE 27. SUMMARY OF MEASURES IDENTIFIED IN THE ACTION PLAN INCLUDING ANTICIPATED 2014 PLANNING LEVEL COSTS (SEE FIGURES 17, 18, AND 19).

Action Item Category	Potential Action Item ID on Figures	Location	2014 Planning Level Cost Estimates	Priority	Anticipated Schedule	Possible Project Sponsors
	RETROFITS					
Stormwater	Retrofit 1	MTA Park n' Ride	$4,000	Low	2025-2030	MTA and City of Biddeford (grants)
Stormwater	Retrofit 2	MTA Park n' Ride	$33,000	Low	2025-2030	MTA and City of Biddeford (grants)
Stormwater	Retrofit 3	MTA Toll Booth Exit 32	$27,000	High	2015-2020	MTA and City of Biddeford (grants)
Stormwater	Retrofit 4	MTA Toll Booth Exit 32	$20,000	High	2015-2020	MTA and City of Biddeford (grants)
Stormwater	Retrofit 5	MTA Toll Booth Exit 32	$2,000	High	2015-2020	MTA and City of Biddeford (grants)
Stormwater	Retrofit 6	Route 111 (Alfred Rd)	$1,300	High	2015-2020	MDOT and City of Biddeford (grants)
Stormwater	Retrofit 7	Route 111 (Alfred Rd)	$6,000	Medium	2020-2025	MDOT and City of Biddeford (grants)
Stormwater	Retrofit 8	Route 111 (Alfred Rd)	$36,000	Medium	2020-2025	MDOT and City of Biddeford (grants)
Stormwater	Retrofit 9 (near Station B1)	Morin St	$50,000	High	2015-2020	City of Biddeford (grants) in cooperation with landowner
	HABITAT RESTORATION					
Instream Habitat Restoration	Station A3	NE of Gateway Plaza, West of I-95	$20,000 - $50,000 based on similar projects in other watersheds	High	2015-2020	City of Biddeford (grants) in cooperation with landowner
Instream Habitat Restoration	Station B2	Off Medical Center Dr	$20,000-$50,000 based on similar projects in other watersheds	High	2020-2025	City of Biddeford (grants) in cooperation with landowner
Buffer Restoration	TH3 (near Station B1)	Morin St	$10,000 – $50,000 depending on landowner interest	High	2015-2020	City of Biddeford (grants) in cooperation with landowner
Buffer Restoration	Buffer 1	Wellspring Rd	N/A – voluntary mowing restriction	Low	2020-2025 (contact owner)	City of Biddeford in cooperation with landowner
Buffer Restoration	Buffer 2	Mountain Rd	N/A – voluntary mowing restriction	Medium	2020-2025 (contact owner)	City of Biddeford in cooperation with landowner
Buffer Restoration	Buffer 3	Mountain Rd	N/A – voluntary mowing restriction	Medium	2020-2025 (contact owner)	City of Biddeford in cooperation with landowner
Buffer Restoration	Buffer 4 (near Station B1)	Elm St and Morin St	N/A – voluntary mowing restriction	Medium	2020-2025 (contact owner)	City of Biddeford in cooperation with landowner
Culvert Replacement	Culvert 1	Jeffs Way	$213,300	Medium	2025-2030	Town of Arundel (grants) with assistance from the Thatcher Brook Workgroup
Culvert Replacement	Culvert 2	Cote Dr	$165,100	Low	2025-2030	Town of Arundel (grants) with assistance from the Thatcher Brook Workgroup
Culvert Replacement	Culvert 7	Briar Ln	$233,900	Medium	2025-2030	Town of Arundel (grants) with assistance from the Thatcher Brook Workgroup
Bank Stabilization	Station B1	Morin St	$23,600	High	2015-2020	City of Biddeford (grants) in cooperation with landowner

COMMUNITY OUTREACH					
1. Outreach to residential landowners on fertilizers, yard/pet waste disposal, and Yardscaping		$20,000	High	2015-ongoing	City of Biddeford and Town of Arundel
2. Outreach to commercial landowners on stormwater the retrofit toolbox, and salt reduction methods.		$20,000	High	2015-ongoing	City of Biddeford
3. Outreach and technical assistance to agricultural landowners		$10,000	Medium	2025-2030	City of Biddeford and Town of Arundel
4. Outreach to schools on watershed cycling, stormwater, and stream health. Assess the feasibility of school participation in installing retrofits (e.g rain gardens, rain barrels) at schools.		$20,000	High	2015-2020	City of Biddeford and Town of Arundel
5. Strengthen ties with local schools and the University of New England. Engage schools during the implementation of each project		N/A	High	2015-ongoing	City of Biddeford
6. Develop an incentive program for landowners with existing developments to implement tool box recommendations		$80,000 (dependent on focus of Workgroup)	High	2015-ongoing	City of Biddeford
7. Install educational signs at stream crossings and at completed projects		$3,000	High	2015-ongoing	City of Biddeford
8. Identify partnerships and incentives for encouraging low salt application alternatives		$3,000	Medium	2020-2025	MDEP and City of Biddeford
ORDINANCE DEVELOPMENT					
1. Require stormwater treatment for projects under 1 acre in size.		$5,000	High	2015-2020	City of Biddeford
2. Encourage the reduction and disconnection of impervious surface (e.g. maximum versus minimum parking requirements)		$3,000	High	2015-2020	City of Biddeford
3. Encourage conservation and buffer implementation in areas with High Interest Habitats or intact riparian buffers.		N/A (But potential land purchase costs are not included)	Med/ High	2015-ongoing	City of Biddeford and Town of Arundel
PLAN IMPLEMENTATION					
1. Establish Thatcher Brook Workgroup		$7,000	High	2015 – first step	City of Biddeford
2. Prepare grants/secure funds		$8,000 (if not performed by volunteers)	High	2015-ongoing	City of Biddeford and Thatcher Brook Workgroup
3. Track completed sites, pollutant load reductions, and milestones		$2,000	High	2015-ongoing	City of Biddeford
4. Provide annual updates to the Biddeford City Council and Town of Arundel		$2,500	High	2015-ongoing	City of Biddeford
5. Maintain and update the Thatcher Brook Project web page and provide updates to an e-mail list serve of interested watershed stakeholders		$2,000	High	2015-ongoing	City of Biddeford
MONITORING					
1. Conduct macroinvertebrate monitoring after implementation of high priority retrofits and restoration projects.		$31,000 ($7,700/cycle if all 4 stations are assessed)	High	2020-2025 (depending on actual implementation dates)	MDEP and City of Biddeford consultant as approved by MDEP where sampling does not overlap MDEP schedule
2. Conduct habitat evaluations at all in-stream and buffer restoration areas after implementation		$4,000	High	2020-2025 (depending on actual implementation dates)	City of Biddeford consultant
3. Complete dissolved oxygen sampling to assess the influence of wetlands and relic nutrient sources on low dissolved oxygen values.		$82,000	Med	2020-2025	City of Biddeford consultant

4. Research salt application practices in the watershed and consider a chloride source study.		$5,000	Low	2025-2030	City of Biddeford
5. Assess salt application practices and subsurface geology where future infiltration BMPs are proposed.		$2,000	Medium	2020-2025	MDEP and City of Biddeford

8.3.6 DEVELOP AN OUTREACH PROGRAM FOR CITIZENS

A major task of the Thatcher Brook Workgroup will be to develop a locally tailored outreach program for citizens. Densely developed residential areas (e.g. in the northeastern portion of the watershed) should be targeted for educational campaigns on both stormwater and natural landscaping options.

The following are targeted goals for the public outreach campaign:

1. Develop and implement a presentation on yardscaping for either a residential neighborhood or local garden club.
2. Develop a presentation for local middle and high school classes on stream health and aquatic communities. Coordinate with local science teachers to complete school monitoring.
3. Host a BMP or yardscaping installation workshop. Target measures that individual owners can implement on their own property (e.g. rain garden, rain barrel, or pervious patios).
4. Develop signs for restoration/retrofit projects, and stream crossings at public access trails, to increase awareness of Thatcher Brook. Develop at least five signs.

8.3.7 FUTURE PROTECTION STRATEGIES

The potential BMPs and restoration projects discussed throughout this plan provide measures to encourage stream recovery. However, conditions of the watershed are not static, and the plan will need to account for changes in the watershed. The following strategies are recommended to foster future protection efforts:

1. Require stormwater treatment for projects less than one acre in size. The City of Biddeford currently requests, but does not require, stormwater treatment for new development projects. IN addition, stormwater treatment is not required by the State of Maine for projects with impervious cover under one acre in size, or for projects under five acres of developed area (that have less than one acre of impervious surface). As a result, requesting stormwater treatment for projects (via ordinance changes) would provide additional protection for future build-out in the watershed. The Technical Committee recommends that the City develop a stormwater ordinance and consider implementing the treatment standards already in place for projects greater than one acre in size (see **Figure 16,** Stormwater Catchments and Impervious Cover).
2. Monitor development plans throughout the watershed. New developments should strive to avoid acerbating priority stressors within each subwatershed. The City of Biddeford currently requests mitigation for projects greater than five acres in size that pose impacts to significant wildlife or fisheries habitats. Mitigation measures could include items identified in the plan.
3. The watershed should strive to reduce and disconnect impervious surface. Pervious surface technologies, in areas where salt contamination is not a concern, should be encouraged and implemented where possible.
4. Pursue Conservation in Areas with High Interest Habitats (see **Figure 19**, High Interest Habitat and Conserved Land), and/or where conservation can protect riparian corridor buffers.

8.3.8 DEVELOP A THATCHER BROOK WORKGROUP TO OVERSEE PLAN IMPLEMENTATION

A critical component of the Thatcher Brook Action Plan is to establish the Thatcher Brook Workgroup in order to ensure that Watershed-wide restoration goals are being met. The workgroup will:

- Ensure that all watershed stakeholders are represented
- Conduct at least three meetings per year to oversee and guide plan implementation
- Promote one of the meetings with the public and share information about the progress made in restoration efforts
- Apply for grants and other funding to implement plan (see Section 11 for potential funding opportunities)

9.0 MONITORING PLAN

Long-term monitoring will be necessary to determine whether Thatcher Brook is meeting water quality and aquatic life use standards. In addition, monitoring provides valuable information in reviewing and updating the remedial actions identified in the WMP.

9.1 MACROINVERTEBRATE COMMUNITY

MDEP's macroinvertebrate monitoring (or biomonitoring) protocol is the primary method in determining whether Maine rivers and streams meet their designated uses. Benthic macroinvertebrates communities are studied to determine whether Maine streams meet their aquatic life criteria. MDEP's past macroinvertebrate monitoring indicates that two nearby stations within Upper and Lower Thatcher Brook do not meet Class B standards for aquatic life. However, the MDEP monitoring also demonstrates that a downstream station within Lower Thatcher Brook has consistently met Class B standards. Since benthic macroinvertebrate sampling is MDEP's primary indicator for 303(d) listing, future monitoring in the watershed must include additional macroinvertebrate monitoring to determine the current status of macroinvertebrate communities. Based on current MDEP standards, a station has passed when it has met aquatic life use criteria for two consecutive sampling periods.

This Plan recommends two levels of macroinvertebrate sampling to monitor water quality improvements within the Watershed (see **Table 28**).

Table 28. Biomonitoring Program Summary.

Sample Frequency	Conducted by	Number of Sites	Protocol	Notes
Biennial	Project Stakeholders and MDEP	4	MDEP Rock Bag	TH3, TH2, TH1, and S-451 (see Figure 13). Monitoring should be conducted within one to two years after habitat restoration efforts at respective reaches. Sites may be rotated. The exact location of TH3 and TH2 may need to be adjusted due to indeterminate scores, subject to approval by MDEP.
3 to 5 years, in opposite years of rock bag sampling	Project Stakeholders, under consultation with MDEP	3	D-frame net sampling, overseen by appropriate field scientists.	TH3, TH2, and TH1 (see Figure 13). D-frame net sampling provides additional data where rock bag samples are Indeterminate due to low sample size. D-frame net sampling allows for focused review of macroinvertebrate use of specific microhabitats after restoration

Existing macroinvertebrate sites will be sampled on a rotating basis. Four sites will be sampled every other year, starting two years after restoration and retrofits are completed at individual sites. It is likely that MDEP will continue to implement its biomonitoring program in Thatcher Brook every 5 years, however more frequent analysis will be necessary to determine if Plan measures are improving aquatic life. Where habitat restoration is completed, and where rock bag samples are categorized as indeterminate, the plan also calls for d-frame net sampling. D-frame net sampling provides a means to calculate raw indices in individual stream microhabitats that are potentially affected by restoration efforts. These data are designed to be used to guide future restoration efforts in the watershed, and are designed to supplement rock bag data.

MDEP's biomonitoring protocol specifies that identification must be performed by personnel under the supervision of a professional aquatic biologist, and sample taxonomy must be performed by a professional freshwater macroinvertebrate taxonomist (Davies and Tsomides 2002) in order for the results to be used to determine compliance with state water quality criteria [i.e., to remove a stream from the 303(d) list]. When MDEP is not available to complete sampling, this Plan proposes to complete the biennial macroinvertebrate monitoring events by an appropriate professional in accordance with MDEP protocol. The macroinvertebrate identification will be completed by a MDEP approved macroinvertebrate expert. However, the collection of d-frame net samples may be completed with the assistance of local students. These results will be used as screening level results to monitor stream recovery. However, the data will not be used to determine inclusion/exclusion on the 303(d) list. If the screening data suggests that the stream is achieving its cleanup goals and could be de-listed, then additional sampling with rock bags will be conducted by an appropriate professional following the complete MDEP protocol for sample collection and invertebrate identification.

Macroinvertebrate sampling is required to evaluate the cumulative impacts of all potential stressors in the Watershed, attempting to identify each contaminant's effect on the macroinvertebrate community. If the macroinvertebrate communities do not show substantial recovery following implementation of the measures identified in this Plan, then additional stressor analysis could be undertaken at a later date.

9.2 WATER CHEMISTRY

This Plan proposes to conduct periodic water quality monitoring to evaluate long-term trends in water quality, and to provide a general assessment of whether additional remedial measures are necessary in the watershed. At a minimum, specific conductance, pH, DO, and water temperature data will be collected during macroinvertebrate sampling. In addition, GZA recommends that the Thatcher Brook Workgroup consider additional dissolved oxygen monitoring to discern the degree to which natural wetland conditions and/or legacy groundwater baseflow contributions may be contributing to low DO. Based upon the dissolved oxygen (DO) and watershed data gathered for Thatcher Brook to date, it is likely that the low DO observed is variably a result of both anthropogenic and natural conditions. Elsewhere in the U.S., other watersheds are also working with the assessment of stream DO and examining the contributions of natural wetlands to low DO (VDEQ, 2012; Bales & Walters, 2003). Because the ultimate goal will be to improve water quality within Thatcher Brook with the possible implementation of BMPs to address nutrient introductions, it makes logical sense to determine as accurately as possible the actual sources of the nutrients and other natural factors that may be contributing to the observed low DO. Otherwise, costly corrective measures may be ineffective and not achieve the desired goals for lowering the degree of eutrophication and improving biotic conditions

within Thatcher Brook. This will help prioritize future retrofit recommendations and help guide the use of limited funds. The Thatcher Brook Workgroup may also want to consider assisting other City Departments with bacteria monitoring. Additional phosphorus and bacteria samples may need to be collected after management plan remedies are implemented to target future retrofit and restoration activities, and to assess the effectiveness of maintenance measures.

9.3 STREAM HABITAT

This plan identifies locations for improving riparian and in-stream habitat in the watershed. Habitat restoration is a critical component to improving aquatic life use scores, and meeting Class B water quality standards. Appropriate habitat conditions are necessary to provide the necessary food and shelter for macroinvertebrates and other stream biota.

Monitoring is highly recommended for all in-stream and bank stabilization restoration projects. Monitoring during and after construction is critical to assess whether projects are functioning, and to determine if future habitat restoration plans need to be adjusted. Approximately, one year after implementation, restoration areas should be reevaluated for evidence of erosion and scour. In addition, in-stream restoration projects should be reevaluated using EPA's rapid bioassessment methodology.

10.0 MEASURES OF SUCCESS

Thatcher Brook does not currently meet State water quality standards due to aquatic life use impairments. The goal of this plan is for Thatcher Brook to meet State water quality standards by 2025.

It is proposed that this goal may be accomplished by implementing stream corridor and channel restoration projects, applying BMPs to reduce nutrient and chloride loading, and implementing nonstructural and structural measures to limit the impact of all impervious cover.

Since it may take ten years or more for Thatcher Brook to meet State water quality standards, interim milestones should also be tracked to measure progress on Plan implementation. Interim and long term measurable milestones are discussed in the following sections.

10.1 ORGANIZATIONAL MILESTONES

- Establish Thatcher Brook Workgroup;
- Conduct three meetings annually of the Thatcher Brook Workgroup;
- Update City of Biddeford Council and Town of Arundel annually;
- Maintain and update Thatcher Brook Project web page;
- Develop an email list serve for watershed stakeholders; and,
- Secure funding adequate to complete restoration priorities identified in this Plan.

10.2 ENVIRONMENTAL AND STRUCTURAL MILESTONES

- Track number of nutrient and sediment load reductions associated with identified “hot spots”;
- Track number of existing sites redeveloped with stormwater retrofits
- Track number of habitat restoration projects completed;
- Track linear footage of total riparian buffer restoration completed;
- Track number of impervious acres treated with stormwater retrofits;
- Track number of fish passage barriers addressed and amount of in-stream habitat connected by barrier removal; and
- Track number of landowners participating in outreach programs

10.3 WATER QUALITY MILESTONES

- Documentation of improved water quality measurements for DO (where not from naturally occurring sources);
- Documentation of improving and maintaining low chloride values;
- Documentation that stream habitat restoration projects are stable and/or functioning;
- Documentation that the brook meets Class B standards for macroinvertebrates at designated sites; and,
- Eventual removal from the 303(d) list for aquatic life impairments.

11.0 FUNDING OPPORTUNITIES

The following are potential funding mechanisms for the implementation of activities identified in this plan. The City of Biddeford staff (e.g. City Engineer, City Planner) expect to be heavily involved in the implementation of the plan, through coordination and participation in the Thatcher Brook Workgroup. Currently, it is expected that the initial phases of the Plan will reply heavily on grant funding, and collaboration with stakeholders, as there are no existing local funding sources for the Plan.

11.1 GRANT FUNDING

US EPA 5 Star Grants

US EPA 5 Star Grants are available to any public or private entity engaging in community-based restoration. Projects must include a wetland, riparian or coastal habitat component and must also include a specific training, education, community stewardship and/or outreach component. Projects must involve diverse partnerships that contribute funding, technical assistance, workforce support and in-kind services.

- Competitive—grants up to $500,000
- Applications due in March and June
- Projects must be complete in one year
- Stream Enhancement Buffers
- Yardscaping Outreach Program

US EPA 5 Urban Waters Small Grants

The US EPA Urban Waters Small Grants program funds research, investigations, experiments, training, surveys, studies, and demonstrations that will advance the restoration of urban waters by improving water quality. The fund is geared towards projects that include community revitalization components and other local priorities. Grants are awarded every two years (e.g. 2016, 2018). During 2014, successful projects ranged from approximately $40,000 – 60,000 each, with a total of 2.1 million dollars awarded.

- Competitive—grants up to $500,000
- Applications due in March and June
- Projects must be complete in one year

Nonpoint Source Grants Programs 2014 (319 grants)

Nonpoint Source Grant projects are designed to prevent or reduce nonpoint source pollutant loadings entering water resources so that beneficial uses of the water resources are maintained or restored. Maine public organizations such as state agencies, soil and water conservation districts, regional planning agencies, watershed districts, municipalities, and nonprofit (501(c)(3)) organizations are eligible to receive NPS grants from MDEP.

- Annual grant RFP issues in April with project commencing following April
- Town roadway retrofits, private facility retrofits, stream enhancement-buffers, regional facilities.

Fund for Maine Land Conservation

The Fund for Maine Land Conservation is designed to assist in the conservation and preservation of Maine Land. The fund does not specifically provide monies for the purchase of land but is designed to support related activities including field surveys, Natural Resource Inventories, voluntary stewardship planning, and community outreach.

- Currently provides funds up to $7500
- Applications due October 15th of each year

Land for Maine's Future (LMF)

The Land for Maine's Future program is managed by the Maine Department of Agriculture, Conservation and Forestry, and is considered the State of Maine's primary funding mechanism for conserving land for natural resource and recreational value. The City of Biddeford was awarded funds during 2014 for the Biddeford Riverwalk Park.

Maine Natural Resources Conservation Program (MNRCP)

The Maine Natural Resources Conservation Program awards grants to restore and preserve high priority aquatic resources. Fees from the In Lieu Fee Compensation Program are collected by MDEP and deposited in the NNRCP. The program is administered by The Nature Conservancy.

- Letters of Intent are due in June
- Final decisions on full proposals are made in December

Clean Water Bond

The Clean Water Bond was approved by Maine voters in November 2012. Of the $10 million bond, $5.4 million is designated to upgrade stream crossings to improve habitat for fish and wildlife. Detailed guidelines and application information are expected to be released in 2015.

Forest Legacy Program

The Forest Legacy Program is administered by the U.S. Forest Service and is designed to support state efforts to work with forest land owners on a voluntary basis to protect environmentally sensitive forest lands through the establishment of conservation easements. The program may fund up to 75% of project costs, with at least 25% of costs required to be matched by private, state, or local sources. Successful projects are required to develop a multiple resource management plan to protect and

maintain natural resources such as wildlife, habitat diversity, threatened and endangered species, water quality, wetlands and riparian buffers, and recreational opportunities.

Healthy Forests Reserve Program (HFRP)

The Healthy Forests Reserve Program (HFRP) provides funds to aid in the recovery of threatened and endangered species, improve biodiversity, and enhance carbon sequestration. Funds are provided to acquire term and permanent conservation easements and agreements.

Wildlife Habitat Incentive Program (WHIP)

The Wildlife Habitat Incentive Program (WHIP) is a voluntary program of the Natural Resource Conservation Service (NRCS) for landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land. The WHIP provides funding to promote the restoration of declining or important native fish and wildlife habitats; reduce the impacts of invasive species on fish and wildlife habitats; and to protect, restore, develop or enhance declining or important aquatic wildlife habitats. WHIP funds could be used for habitat restoration and protection within Thatcher Brook, invasive species removal and buffer restoration, and preserve other wildlife habitat within the stream corridor.

Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is a voluntary program of the NRCS that provides financial and technical assistance to agricultural producers to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plant, animal, air and related resources on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to help producers meet Federal, State, Tribal and local environmental regulations.

Agricultural producers within the watershed could access EQIP funds to implement BMPs on their properties that support stream restoration (such as nutrient management practices and buffer improvement or maintenance activities as needed).

11.2 PRIVATE FOUNDATION FUNDING

DAVIS CONSERVATION FOUNDATION

The Davis Conservation Foundation is only open to organizations that are tax exempt under Section 501(c)(3) of the IRS code. The Foundation supports organizations whose primary interested are related to wildlife, wildlife habitat, environmental protection or outdoor recreation. Funding is available for monitoring, yardscaping, outreach, town roadway retrofits, and stream enhancement buffers. Projects that strengthen volunteer activity and outreach/community involvement are of particular interest.

- Grants range from $2,000 to $100,000
- Bi-annual submissions deadlines are April 10 and October 10

John Sage Foundation
The John Sage Foundation is only open to organizations that are tax exempt under Section 501(c)(3) of the IRS code. Types of projects that have been funded include land acquisition and site evaluations, water testing programs, environmental education, and community garden programs.

- Grants range from $500 to $2500
- Bi-annual submission deadlines are February 15 and August 15.

Henry P. Kendall Foundation
The Henry P. Kendall Foundation is only open to non-profit organizations classified as public charities under Section 501(c)(3) of the IRS code. Funds are provided for general operating needs and for specific programs and initiatives. Previous projects funded include advocacy, public education, policy research and analysis, on-the-ground resource management experiments and institutional development.

- Grants range from $20,000 to $50,000
- Bi-annual submission deadlines in June and December

11.3 COMMUNITY-BASED FUNDING

There are currently no formal community-based funding sources for the implementation of watershed projects. It is anticipated that the Thatcher Brook Workgroup will work with municipal leaders to identify local sources of funding to act as matches for grant applications.

Stormwater Utility Fee
A stormwater utility fee is a potential funding option recommended by the Biddeford Conservation Commission. This type of funding mechanism imposes fees based on the amount of impervious surface present on a given property in a watershed, and can be set-up to provide financial incentives for owners to reduce impervious surface. A stormwater fee, or similar revenue-generating structure, may be necessary for implementation of goals if milestones are not met as anticipated with grant funding, and additional stormwater retrofits and habitat restoration work is required. This option requires review and approval by the Biddeford City Council.

Compensation Fee Utilization Plan
The City of Biddeford may explore the use of a Compensation Fee Utilization Plan (CFUP), dependent on City Council review and approval. Thatcher Brook is not currently listed as an Urban Impaired Stream under Chapter 502 of the Maine Stormwater Law (38 M.R.S.A. §420-D.11.). However, it is anticipated that it will be added in future revisions. The Stormwater Management Law authorizes the DEP to accept a compensation fee in lieu of meeting all or part of water quality standards, and Chapter 500, Section 6, establishes compensation fee requirements for projects located in the watersheds of urban impaired streams. The City of Biddeford could elect to develop a compensation fee utilization plan (CFUP) that outlines eligible mitigation projects where compensation fee could be used. Several municipalities in Maine have adopted CFUPs and used fees to install BMPs identified in watershed-based plans. This arrangement could also be pursued for Thatcher Brook. Some communities have chosen to adopt the

same fee structure for projects outside the urban impaired watershed boundary to eliminate the potential disincentive to locating in the growth area.

12.0 ACRONYMS

BMPs	Best Management Practices
CCC	Criterion Chronic Concentration
CFUP	Compensation Fee Utilization Plan
YCSWCD	York County Soil & Water Conservation District
CMC	Criterion Maximum Concentration
CSO	Combined Sewer Overflow
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
IC	Impervious Cover
IDDE	Illicit Discharge Detection and Elimination
LID	Low Impact Development
LMF	Land for Maine's Future
MDEP	Maine Department of Environmental Protection
mg/L	milligrams per liter
Ug/L	Micrograms per liter
MNRCP	Maine Natural Resources Conservation Program
mS/cm	milliSiemens per centimeter
MS4	Municipal Small Separate Stormwater System
NRCS	Natural Resource Conservation Service
Plan	Watershed Management Plan
RGA	Rapid Geomorphic Assessment
TMDL	Total Maximum Daily Load
WHIP	Wildlife Habitat Incentive Program
WMP	Watershed Management Plan

13.0 REFERENCES

Bales, J.D. and D.A. Walters. 2003. Relations Among Floodplain Levels, Instream Dissolved-Oxygen Conditions, and Streamflow in the Lower Roanoke River, North Carolina, 1997-2001. U.S. Geological Survey Water-Resources Investigations Report 03-4295. 81 pp.

Barbour, M.T., J. Gerritsen, B. D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Center for Watershed Protection. 2003. Impacts of Impervious Cover on Aquatic Systems. Center for Watershed Protection, Ellicott, MD.

City of Biddeford Open Space Committee. November 2012. City of Biddeford, Maine Open Space Plan.

Cumberland County Soil & Water Conservation District. December 2012. Trout Brook Watershed Management Plan. Prepared for the City of South Portland, Maine. 70 pp.

Davies, S.P. and L.T. Tsomides. 2002. Methods for Biological Sampling and Analysis of Maine's Rivers and Streams. Maine Department of Environmental Protection. Revised August 2002. DEP L W0387-B2002.

Grey, M., D. Sorem, C. Alexander, and R. Boon. February 13, 2013. The Costs of LID. Stormwater Magazine.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist 20(1):31-39.

Hilsenhoff, W.L, Hine, R.L. (eds). 1982. Using a Biotic Index to Evaluate Water Quality in Streams. Technical Bulletin No. 132, Department of Natural Resources, Madison, Wisconsin.

HNTB Corporation. May 5, 2014. Memorandum to Steve Tartre of the Maine Turnpike Authority.

Houle, J.J., R.M. Roseen, T.P. Ballestero, T.A. Puls, and J. Sherrard Jr. July 2013. Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management. J. Environ. Eng. 2013.139:932-938.

Maine Department of Environmental Protection. 2012. TMDL Assessment Summary: Thatcher Brook. 6 pp.

Maine Department of Environmental Protection. February 2009. Stream Survey Manual: A Citizen's Guide to Basic Watershed, Habitat, and Geomorphology Surveys in Stream and River Watersheds – Volume I.

Maine Department of Environmental Protection, Maine Stream Team Program. October 2010. A Citizen's Primer on Stream Ecology, Water Quality, Hydrology, and Fluvial Geomorphology – Volume II.

Maine Department of Environmental Protection. September 2012. Maine Impervious Cover Maximum Daily Load Assessment (TMDL) for Impaired Streams. DEPLW-1239. 57 pp.

Maine Department of Environmental Protection. Accessed November 2014. Maine Stormwater Best Management Practices Manual. Online at http://www.maine.gov/dep/land/stormwater/stormwaterbmps/

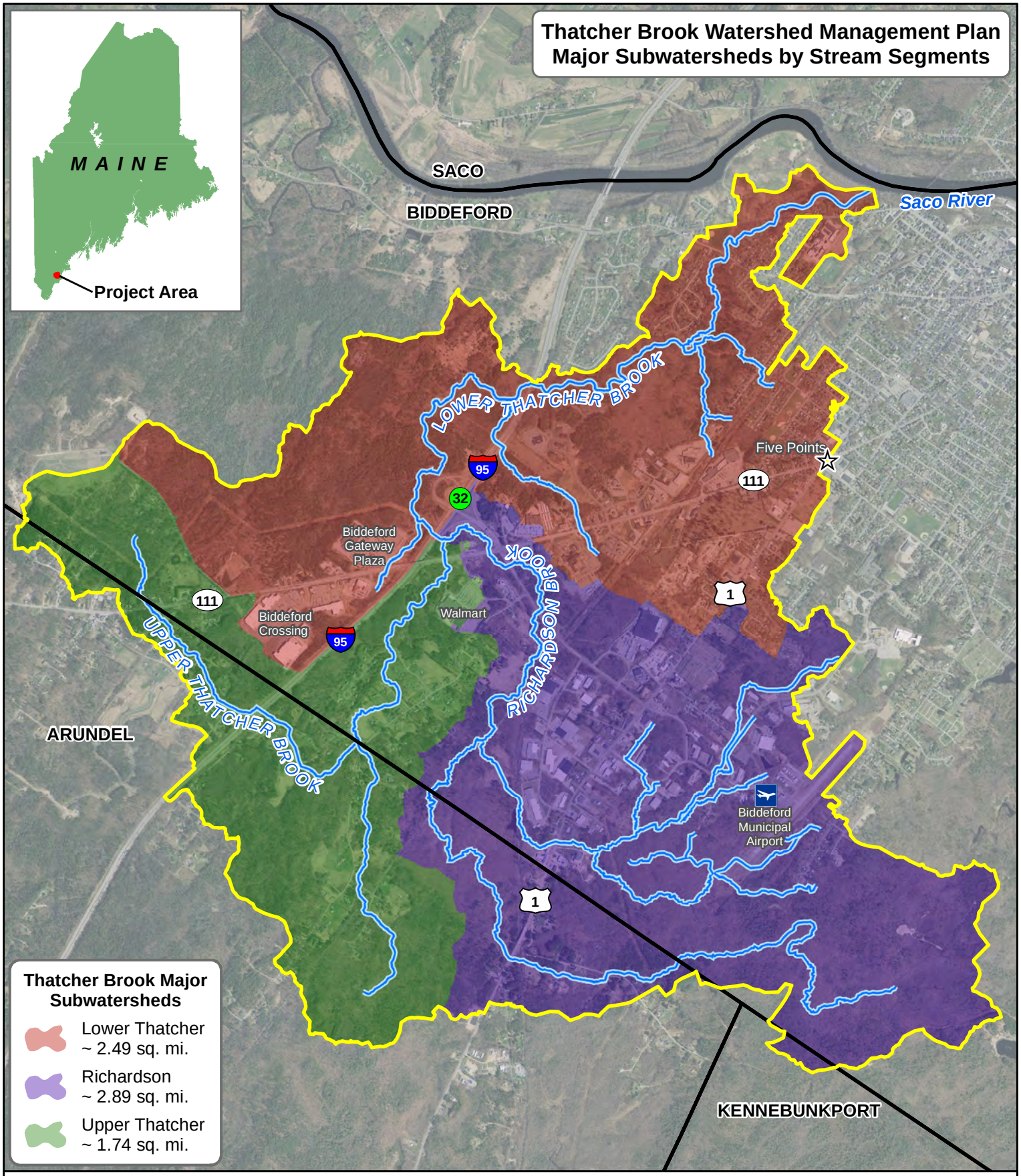
Massachusetts Department of Environmental Protection. Stormwater Management Standards Handbook.

Oregon Department of Transportation. 2006. Operation Notice Number PD-)5. http://www.oregon.gov/odot/hwy/pdu/docs/pdf/pdltnotice05.pdf.

University of New Hampshire Stormwater Center. 2012 Biennial Report.

U.S. Environmental Protection Agency. 2012. Water Quality Standards Handbook, 2nd edition. http://waterepa.gov/scitech/swguidance/standards/handbook/.

Virginia Department of Environmental Quality. 2012. Natural Conditions Assessment for Low Dissolved Oxygen, Masons Mill Swamp in Middlesex County, Virginia. State of Virginia, U.S.A. 17 pp.



N

Thatcher Brook

Thatcher Brook Watershed

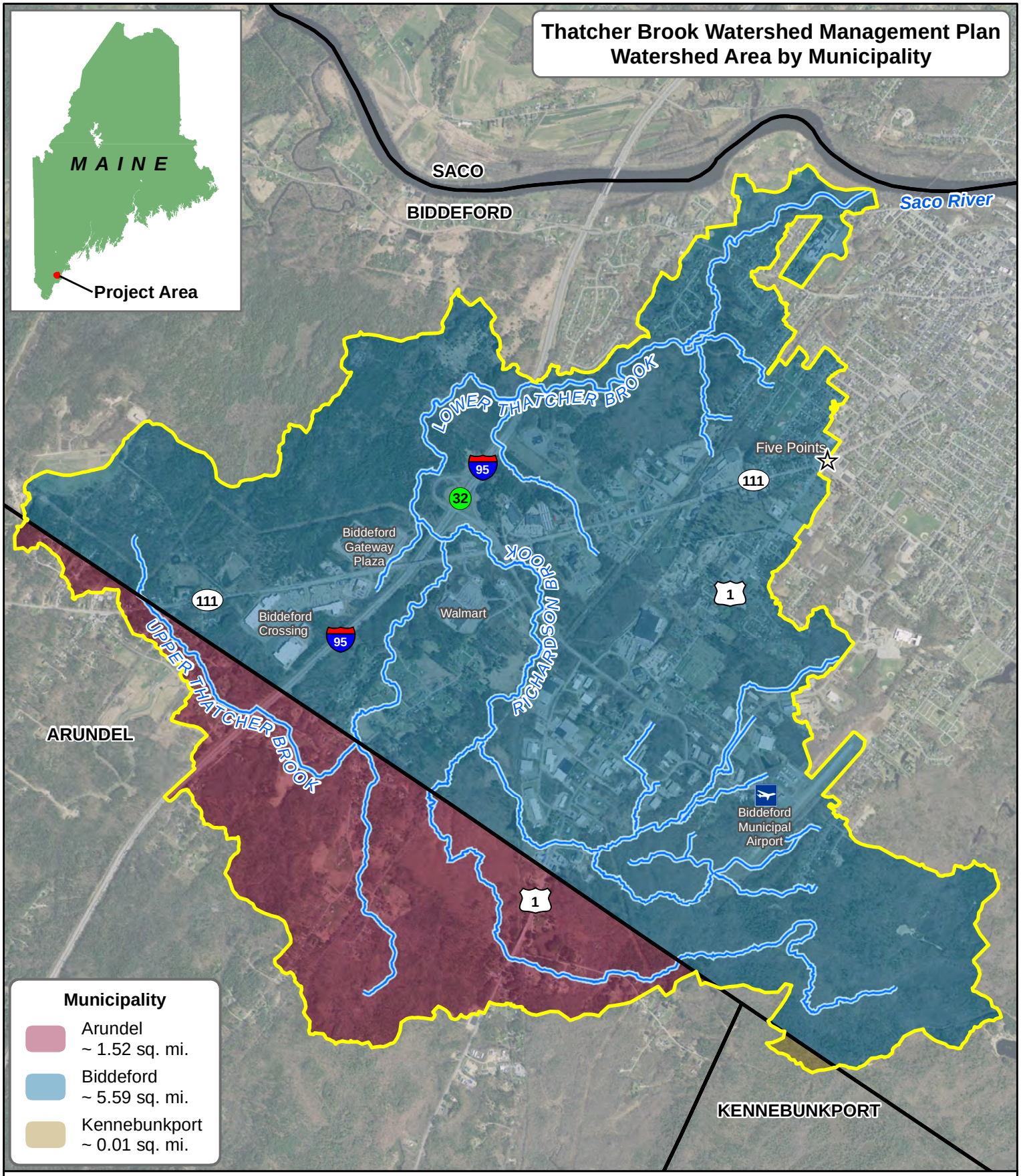
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 1

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

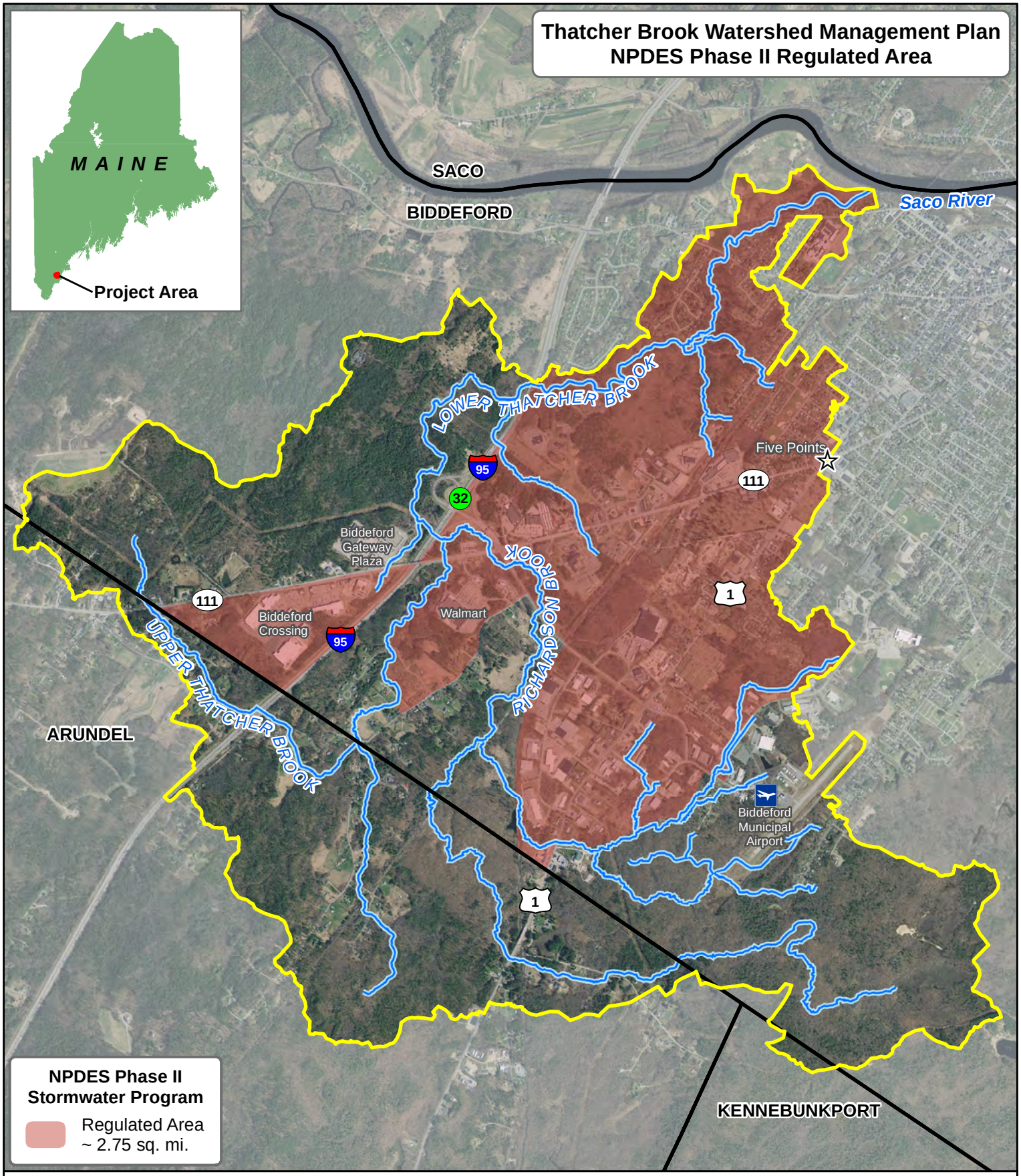
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 2

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

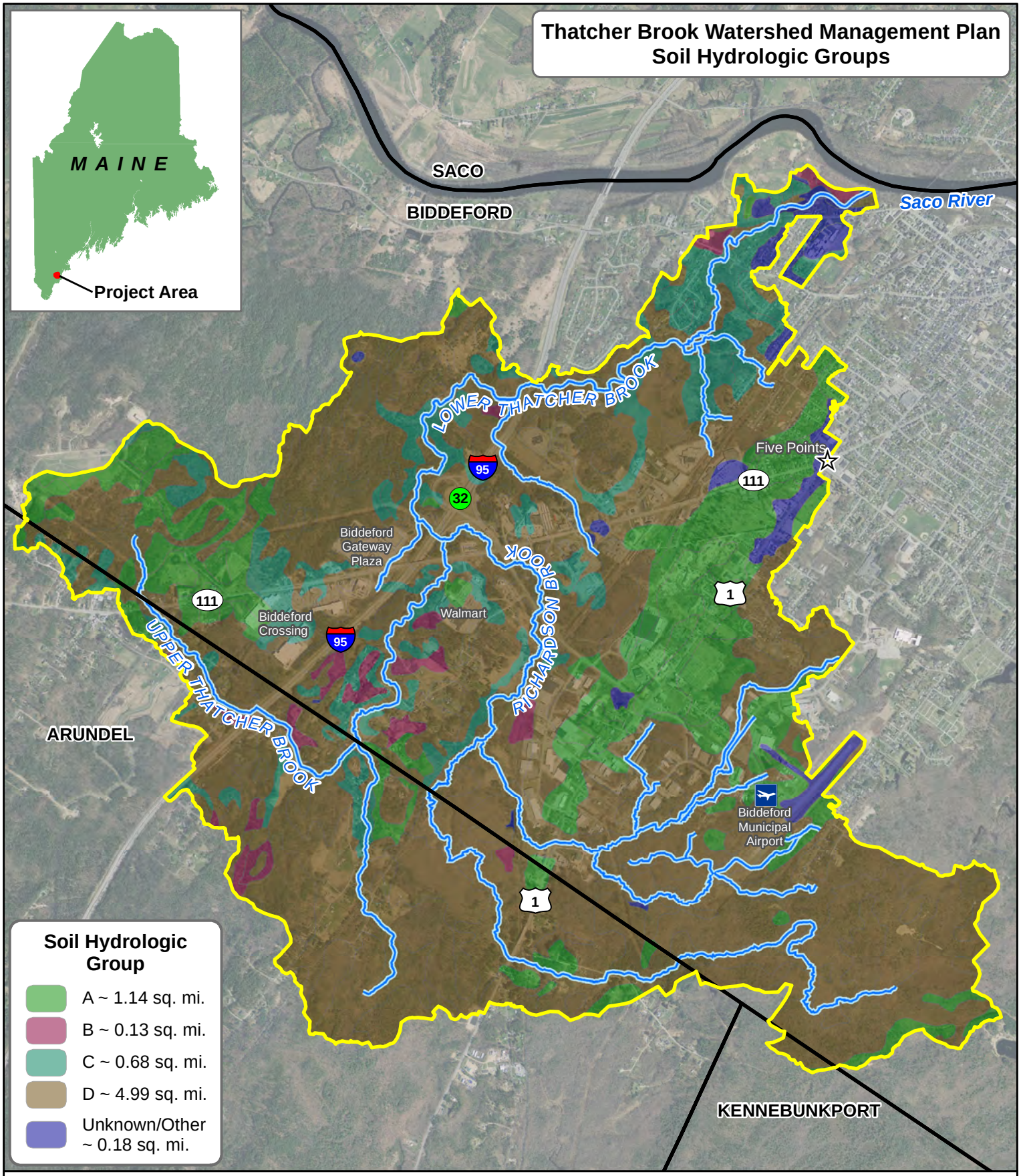
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 3

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

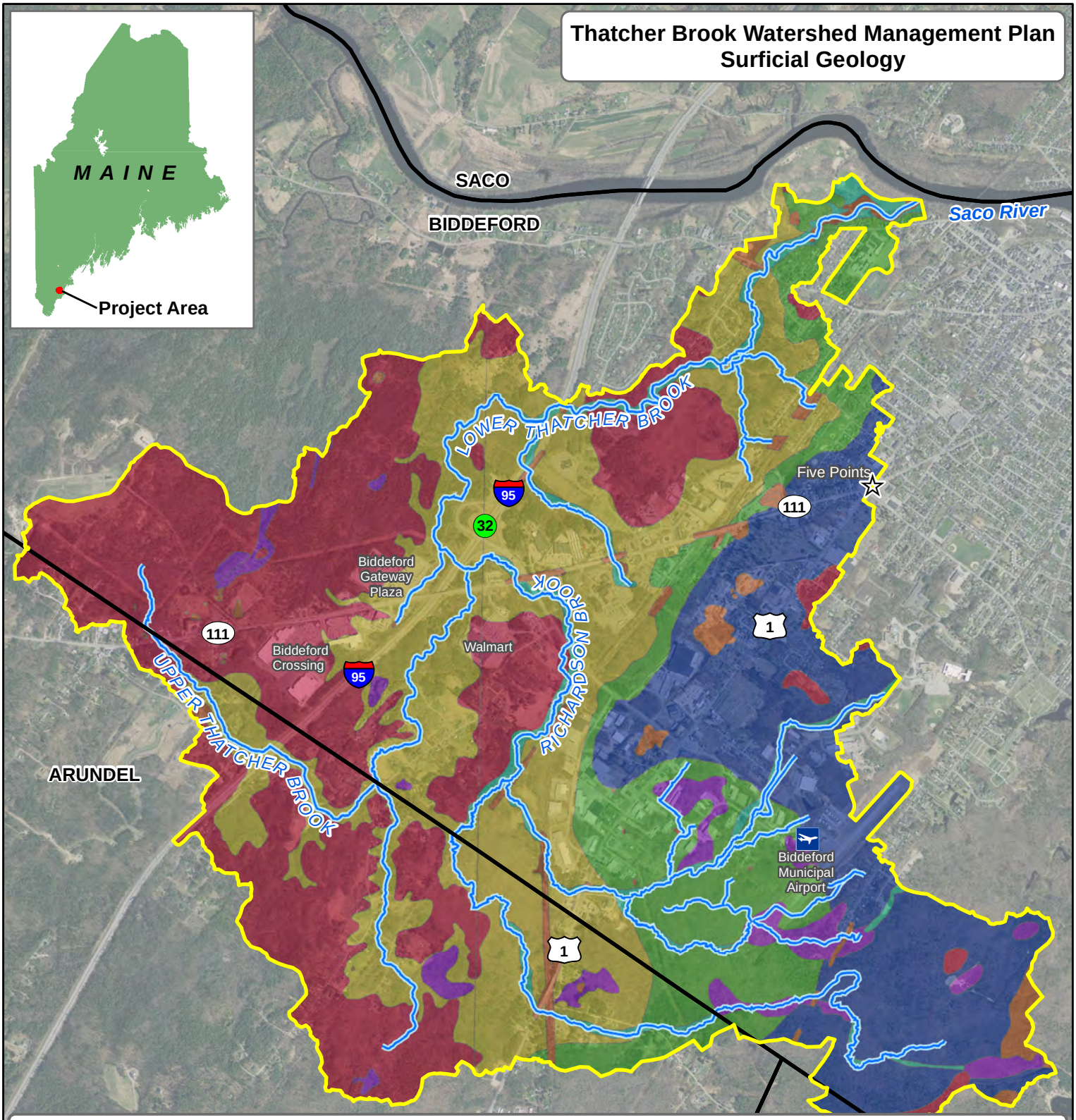
0 0.25 0.5 1 Miles

Figure # 4

York County Soil and Water Conservation District

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, USDA, NRCS



Till ~ 2.21 sq. mi.

Presumpscot Formation ~ 2.08 sq. mi.

Marine shoreline deposits ~ 1.32 sq. mi.

Marine regressive sand deposits ~ 0.86 sq. mi.

Stream alluvium ~ 0.24 sq. mi.

Wetland, swamp ~ 0.23 sq. mi.

Artificial fill / Other ~ 0.19 sq. mi.

N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

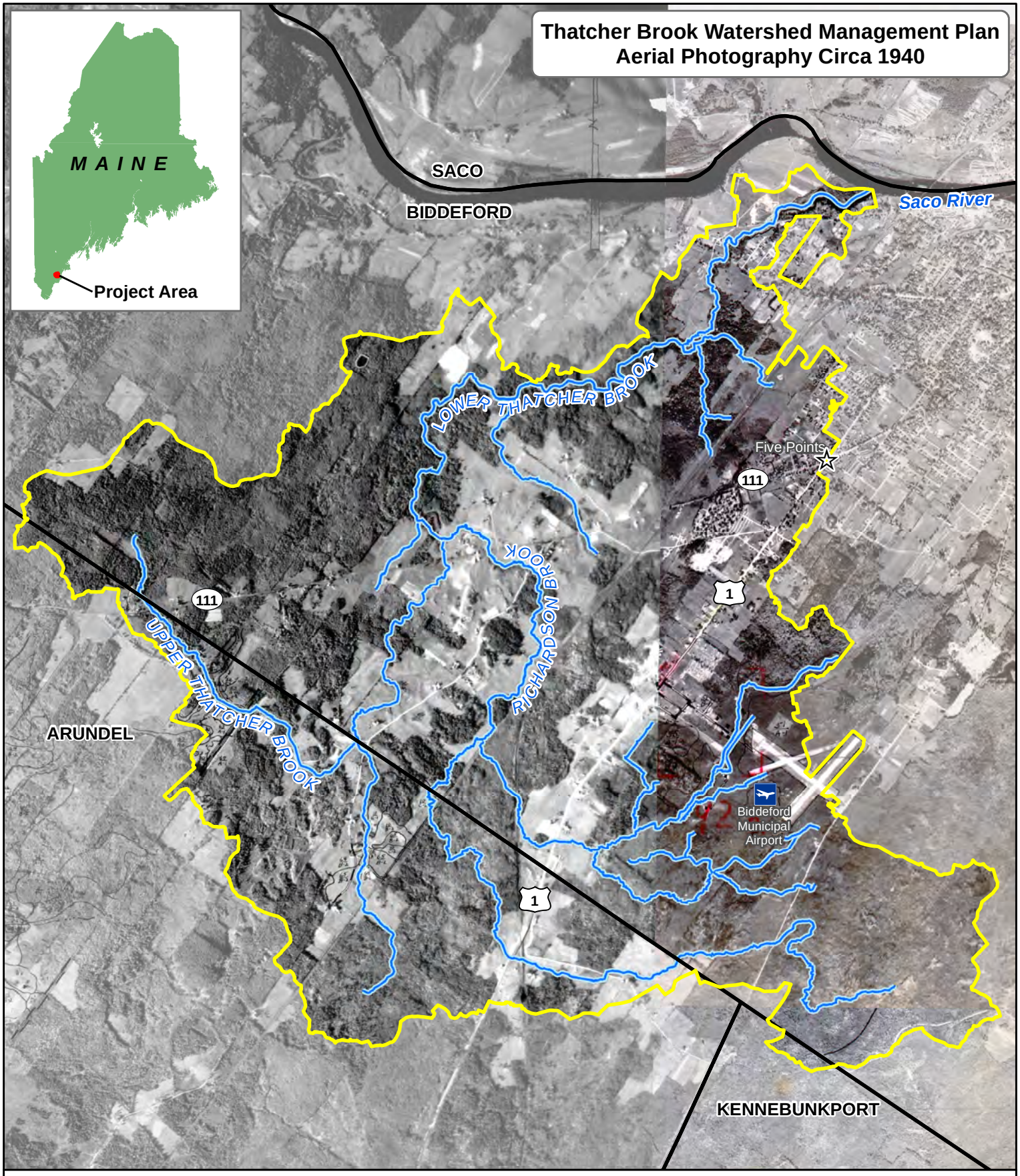
0 0.25 0.5 1 Miles

Figure # 5

York County Soil and Water Conservation District

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

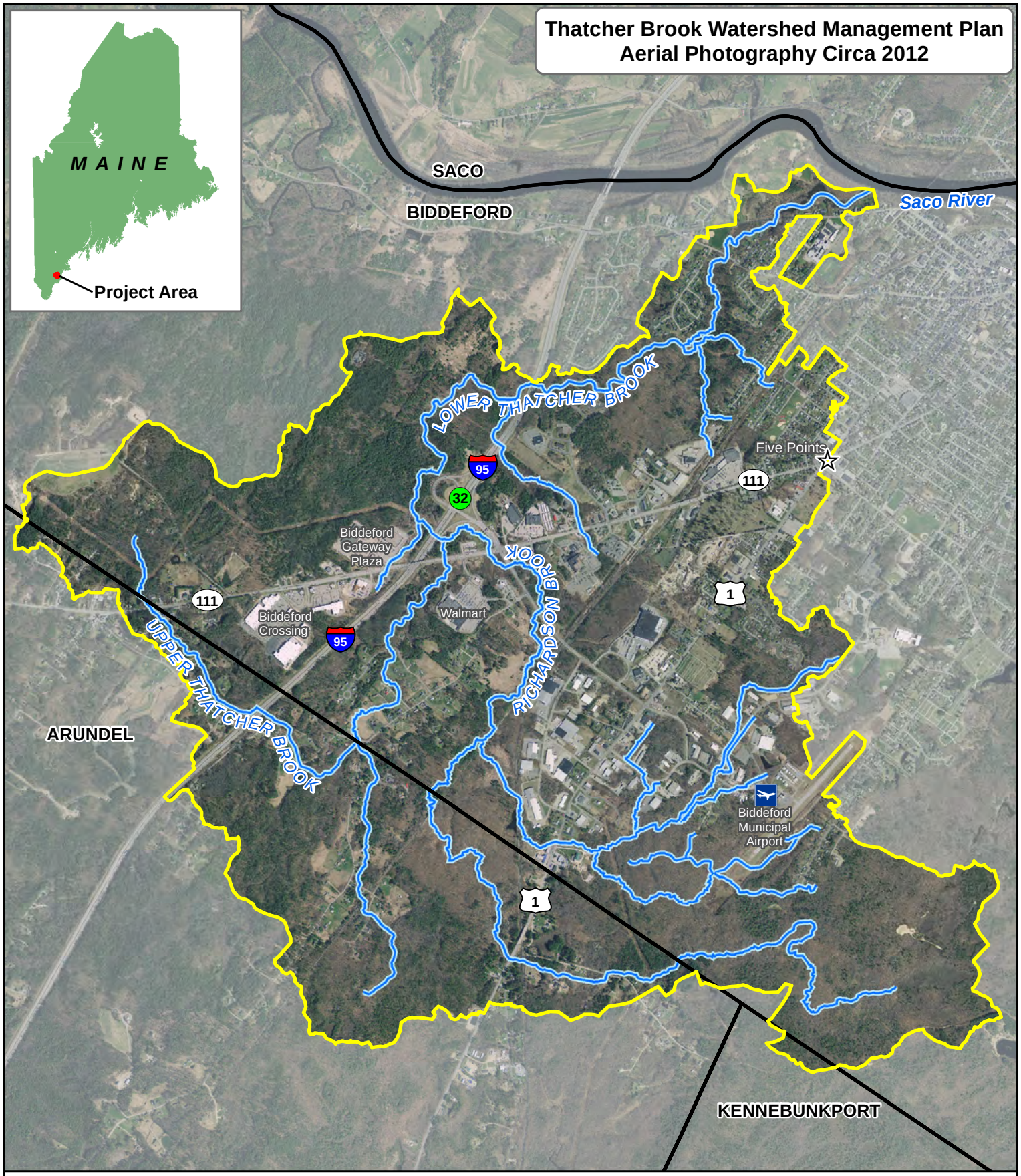
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 6

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

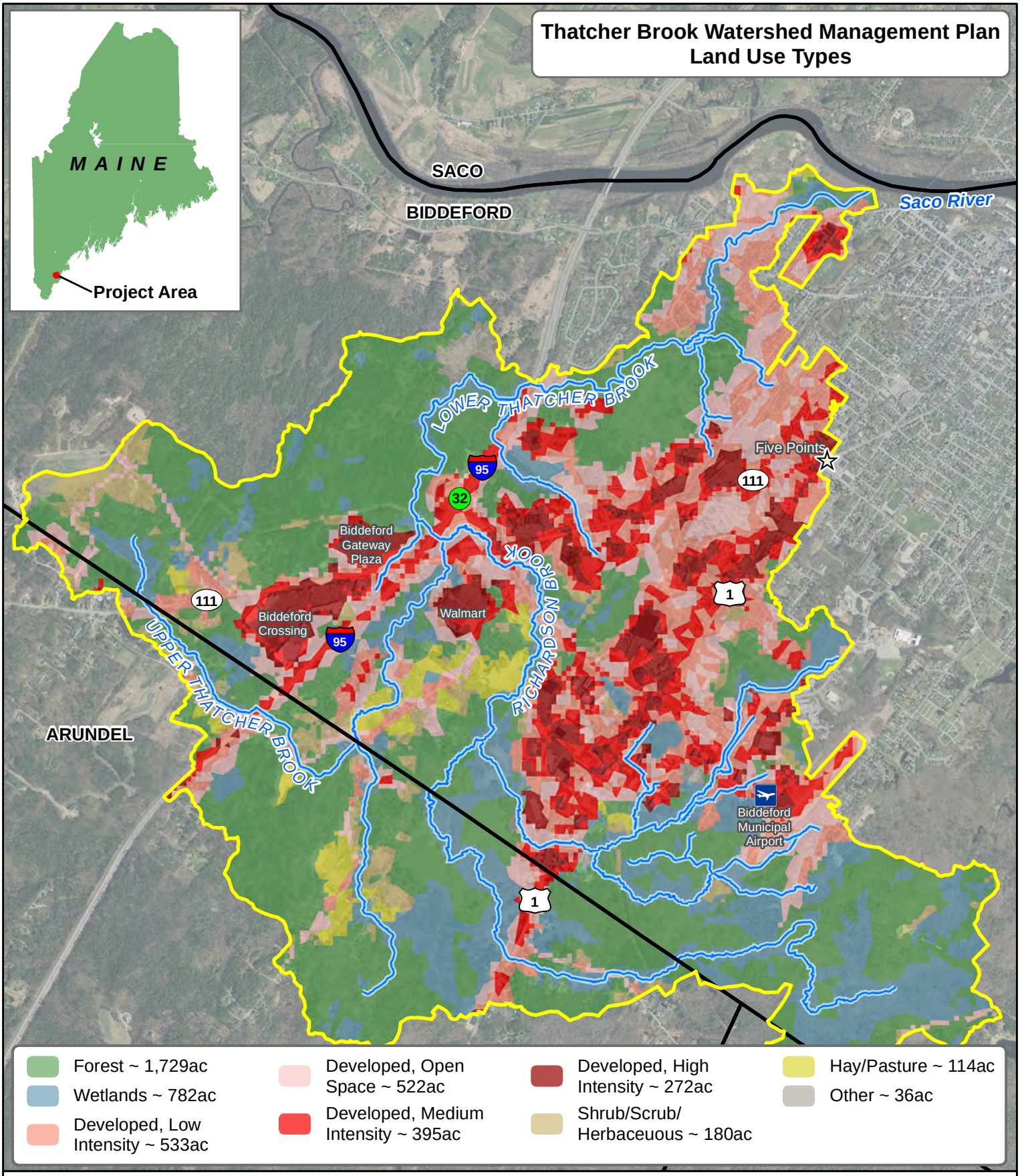
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 7

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

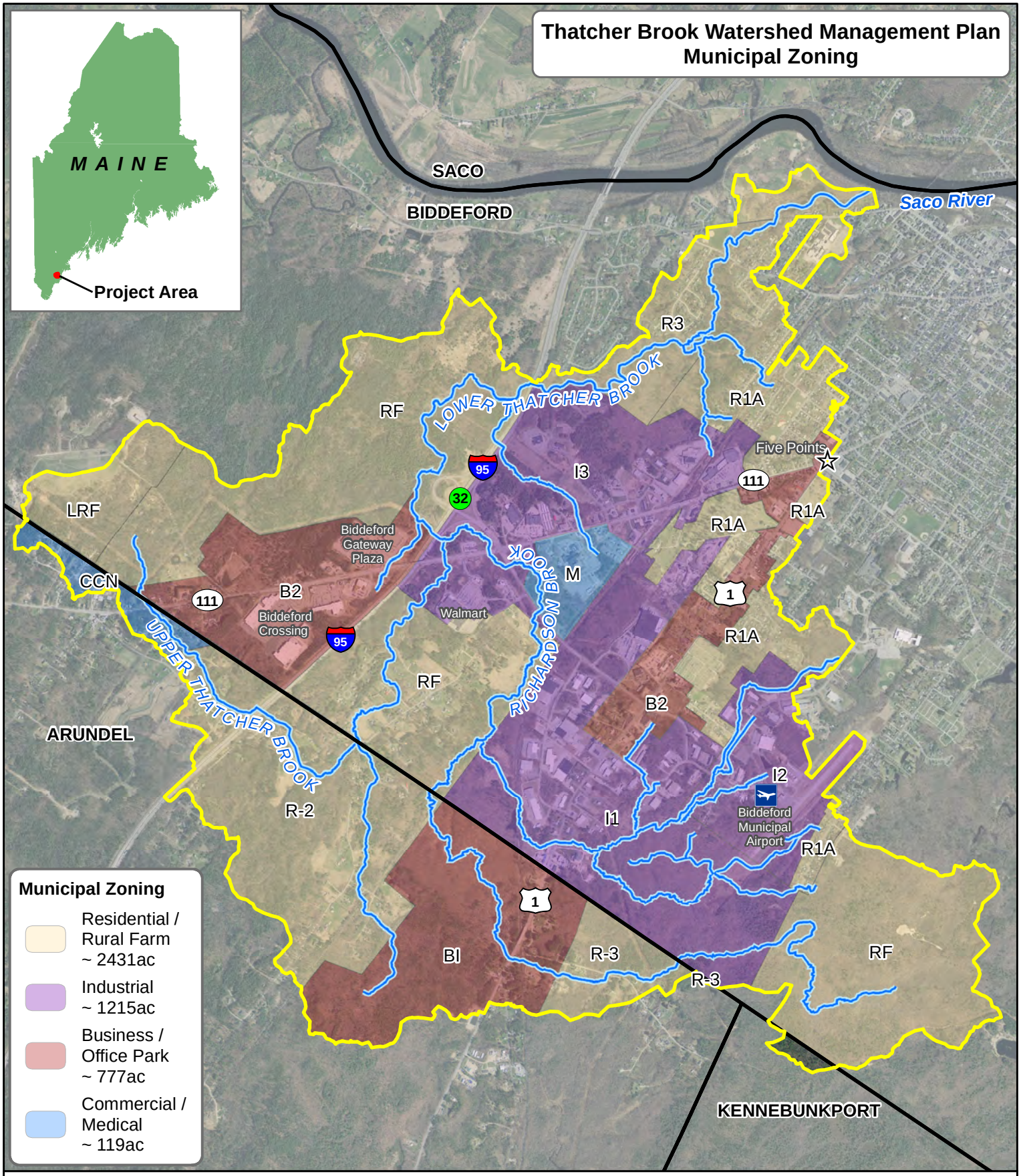
Town Boundaries

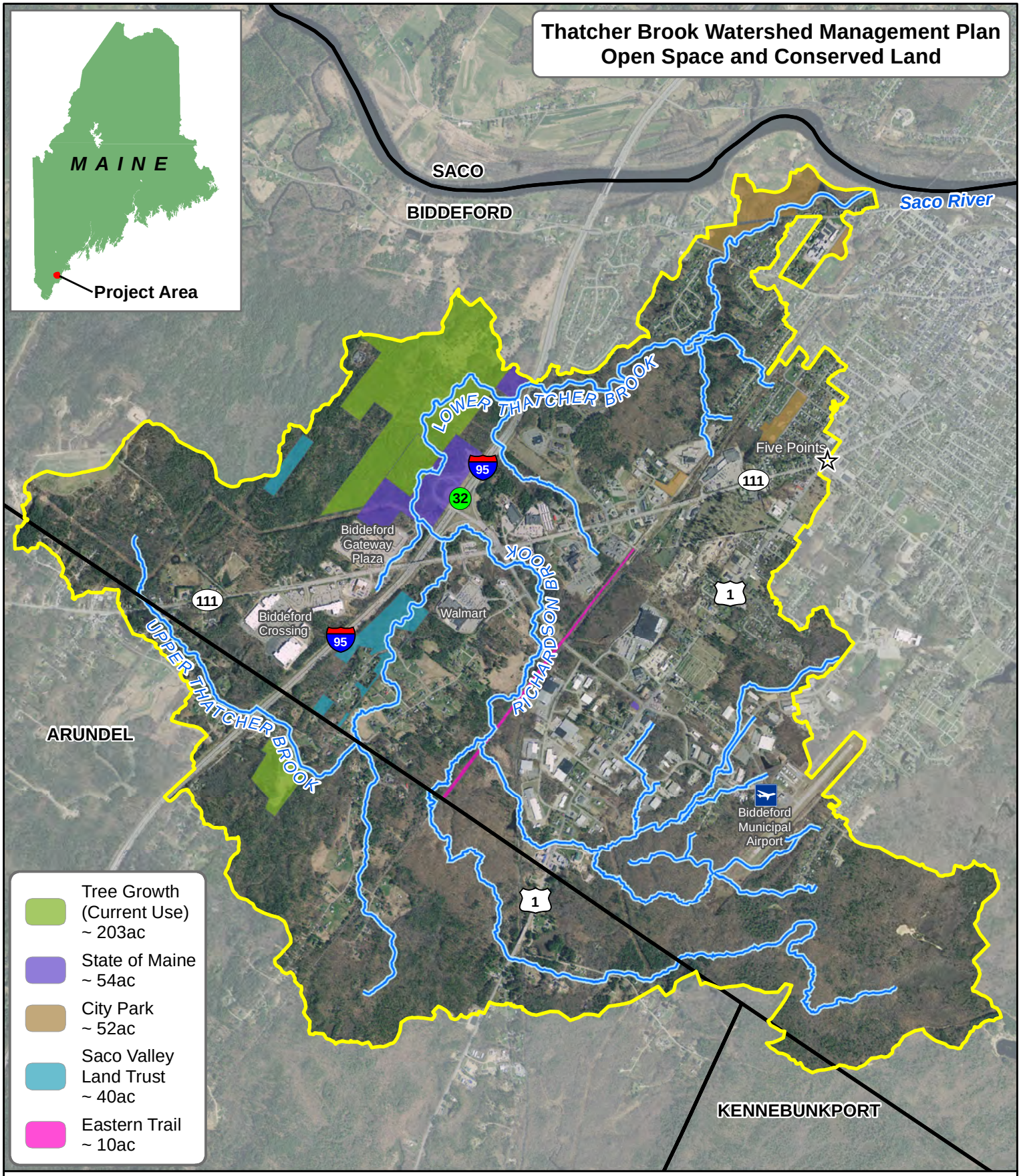
0 0.25 0.5 1 Miles

Figure # 8

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, NLCD 2011


Thatcher Brook Watershed Management Plan
Municipal Zoning
MAINE
Project Area
SACO
BIDDEFORD
Saco River
R3
RF
LOWER THATCHER BROOK
R1A
Five Points
I3
95
32
111
LRF
R1A
Biddeford Gateway Plaza
CCN
B2
Biddeford Crossing
Walmart
M
1
UPPER THATCHER BROOK
RICHARDSON BROOK
ARUNDEL
B2
I2
Biddeford Municipal Airport
R-2
I1
BI
R-3
KENNEBUNKPORT
Municipal Zoning
Residential / Rural Farm ~ 2431ac
Industrial ~ 1215ac
Business / Office Park ~ 777ac
Commercial / Medical ~ 119ac
N
Thatcher Brook
Thatcher Brook Watershed
Town Boundaries
0 0.25 0.5 1 Miles
thatcher brook for everyone
CITY OF BIDDEFORD MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION STATE OF MAINE
GZA
YORK COUNTY SOIL AND WATER CONSERVATION DISTRICT
Figure # 9
Map Date: 12/29/2014
Data Sources: City of Biddeford, MEGIS, Maine DEP, Town of Arundel



N

Thatcher Brook

Thatcher Brook Watershed

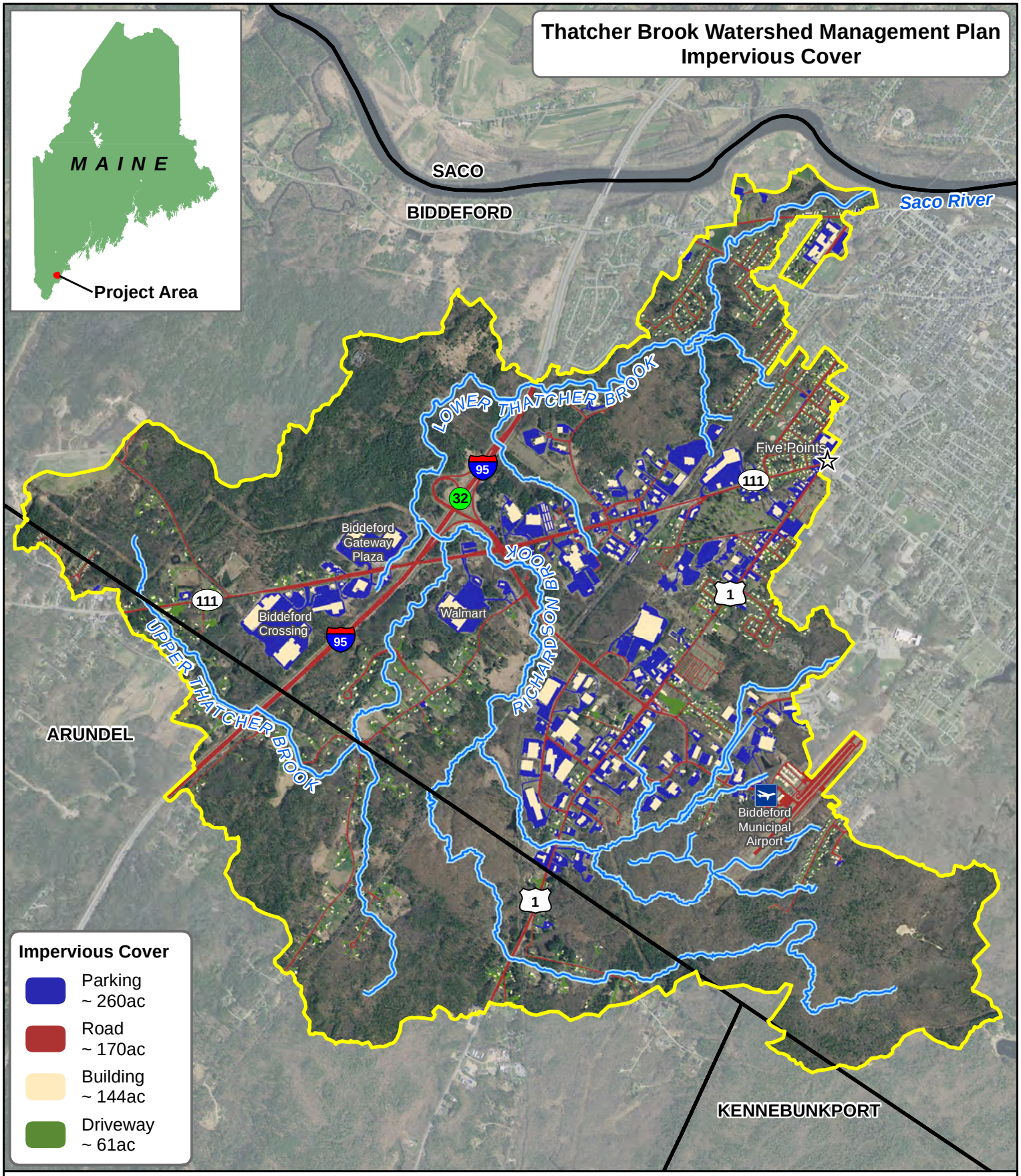
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 10

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, Town of Arundel



N

Thatcher Brook

Thatcher Brook Watershed

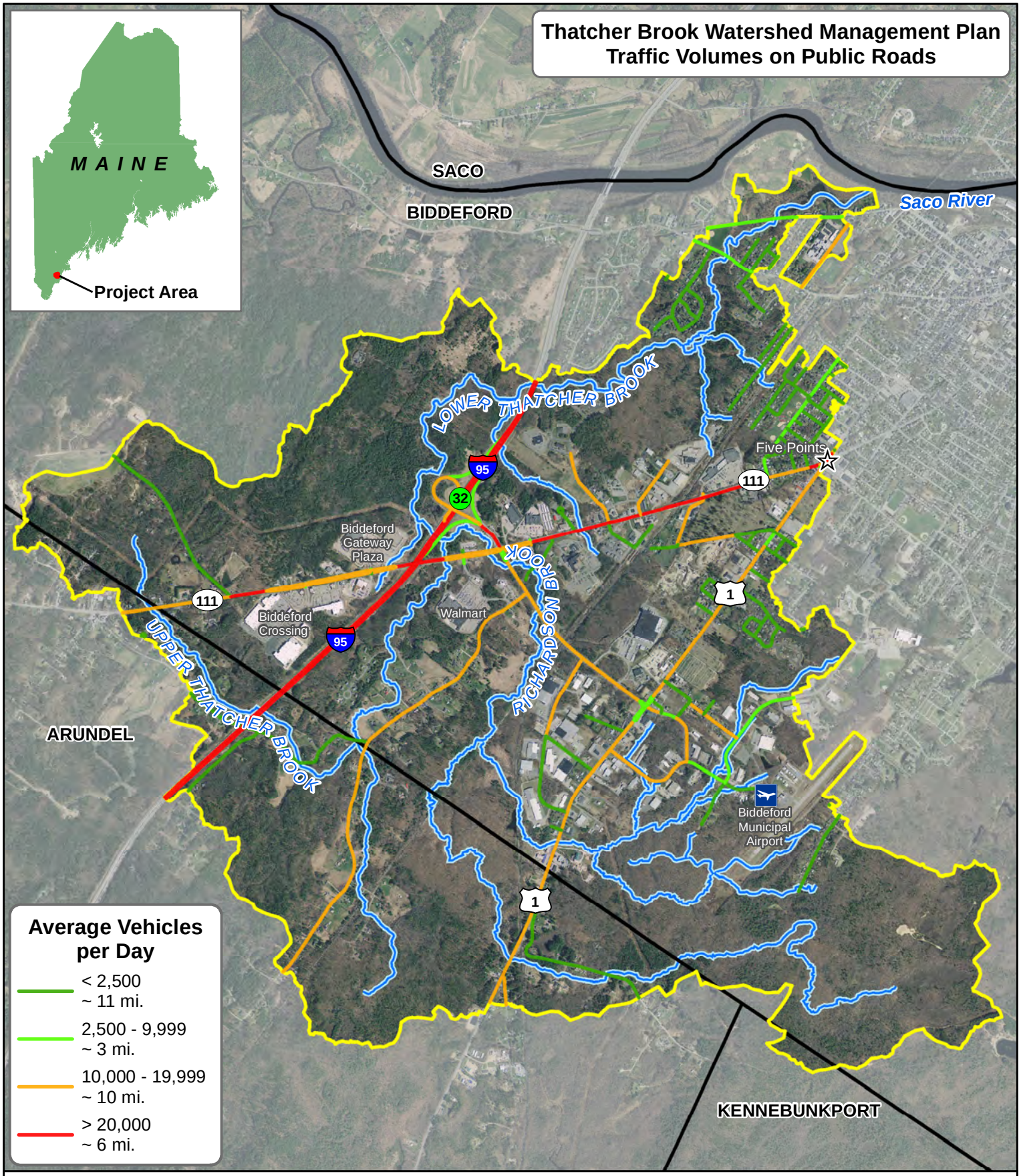
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 11

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

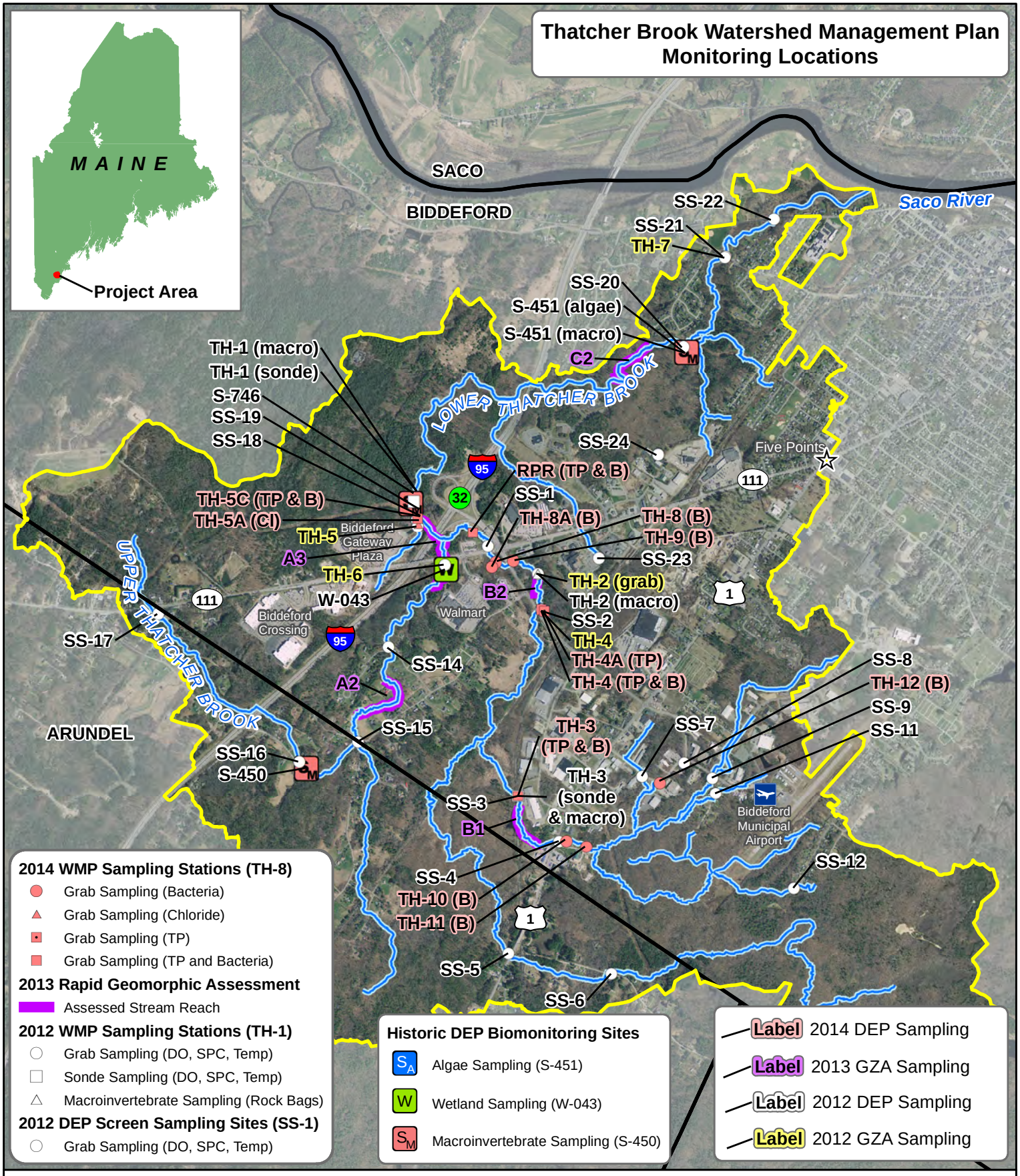
0 0.25 0.5 1 Miles

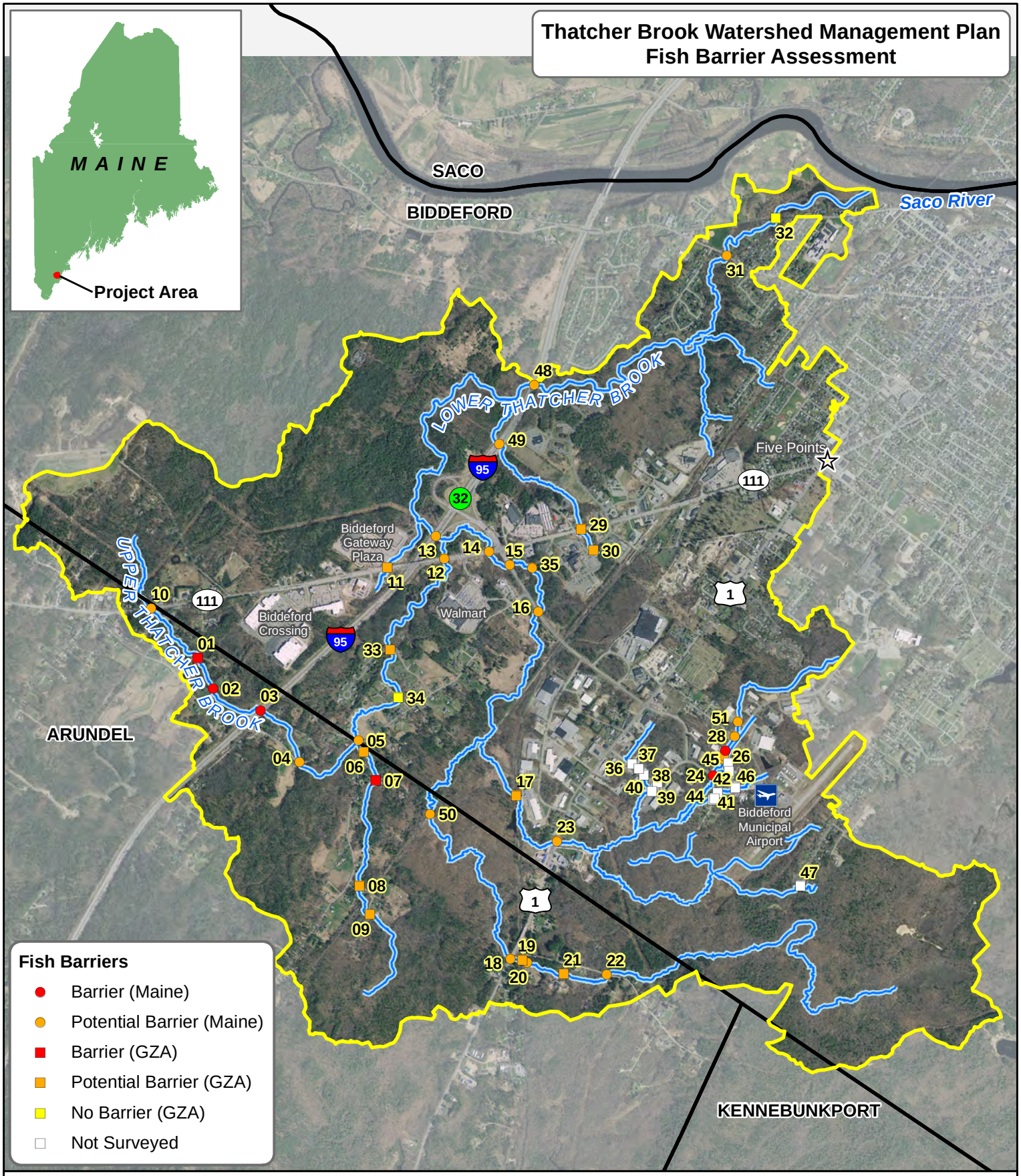
Figure # 12

York County Soil and Water Conservation District

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, MaineDOT


Thatcher Brook Watershed Management Plan
Monitoring Locations
MAINE
Project Area
SACO
BIDDEFORD
Saco River
SS-22
SS-21
TH-7
SS-20
S-451 (algae)
S-451 (macro)
C2
LOWER THATCHER BROOK
TH-1 (macro)
TH-1 (sonde)
S-746
SS-19
SS-18
SS-24
Five Points
RPR (TP & B)
SS-1
TH-5C (TP & B)
TH-5A (Cl)
TH-5
Biddeford Gateway Plaza
TH-8A (B)
TH-8 (B)
TH-9 (B)
SS-23
A3
TH-6
W-043
B2
TH-2 (grab)
TH-2 (macro)
Walmart
Biddeford Crossing
SS-2
TH-4
TH-4A (TP)
TH-4 (TP & B)
SS-17
UPPER THATCHER BROOK
SS-14
A2
SS-8
TH-12 (B)
SS-9
SS-11
ARUNDEL
SS-15
TH-3 (TP & B)
SS-7
SS-16
S-450
TH-3 (sonde & macro)
SS-3
B1
Biddeford Municipal Airport
SS-12
SS-4
TH-10 (B)
TH-11 (B)
SS-5
SS-6
2014 WMP Sampling Stations (TH-8)
Grab Sampling (Bacteria)
Grab Sampling (Chloride)
Grab Sampling (TP)
Grab Sampling (TP and Bacteria)
2013 Rapid Geomorphic Assessment
Assessed Stream Reach
2012 WMP Sampling Stations (TH-1)
Grab Sampling (DO, SPC, Temp)
Sonde Sampling (DO, SPC, Temp)
Macroinvertebrate Sampling (Rock Bags)
2012 DEP Screen Sampling Sites (SS-1)
Grab Sampling (DO, SPC, Temp)
Historic DEP Biomonitoring Sites
Algae Sampling (S-451)
Wetland Sampling (W-043)
Macroinvertebrate Sampling (S-450)
Label 2014 DEP Sampling
Label 2013 GZA Sampling
Label 2012 DEP Sampling
Label 2012 GZA Sampling
N
Thatcher Brook
Thatcher Brook Watershed
Town Boundaries
0 0.25 0.5 1 Miles
thatcher brook for everyone
CITY OF BIDDEFORD MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION STATE OF MAINE
GZA
YORK COUNTY SOIL AND WATER CONSERVATION DISTRICT
Figure # 13
Map Date: 12/29/2014
Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

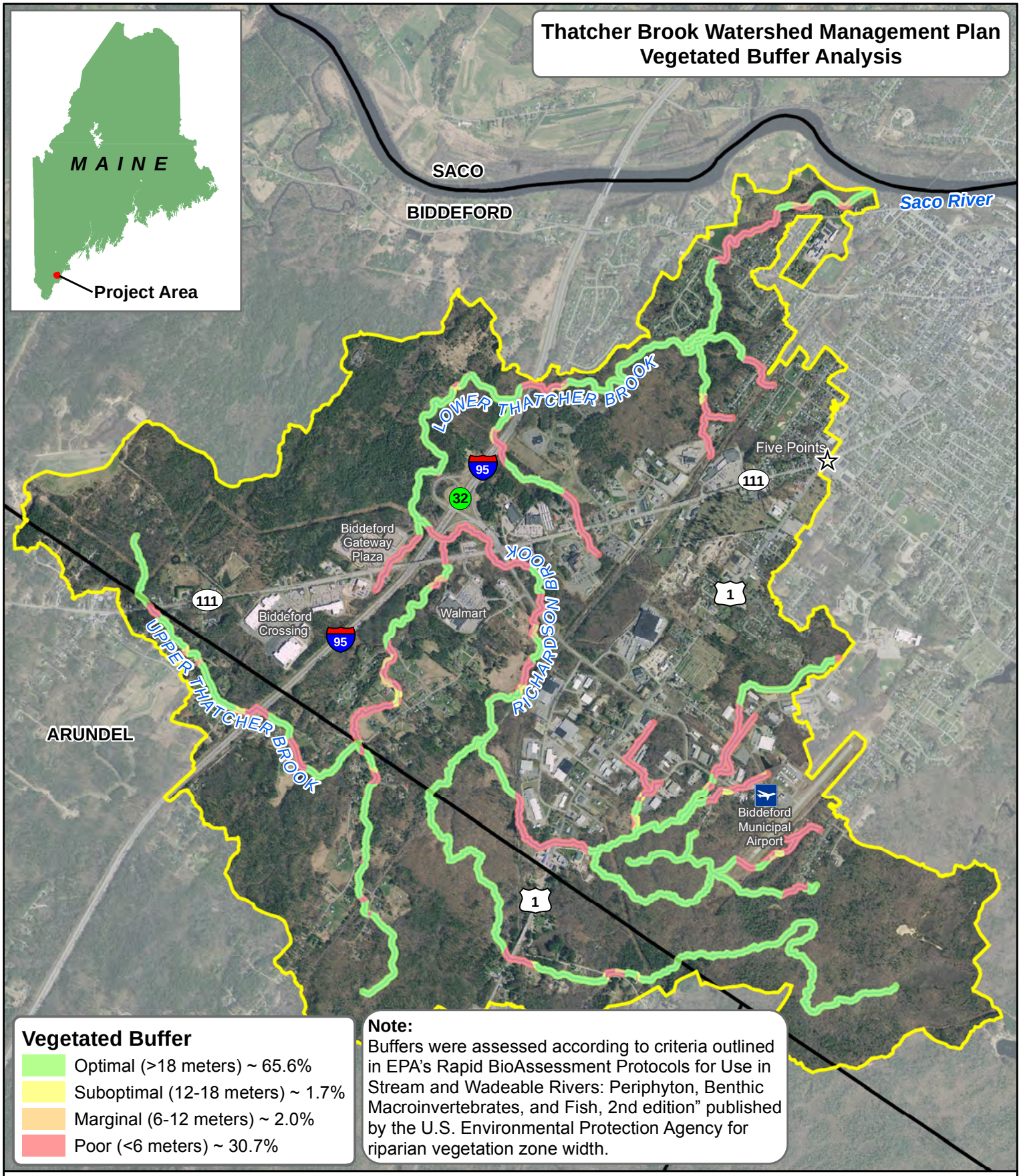
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 14

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, Maine DACF, Maine Coastal Program



N

Thatcher Brook

Thatcher Brook Watershed

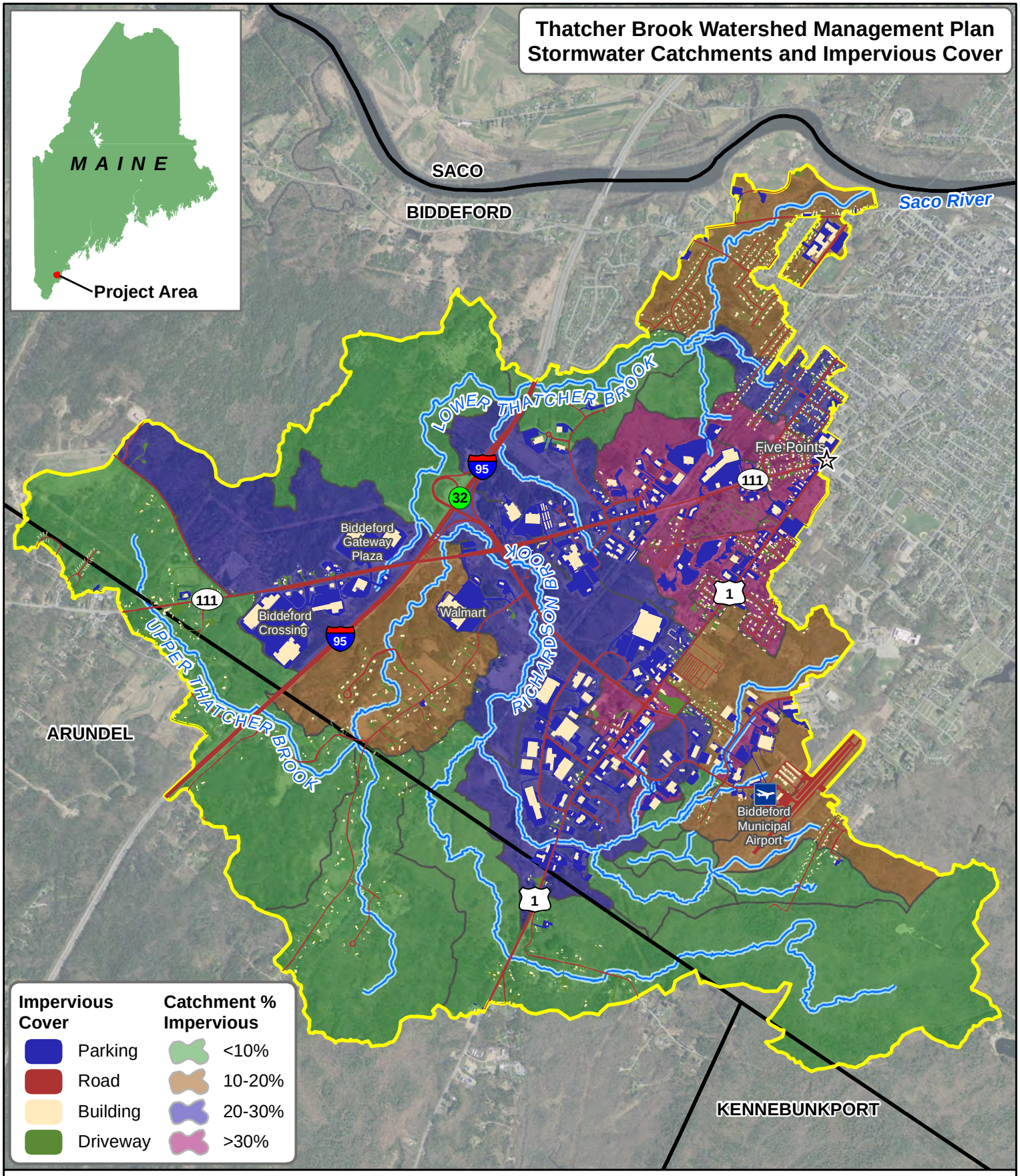
Town Boundaries

0 0.25 0.5 1 Miles

Figure # 15

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

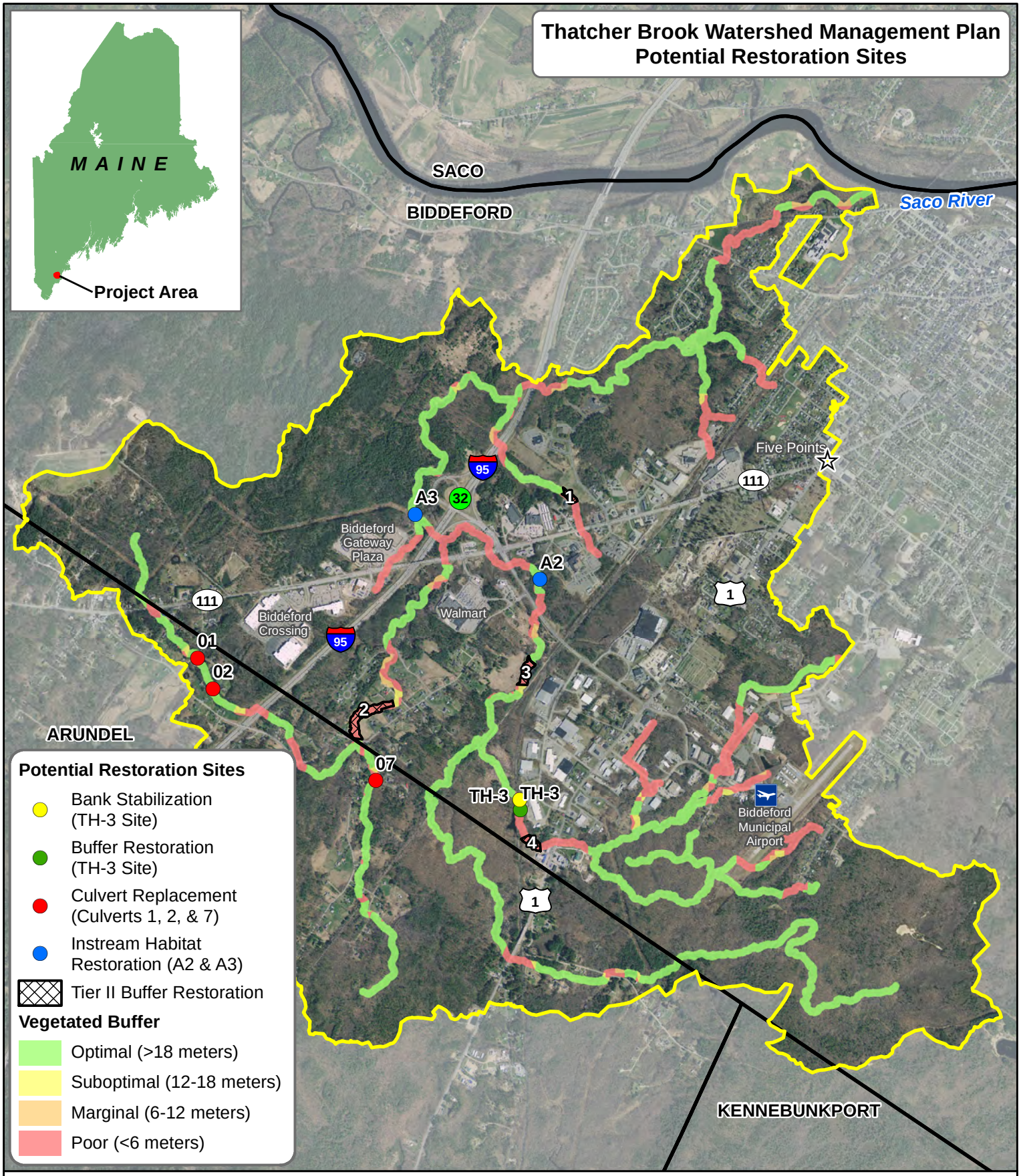
0 0.25 0.5 1 Miles

Figure # 16

York County Soil and Water Conservation District

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

0 0.25 0.5 1 Miles

Figure # 17

York County Soil and Water Conservation District

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP

N

Thatcher Brook

Parcels

Potential Retrofit Site

0 25 50 100 Feet

Figure # 18A

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP

N

Thatcher Brook

Parcels

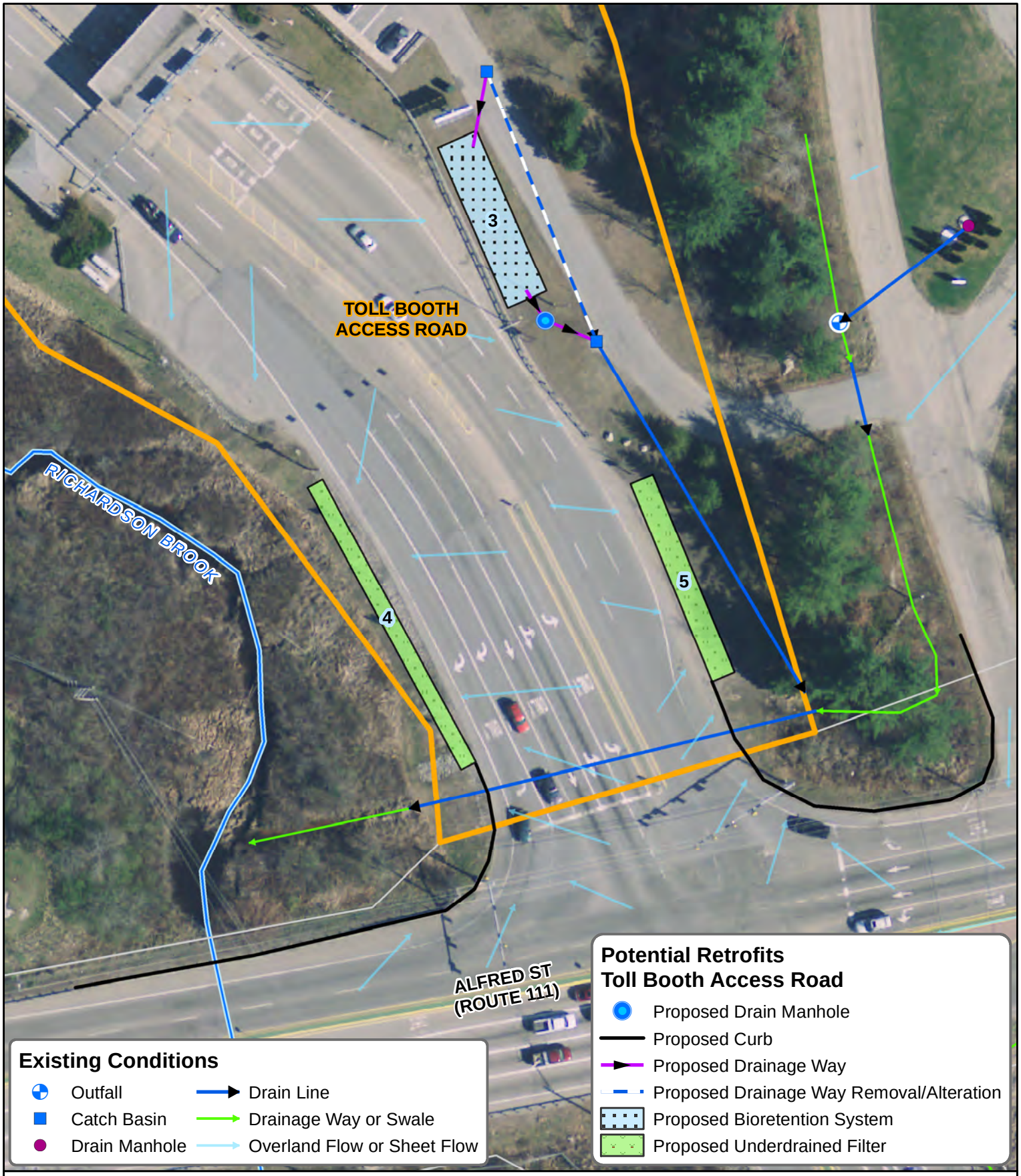
Potential Retrofit Site

0 25 50 100 Feet

Figure # 18B

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Parcels

Potential Retrofit Site

0 30 60 120 Feet

thatcher brook for everyone

CITY OF BIDDEFORD MAINE

DEPARTMENT OF ENVIRONMENTAL PROTECTION STATE OF MAINE

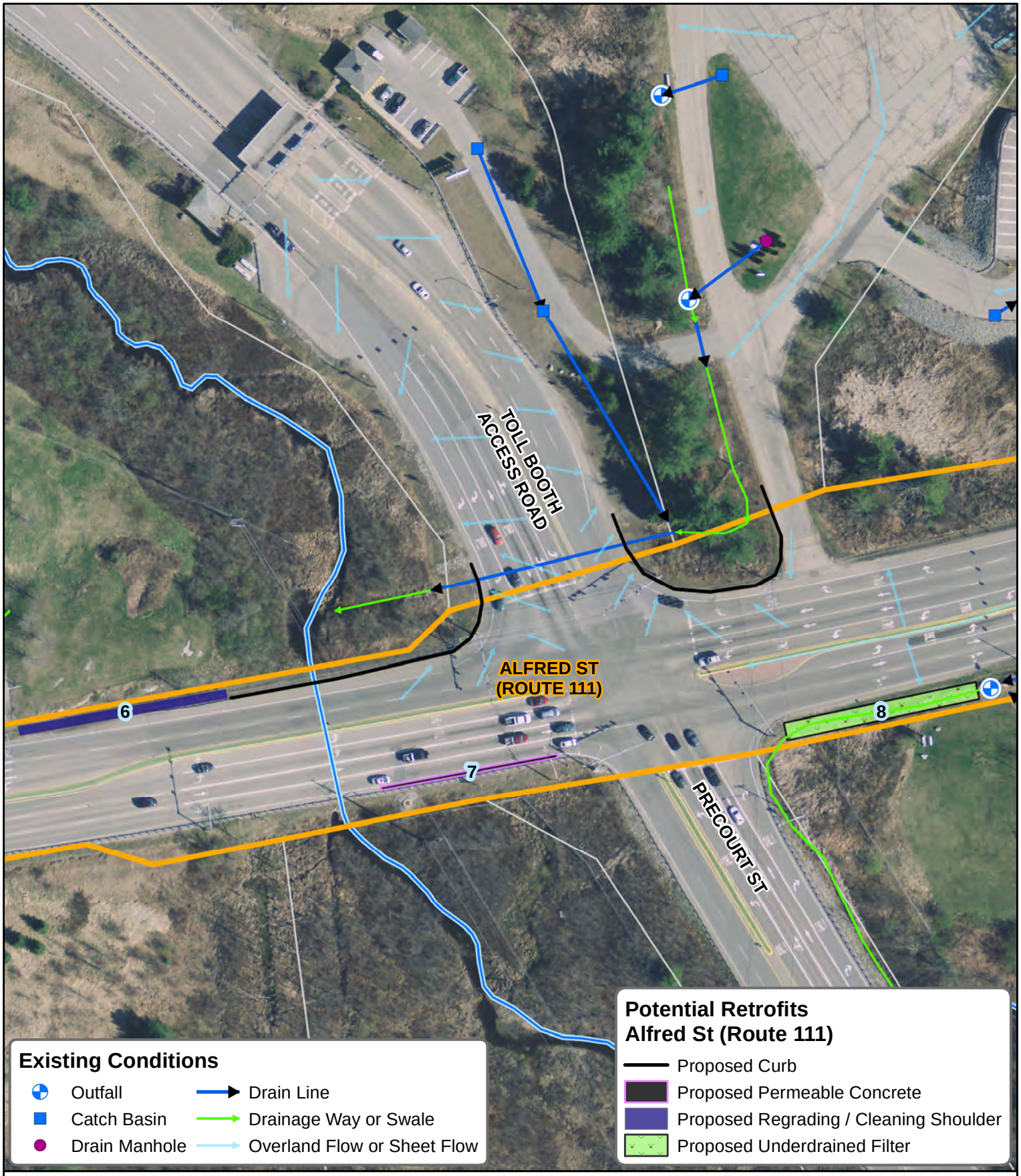
GZA

York County Soil and Water Conservation District

Figure # 18C

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Parcels

Potential Retrofit Site

0 50 100 200 Feet

Figure # 18D

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP

N

Thatcher Brook

Parcels

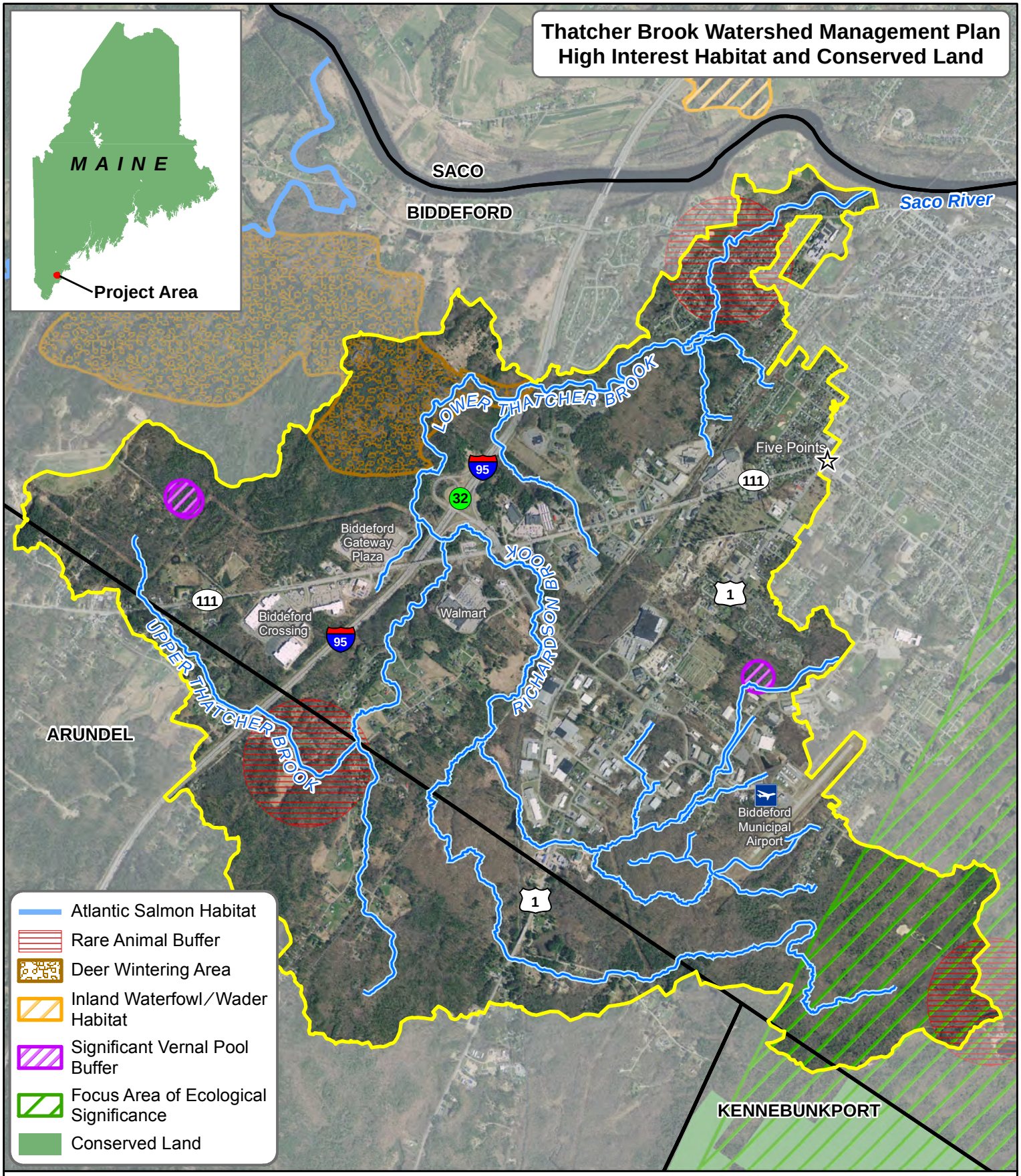
Potential Retrofit Site

0 75 150 300 Feet

Figure #18E

Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP



N

Thatcher Brook

Thatcher Brook Watershed

Town Boundaries

0 0.25 0.5 1 Miles

Figure #19

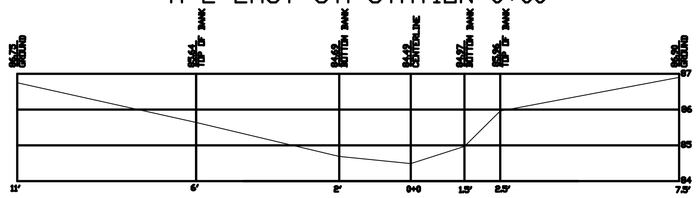
Map Date: 12/29/2014

Data Sources: City of Biddeford, MEGIS, Maine DEP, NRPA, Beginning with Habitat

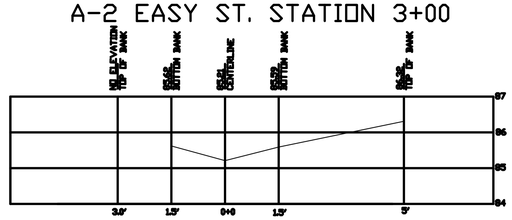
APPENDIX A

STREAM HABITAT AND GEOMORPHIC ASSESSMENTS

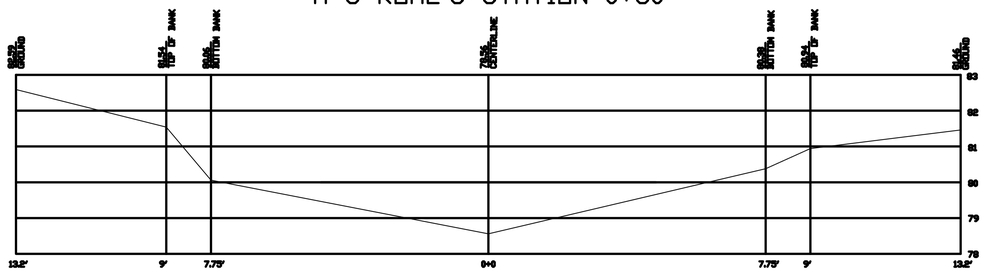
A-2 EASY ST. STATION 0+00



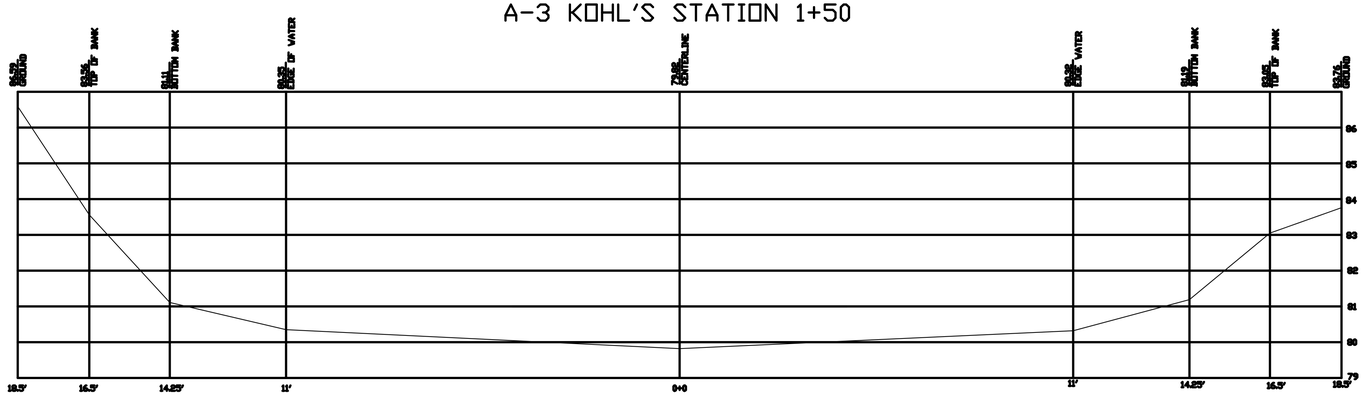
A-2 EASY ST. STATION 3+00



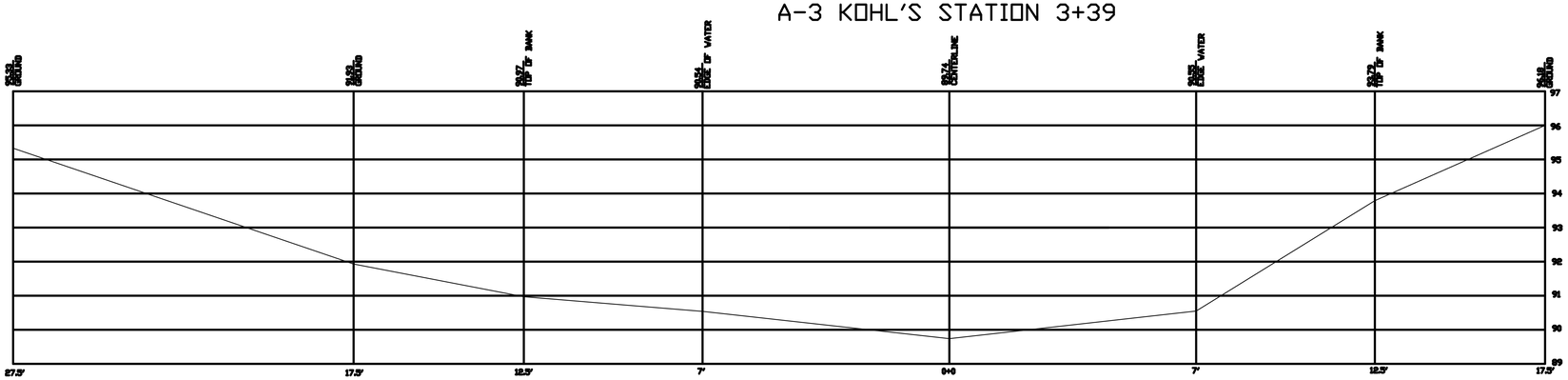
A-3 KOHL'S STATION 0+50



A-3 KOHL'S STATION 1+50



A-3 KOHL'S STATION 3+39



NOTES:

1) FIELD VERIFICATION PERFORMED BY THE CITY OF BIDDEFORD ENGINEERING DEPARTMENT DURING THE MONTHS OF AUGUST 2013 AND SEPTEMBER 2013.

THATCHER BROOK WATERSHED MANAGEMENT PLAN CROSS SECTIONS OF THATCHER BROOK BIDDEFORD, MAINE 04005

SCALE: HOR. 1" = 2' VER. 1" = 2'

DATE: JAN. 22, 2014

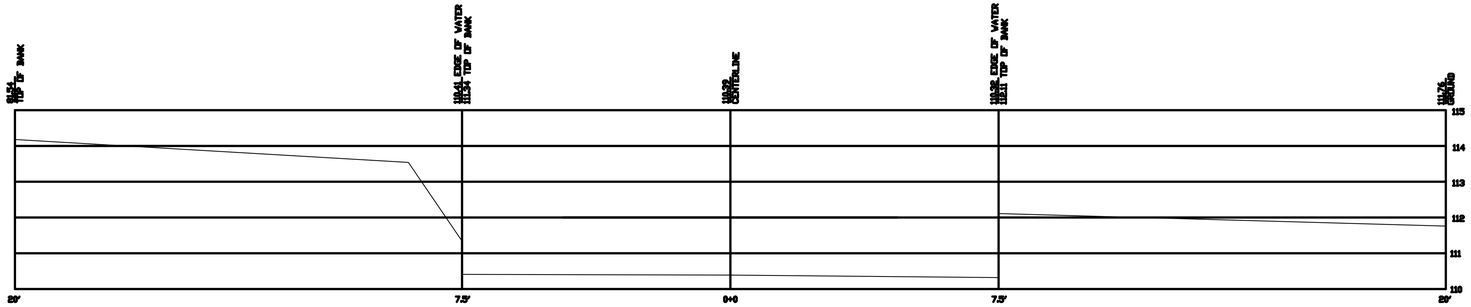
PREPARED BY:

CITY OF BIDDEFORD

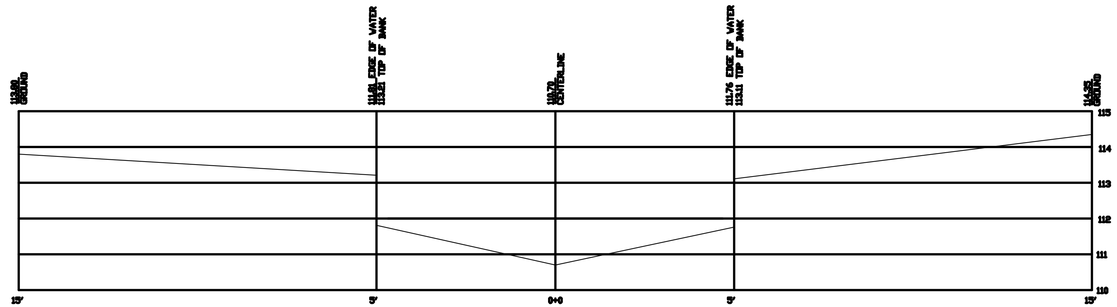
205 MAIN STREET

BIDDEFORD, MAINE 04005

B-1 STERLING ROPE STATION 0+50



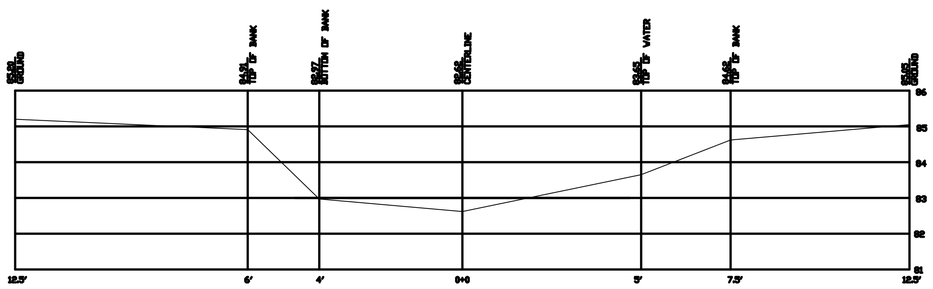
B-1 STERLING ROPE STATION 2+50



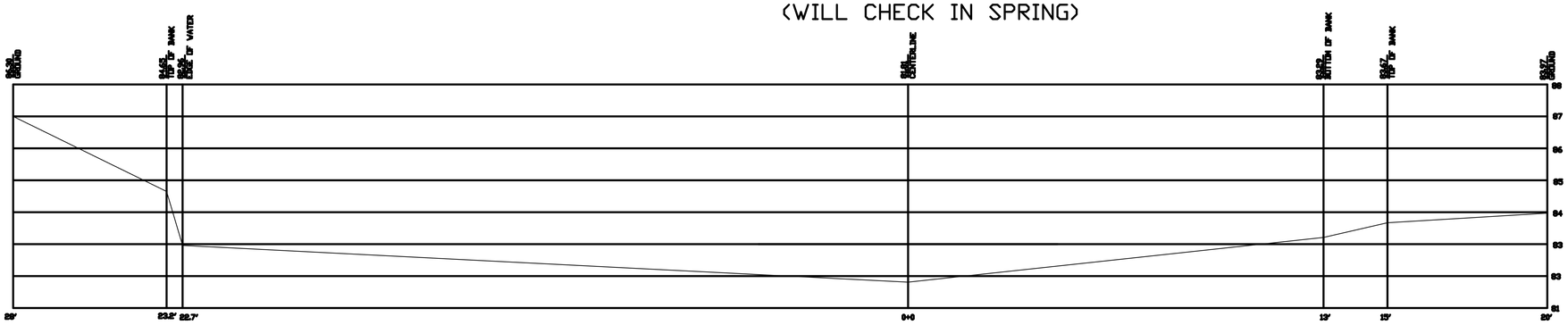
NOTES:

1) FIELD VERIFICATION PERFORMED BY THE CITY OF BIDDEFORD ENGINEERING DEPARTMENT DURING THE MONTHS OF AUGUST 2013 AND SEPTEMBER 2013.

B-2 MEDICAL CENTER DR. STATION 0+60



B-2 MEDICAL CENTER DR. STATION 1+90
(WILL CHECK IN SPRING)



THATCHER BROOK WATERSHED MANAGEMENT PLAN CROSS SECTIONS OF THATCHER BROOK BIDDEFORD, MAINE 04005

SCALE: HOR. 1" = 2' VER. 1" = 2'

DATE: JAN. 22, 2014

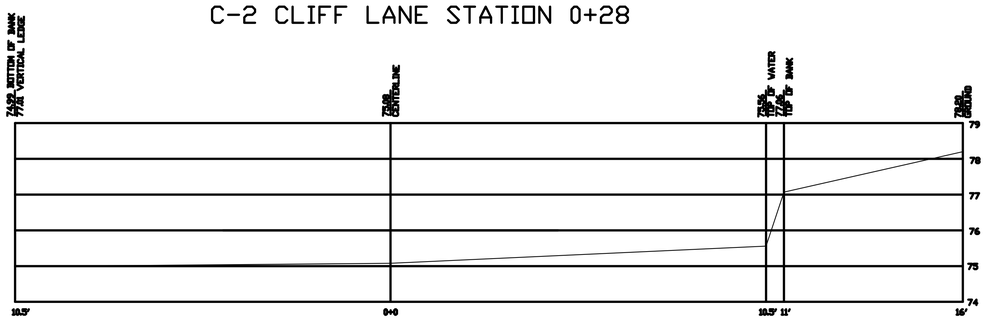
PREPARED BY:

CITY OF BIDDEFORD

205 MAIN STREET

BIDDEFORD, MAINE 04005

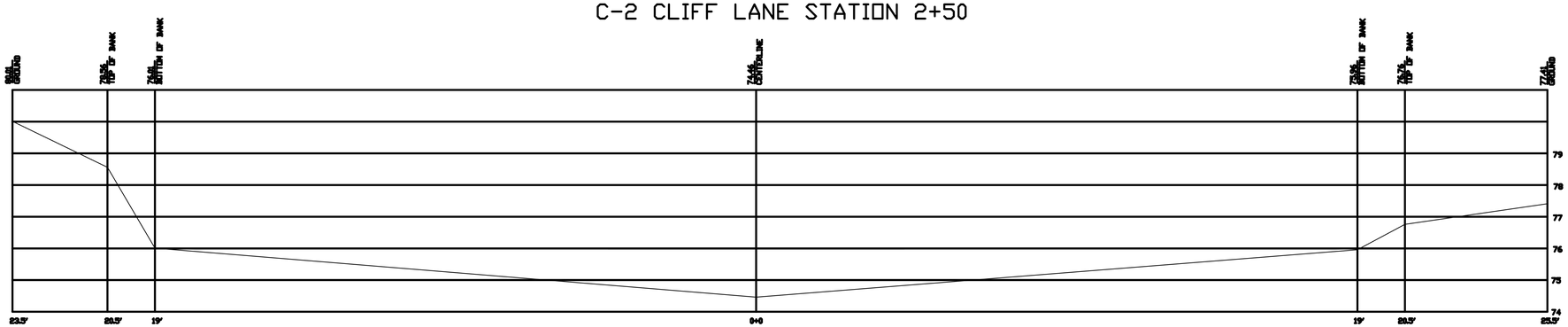
C-2 CLIFF LANE STATION 0+28



NOTES:

1) FIELD VERIFICATION PERFORMED BY THE CITY OF BIDDEFORD ENGINEERING DEPARTMENT DURING THE MONTHS OF AUGUST 2013 AND SEPTEMBER 2013.

C-2 CLIFF LANE STATION 2+50



THATCHER BROOK WATERSHED
MANAGEMENT PLAN
CROSS SECTIONS
OF
THATCHER BROOK
BIDDEFORD, MAINE 04005

SCALE: HOR. 1" = 2' VER. 1" = 2'
DATE: JAN. 22, 2014
PREPARED BY:
CITY OF BIDDEFORD
205 MAIN STREET
BIDDEFORD, MAINE 04005

HNTB Corporation
Engineers Architects Planners

340 County Road Suite 6-C
Westbrook, Maine 04092

Telephone (207) 774-5155
Facsimile (207) 228-0909
www.hntb.com

Date
June 1, 2011
Revised May 5, 2014

To
Steve Tartre, P.E.
Director of Engineering
Maine Turnpike Authority

From
Walter Fagerlund, P.E.

Memorandum

Subject
Maine Turnpike
Biddeford (Thatcher Brook)
Updated Flood Study Review

Memo revised by HNTB on May 5, 2014. Revisions consisted of incorporating MTA April 2, 2014 comments. No additional edits or review of updated information were completed as part of the May 5, 2014 update.

Overview

At the MTA's request, HNTB has completed a more detailed analysis of the portion of the Thatcher Brook watershed associated with the 5x8 double box culvert crossing at Interchange 32. Recent large rainfall events caused overtopping of the turnpike and the Route 111/Precourt Street intersection. Previous work by HNTB in 2008 provided initial estimates of flows and capacity of the culvert and indicated the need for further site investigation and analysis in the region to characterize the flooding conditions in the area. This memo summarizes the results of the limited additional analysis.

The following activities were included in this phase of the updated analysis:

- Initial meetings and coordination with City of Biddeford to scope analysis and identify data sources
- Review of available data from the City of Biddeford
- Site visits during and after significant storm events to document conditions
- Maintenance of select drainage paths by City of Biddeford and MTA
- Development of watershed hydrologic and hydraulic model ("drainage model") using HydroCAD software with focus on critical culvert crossings
- Mitigation recommendations

The updated analysis focused on the following locations as identified by the MTA and City of Biddeford as critical flooded areas during significant rainfall events:

Figure 1: Flooding of Northbound Off Ramp at Interchange 32 (looking north)

Figure 2: Flooding of Northbound Turnpike Mainline at Route 111 (looking to south)

Figure 3: Flooding of City of Biddeford Precourt Street looking east from intersection with Route 111 (intersection is directly east of Interchange 32 toll plaza).

The following aerial photo shows the key locations in this area, and highlight flowpaths and areas that have flooded or overtopped in the past.

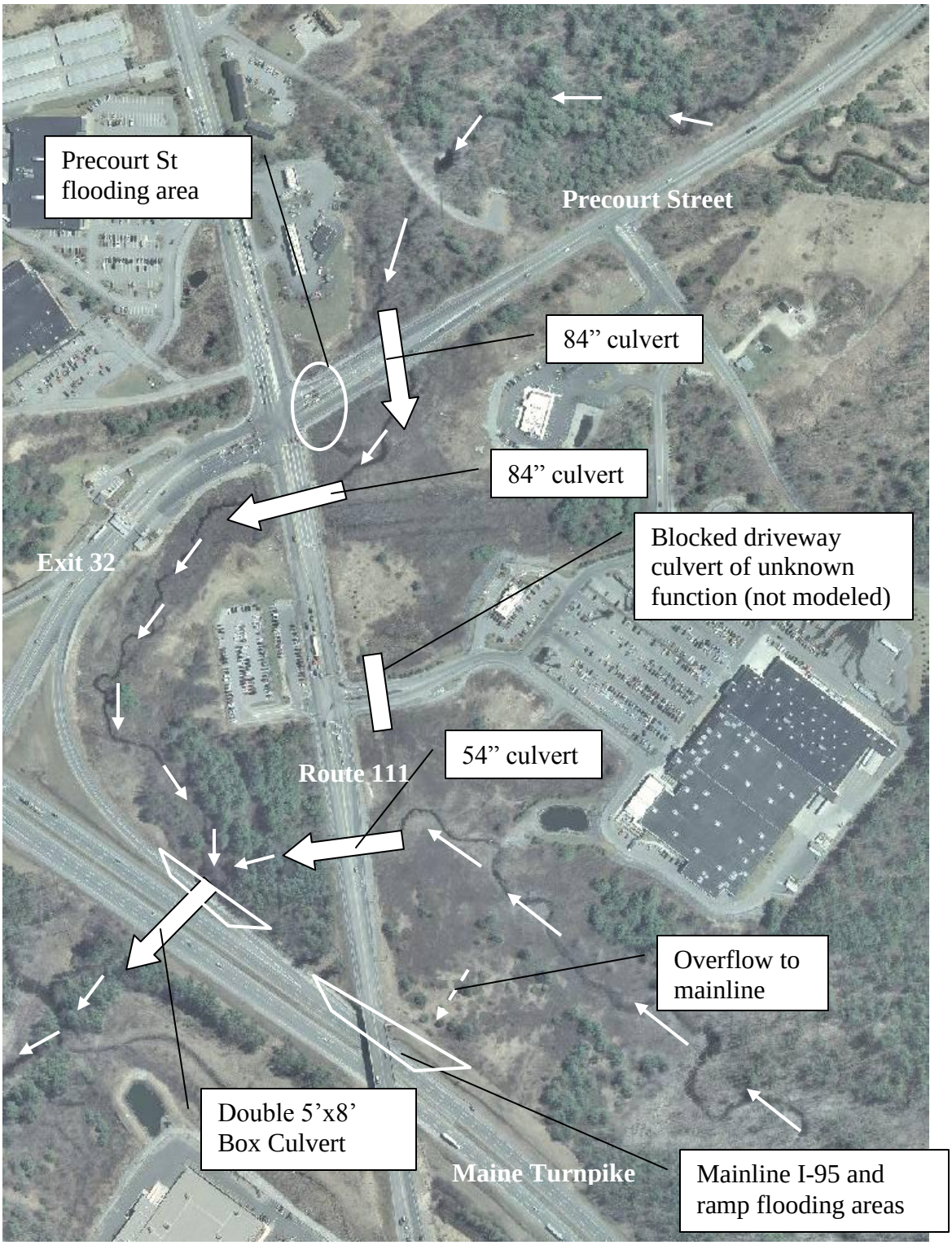


Figure 4: Overview of flooding areas included in the analysis

The area that includes the Turnpike culverts, the ramp, and the Route 111 and Spur Road culverts is very flat. Conditions at each structure and in between structures affect flooding conditions at the next structure upstream. Enlarging culverts may exacerbate flooding conditions at downstream structures. Overflow or backup of one culvert may send water back into an upstream culvert or over one of several roads. Blockage of a channel or culvert impacts multiple upstream sites. The resulting flooding is complex and difficult to tie to one source or structure.

Hydrologic and hydraulic models used to simulate stream flows and structure hydraulics are limited in certain features that simulate flood conditions, and while useful tools, are limited in their ability to simulate this interrelated system.

Data Collection and Maintenance Activities

In order to characterize these locations in the drainage model, HNTB gathered readily available data from the City of Biddeford and the MTA as well as from other sources. The City provided available plans and data including:

- Route 111 and Spur Road culvert sizing and invert data
- Site development plans for many developments associated with the watershed
- Available portions of Route 111 plans

While the City provided extensive data, some information on the critical crossings and watershed storage behind these crossing had to be either supplemented with other data or estimated by lower resolution sources. Where practical, MTA topographic information for the Turnpike or field observations based on photos was used. Where topography could not be reconciled with photos or available detailed survey (such as the ponded area between the Walmart site and Route 111 that floods the mainline), interpolation was done using low resolution (10 foot contour) USGS data and engineering judgment. For these reasons, the analysis and results presented should be considered planning level only. HNTB recommends more detailed ground survey be obtained if further design of mitigation strategies involving enhancing culvert capacity or storage is pursued.

Several site visits were conducted during and after significant rainfall events, including joint visits with the City and Turnpike staff. During these visits, drainage maintenance activities were identified including debris clearing near the major culverts (specifically the 54" culvert under Route 111 near the Walmart site and the area downstream of the 5x8 double box culvert under the Turnpike mainline). This work appeared to improve the capacity of culverts, reducing the amount of ponding behind the Route 111 culvert and a drop in the tailwater conditions at the mainline MTA culvert.

Drainage Model Development

Based on additional information gathered regarding characteristics of the watershed and key sub watershed components, a drainage model was developed using HydroCAD software. The following describes the key inputs and sources of data:

- Water shed and sub-watershed delineation – Building on the 2008 work that defined the limits of the overall watershed, available topographic data from the City, MTA and USGS sources were used to define the sub-watersheds associated with the critical locations. these included areas contributing to:
    - Precourt Street spur road 84" culvert (at the location of flooding)
    - Route 111 84" culvert (between the MTA 5'x8' double box culverts and the Spur Road 84" culvert)
    - MTA mainline 72" culvert located at the top of the watershed south of Interchange 32
    - Route 111 54" culvert near the Walmart site and the Route 111 crossing of the Turnpike
    - 18" culvert under the northbound abutment of the Route 111 bridge over the Turnpike
    - 5'x8' double box culverts at Interchange 32
- Curve number and time of concentration values – Using topographic and aerial photo information, sub-watershed land use characteristics (curve numbers) and flow paths (time of concentration) were estimated.
- Storage volumes – The capacity for flood storage behind each culvert was estimated using available topographic information.

Drainage Model Observations

Once the drainage model was set up, the model was calibrated with the goal of best replicating the observed conditions during flood events. Note the observations are a starting point for the consideration of mitigation strategies and some observed conditions may not be practical to mitigate. Based on the model calibration and review of the interaction of the sub-watersheds in the model, the following was observed:

- Flooding of Northbound Off Ramp at Interchange 32 - Ramp flooding occurs when flood storage to the east overflows onto the ramp. This is influenced by the following:
    - Limited 5x8 double box culvert capacity, due to:
        - Very flat culvert slope (<0.5%)
        - Limited size of culvert
        - Tailwater conditions based on downstream debris
        - Tailwater conditions possibly due to backwater from the Saco River (at least one observed major event showed all downstream channels and culverts at or above capacity to the Saco River)

  - Limited storage behind the 5x8 double box culverts. This area does not have adequate storage capacity to handle the combination of high flows into the area and limited capacity of the 5x8 double box culverts that drain the area given the limitations noted in the previous bullet.
- Flooding of Northbound Turnpike Mainline at Route 111 – The mainline floods when the capacity of the roadside ditch and culvert is exceeded by excessive overflow from the adjacent sub-watershed, resulting in flowing water in the mainline and into the storage area behind the 5x8 double box culvert. This is influenced by:
  - Limited capacity of 54" culvert under Route 111 nearest the Turnpike results in high water behind culvert in the area directly south of Route 111 at the east side of the MTA right of way.
  - Northbound mainline ditch and Route 111 abutment culvert have inadequate capacity to handle overflow volumes from the Route 111 54" culvert.
- Flooding of City of Biddeford "Spur Road" – The roadway at this location is overtopped due to:
  - Limited capacity of the 84" culvert due to high downstream tailwater condition. (Route 111 84" culvert and Turnpike 5X8' double box culvert).
  - Limited storage behind the culvert, primarily due to the low elevation of the roadway.
- Note: The Hydrocad model is limited in its ability to model bridge and culvert hydraulics as well as to simulate backwater conditions. Hydraulic model HECRAS could provide insight into bridge and culvert interactions. However, HECRAS is limited in its ability to model storage and how flows are routed downstream. A combination of these two models may provide improved design data for recommendations on culvert and ditch options.

System Capacity Comparisons

A high level comparison of the capacity of the key culverts in the system was conducted to provide another perspective regarding how these culverts may or may not influence each other. These results are less precise than the combined system models, but provide a high level perspective. Note the flow capacities are presented as a range since capacity is influenced by factors such as headwater conditions. The following flows were modeled assuming no downstream constraints. The primary purpose of this exercise was to determine if under unconstrained conditions, the MTA double box culvert constrains the upstream Route 111 culverts.

Estimated culvert capacities with no downstream constraints

Culvert	**Unconstrained Capacity Range**
MTA 5x8 Double Box Culvert at Exit 32	500-1300 cfs
Combined Route 111 Culverts	270-500 cfs
Route 111 84" culvert near Precourt St	*200-320 cfs*
Route 111 54" culvert just east of Turnpike	*70-180 cfs*

The results show that when downstream conditions do not constrain the culverts, the MTA 5x8 double box culvert at Exit 32 has more than adequate capacity to handle the combined peak flows from the two contributing Route 111 culverts. So while the system is known to have both upstream and downstream constraints due to channel or culvert end obstructions, this analysis shows that the MTA culvert absent of these constraints does not contribute to a decrease in capacity in the upstream Route 111 culverts.

For additional perspective, information was gathered on the channel downstream of the study area. While specific capacity analysis of the channel from the end of the study area to the Saco River was not conducted and the FEMA flood maps do not have any detailed information on this section, the following information is provided.

Characteristics of channel downstream of study area to Saco River

Segment	From	To	Notes
Channel	5x8 double box at end of study area	8x8 double box north of study area on Turnpike	Defined channel in dense woods with wide flood plain, 4-5 feet of drop in 6500 feet, slope <0.1%
MTA 8x8 double Box Culvert about 0.5 mile north	West side of Turnpike	East side of Turnpike	Concrete 8x8 double box, 148 feet long, invert about 74 feet, slope <0.1%
Channel	MTA 8x8 double box	South Street	7000 feet long Elevation 60 feet at 4200 feet from double box culvert, so slope <0.5%
South Street Culvert	South side of South Street	North side of South Street	Estimated by City as 17' arch culvert Invert unknown
Channel	South Street culvert	Main Street	1600 feet long
Bridge			MDOT plans list Q100 as 700 cfs, channel invert listed at around 48 feet.
Total downstream run from Exit 32 to Saco River			**About 18,000 feet (3.3 miles)** **About 30 feet of elevation change** **Slope <0.2%**

Given the observed conditions and lack of vertical drop to the Saco River, the downstream channels and crossings south of the study area have shallow slopes that limit capacity. These conditions produce significant backwater during major storm events, constraining the capacity of the study area by raising water levels downstream of the study area culverts.

Potential Mitigation Strategies

The following lists the observed conditions by location and potential approaches to mitigating these conditions, along with general practicality.

Flooding of Northbound Interchange 32 Off Ramp (Near inlet to MTA 5'x8' double box culvert)

Observation	Mitigation	Cost	Impact	Comment
Limited culvert capacity	Clear downstream debris	Low	Moderate	Technique already implemented by MTA. Continuous monitoring and cleaning will maximize existing channel capacity but will not resolve cases where channel capacity is overwhelmed.
	Increase downstream channel capacity	High	Unknown	This was beyond the available information for this analysis. Channel modifications would likely need to be extensive and off MTA property, with minimal results in Saco River.
	Add additional 5x8 culverts	High	Low to Moderate	Increasing the culvert capacity would only reduce flooding of ramp in cases where the downstream condition is not constrained.
Limited storage behind culvert	Raise mainline and ramp profile	Very high	Moderate	Raising the mainline and ramp elevations would allow for more storage behind the culverts and larger culverts. This would be prohibitively expensive given the frequency of flooding events.
	Enlarge storage capacity behind the culverts	High	Low to Moderate	This option would require significant excavation and reshaping of the storage area (in a wetland) behind the culverts. Even if the necessary permits could be obtained, the model suggests that there is likely not enough capacity that could be created given the low surrounding elevations of the Spur Road and adjacent toll plaza.

Flooding of Northbound Turnpike Mainline at Route 111 (near inlet of 54" culvert under Route 111)

Observation	Mitigation	Cost	Impact	Comment
Limited culvert capacity	Clear debris at culvert entrance	Low	Moderate	Technique already implemented by City. Continuous monitoring and cleaning will maximize existing culvert inlet capacity but will not resolve cases where culvert capacity is overwhelmed.
	Add capacity to existing culvert at the same point	Moderate	High	Adding capacity to the 54" culvert would reduce or eliminate the storage overflow condition that results in mainline flooding.
	Add capacity to MTA ditch line	Low to moderate	High	Adding capacity to the mainline ditch would reduce or eliminate the potential for overflow to reach the mainline.
Limited storage behind culvert	Excavate additional storage capacity behind 54" culvert	High	Low to Moderate	This option would require significant excavation and reshaping of the storage area (in a wetland) behind the culverts. Even if the necessary permits could be obtained, the model suggests that there is likely not enough capacity that could be created given the low surrounding elevations of the Spur Road and adjacent toll plaza.
	Add berm at MTA right of way to increase storage behind culvert	Low	Low	While adding a berm at the MTA right of way would reduce the potential for the overflow condition, this solution would exacerbate the already flooded conditions in residential areas to the south of this storage area.

Flooding of City of Biddeford Precourt Street (near inlet of 84" culvert under Precourt Street)

Observation	Mitigation	Cost	Impact	Comment
Limited culvert capacity	Increase culvert capacity	Moderate	Low	Flooding at this culvert is affected by the 84" culvert under Route 111 and by the 5'X8' culvert under the turnpike as well as by channel conditions downstream of the turnpike, so changing capacity at the location would have minimal impact.
	Raise the road	High	Moderate	Raising the roadway would bring the street above the flooding elevation, allowing passage.
	Improve downstream capacity	High	High	This option could be key for mitigation at this location, but could impact downstream structures

Recommendations

- Review results of analysis with City
- Continued maintenance of inlets and outlets by City and MTA where appropriate
- Investigate further the options for adding capacity to 54" culvert on Route 111
- MTA to investigate increasing ditch capacity under Route 111 bridge at the east abutment.
- Suggest the City pursue options for mitigating Precourt Street via cost benefit analysis of raising roadway elevation.

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-979
Waterbody: Richardson Brook - Station 979
Town: Biddeford
Directions: RT. 111, RIGHT ON MEDICAL CENTER DRIVE (DEAD END), 200' ABOVE CROSSING

DEP Drainage: Saco
HUC8: 01060002
HUC8 Name: Saco
Latitude: 43 28 35.7 N
Longitude: 70 29 35.4 W
Stream Order: 2

Sample Information

Log Number: 2137 Type of Sample: ROCK BAG Date Deployed: 7/25/2012
Subsample Factor: X1 Replicates: 3 Date Retrieved: 8/21/2012

Classification Attainment

Statutory Class: B **Final Determination: I** Date: 8/28/2013
Model Result with P>.6: I **Reason for Determination: Best Professional Judgement**
Date Last Calculated: 7/17/2013 Comments: Minimum provision for Total Mean Abundance not met.

Model Probabilities

First Stage Model			
Class A	0.04	Class C	0.80
Class B	0.05	NA	0.12

C or Better Model	
Class A, B, or C	0.91
Non-Attainment	0.09

B or Better Model	
Class A or B	0.01
Class C or Non-Attainment	0.99

A Model	
Class A	0.01
Class B or C or Non-Attainment	0.99

Model Variables

01	Total Mean Abundance	29.67
02	Generic Richness	22.00
03	Plecoptera Mean Abundance	0.00
04	Ephemeroptera Mean Abundance	12.33
05	Shannon-Wiener Generic Diversity	3.68
06	Hilsenhoff Biotic Index	4.07
07	Relative Abundance - Chironomidae	0.19
08	Relative Generic Richness Diptera	0.41
09	*Hydropsyche* Abundance	0.00
11	*Cheumatopsyche* Abundance	0.00
12	EPT Generic Richness/ Diptera Generic Richness	0.78
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	0.00
16	Tanypodinae Mean Abundance (Family Functional Group)	1.33
17	Chironomini Abundance (Family Functional Group)	1.67
18	Relative Abundance Ephemeroptera	0.42
19	EPT Generic Richness	7.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.00
23	Relative Generic Richness- Plecoptera	0.00
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	1.67
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	0.00
28	EP Generic Richness/14	0.21
30	Presence of Class A Indicator Taxa/7	0.00

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Paraleptophlebia*	24.72
2	*Stenacron*	14.61
3	*Boyeria*	13.48
4	*Stenelmis*	6.74
5	*Calopteryx*	4.49
6	*Argia*	4.49
7	*Tanytarsus*	4.49
8	*Microtendipes*	4.49

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number:	**S-979**	Town:	Biddeford	Date Deployed:	7/25/2012
Log Number:	**2137**	Waterbody:	Richardson Brook - Station 979	Date Retrieved:	8/21/2012

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: LOTIC INC.

Waterbody Information - Deployment			Waterbody Information - Retrieval		
Temperature:	20.9	deg C	Temperature:	20.2	deg C
Dissolved Oxygen:	7.7	mg/l	Dissolved Oxygen:	7.54	mg/l
Specific Conductance:	255	uS/cm	Specific Conductance:	296	uS/cm
Velocity:	7.6	cm/s	Velocity:	15	cm/s
pH:			pH:		
Wetted Width:	5	m	Wetted Width:	4.6	m
Bankfull Width:	5.8	m	Bankfull Width:	5.4	m
Depth:	29	cm	Depth:	36	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Hardwood	Dense	Hilly
Urban		

Potential Stressor	Location	Substrate	
Urban Runoff	Above Road Crossing	Boulder	20 %
	Below Urban NPS	Detritus	5 %
		Rubble/Cobble	25 %
		Sand	40 %
		Silt	10 %

Landcover Summary - 2004 Data

Sample Comments

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-979 Waterbody: Richardson Brook - Station 979 Town: Biddeford

Log Number: 2137 Subsample Factor: X1 Replicates: 3 Calculated: 7/17/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance Actual	Relative Abundance Adjusted
Boyeria	09020301004		4.00	2	PR		13.5
Boyeria vinosa	09020301004012	4.00			--	13.5	
Calopteryx	09020307043	1.33	1.33	5	PR	4.5	4.5
Argia	09020309048	1.33	1.33	7	PR	4.5	4.5
Stenacron	09020402014	4.33	4.33	7	SC	14.6	14.6
Paraleptophlebia	09020406026	7.33	7.33	1	CG	24.7	24.7
Caenis	09020412040	0.67	0.67	7	CG	2.2	2.2
Polycentropus	09020603010	0.67	0.67	6	PR	2.2	2.2
Diplectrona	09020604014	0.33	0.33	0	CF	1.1	1.1
Limnephilus	09020610055	0.67	0.67	3	SH	2.2	2.2
Oecetis	09020618078	0.67	0.67	8	PR	2.2	2.2
Nigronia	09020701003		0.33	0	PR		1.1
Nigronia serricornis	09020701003003	0.33			--	1.1	
Ablabesmyia	09021011001	0.33	0.33	8	PR	1.1	1.1
Paramerina	09021011013	0.33	0.33		--	1.1	1.1
Thienemannimyia	09021011020		0.67	3	PR		2.2
Thienemannimyia/arctopelopia group	09021011020041	0.67			--	2.2	
Corynoneura	09021011036	0.33	0.33	7	CG	1.1	1.1
Parametriocnemus	09021011053	0.33	0.33	5	CG	1.1	1.1
Paratanytarsus	09021011071	0.67	0.67	6	--	2.2	2.2
Tanytarsus	09021011076	1.33	1.33	6	CF	4.5	4.5
Microtendipes	09021011094		1.33	6	CF		4.5
Microtendipes rydalensis group	09021011094168	1.33			--	4.5	
Polypedilum	09021011102		0.33	6	SH		1.1
Polypedilum illinoense group	09021011102185	0.33			--	1.1	
Optioservus	09021113067	0.33	0.33	3	SC	1.1	1.1
Stenelmis	09021113070	2.00	2.00	5	SC	6.7	6.7

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-978
Waterbody: Richardson Brook - Station 978
Town: Biddeford
Directions: RT. 111; RIGHT ON BIDDEFORD CONNECTOR; RIGHT ON MORIN ST.; BEHIND STERLING ROPE

DEP Drainage: Saco
HUC8: 01060002
HUC8 Name: Saco
Latitude: 43 27 49.57 N
Longitude: 70 29 39.55 W
Stream Order: 2

Sample Information

Log Number: 2138 Type of Sample: ROCK BAG Date Deployed: 7/25/2012
Subsample Factor: X1 Replicates: 3 Date Retrieved: 8/21/2012

Classification Attainment

Statutory Class: B **Final Determination: I** Date: 8/28/2013
Model Result with P>.6: I **Reason for Determination: Best Professional Judgement**
Date Last Calculated: 7/17/2013 Comments: Minimum provision for Total Mean Abundance not met.

Model Probabilities

First Stage Model

Class A	0.00	Class C	0.02
Class B	0.00	NA	0.98

C or Better Model

Class A, B, or C	0.00
Non-Attainment	1.00

B or Better Model

Class A or B	0.00
Class C or Non-Attainment	1.00

A Model

Class A	0.01
Class B or C or Non-Attainment	0.99

Model Variables

01	Total Mean Abundance	6.00
02	Generic Richness	11.00
03	Plecoptera Mean Abundance	0.00
04	Ephemeroptera Mean Abundance	0.33
05	Shannon-Wiener Generic Diversity	3.19
06	Hilsenhoff Biotic Index	4.69
07	Relative Abundance - Chironomidae	0.22
08	Relative Generic Richness Diptera	0.27
09	*Hydropsyche* Abundance	0.00
11	*Cheumatopsyche* Abundance	0.00
12	EPT Generic Richness/ Diptera Generic Richness	0.67
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	0.00
16	Tanypodinae Mean Abundance (Family Functional Group)	0.33
17	Chironomini Abundance (Family Functional Group)	0.67
18	Relative Abundance Ephemeroptera	0.06
19	EPT Generic Richness	2.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.00
23	Relative Generic Richness- Plecoptera	0.00
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	0.67
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	0.00
28	EP Generic Richness/14	0.07
30	Presence of Class A Indicator Taxa/7	0.00

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Boyeria*	27.78
2	*Polycentropus*	11.11
3	*Phaenopsectra*	11.11
4	*Stenelmis*	11.11
5	*Hyalella*	5.56
6	Cambaridae	5.56
7	*Paraleptophlebia*	5.56
8	*Ablabesmyia*	5.56
9	*Tanytarsus*	5.56
10	*Dubiraphia*	5.56

11	*Lymnaea*	5.56

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-978 Town: Biddeford Date Deployed: 7/25/2012
Log Number: 2138 Waterbody: Richardson Brook - Station 978 Date Retrieved: 8/21/2012

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT
Taxonomist: LOTIC INC.

Waterbody Information - Deployment			Waterbody Information - Retrieval		
Temperature:	19.8	deg C	Temperature:	20.1	deg C
Dissolved Oxygen:	6.88	mg/l	Dissolved Oxygen:	6.76	mg/l
Specific Conductance:	329	uS/cm	Specific Conductance:	351	uS/cm
Velocity:	26	cm/s	Velocity:	18	cm/s
pH:			pH:		
Wetted Width:	1.47	m	Wetted Width:	1.75	m
Bankfull Width:	2.69	m	Bankfull Width:	2.23	m
Depth:	35.6	cm	Depth:	71	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Hardwood	Dense	Rolling
Urban		

Potential Stressor	Location	Substrate	
Nps Pollution	Above Road Crossing	Bedrock	15 %
Urban Runoff	Below Urban NPS	Boulder	25 %
		Gravel	25 %
		Rubble/Cobble	25 %
		Sand	10 %

Landcover Summary - 2004 Data

Sample Comments

DISCHARGES - FOUNDATION DRAIN? - WAREHOUSE; IMPERVIOUS AREA RUNOFF - OUTFALL (LARGE PARKING AREA - WAREHOUSES).

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-978 Waterbody: Richardson Brook - Station 978 Town: Biddeford

Log Number: 2138 Subsample Factor: X1 Replicates: 3 Calculated: 7/17/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance Actual	Relative Abundance Adjusted
Hyalella	09010203006	0.33	0.33	8	CG	5.6	5.6
Cambaridae	09010301	0.33	0.33		--	5.6	5.6
Boyeria	09020301004		1.67	2	PR		27.8
Boyeria vinosa	09020301004012	1.67			--	27.8	
Paraleptophlebia	09020406026	0.33	0.33	1	CG	5.6	5.6
Polycentropus	09020603010	0.67	0.67	6	PR	11.1	11.1
Ablabesmyia	09021011001		0.33	8	PR		5.6
Ablabesmyia mallochi	09021011001004	0.33			--	5.6	
Tanytarsus	09021011076	0.33	0.33	6	CF	5.6	5.6
Phaenopsectra	09021011101		0.67	7	SC		11.1
Phaenopsectra punctipes group	09021011101181	0.67			--	11.1	
Dubiraphia	09021113064	0.33	0.33	6	--	5.6	5.6
Stenelmis	09021113070	0.67	0.67	5	SC	11.1	11.1
Lymnaea	10010201022	0.33	0.33		SC	5.6	5.6

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-746
Waterbody: Thacher Brook - Station 746
Town: Biddeford
Directions: ~250 M DOWNSTREAM OF TURNPIKE, KOHL'S STORE - BACK LEFT CORNER

DEP Drainage: Saco
HUC8: 01060002
HUC8 Name: Saco
Latitude: 43 28 49.43 N
Longitude: 70 30 11.45 W
Stream Order: 3

Sample Information

Log Number: 2136 Type of Sample: ROCK BAG Date Deployed: 7/25/2012
Subsample Factor: X1 Replicates: 3 Date Retrieved: 8/21/2012

Classification Attainment

Statutory Class: B **Final Determination: C** Date: 8/28/2013
Model Result with P>.6: C **Reason for Determination: Model**
Date Last Calculated: 7/17/2013 Comments:

Model Probabilities

First Stage Model			
Class A	0.00	Class C	0.96
Class B	0.03	NA	0.01

C or Better Model	
Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model	
Class A or B	0.01
Class C or Non-Attainment	0.99

A Model	
Class A	0.01
Class B or C or Non-Attainment	0.99

Model Variables

01	Total Mean Abundance	256.67
02	Generic Richness	44.00
03	Plecoptera Mean Abundance	0.00
04	Ephemeroptera Mean Abundance	46.33
05	Shannon-Wiener Generic Diversity	4.36
06	Hilsenhoff Biotic Index	5.42
07	Relative Abundance - Chironomidae	0.22
08	Relative Generic Richness Diptera	0.34
09	*Hydropsyche* Abundance	4.00
11	*Cheumatopsyche* Abundance	17.67
12	EPT Generic Richness/ Diptera Generic Richness	1.00
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	0.00
16	Tanypodinae Mean Abundance (Family Functional Group)	18.33
17	Chironomini Abundance (Family Functional Group)	6.33
18	Relative Abundance Ephemeroptera	0.18
19	EPT Generic Richness	15.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.00
23	Relative Generic Richness- Plecoptera	0.00
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	45.33
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	1.67
28	EP Generic Richness/14	0.50
30	Presence of Class A Indicator Taxa/7	0.00

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Polycentropus*	13.51
2	*Dubiraphia*	11.43
3	*Hyalella*	11.17
4	*Paraleptophlebia*	8.05
5	*Cheumatopsyche*	6.88

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-746 Town: Biddeford Date Deployed: 7/25/2012
Log Number: 2136 Waterbody: Thacher Brook - Station 746 Date Retrieved: 8/21/2012

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT
Taxonomist: LOTIC INC.

Waterbody Information - Deployment			Waterbody Information - Retrieval		
Temperature:	21.8	deg C	Temperature:	19.9	deg C
Dissolved Oxygen:	7.51	mg/l	Dissolved Oxygen:	8.61	mg/l
Specific Conductance:	367	uS/cm	Specific Conductance:	393	uS/cm
Velocity:	22.8	cm/s	Velocity:	19	cm/s
pH:			pH:		
Wetted Width:	3.56	m	Wetted Width:	3.4	m
Bankfull Width:	6.22	m	Bankfull Width:	5.9	m
Depth:	38	cm	Depth:	30	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Hardwood	Partly Open	Rolling
Urban		

Potential Stressor	Location	Substrate	
Chlorine	Below Urban NPS	Detritus	10 %
Nps Pollution	Main Stem	Gravel	35 %
Urban Runoff		Rubble/Cobble	55 %

Landcover Summary - 2004 Data

Total Area (ac)	3184	High Int. Dev. %	8.7	Water %	0.0	Non-vegetated %	0.1
		Med Int. Dev. %	3.3	Wetland %	5.8	Tilled Agriculture %	0.5
		Low Int. Dev. %	7.9	Upland Woody %	60.7	Grassland %	6.0
		Development %	19.9	Natural %	66.9	Human Altered %	33.0
						Impervious %	15.6

Sample Comments

7/25/12: MACROPHYTES PRESENT. 7/25/12: STREAM FLOW IS SLOW IN AREAS.

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-746 Waterbody: Thacher Brook - Station 746 Town: Biddeford

Log Number: 2136 Subsample Factor: X1 Replicates: 3 Calculated: 7/17/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance Actual	Relative Abundance Adjusted
Caecidotea	09010101001	1.67	1.67	8	SH	0.6	0.6
Hyalella	09010203006	28.67	28.67	8	CG	11.2	11.2
Cambaridae	09010301	1.00	1.00		--	0.4	0.4
Cladocera	090104	0.67	0.67		--	0.3	0.3
Boyeria	09020301004		3.33	2	PR		1.3
Boyeria vinosa	09020301004012	3.33			--	1.3	
Calopteryx	09020307043	7.67	7.67	5	PR	3.0	3.0
Argia	09020309048	4.33	4.33	7	PR	1.7	1.7
Baetis	09020401001		0.67	4	CG		0.3
Baetis intercalaris	09020401001008	0.67			--	0.3	
Centroptilum	09020401003	3.33	3.33	2	CG	1.3	1.3
Plauditus	09020401012		3.00		CG		1.2
Plauditus punctiventris	09020401012027	3.00			--	1.2	
Maccaffertium	09020402015	1.67	1.67	4	SC	0.6	0.6
Paraleptophlebia	09020406026	20.67	20.67	1	CG	8.1	8.1
Hexagenia	09020407028	0.67	0.67	6	CG	0.3	0.3
Caenis	09020412040	16.33	16.33	7	CG	6.4	6.4
Lype	09020602004	0.33	0.33	2	SC	0.1	0.1
Nyctiophylax	09020603009	0.33	0.33	5	PR	0.1	0.1
Polycentropus	09020603010	34.67	34.67	6	PR	13.5	13.5
Cheumatopsyche	09020604015	17.67	17.67	5	CF	6.9	6.9
Hydropsyche	09020604016		4.00	4	CF		1.6
Hydropsyche alhedra	09020604016028	4.00			--	1.6	
Oxyethira	09020607028	0.33	0.33	3	P	0.1	0.1
Limnephilus	09020610055	0.67	0.67	3	SH	0.3	0.3
Oecetis	09020618078	2.00	2.00	8	PR	0.8	0.8
Nigronia	09020701003		5.33	0	PR		2.1
Nigronia serricornis	09020701003003	5.33			--	2.1	
Sialis	09020702004	4.00	4.00	4	PR	1.6	1.6
Ablabesmyia	09021011001	5.00	6.33	8	PR	1.9	2.5
Ablabesmyia peleensis	09021011001006	1.33			--	0.5	
Labrundinia	09021011008		0.67	7	PR		0.3
Labrundinia neopilosella	09021011008021	0.67			--	0.3	
Procladius	09021011015	0.67	0.67	9	PR	0.3	0.3
Thienemannimyia	09021011020		10.67	3	PR		4.2
Thienemannimyia/arctopelopia group	09021011020041	10.67			--	4.2	
Cricotopus	09021011037	1.33	4.33	7	SH	0.5	1.7

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-746 Waterbody: Thacher Brook - Station 746 Town: Biddeford

Log Number: 2136 Subsample Factor: X1 Replicates: 3 Calculated: 7/17/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance Actual	Relative Abundance Adjusted
Cricotopus bicinctus	09021011037057	3.00			--	1.2	
Orthocladius	09021011050		0.33	6	CG		0.1
Orthocladius annectens	09021011050092	0.33			--	0.1	
Parametriocnemus	09021011053	2.00	2.00	5	CG	0.8	0.8
Paratanytarsus	09021011071	7.00	7.00	6	--	2.7	2.7
Tanytarsus	09021011076	17.00	17.00	6	CF	6.6	6.6
Cladopelma	09021011081	1.33	1.33	9	CG	0.5	0.5
Cryptotendipes	09021011083	0.33	0.33	6	--	0.1	0.1
Microtendipes	09021011094		2.00	6	CF		0.8
Microtendipes pedellus group	09021011094166	1.00			--	0.4	
Microtendipes rydalensis group	09021011094168	1.00			--	0.4	
Polypedilum	09021011102		2.67	6	SH		1.0
Polypedilum aviceps	09021011102181	2.67			--	1.0	
Simulium	09021012047	0.67	0.67	4	CF	0.3	0.3
Chrysops	09021014052	4.67	4.67	6	CG	1.8	1.8
Peltodytes	09021101002	0.33	0.33		P	0.1	0.1
Dubiraphia	09021113064	29.33	29.33	6	--	11.4	11.4
Optioservus	09021113067	1.67	1.67	3	SC	0.6	0.6
Stenelmis	09021113070	1.00	1.00	5	SC	0.4	0.4
Sphaerium	10020201003	0.67	0.67		CF	0.3	0.3

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Station Information

Station Number: W-043 Trip ID 2013-043

Waterbody: THACHER BROOK
Town: Biddeford

DEP Drainage: Saco
HUC8: 01060002
HUC8 Name: Saco
Latitude: 43 28 34.44 N
Longitude: 70 30 2.43 W
Mitigation Monitoring Site: No

Sample Information

Sample ID: DN-2013-043 Type of Sample: DIPNET Date Sampled: 6/3/2013
Subsample Factor: X1 Replicates: 3

Classification Attainment

Statutory Class: B **Final Determination:** C Date:
Model Result with P>.6: C **Reason for Determination:** Model
Date Last Calculated: 10/28/2013 Comments:

Model Probabilities

Class A: 0.00 Class B: 0.03 Class C: 0.97 NA: 0.00

Model Variables

		Reference Range
Total Mean Abundance	208	< 787
Ephemeroptera Abundance	17.33	most > 35
Odonata Relative Abundance	0.072	most > 0.04
Trichoptera Relative Abundance	0.005	most > 0.02
Shredder Taxa Relative Abundance	0.20	< 0.2
Non-insect Taxa Relative Richness	0.19	< 0.4
MTI Sensitive Taxa Abundance	2.67	most > 30
MTI Sensitive Taxa Relative Abundance	0.02	most > 0.05
MTI Sensitive Taxa Richness	5	most > 7
MTI Intermediate Taxa Relative Abundance	0.69	> 0.5
MTI Intermediate Taxa Richness	19	< 25
Ratio of MTI Sensitive to Eurytopic Taxa Abundance	0.05	most > 1

Other Variables

Generic Richness:	37
Hilsenhoff Biotic Index:	6.71
Shannon-Weiner Diversity:	3.55
Maine Tolerance Index:	35.85

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Hyalella*	26.00
2	*Caecidotea*	18.62
3	*Thienemannimyia/arctopelopia*	12.68
4	*Paramerina*	7.06
5	*Baetis brunneicolor*	5.94
5	*Helisoma*	5.94

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT
Taxonomist: LOTIC INC.

Water Chemistry

Sample Date: 6/3/2013 8:45:00 AM

Sample Type	Collection Method	Parameter	Value	Units	Qualifier
Surface Water	Grab Sample	Chloride	41	mg/l	
Surface Water	Grab Sample	Chlorophyll A	0.0079	mg/l	
Surface Water	Grab Sample	Chlorophyll A - Phaeophytin	0.0075	mg/l	
Surface Water	Grab Sample	Dissolved Organic Carbon	7.8	mg/l	
Surface Water	Grab Sample	Nitrate+nitrite As N	0.01	mg/l	
Surface Water	Grab Sample	Silica	4.1	mg/l	
Surface Water	Grab Sample	Silicon	1.9	mg/l	
Surface Water	Grab Sample	Soluble Reactive Phosphorus	2	ug/l	
Surface Water	Grab Sample	Total Alkalinity	40	mg/l	
Surface Water	Grab Sample	Total Kjeldahl Nitrogen	0.6	mg/l	
Surface Water	Grab Sample	Total Phosphorus	0.033	mg/l	
Surface Water	Grab Sample	True Color	70	unit	
Surface Water	In-situ	Dissolved Oxygen	2.7	mg/l	
Surface Water	In-situ	pH	6.15		
Surface Water	In-situ	Specific Conductance	214	us/cm	
Surface Water	In-situ	Temperature	22.7	deg c	

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Summary of Habitat Characteristics

Human Disturbance		Landscape-level Cowardin Classification		Hydrogeomorphic Setting	
Total Score:	28	System:	PALUSTRINE	Landscape Position	LOTIC STREAM
Hydrologic Modifications:	9	Subsystem		Lotic Gradient:	LOW GRADIENT
Vegetative Modifications:	4	Class 1:	SCRUB SHRUB	Flow Path:	THROUGHFLOW
Chemical Contaminants:	4	Subclass 1	BROAD-LEAVED DECIDUOUS	Land Form:	FRINGE
Impervious Surface:	0	Class 2:		Land Form Type:	LOTIC STREAM
Non-point Sources:	0	Subclass 2		Waterbody Type:	STREAM
		Class 3:		Waterbody Subtype	
		Subclass 3:		Comments:	

Yes, still accurate in new location

Dominant Plant Species: PICKEREL WEED (PONTEDERIA CORDATA), UNKNOWN AQUATIC BED VEGETATION, GRASSES (ECHINOCHLOA), 3-WAY SEDGE (DULICHIUM ARUNDINACEUM)

Habitat Classification:
AQUATIC MACROPHYTE BED
EMERGENT NON-PERSISTENT VEGETATION

Substrate Classification:
SAND SUBSTRATE
SILT/MUCK SUBSTRATE

Landcover Summary - 2004 Data

Total Area (ac)	1109	High Int. Dev. %	3.1	Water %	0.0	Non-vegetated %	0.1
		Med Int. Dev. %	1.5	Wetland %	1.2	Tilled Agriculture %	0.4
		Low Int. Dev. %	6.5	Upland Woody %	72.5	Grassland %	12.6
		Development %	11.1	Natural %	74.5	Human Altered %	25.5
						Impervious %	9.5
Total Land (ac)	1109	High Int. Dev. %	3.1	Water %	N/A	Non-vegetated %	N/A
		Med Int. Dev. %	1.5	Wetland %	1.2	Tilled Agriculture %	0.4
		Low Int. Dev. %	6.5	Upland Woody %	72.5	Grassland %	12.6
		Development %	11.1	Natural %	74.5	Human Altered %	25.5
						Impervious %	9.5

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Additional Summary Variables

Station Number: W-043 Waterbody: THACHER BROOK Town: Biddeford

Log Number: DN-2013-043 Subsample Factor: X1 Replicates: 3 Calculated: 10/28/2013

	Abundance	Relative Abundance	Richness	Relative Richness
EOT Taxa:	33.33	0.161	12	0.32
EPT Taxa:	20.33	0.098	10	0.27
Insects:	95.33	0.459	30	0.81
Non-Insects:	112.33	0.541	7	0.19
Leeches:	3.00	0.014	1	0.03
Oligochaetes:	0.00	0.000	0	0.00
Snails:	15.67	0.075	3	0.08
Bivalves:	1.00	0.005	1	0.03
Isopods:	38.67	0.186	1	0.03
Amphipods:	54.00	0.260	1	0.03
Mites:	0.00	0.000	0	0.00
Stoneflies:	2.00	0.010	2	0.05
Mayflies:	17.33	0.083	5	0.14
Odonates:	15.00	0.072	4	0.11
Caddisflies:	1.00	0.005	3	0.08
Diptera:	53.00	0.255	8	0.22
Hemiptera:	1.00	0.005	2	0.05
Beetles:	6.00	0.029	6	0.16
Chironomids:	53.00	0.255	8	0.22
Tanypodinae Tribe:	41.00	0.197	2	0.05
Chironomiinae Tribe:	7.00	0.034	1	0.03
Orthoclodiinae Tribe:	5.00	0.024	5	0.14
Collector-Filterers:	8.00	0.039	2	0.05
Collector-Gatherers:	74.00	0.356	9	0.24
Predators:	49.67	0.239	13	0.35
Piercers:	0.00	0.000	0	0.00
Shredders:	41.67	0.201	5	0.14
Scrapers:	15.67	0.075	3	0.08
Maine Tolerance:				
Sensitive:	2.67	0.016	5	0.17
Intermediate:	117.33	0.693	19	0.66
Eurytopic:	49.33	0.291	5	0.17
Ratio of MTI Sensitive to Eurytopic	0.05	0.054	1.00	1.00

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Aquatic Life Taxonomic Inventory Report

Station Number: W-043 Waterbody: THACHER BROOK Town: Biddeford

Log Number: DN-2013-043 Subsample Factor: X1 Replicates: 3 Calculated: 10/28/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samples) Actual	Count (Mean of Samples) Adjusted	Hilsen-hoff Biotic Index	Func-tional Feeding Group	Maine Toler-ance Index	Tribe	Taxa Group
Helobdella	08030101005	0.00	3.00	--	--	43-E	--	Leech
Helobdella stagnalis	08030101005004	3.00	0.00	--	--	--	--	Leech
Caecidotea	09010101001	38.67	38.67	8	SH	51.9-E	--	Isopod
Hyalella	09010203006	54.00	54.00	8	CG	24.5-I	--	Amphipod
Leuctra	09020204020	0.33	0.33	0	SH	--	--	Stonefly
Perlesta	09020209046	1.67	1.67	5	PR	--	--	Stonefly
Aeshna	09020301001	0.33	0.33	5	PR	27.9-I	--	Dragonfly/damsefly
Sympetrum	09020306041	5.67	5.67	10	PR	37-I	--	Dragonfly/damsefly
Lestes	09020308045	0.33	0.33	9	PR	32.6-I	--	Dragonfly/damsefly
Argia	09020309048	8.67	8.67	7	PR	--	--	Dragonfly/damsefly
Baetis	09020401001	0.00	12.33	4	CG	29.9-I	--	Mayfly
Baetis brunneicolor	09020401001003	12.33	0.00	--	--	--	--	Mayfly
Procloeon	09020401010	0.67	0.67	--	CG	21-S	--	Mayfly
Leptophlebiidae	09020406	0.33	0.33	--	--	--	--	Mayfly
Eurylophella	09020410036	0.33	0.33	3	CG	23.2-I	--	Mayfly
Caenis	09020412040	3.67	3.67	7	CG	22.1-I	--	Mayfly
Belostoma	09020502009	0.67	0.67	--	PR	41.7-I	--	True Bug
Notonectidae	09020505	0.33	0.33	--	--	--	--	True Bug
Nyctiophylax	09020603009	0.33	0.33	5	PR	--	--	Caddisfly
Limnephilus	09020610055	0.33	0.33	3	SH	24.6-I	--	Caddisfly
Triaenodes	09020618077	0.33	0.33	6	SH	19.3-S	--	Caddisfly
Paramerina	09021011013	14.67	14.67	--	--	29.3-I	T	Fly: Midge
Thienemannimyia	09021011020	0.00	26.33	3	PR	--	T	Fly: Midge
Thienemannimyia/arctopelopia group	09021011020041	26.33	0.00	--	--	--	T	Fly: Midge
Corynoneura	09021011036	1.33	1.33	7	CG	40.1-I	--	Fly: Midge
Cricotopus	09021011037	0.00	2.00	7	SH	43-E	--	Fly: Midge
Cricotopus bicinctus	09021011037057	2.00	0.00	--	--	--	--	Fly: Midge
Limnophyes	09021011047	0.33	0.33	8	CG	26.5-I	--	Fly: Midge
Orthocladius	09021011050	0.00	0.33	6	CG	22-S	--	Fly: Midge
Orthocladius annectens	09021011050092	0.33	0.00	--	--	--	--	Fly: Midge
Psectrocladius	09021011056	1.00	1.00	8	CG	22-S	--	Fly: Midge
Tanytarsus	09021011076	7.00	7.00	6	CF	25.7-I	Y	Fly: Midge
Agabus	09021103016	1.67	1.67	--	PR	34.5-I	--	Beetle
Matus	09021103021	0.67	0.67	--	PR	42.9-I	--	Beetle

Maine Department of Environmental Protection
Biological Monitoring Program
Wetland Aquatic Life Classification Attainment Report

Aquatic Life Taxonomic Inventory Report

Station Number: W-043 Waterbody: THACHER BROOK Town: Biddeford

Log Number: DN-2013-043 Subsample Factor: X1 Replicates: 3 Calculated: 10/28/2013

Taxon	Maine Taxonomic Code	Count (Mean of Samples) Actual	Count (Mean of Samples) Adjusted	Hilsen-hoff Biotic Index	Func-tional Feeding Group	Maine Toler-ance Index	Tribe	Taxa Group
Coptotomus	09021103023	0.33	0.33	--	PR	32-I	--	Beetle
Dytiscus	09021103027	0.33	0.33	--	PR	--	--	Beetle
Tropisternus	09021105038	2.67	2.67	--	PR	61.8-E	--	Beetle
Dubiraphia	09021113064	0.33	0.33	6	--	10.4-S	--	Beetle
Lymnaea	10010201022	3.00	3.00	--	SC	83.3-E	--	Snail
Gyraulus	10010203029	0.33	0.33	--	SC	37.2-I	--	Snail
Helisoma	10010203030	12.33	12.33	--	SC	42.8-I	--	Snail
Sphaerium	10020201003	1.00	1.00	--	CF	24.8-I	--	Mussel/clam

Appendix A.3
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME Thatcher Brook	LOCATION C2	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, IK, JF, WG		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13 TIME 3:30 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No
	❑ storm (heavy rain)	❑	**Air Temperature**_____ ^{0} C
	❑ rain (steady rain)	❑	
	❑ showers (intermittent)	❑	**Other**_____
	____%❑ %cloud cover	❑____%	
	☑ clear/sunny	❑	
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)** (See the RGA map)		
STREAM CHARACTERIZATION	**Stream Subsystem** ☑ Perennial ❑ Intermittent ❑ Tidal **Stream Origin** ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____		**Stream Type** ❑ Coldwater ❑ Warmwater **Catchment Area**_____km^2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Thatcher Brook	LOCATION C2	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY Maine DEP	
INVESTIGATORS TT, IK, JF, WG,		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13, 8/15/13 TIME 3:30 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

Total Score 110

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME Thatcher Brook	LOCATION C2	
STATION # C2 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, JF, WG, IK		LOT NUMBER
FORM COMPLETED BY TT, JF, WG	DATE 8/15/13 TIME 3:30 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble 33 % ❑ Snags 15 % ❑ Vegetated Banks_____% ❑ Sand_____% ❑ Submerged Macrophytes_____% ❑ Other (Fines) 52 %
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other _____ **How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble 4/3 ❑ Snags 3 ❑ Vegetated Banks_____ ❑ Sand_____ ❑ Submerged Macrophytes_____ ❑ Other (Fines) 7 Boulder 3
GENERAL COMMENTS	

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	0	(1)	2	3	4	Slimes	(0)	1	2	3	4
Filamentous Algae	(0)	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	(1)	2	3	4	Fish	0	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	(1)	2	3	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	(1	2)	3	4	Ephemeroptera	0	1	(2)	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	1	(2)	3	4	Trichoptera	0	1	(2)	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	(1)	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	(2)	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	2	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	1	2	3	4	Empididae	0	1	2	3	4						
Gastropoda	0	1	2	3	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabinidae	0	1	2	3	4						
						Culcidae	0	1	2	3	4						

page __ of __

BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish; P = Periphyton)**#** 0754 = project number **#** 001 = sample number **#** (1) = lot number (e.g., winter 1996 =1; summer 1996 = 2)

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT #
TAXONOMIST DATE_____	SUBSAMPLE TARGET ❑ 100 ❑ 200 ❑ 300 ❑ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms _____ **Total No. Taxa** _____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter _____ Date _____	Number of grids picked: _____ Time expenditure _____ No. of organisms _____ Indicate the presence of large or obviously abundant organisms: **QC:** ❑ YES ❑ NO **QC Checker** _____ # organisms originally sorted [ ] ÷ (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes _____ <90%, sample fails, action taken _____
TAXONOMY ID _____ Date _____	Explain TCR ratings of 3-5: Other Comments (e.g. condition of specimens): **QC:** ❑ YES ❑ NO **QC Checker** _____ Organism recognition ❑ pass ❑ fail Verification complete ❑ YES ❑ NO

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT # _____ NUMBER OF SWEEPS _____
HABITATS: ❑ COBBLE ❑ SHOREZONE	❑ SNAGS ❑ VEGETATION

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials					
Hemiptera											

	Site Value	Target Threshold	
Total No. Taxa			If 2 or more metrics are ≥ target threshold, site is **HEALTHY**
EPT Taxa			If less than 2 metrics are within target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Appendix A.3
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME Thatcher Brook	LOCATION B2, Medical Center Dr	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, IK, JF, WG		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13 TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No
	❑ storm (heavy rain)	❑	**Air Temperature**_____ ^{0} C
	❑ rain (steady rain)	❑	
	❑ showers (intermittent)	❑	**Other**_____
	____%❑ %cloud cover	❑____%	
	☑ clear/sunny	❑	
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)** (See the RGA map)		
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal **Stream Origin** ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____		**Stream Type** ❑ Coldwater ❑ Warmwater **Catchment Area**_____km^2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME	LOCATION B2, Medical Center Dr	
STATION # B2 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT,JF, WG, IK		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13, 8/15/13 TIME 2:00 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	Suboptimal	Marginal	Poor
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 (12) 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 (7) 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 (4) 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 (4) 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 (6)	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

Total Score 106

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME	LOCATION	
STATION # B2 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, JF, WG, IK		LOT NUMBER
FORM COMPLETED BY TT, JF, WG	DATE 8/15/13 TIME 12:00 AM PM	REASON FOR SURVEY Biomonitoring evaluation

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble 40 % ❑ Snags 5 % ❑ Vegetated Banks_____% ❑ Sand 20 % ❑ Submerged Macrophytes_____% ❑ Other (Fines) 35 %
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other _____ **How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble 7 ❑ Snags 4 ❑ Vegetated Banks_____ ❑ Sand 2 ❑ Submerged Macrophytes_____ ❑ Other (Fines/Gravel) 4 Boulder 3
GENERAL COMMENTS	Small woody debris over silty/sand/gravel - Dead zones in pools - Where rocks present - good selection of bugs

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	0	1	2	3	4	Slimes	0	1	2	3	4
Filamentous Algae	0	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	1	2	3	4	Fish	0	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	1	2	3	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	1	2	3	4	Ephemeroptera	0	1	2	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	1	2	3	4	Trichoptera	0	1	2	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	1	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	2	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	2	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	1	2	3	4	Empididae	0	1	2	3	4						
Gastropoda	0	1	2	3	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabinidae	0	1	2	3	4						
						Culcidae	0	1	2	3	4						

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BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish; P = Periphyton)**#** 0754 = project number **#** 001 = sample number **#** (1) = lot number (e.g., winter 1996 =1; summer 1996 = 2)

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT #
TAXONOMIST DATE_____	SUBSAMPLE TARGET ❑ 100 ❑ 200 ❑ 300 ❑ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms _____ **Total No. Taxa** _____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter _____ Date _____	Number of grids picked: _____ Time expenditure _____ No. of organisms _____ Indicate the presence of large or obviously abundant organisms: **QC:** ❑ YES ❑ NO **QC Checker** _____ # organisms originally sorted [ ] ÷ (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes _____ <90%, sample fails, action taken _____
TAXONOMY ID _____ Date _____	Explain TCR ratings of 3-5: Other Comments (e.g. condition of specimens): **QC:** ❑ YES ❑ NO **QC Checker** _____ Organism recognition ❑ pass ❑ fail Verification complete ❑ YES ❑ NO

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT # _____ NUMBER OF SWEEPS _____
HABITATS: ❑ COBBLE ❑ SHOREZONE	❑ SNAGS ❑ VEGETATION

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials					
Hemiptera											

	Site Value	Target Threshold	
Total No. Taxa			If 2 or more metrics are ≥ target threshold, site is **HEALTHY**
EPT Taxa			If less than 2 metrics are within target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Appendix A.3
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No
	❑ storm (heavy rain)	❑	
	❑ rain (steady rain)	❑	**Air Temperature**_____ ^{0} C
	❑ showers (intermittent)	❑	
	____%❑ %cloud cover	❑____%	**Other**_____
	❑ clear/sunny	❑	
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)**		
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal		**Stream Type** ❑ Coldwater ❑ Warmwater
	Stream Origin ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____		**Catchment Area**_____km^2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Thatcher Brook	LOCATION B1 (behind Sterling Rope)	
STATION # B1 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY Maine DEP	
INVESTIGATORS TT, JF, WG, IK		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13, 8/15/13 TIME 12:30 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 (8) 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	(15) 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 (16)	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 (6)	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 (3)	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 (3)	2 1 0

Parameters to be evaluated broader than sampling reach

Total Score 127

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME Thatcher Brook	LOCATION	
STATION # B1 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, JF, WG, IK		LOT NUMBER
FORM COMPLETED BY TT, JF, WG	DATE 8/15/13 TIME 12:30 AM (PM)	REASON FOR SURVEY Biomonitoring evaluation

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble_____% ❑ Snags_____% ❑ Vegetated Banks_____% ❑ Sand_____% ❑ Submerged Macrophytes_____% ❑ Other ( )_____%
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other _____ **How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble 7 ❑ Snags 1 ❑ Vegetated Banks_____ ❑ Sand 10 ❑ Submerged Macrophytes_____ ❑ Other (Boulder) 2
GENERAL COMMENTS	Salamander found in net

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	0	1	2	3	4	Slimes	(0)	1	2	3	4
Filamentous Algae	(0)	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	1	2	3	4	Fish	0	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	1	2	(3)	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	1	2	3	4	Ephemeroptera	0	1	2	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	(1)	2	3	4	Trichoptera	0	(1)	2	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	1	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	2	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	2	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	1	(2)	3	4	Empididae	0	1	2	3	4						
Gastropoda	0	1	2	3	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabinidae	0	1	2	3	4						
						Culcidae	0	1	2	3	4						

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BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish; P = Periphyton)**#** 0754 = project number **#** 001 = sample number **#** (1) = lot number (e.g., winter 1996 =1; summer 1996 = 2)

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT #
TAXONOMIST DATE_____	SUBSAMPLE TARGET ❑ 100 ❑ 200 ❑ 300 ❑ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms _____ **Total No. Taxa** _____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter _____ Date _____	Number of grids picked: _____ Time expenditure _____ No. of organisms _____ Indicate the presence of large or obviously abundant organisms: **QC:** ❑ YES ❑ NO **QC Checker** _____ # organisms originally sorted [ ] ÷ (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes _____ <90%, sample fails, action taken _____
TAXONOMY ID _____ Date _____	Explain TCR ratings of 3-5: Other Comments (e.g. condition of specimens): **QC:** ❑ YES ❑ NO **QC Checker** _____ Organism recognition ❑ pass ❑ fail Verification complete ❑ YES ❑ NO

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT # _____ NUMBER OF SWEEPS _____
HABITATS: ❑ COBBLE ❑ SHOREZONE	❑ SNAGS ❑ VEGETATION

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials					
Hemiptera											

	Site Value	Target Threshold	
Total No. Taxa			If 2 or more metrics are ≥ target threshold, site is **HEALTHY**
EPT Taxa			If less than 2 metrics are within target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Appendix A.3
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME	LOCATION	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS		
FORM COMPLETED BY	DATE _____ TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No
	❑ storm (heavy rain)	❑	
	❑ rain (steady rain)	❑	**Air Temperature**_____ ^{0} C
	❑ showers (intermittent)	❑	
	____%❑ %cloud cover	❑____%	**Other**_____
	❑ clear/sunny	❑	
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)**		
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal		**Stream Type** ❑ Coldwater ❑ Warmwater
	Stream Origin ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____		**Catchment Area**_____km^2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Thatcher Brook	LOCATION Behind Kohls (adjacent to turnpike)	
STATION # A3 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY Maine DEP	
INVESTIGATORS TT, JF, WG, IK		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13, 8/15/13 TIME 9:00 (AM) PM	REASON FOR SURVEY Biomonitoring evaluation

Parameters to be evaluated in sampling reach	Habitat Parameter	Condition Category			
		Optimal	**Suboptimal**	**Marginal**	**Poor**
	1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
	2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
	SCORE	20 19 18 17 16	15 14 (13) 12 11	10 9 8 7 6	5 4 3 2 1 0
	3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
	SCORE	20 19 18 17 16	15 14 13 12 11	10 9 (8) 7 6	5 4 3 2 1 0
	4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
	SCORE	20 19 18 17 16	15 14 13 12 11	(10) 9 8 7 6	5 4 3 2 1 0
	5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
	SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	(5) 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	(2) 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	(2) 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	(8) 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

Total Score 105

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME Thatcher Brook	LOCATION Behind Kohls (Adjacent to turnpike)
STATION # A3 RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY Maine DEP
INVESTIGATORS TT, JF, WG, IK	LOT NUMBER
FORM COMPLETED BY TT,JF, WG	DATE 8/15/13 TIME 9-!0:30 (AM) PM / REASON FOR SURVEY Biomonitoring evaluation

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble 10 % ❑ Snags_____% ❑ Vegetated Banks_____% ❑ Sand_____% ❑ Submerged Macrophytes 50 % ❑ Other (Clay) 40 %
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other _____ **How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble 2 ❑ Snags_____ ❑ Vegetated Banks_____ ❑ Sand_____ ❑ Submerged Macrophytes 10 ❑ Other (Clay) 8
GENERAL COMMENTS	The macroinvertebrates were found predominantly in the macrophyte portion of the reach. The upper portion of the reach is dominated by clay with few interstitial spaces.

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	0	1	2	3	4	Slimes	(0)	1	2	3	4
Filamentous Algae	(0)	1	2	3	4	Macroinvertebrates	0	1	(2)	3	4
Macrophytes	0	1	2	3	(4)	Fish	(0)	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	1	2	(3)	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	1	(2)	3	4	Ephemeroptera	0	1	2	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	1	(2)	3	4	Trichoptera	0	1	2	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	(1)	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	2	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	(2)	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	(1)	2	3	4	Empididae	0	1	2	3	4						
Gastropoda	0	(1)	2	3	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabinidae	0	1	2	3	4						
						Culcidae	0	1	2	3	4						

page __ of __

BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish; P = Periphyton)**#** 0754 = project number **#** 001 = sample number **#** (1) = lot number (e.g., winter 1996 =1; summer 1996 = 2)

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT #
TAXONOMIST DATE_____	SUBSAMPLE TARGET ❑ 100 ❑ 200 ❑ 300 ❑ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms _____ **Total No. Taxa** _____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter _____ Date _____	Number of grids picked: _____ Time expenditure _____ No. of organisms _____ Indicate the presence of large or obviously abundant organisms: **QC:** ❑ YES ❑ NO **QC Checker** _____ # organisms originally sorted [ ] ÷ (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes _____ <90%, sample fails, action taken _____
TAXONOMY ID _____ Date _____	Explain TCR ratings of 3-5: Other Comments (e.g. condition of specimens): **QC:** ❑ YES ❑ NO **QC Checker** _____ Organism recognition ❑ pass ❑ fail Verification complete ❑ YES ❑ NO

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT # _____ NUMBER OF SWEEPS _____
HABITATS: ❑ COBBLE ❑ SHOREZONE	❑ SNAGS ❑ VEGETATION

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials					
Hemiptera											

	Site Value	Target Threshold	
Total No. Taxa			If 2 or more metrics are ≥ target threshold, site is **HEALTHY**
EPT Taxa			If less than 2 metrics are within target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Appendix A.3
PHYSICAL CHARACTERIZATION/WATER QUALITY FIELD DATA SHEET (FRONT)

STREAM NAME Thatcher Brook	LOCATION A2 (Easy St.)	
STATION #_____ RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, IK, JF, WG		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13 TIME _____ AM PM	REASON FOR SURVEY

WEATHER CONDITIONS	**Now**	**Past 24 hours**	**Has there been a heavy rain in the last 7 days?** ❑ Yes ❑ No
	❑ storm (heavy rain)	❑	**Air Temperature**_____ ^{0} C
	❑ rain (steady rain)	❑	
	❑ showers (intermittent)	❑	**Other**_____
	____%❑ %cloud cover	❑____%	
	❑ clear/sunny	❑	
SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled (or attach a photograph)** (See RGA Map)		
STREAM CHARACTERIZATION	**Stream Subsystem** ❑ Perennial ❑ Intermittent ❑ Tidal **Stream Origin** ❑ Glacial ❑ Spring-fed ❑ Non-glacial montane ❑ Mixture of origins ❑ Swamp and bog ❑ Other_____		**Stream Type** ❑ Coldwater ❑ Warmwater **Catchment Area**_____km^2

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (FRONT)

STREAM NAME Thatcher Brook	LOCATION A2 (Easy St.)	
STATION # A2 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY Maine DEP	
INVESTIGATORS TT, JF, WG, IK		
FORM COMPLETED BY TT, JF, WG	DATE 8/1/13, 8/15/13 TIME 11 (AM) PM	REASON FOR SURVEY Biomonitoring evaluation

Parameters to be evaluated in sampling reach

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/ Available Cover	Greater than 50% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i.e., logs/snags that are not new fall and not transient).	30-50% mix of stable habitat; well-suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	(5) 4 3 2 1 0
2. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	(5) 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than <20% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 20-50% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 50-80% of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 80% of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 (18) 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills >75% of the available channel; or <25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 (11)	10 9 8 7 6	5 4 3 2 1 0

HABITAT ASSESSMENT FIELD DATA SHEET—LOW GRADIENT STREAMS (BACK)

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yr) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.)	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	The bends in the stream increase the stream length 1 to 2 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 (6)	5 4 3 2 1 0
8. Bank Stability (score each bank)	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
9. Vegetative Protection (score each bank) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 10 (RB)	Right Bank (10) 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone >18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone <6 meters: little or no riparian vegetation due to human activities.
SCORE 10 (LB)	Left Bank (10) 9	8 7 6	5 4 3	2 1 0
SCORE 8 (RB)	Right Bank 10 9	(8) 7 6	5 4 3	2 1 0

Parameters to be evaluated broader than sampling reach

Total Score 133

BENTHIC MACROINVERTEBRATE FIELD DATA SHEET

STREAM NAME Thatcher Brook	LOCATION A2 (Easy St.)	
STATION # A2 RIVERMILE_____	STREAM CLASS	
LAT _____ LONG _____	RIVER BASIN	
STORET #	AGENCY	
INVESTIGATORS TT, JF, WG, IK		LOT NUMBER
FORM COMPLETED BY TT, JF, WG	DATE 8/15/13 TIME 11 AM PM	REASON FOR SURVEY Biomonitoring evaluation

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble 0 % ❑ Snags____% ❑ Vegetated Banks 10 % ❑ Sand 0 % ❑ Submerged Macrophytes 5 % ❑ Other (Fine/Wood Particles) 85 %
SAMPLE COLLECTION	**Gear used** ❑ D-frame ❑ kick-net ❑ Other _____ **How were the samples collected?** ☑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble____ ❑ Snags____ ❑ Vegetated Banks 1 ❑ Sand____ ❑ Submerged Macrophytes 1 ❑ Other (Fine/Woody Particles) 18
GENERAL COMMENTS	Clay/Woody particles is predominant stream bed makeup

QUALITATIVE LISTING OF AQUATIC BIOTA
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare, 2 = Common, 3= Abundant, 4 = Dominant

Periphyton	(0)	1	2	3	4	Slimes	(0)	1	2	3	4
Filamentous Algae	(0)	1	2	3	4	Macroinvertebrates	0	1	2	3	4
Macrophytes	0	(1)	2	3	4	Fish	(0)	1	2	3	4

FIELD OBSERVATIONS OF MACROBENTHOS
Indicate estimated abundance: 0 = Absent/Not Observed, 1 = Rare (1-3 organisms), 2 = Common (3-9 organisms), 3= Abundant (>10 organisms), 4 = Dominant (>50 organisms)

Porifera	0	1	2	3	4	Anisoptera	0	1	2	3	4	Chironomidae	0	1	2	3	4
Hydrozoa	0	1	2	3	4	Zygoptera	0	1	2	3	4	Ephemeroptera	0	1	2	3	4
Platyhelminthes	0	1	2	3	4	Hemiptera	0	1	(2)	3	4	Trichoptera	0	(1)	2	3	4
Turbellaria	0	1	2	3	4	Coleoptera	0	1	2	3	4	Other	0	1	2	3	4
Hirudinea	0	1	2	3	4	Lepidoptera	0	1	2	3	4						
Oligochaeta	0	1	2	3	4	Sialidae	0	1	2	3	4						
Isopoda	0	1	2	3	4	Corydalidae	0	1	2	3	4						
Amphipoda	0	1	2	3	4	Tipulidae	0	1	2	3	4						
Decapoda	0	1	2	3	(4)	Empididae	0	1	2	3	4						
Gastropoda	0	1	2	(3)	4	Simuliidae	0	1	2	3	4						
Bivalvia	0	1	2	3	4	Tabinidae	0	1	2	3	4						
						Culcidae	0	1	2	3	4						

page __ of __

BENTHIC MACROINVERTEBRATE SAMPLE LOG-IN SHEET

Date Collected	Collected By	Number of Containers	Preservation	Station #	Stream Name and Location	Date Received by Lab	Lot Number	Date of Completion		
								sorting	mounting	identification

Serial Code Example: B0754001(1)
B = Benthos (F = Fish; P = Periphyton)**#** 0754 = project number **#** 001 = sample number **#** (1) = lot number (e.g., winter 1996 =1; summer 1996 = 2)

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (FRONT)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT #
TAXONOMIST DATE_____	SUBSAMPLE TARGET ❑ 100 ❑ 200 ❑ 300 ❑ Other ____

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
Hemiptera											

Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials

Total No. Organisms _____ **Total No. Taxa** _____

BENTHIC MACROINVERTEBRATE LABORATORY BENCH SHEET (BACK)

SUBSAMPLING/SORTING INFORMATION Sorter _____ Date _____	Number of grids picked: _____ Time expenditure _____ No. of organisms _____ Indicate the presence of large or obviously abundant organisms: **QC:** ❑ YES ❑ NO **QC Checker** _____ # organisms originally sorted [ ] ÷ (# organisms recovered by checker [ ] + # organisms originally sorted [ ]) = % sorting efficiency [ ] ≥90%, sample passes _____ <90%, sample fails, action taken _____
TAXONOMY ID _____ Date _____	Explain TCR ratings of 3-5: Other Comments (e.g. condition of specimens): **QC:** ❑ YES ❑ NO **QC Checker** _____ Organism recognition ❑ pass ❑ fail Verification complete ❑ YES ❑ NO

PRELIMINARY ASSESSMENT SCORE SHEET
(PASS)

page _____ of _____

STREAM NAME	LOCATION
STATION #_____ RIVERMILE_____	STREAM CLASS
LAT _____ LONG _____	RIVER BASIN
STORET #	AGENCY
COLLECTED BY DATE_____	LOT # _____ NUMBER OF SWEEPS _____
HABITATS: ❑ COBBLE ❑ SHOREZONE	❑ SNAGS ❑ VEGETATION

Enter Family and/or Genus and Species name on blank line.

Organisms		No.	LS	TI	TCR	Organisms		No.	LS	TI	TCR
Oligochaeta						Megaloptera					
Hirudinea						Coleoptera					
Isopoda											
Amphipoda						Diptera					
Decapoda											
Ephemeroptera											
						Gastropoda					
						Pelecypoda					
Plecoptera											
						Other					
Trichoptera											
						Taxonomic certainty rating (TCR) 1-5:1=most certain, 5=least certain. If rating is 3-5, give reason (e.g., missing gills). LS= life stage: I = immature; P = pupa; A = adult TI = Taxonomists initials					
Hemiptera											

	Site Value	Target Threshold	
Total No. Taxa			If 2 or more metrics are ≥ target threshold, site is **HEALTHY**
EPT Taxa			If less than 2 metrics are within target range, site is **SUSPECTED IMPAIRED**
Tolerance Index			

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: 8/1/13 **Site/Reach ID:** A2 **Recorder:** TT

Location: Easy St. **Crew:** TT, IK, JF, WG

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars	✓		0
	2	Coarse materials in riffles embedded	✓		0
	3	Siltation in pools	✓		0
	4	Mid-channel bars	✓		0
	5	Deposition on point bars	✓		0
	6	Poor lateral sorting of bed materials	✓		0
	7	Soft, unconsolidated bed		✓	1
	8	Evidence of deposition in / around bank structures	✓		0
	9	Deposition in the overbank zone		✓	1
		Sum of Indices:			0.22
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed	✓		0
	3	Bank height increases		✓	1
	4	Absence of depositional features (no bars)		✓	0
	5	Cut face on bar forms	✓		0
	6	Head cutting due to knick point migration	✓		0
	7	Suspended armor layer visible in bank	✓		0
		Sum of Indices:			0.29
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		0
	2	Occurrence of large organic debris		✓	1
	3	Exposed tree roots	✓		0
	4	Basal scour on inside meander bends	✓		0
	5	Toe erosion on both sides of channel through riffle	✓		0
	6	Steep bank angles through most of subject reach	✓		0
	7	Length of bank scour >50% through subject reach	✓		0
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.13
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes	✓		0
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form	✓		0
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form	✓		0
	7	Bar forms poorly formed / reworked / removed	✓		0
		Sum of Indices:			0

Stability Index: 0.16

Condition: "in regime"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: A2

STREAM CORRIDOR SURVEY

Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Easy Street

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	28 '	12.2 "	70 °	30 '	15.1 "		up stream
End	43 °	28 '	13.5 "	70 °	30 '	17.7 "		downstream

GPS Map Datum (e.g., NAD83, WGS84, etc.):

Site or Map Number (if applicable):

Date: 8/15/13 **Time:** 11:15 am

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	_____-_____		____° ____' ____"	____° ____' ____"	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
	_____-_____		____° ____' ____"	____° ____' ____"	
End of reach: facing towards survey reach	_____-_____		____° ____' ____"	____° ____' ____"	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

❑ Pool(s) ❑ Riffle(s) ❑ Run(s) ❑ Cascade(s)
❑ Rapid(s) ❑ Deadwater(s) ❑ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	≥50%
Silt/Clay/Mud (< 0.002" in diam.)	❑	❑	❑	❑ ✓
Sand (0.002 – 0.08" in diam.)	❑	❑	❑	❑
Fine or Med [Pea] Gravel (0.08 – 0.6")	❑	❑	❑	❑
Coarse Gravel (0.6 – 2.5" in diam.)	❑	❑	❑	❑
Cobble (2.5 - 10" in diam.)	❑	❑	❑	❑
Rubble (10 – 20" in diam.)	❑	❑	❑	❑
Boulder (over 20" in diam.)	❑	❑	❑	❑
Bedrock (solid)	❑	❑	❑	❑

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

❑ Not embedded (0-5%) ❑ Somewhat (5-25%) ❑ Halfway (50%)
❑ Mostly embedded (75%) ❑ Completely (100%)

4. Presence of logs or large woody debris in stream

❑ None ❑ Few ❑ Many ❑ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

❑ None ❑ Occasional ❑ Plentiful

6. Water appearance:

❑ Clear ❑ Light brown ❑ Orange
❑ Milky ❑ Dark brown / tea ❑ Greenish
❑ Foamy ❑ Oily sheen ❑ Turbid
❑ Other _____

7. Water odor:

❑ Sewage ❑ Fishy ❑ None
❑ Chlorine ❑ Rotten eggs ❑ Other_____

8. Water temperature: _____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):
❑ < 1 ft ❑ 1-2 ft ❑ > 2 ft

(b) Average depth of pool(s):
❑ < 1 ft ❑ 1-2 ft ❑ > 2 ft

(c) Number of pool(s) >2 ft deep: _____

(d) Avg. distance between pools: _____ ft

10. Average width of stream channel:
_____ feet ❑ measured ❑ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:
Vertical/undercut ❑
Steeply sloping (> 30°) ❑
Gradual/no slope (< 30°) ❑

(b) Extent of artificial bank modifications:
Bank 0-25% covered ❑
Bank 25-50% covered ❑
Bank 50-75% covered ❑
Bank 75-100% covered ❑

(c) Shape of the channel:
❑ Narrow, deep ❑ Wide, deep
❑ Narrow, shallow ❑ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	❑	❑	❑
Rootwads	❑	❑	❑
Overhanging vegetation	❑	❑	❑
Small woody debris	❑	❑	❑
Boulders/rocks	❑	❑	❑
Undercut banks	❑	❑	❑
Anthropogenic (manmade) structures	❑	❑	❑
Deep water, turbulence or foam	❑	❑	❑
Lawn	❑	❑	❑
Bare soil	❑	❑	❑

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	❑	❑	❑
Bushes, shrubs	❑	❑	❑
Tall grasses, ferns, etc.	❑	❑	❑
Lawn	❑	❑	❑
Boulders/rocks	❑	❑	❑
Gravel/sand	❑	❑	❑
Bare soil	❑	❑	❑
Pavement, structures	❑	❑	❑
Agricultural land	❑	❑	❑

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

❑ 0% ❑ 25% ❑ 50% ❑ 75% ❑ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	❑	❑	❑
Banks collapsed/eroded	❑	❑	❑
Garbage/junk adjacent to the stream	❑	❑	❑
Foam or sheen on bank	❑	❑	❑

Stream	0	1	2
Mud, silt, or sand in or entering the stream	❑	❑	❑
Garbage/junk in the stream	❑	❑	❑

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	❑	❑	❑
Livestock in or with unrestricted access to stream	❑	❑	❑
Actively discharging pipe(s)	❑	❑	❑
Other pipe(s) entering the stream	❑	❑	❑
Ditches entering the stream	❑	❑	❑

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
❑	❑	❑	Single-family housing
❑	❑	❑	Multifamily housing
❑	❑	❑	Lawns
❑	❑	❑	Commercial/institutional

0	1	2	**Roads, etc.**
❑	❑	❑	Paved roads or bridges
❑	❑	❑	Unpaved roads

0	1	2	**Construction underway on:**
❑	❑	❑	Housing development
❑	❑	❑	Commercial development
❑	❑	❑	Road bridge construction/repair

0	1	2	**Agricultural**
❑	❑	❑	Grazing land
❑	❑	❑	Feeding lots or animal holding areas
❑	❑	❑	Cropland
❑	❑	❑	Inactive agricultural land/fields

0	1	2	**Recreation**
❑	❑	❑	Power boating
❑	❑	❑	Golfing
❑	❑	❑	Camping
❑	❑	❑	Swimming/fishing/canoeing
❑	❑	❑	Hiking/paths

0	1	2	**Other**
❑	❑	❑	Mining or gravel pits
❑	❑	❑	Logging / industrial forest
❑	❑	❑	Industry
❑	❑	❑	Oil and gas drilling
❑	❑	❑	Trash dump
❑	❑	❑	Landfills
❑	❑		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

❑ Amphibians ❑ Waterfowl ❑ Reptiles ❑ Mammals

❑ Other wildlife / notes: _____

18. Fish in the stream? (Mark all that apply)

❑ No ❑ Yes, but rare ❑ Yes, abundant

❑ Small (1-2 in.) ❑ Medium (3-6 in.) ❑ Large (7 in. and above)

Are there any potential barriers to fish movement?

❑ Beaver dams ❑ Waterfalls > 1' ❑ None

❑ Dams ❑ Road barriers / culverts ❑ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

❑ None ❑ Occasional ❑ Plentiful

❑ Attached ❑ Free-floating

❑ Stream margin ❑ Pools ❑ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

❑ None ❑ Occasional ❑ Plentiful

❑ Light coating ❑ Heavy coating

❑ Brownish ❑ Greenish ❑ Other _____

(b) **Are there any filamentous (string-like) algae?**

❑ None ❑ Occasional ❑ Plentiful

❑ Brownish ❑ Greenish ❑ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

❑ None ❑ Occasional ❑ Plentiful

❑ Brownish ❑ Greenish ❑ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

❑ Rock-rubbing method: From cobbles and large stones selected from riffles.

❑ Stick-picking method: From woody objects in streams with sandy, silty bottoms.

❑ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

❑ No ❑ Yes, but rare ❑ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	❑ Occasional	❑ Plentiful
Snails/clamlike	❑ Occasional	❑ Plentiful
Insects	❑ Occasional	❑ Plentiful
Crayfish	❑ Occasional	❑ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

❑ Valley / flat (0 – 2 %) ❑ Hill / medium (3 – 4 %)

❑ Ridge / high (5 – 9 %) ❑ Mountain / very high (10 – 13 %)

❑ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: 8/1/13 **Site/Reach ID:** C2 **Recorder:** TT

Location: Near Barra Road **Crew:**

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars	✓		0
	2	Coarse materials in riffles embedded	✓		0
	3	Siltation in pools	✓		0
	4	Mid-channel bars	✓		0
	5	Deposition on point bars		✓	1
	6	Poor lateral sorting of bed materials	✓		0
	7	Soft, unconsolidated bed	✓		0
	8	Evidence of deposition in / around bank structures	✓		0
	9	Deposition in the overbank zone	✓		0
		Sum of Indices:			0.11
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed	✓		0
	3	Bank height increases	✓		0
	4	Absence of depositional features (no bars)	✓		0
	5	Cut face on bar forms	✓		0
	6	Head cutting due to knick point migration	✓		0
	7	Suspended armor layer visible in bank	✓		0
		Sum of Indices:			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1
	2	Occurrence of large organic debris		✓	1
	3	Exposed tree roots		✓	1
	4	Basal scour on inside meander bends		✓	1
	5	Toe erosion on both sides of channel through riffle	✓		0
	6	Steep bank angles through most of subject reach	✓		0
	7	Length of bank scour >50% through subject reach		✓	1
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.63
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes	✓		0
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form	✓		0
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form	✓		0
	7	Bar forms poorly formed / reworked / removed	✓		0
		Sum of Indices:			0

Stability Index: 0.19

Condition: "in regime"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: C2

STREAM CORRIDOR SURVEY
Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Residential Access Point

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	29 '	20.97"	70 °	29 '	8.1 "	____	____stream
End	43 °	29 '	18.1 "	70 °	29 '	14.3 "	____	____stream

GPS Map Datum (e.g., NAD83, WGS84, etc.):

Site or Map Number (if applicable):

Date: 8/15/13 **Time:** 2:45 pm

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	C2 - 76	Looking upstream, very wide/deep	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	C2 - 69	Exposed roots	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 70	Downstream, organics	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 71	Rocky substrate, leaning trees	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 72	Riffels, rock barrier	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 74	Rock barrier	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 75	Exposed roots, Cut A	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	C2 - 69	Cut B, Cross Section	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
End of reach: facing towards survey reach	C2 - 73	Rock barrier, large pool	___ ° ___ ' ___ "	___ ° ___ ' ___ "	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

- ☑ Pool(s)
- ☑ Riffle(s)
- ☑ Run(s)
- ☐ Cascade(s)
- ☐ Rapid(s)
- ☑ Deadwater(s)
- ☐ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	≥50%
Silt/Clay/Mud (< 0.002" in diam.)	☐	☐	☐	☑
Sand (0.002 – 0.08" in diam.)	☐	☐	☐	☐
Fine or Med [Pea] Gravel (0.08 – 0.6")	☐	☐	☐	☐
Coarse Gravel (0.6 – 2.5" in diam.)	☐	☑	☐	☐
Cobble (2.5 - 10" in diam.)	☐	☑	☐	☐
Rubble (10 – 20" in diam.)	☐	☑	☐	☐
Boulder (over 20" in diam.)	☐	☑	☐	☐
Bedrock (solid)	☐	☐	☐	☐

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

- ☑ Not embedded (0-5%)
- ☐ Somewhat (5-25%)
- ☐ Halfway (50%)
- ☐ Mostly embedded (75%)
- ☐ Completely (100%)

4. Presence of logs or large woody debris in stream

- ☐ None
- ☐ Few
- ☑ Many
- ☐ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

- ☐ None
- ☐ Occasional
- ☑ Plentiful

6. Water appearance:

- ☐ Clear
- ☐ Light brown
- ☐ Orange
- ☐ Milky
- ☑ Dark brown / tea
- ☐ Greenish
- ☐ Foamy
- ☐ Oily sheen
- ☐ Turbid
- ☐ Other _____

7. Water odor:

- ☐ Sewage
- ☐ Fishy
- ☑ None
- ☐ Chlorine
- ☐ Rotten eggs
- ☐ Other_____

8. Water temperature: 22.4 °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):

- ☑ < 1 ft
- ☐ 1-2 ft
- ☐ > 2 ft

(b) Average depth of pool(s):

- ☐ < 1 ft
- ☐ 1-2 ft
- ☑ > 2 ft

(c) Number of pool(s) >2 ft deep: 1

(d) Avg. distance between pools: N/A ft

10. Average width of stream channel:
29 feet ☐ measured ☐ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:

- Vertical/undercut ☑
- Steeply sloping (> 30°) ☑
- Gradual/no slope (< 30°) ☐

(b) Extent of artificial bank modifications:

- Bank 0-25% covered ☑
- Bank 25-50% covered ☐
- Bank 50-75% covered ☐
- Bank 75-100% covered ☐

(c) Shape of the channel:

- ☐ Narrow, deep
- ☑ Wide, deep
- ☑ Narrow, shallow
- ☑ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	☐	☐	☑
Rootwads	☑	☐	☐
Overhanging vegetation	☐	☑	☐
Small woody debris	☐	☑	☐
Boulders/rocks	☐	☑	☑
Undercut banks	☐	☑	☐
Anthropogenic (manmade) structures	☐	☑	☐
Deep water, turbulence or foam	☑	☐	☐
Lawn	☑	☐	☐
Bare soil	☑	☐	☐

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	☐	☐	☑
Bushes, shrubs	☑	☐	☐
Tall grasses, ferns, etc.	☑	☐	☐
Lawn	☑	☐	☐
Boulders/rocks	☑	☐	☐
Gravel/sand	☑	☐	☐
Bare soil	☑	☐	☐
Pavement, structures	☑	☐	☐
Agricultural land	☑	☐	☐

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

☐ 0% ☐ 25% ☐ 50% ☑ 75% ☐ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	☑	☐	☐
Banks collapsed/eroded	☐	☑	☐
Garbage/junk adjacent to the stream	☐	☑	☐
Foam or sheen on bank	☑	☐	☐

Stream	0	1	2
Mud, silt, or sand in or entering the stream	☑	☐	☐
Garbage/junk in the stream	☐	☑	☐

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	☑	☐	☐
Livestock in or with unrestricted access to stream	☑	☐	☐
Actively discharging pipe(s)	☑	☐	☐
Other pipe(s) entering the stream	☑	☐	☐
Ditches entering the stream	☑	☐	☐

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
☐	☑	☐	Single-family housing
☐	☑	☐	Multifamily housing
☐	☑	☐	Lawns
☐	☑	☐	Commercial/institutional

0	1	2	**Roads, etc.**
☐	☑	☐	Paved roads or bridges
☑	☐	☐	Unpaved roads

0	1	2	**Construction underway on:**
☑	☐	☐	Housing development
☐	☑	☐	Commercial development
☑	☐	☐	Road bridge construction/repair

0	1	2	**Agricultural**
☑	☐	☐	Grazing land
☑	☐	☐	Feeding lots or animal holding areas
☑	☐	☐	Cropland
☑	☐	☐	Inactive agricultural land/fields

0	1	2	**Recreation**
☑	☐	☐	Power boating
☑	☐	☐	Golfing
☑	☐	☐	Camping
☑	☐	☐	Swimming/fishing/canoeing
☐	☑	☐	Hiking/paths

0	1	2	**Other**
☑	☐	☐	Mining or gravel pits
☑	☐	☐	Logging / industrial forest
☐	☑	☐	Industry
☑	☐	☐	Oil and gas drilling
☑	☐	☐	Trash dump
☑	☐	☐	Landfills
☐	☑		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

- ☑ Amphibians
- ☐ Waterfowl
- ☐ Reptiles
- ☐ Mammals
- ☐ Other wildlife / notes: _____

18. Fish in the stream? (Mark all that apply)

- ☐ No
- ☐ Yes, but rare
- ☑ Yes, abundant
- ☑ Small (1-2 in.)
- ☐ Medium (3-6 in.)
- ☐ Large (7 in. and above)

Are there any potential barriers to fish movement?

- ☐ Beaver dams
- ☐ Waterfalls > 1'
- ☑ None
- ☐ Dams
- ☐ Road barriers / culverts
- ☐ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

- ☐ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Attached
- ☐ Free-floating
- ☐ Stream margin
- ☑ Pools
- ☐ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Light coating
- ☐ Heavy coating
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

- ☐ Rock-rubbing method: From cobbles and large stones selected from riffles.
- ☐ Stick-picking method: From woody objects in streams with sandy, silty bottoms.
- ☐ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

- ☐ No
- ☐ Yes, but rare
- ☐ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	☐ Occasional	☐ Plentiful
Snails/clamlike	☐ Occasional	☐ Plentiful
Insects	☐ Occasional	☐ Plentiful
Crayfish	☐ Occasional	☐ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

- ☐ Valley / flat (0 – 2 %)
- ☐ Hill / medium (3 – 4 %)
- ☐ Ridge / high (5 – 9 %)
- ☐ Mountain / very high (10 – 13 %)
- ☐ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

The reach has small informal rock dams. The City will check on whether ice skating or ice harvesting was conducted in the past. A portion of the reach appears to have been straightened.

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: 8/1/13 **Site/Reach ID:** B2 **Recorder:** TT

Location: Medical Center Road **Crew:** TT, IK, JF, WG

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars	✓		0
	2	Coarse materials in riffles embedded	✓		0
	3	Siltation in pools		✓	1
	4	Mid-channel bars	✓		0
	5	Deposition on point bars	✓		0
	6	Poor lateral sorting of bed materials	✓		0
	7	Soft, unconsolidated bed		✓	1
	8	Evidence of deposition in / around bank structures		✓	1
	9	Deposition in the overbank zone		✓	1
		Sum of Indices:			0.45
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed	✓		0
	3	Bank height increases	✓		0
	4	Absence of depositional features (no bars)	✓		0
	5	Cut face on bar forms	✓		0
	6	Head cutting due to knick point migration	✓		0
	7	Suspended armor layer visible in bank	✓		0
		Sum of Indices:			0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1
	2	Occurrence of large organic debris		✓	1
	3	Exposed tree roots	✓		0
	4	Basal scour on inside meander bends		✓	1
	5	Toe erosion on both sides of channel through riffle	✓		0
	6	Steep bank angles through most of subject reach		✓	1
	7	Length of bank scour >50% through subject reach		✓	1
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.63
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes		✓	1
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form		✓	1
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form		✓	1
	7	Bar forms poorly formed / reworked / removed		✓	1
		Sum of Indices:			0.57

Stability Index: 0.41

Condition: "in adjustment"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: _____

STREAM CORRIDOR SURVEY

Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Beside Hospital

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	28 '	35.6 "	70 °	29 '	36.3 "	____	downstream
End	43 °	28 '	32.4 "	70 °	29 '	35.7 "	____	up stream

GPS Map Datum (e.g., NAD83, WGS84, etc.): _____

Site or Map Number (if applicable): _____

Date: 8/15/13 **Time:** 1:20 pm

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	B2 - 58	Various large rock structures	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	B2 - 59	Rocky substrate, accumulation of organics	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 60	Looking upstream, shallow soft substrate	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 61	Bottle Neck	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 62	Ponding	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 63	Dam	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 64	Large Pool	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 66	Cross Section A	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 67	Cross Section A	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B2 - 68	Cross Section A	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
End of reach: facing towards survey reach	B3 - 65	Cascade	___ ° ___ ' ___ "	___ ° ___ ' ___ "	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

☑ Pool(s) ☐ Riffle(s) ☑ Run(s) ☐ Cascade(s)
☐ Rapid(s) ☐ Deadwater(s) ☐ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	≥50%
Silt/Clay/Mud (< 0.002" in diam.)	☐	☐	☑	☐
Sand (0.002 – 0.08" in diam.)	☐	☐	☑	☐
Fine or Med [Pea] Gravel (0.08 – 0.6")	☐	☐	☑	☐
Coarse Gravel (0.6 – 2.5" in diam.)	☐	☐	☑	☐
Cobble (2.5 - 10" in diam.)	☐	☐	☐	☐
Rubble (10 – 20" in diam.)	☐	☐	☐	☐
Boulder (over 20" in diam.)	☐	☐	☐	☐
Bedrock (solid)	☐	☐	☐	☐

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

☐ Not embedded (0-5%) ☐ Somewhat (5-25%) ☐ Halfway (50%)
☐ Mostly embedded (75%) ☐ Completely (100%)

4. Presence of logs or large woody debris in stream

☐ None ☑ Few ☐ Many ☐ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

☐ None ☑ Occasional ☐ Plentiful

6. Water appearance:

☑ Clear ☑ Light brown ☐ Orange
☐ Milky ☐ Dark brown / tea ☐ Greenish
☐ Foamy ☐ Oily sheen ☐ Turbid
☐ Other _____

7. Water odor:

☐ Sewage ☐ Fishy ☐ None
☐ Chlorine ☐ Rotten eggs ☐ Other organics

8. Water temperature: _____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):
☑ < 1 ft ☐ 1-2 ft ☐ > 2 ft

(b) Average depth of pool(s):
☐ < 1 ft ☐ 1-2 ft ☑ > 2 ft

(c) Number of pool(s) >2 ft deep: 3

(d) Avg. distance between pools: 6 ft

10. Average width of stream channel:
13 feet ☐ measured ☐ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:
Vertical/undercut ☐
Steeply sloping (> 30°) ☐
Gradual/no slope (< 30°) ☐

(b) Extent of artificial bank modifications:
Bank 0-25% covered ☐
Bank 25-50% covered ☐
Bank 50-75% covered ☐
Bank 75-100% covered ☐

(c) Shape of the channel:
☐ Narrow, deep ☐ Wide, deep
☑ Narrow, shallow ☑ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	☑	☐	☐
Rootwads	☐	☑	☐
Overhanging vegetation	☐	☑	☐
Small woody debris	☐	☑	☐
Boulders/rocks	☐	☑	☐
Undercut banks	☐	☑	☐
Anthropogenic (manmade) structures	☑	☐	☐
Deep water, turbulence or foam	☑	☐	☐
Lawn	☑	☐	☐
Bare soil	☐	☐	☐

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	❑	❑	✓
Bushes, shrubs	❑	✓	❑
Tall grasses, ferns, etc.	✓	❑	❑
Lawn	✓	✓	❑
Boulders/rocks	❑	✓	❑
Gravel/sand	✓	❑	❑
Bare soil	✓	❑	❑
Pavement, structures	✓	❑	❑
Agricultural land	✓	❑	❑

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

❑ 0% ❑ 25% ❑ 50% ✓ 75% ❑ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	✓	❑	❑
Banks collapsed/eroded	✓	✓	❑
Garbage/junk adjacent to the stream	✓	❑	❑
Foam or sheen on bank	✓	❑	❑

Stream	0	1	2
Mud, silt, or sand in or entering the stream	✓	❑	❑
Garbage/junk in the stream	❑	✓	❑

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	✓	❑	❑
Livestock in or with unrestricted access to stream	✓	❑	❑
Actively discharging pipe(s)	✓	❑	❑
Other pipe(s) entering the stream	✓	❑	❑
Ditches entering the stream	✓	❑	❑

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
✓	❑	❑	Single-family housing
✓	❑	❑	Multifamily housing
✓	✓	❑	Lawns
❑	✓	❑	Commercial/institutional

0	1	2	**Roads, etc.**
❑	✓	❑	Paved roads or bridges
❑	❑	❑	Unpaved roads

0	1	2	**Construction underway on:**
✓	❑	❑	Housing development
✓	❑	❑	Commercial development
✓	❑	❑	Road bridge construction/repair

0	1	2	**Agricultural**
✓	❑	❑	Grazing land
✓	❑	❑	Feeding lots or animal holding areas
✓	❑	❑	Cropland
✓	❑	❑	Inactive agricultural land/fields

0	1	2	**Recreation**
✓	❑	❑	Power boating
✓	❑	❑	Golfing
✓	❑	❑	Camping
✓	❑	❑	Swimming/fishing/canoeing
✓	❑	❑	Hiking/paths

0	1	2	**Other**
✓	❑	❑	Mining or gravel pits
✓	❑	❑	Logging / industrial forest
✓	❑	❑	Industry
✓	❑	❑	Oil and gas drilling
✓	❑	❑	Trash dump
✓	✓	❑	Landfills
❑	❑		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

- ❑ Amphibians ❑ Waterfowl ❑ Reptiles ❑ Mammals
- ❑ Other wildlife / notes: freshwater clam

18. Fish in the stream? (Mark all that apply)

- ❑ No ❑ Yes, but rare ❑ Yes, abundant
- ❑ Small (1-2 in.) ❑ Medium (3-6 in.) ❑ Large (7 in. and above)

Are there any potential barriers to fish movement?

- ❑ Beaver dams ❑ Waterfalls > 1' ❑ None
- ❑ Dams ❑ Road barriers / culverts ❑ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

- ❑ None ❑ Occasional ❑ Plentiful
- ❑ Attached ❑ Free-floating
- ❑ Stream margin ❑ Pools ❑ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Light coating ❑ Heavy coating
- ❑ Brownish ❑ Greenish ❑ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Brownish ❑ Greenish ❑ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Brownish ❑ Greenish ❑ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

- ❑ Rock-rubbing method: From cobbles and large stones selected from riffles.
- ❑ Stick-picking method: From woody objects in streams with sandy, silty bottoms.
- ❑ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

- ❑ No ❑ Yes, but rare ❑ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	❑ Occasional	❑ Plentiful
Snails/clamlike	❑ Occasional	❑ Plentiful
Insects	❑ Occasional	❑ Plentiful
Crayfish	✓ Occasional	❑ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

- ❑ Valley / flat (0 – 2 %) ❑ Hill / medium (3 – 4 %)
- ❑ Ridge / high (5 – 9 %) ❑ Mountain / very high (10 – 13 %)
- ❑ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: **Site/Reach ID:** B1 **Recorder:**

Location: Sterling Rope Factory **Crew:**

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars		✓	0
	2	Coarse materials in riffles embedded	✓		0
	3	Siltation in pools	✓		0
	4	Mid-channel bars	✓		0
	5	Deposition on point bars	✓		0
	6	Poor lateral sorting of bed materials	✓		0
	7	Soft, unconsolidated bed	✓		0
	8	Evidence of deposition in / around bank structures	✓		8
	9	Deposition in the overbank zone		✓	1
		Sum of Indices:			0.22
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed		✓	1
	3	Bank height increases		✓	1
	4	Absence of depositional features (no bars)		✓	1
	5	Cut face on bar forms	✓		0
	6	Head cutting due to knick point migration	✓		0
	7	Suspended armor layer visible in bank	✓		0
		Sum of Indices:			0.43
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1
	2	Occurrence of large organic debris	✓		0
	3	Exposed tree roots		✓	1
	4	Basal scour on inside meander bends		✓	0
	5	Toe erosion on both sides of channel through riffle	✓		0
	6	Steep bank angles through most of subject reach	✓		0
	7	Length of bank scour >50% through subject reach	✓		0
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.38
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes		✓	1
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form	✓		0
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form	✓		0
	7	Bar forms poorly formed / reworked / removed	✓		0
		Sum of Indices:			0.14

Stability Index: 0.29

Condition: "in transition or stressed"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: B1

STREAM CORRIDOR SURVEY

Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Behind rope factory

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	27 '	50.2 "	70 °	29 '	40.1 "		down stream
End	43 °	27 '	46.9 "	70 °	29 '	39.97 "		up stream

GPS Map Datum (e.g., NAD83, WGS84, etc.):

Site or Map Number (if applicable):

Date: 8/15/13 **Time:** 12:15 pm

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	B1 - 32	Double box culvert (3.5' x 5')	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	B1 - 35	Outfall, erosion, iron	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 36	Outfall, erosion, iron	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 37	Upstream, some undercuts	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 38	Upstream, some undercuts	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 39	Exposed roots, iron deposit	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 41	Deposition caused by erosion	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 42	Upstream minor pollution, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 43	Ditch line, eroded	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 44	Outfall, Iron, eroded	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 45	Ditch line, erosion	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 46	Overflow	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 54	Bank Cut	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 49	Organic Obstruction	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	B1 - 33	Cascade, small ponds	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 34	Upstream, cascade	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 40	Upstream riffles	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 47	Defined channel	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	B1 - 56	Riffles in stream	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
End of reach: facing towards survey reach	B1 - 57	Some riffles, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

- ☐ Pool(s) ☑ Riffle(s) ☑ Run(s) ☑ Cascade(s)
- ☐ Rapid(s) ☐ Deadwater(s) ☐ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	≥50%
Silt/Clay/Mud (< 0.002" in diam.)	☐	☐	☐	☑
Sand (0.002 – 0.08" in diam.)	☐	☐	☐	☐
Fine or Med [Pea] Gravel (0.08 – 0.6")	☐	☐	☑	☐
Coarse Gravel (0.6 – 2.5" in diam.)	☐	☐	☑	☐
Cobble (2.5 - 10" in diam.)	☐	☐	☑	☐
Rubble (10 – 20" in diam.)	☐	☑	☐	☐
Boulder (over 20" in diam.)	☐	☑	☐	☐
Bedrock (solid)	☐	☑	☐	☐

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

- ☑ Not embedded (0-5%) ☐ Somewhat (5-25%) ☐ Halfway (50%)
- ☐ Mostly embedded (75%) ☐ Completely (100%)

4. Presence of logs or large woody debris in stream

- ☐ None ☑ Few ☐ Many ☐ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

- ☐ None ☑ Occasional ☐ Plentiful

6. Water appearance:

- ☐ Clear ☑ Light brown ☐ Orange
- ☐ Milky ☐ Dark brown / tea ☐ Greenish
- ☐ Foamy ☐ Oily sheen ☐ Turbid
- ☐ Other _____

7. Water odor:

- ☐ Sewage ☐ Fishy ☑ None
- ☐ Chlorine ☐ Rotten eggs ☐ Other_____

8. Water temperature: _____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):
☑ < 1 ft ☐ 1-2 ft ☐ > 2 ft

(b) Average depth of pool(s):
☐ < 1 ft ☑ 1-2 ft ☐ > 2 ft

(c) Number of pool(s) >2 ft deep: 1

(d) Avg. distance between pools: N/A ft

10. Average width of stream channel:
_____ feet ☐ measured ☐ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:

- Vertical/undercut ☐
- Steeply sloping (> 30°) ☑
- Gradual/no slope (< 30°) ☐

(b) Extent of artificial bank modifications:

- Bank 0-25% covered ☐
- Bank 25-50% covered ☐
- Bank 50-75% covered ☐
- Bank 75-100% covered ☐

(c) Shape of the channel:

- ☐ Narrow, deep ☐ Wide, deep
- ☐ Narrow, shallow ☐ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	☐	☑	☐
Rootwads	☑	☐	☐
Overhanging vegetation	☐	☑	☐
Small woody debris	☐	☑	☐
Boulders/rocks	☐	☑	☐
Undercut banks	☐	☑	☐
Anthropogenic (manmade) structures	☑	☐	☐
Deep water, turbulence or foam	☑	☐	☐
Lawn	☑	☐	☐
Bare soil	☐	☐	☐

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	❑	❑	✓
Bushes, shrubs	✓	❑	❑
Tall grasses, ferns, etc.	✓	❑	❑
Lawn	❑	❑	✓
Boulders/rocks	✓	❑	❑
Gravel/sand	✓	❑	❑
Bare soil	❑	❑	✓
Pavement, structures	✓	❑	❑
Agricultural land	❑	❑	❑

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

❑ 0% ❑ 25% ❑ 50% ❑ 75% ✓ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	✓	❑	❑
Banks collapsed/eroded	✓	❑	❑
Garbage/junk adjacent to the stream	❑	✓	❑
Foam or sheen on bank	✓	❑	❑

Stream	0	1	2
Mud, silt, or sand in or entering the stream	❑	✓	❑
Garbage/junk in the stream	✓	❑	❑

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	✓	❑	❑
Livestock in or with unrestricted access to stream	✓	❑	❑
Actively discharging pipe(s)	❑	❑	✓
Other pipe(s) entering the stream	❑	✓	❑
Ditches entering the stream	✓	❑	❑

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
✓	❑	❑	Single-family housing
✓	❑	❑	Multifamily housing
✓	❑	❑	Lawns
❑	❑	✓	Commercial/institutional

0	1	2	**Roads, etc.**
❑	✓	❑	Paved roads or bridges
❑	❑	✓	Unpaved roads

0	1	2	**Construction underway on:**
✓	❑	❑	Housing development
✓	❑	❑	Commercial development
✓	❑	❑	Road bridge construction/repair

0	1	2	**Agricultural**
✓	❑	❑	Grazing land
✓	❑	❑	Feeding lots or animal holding areas
✓	❑	❑	Cropland
✓	❑	❑	Inactive agricultural land/fields

0	1	2	**Recreation**
✓	❑	❑	Power boating
✓	❑	❑	Golfing
✓	❑	❑	Camping
✓	❑	❑	Swimming/fishing/canoeing
✓	❑	❑	Hiking/paths

0	1	2	**Other**
✓	❑	❑	Mining or gravel pits
✓	❑	❑	Logging / industrial forest
✓	❑	✓	Industry
✓	❑	❑	Oil and gas drilling
✓	❑	❑	Trash dump
✓	❑	❑	Landfills
✓	❑		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

- ☑ Amphibians
- ☐ Waterfowl
- ☐ Reptiles
- ☐ Mammals
- ☐ Other wildlife / notes: Green frogs observed

18. Fish in the stream? (Mark all that apply)

- ☐ No
- ☐ Yes, but rare
- ☐ Yes, abundant
- ☐ Small (1-2 in.)
- ☐ Medium (3-6 in.)
- ☐ Large (7 in. and above)

Are there any potential barriers to fish movement?

- ☐ Beaver dams
- ☐ Waterfalls > 1'
- ☐ None
- ☐ Dams
- ☑ Road barriers / culverts
- ☐ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Attached
- ☐ Free-floating
- ☐ Stream margin
- ☐ Pools
- ☐ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

- ☐ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Light coating
- ☐ Heavy coating
- ☑ Brownish
- ☐ Greenish
- ☐ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

- ☐ Rock-rubbing method: From cobbles and large stones selected from riffles.
- ☐ Stick-picking method: From woody objects in streams with sandy, silty bottoms.
- ☐ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

- ☐ No
- ☐ Yes, but rare
- ☐ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	☐ Occasional	☐ Plentiful
Snails/clamlike	☐ Occasional	☐ Plentiful
Insects	☐ Occasional	☐ Plentiful
Crayfish	☐ Occasional	☐ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

- ☐ Valley / flat (0 – 2 %)
- ☐ Hill / medium (3 – 4 %)
- ☐ Ridge / high (5 – 9 %)
- ☐ Mountain / very high (10 – 13 %)
- ☐ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

The site is burdened by the Sterling Rope Factory and a railroad bed. Both of these land uses are located within 25 meters of the stream. Two pipes are discharging to the stream from the direction of the factory. Garbage is present. The stream channel itself has a diversity of habitats (riffle, run) and has natural birds in the downstream area. The upstream area has been straightened adjacent to the existing railroad bed.

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: 7/3/13 **Site/Reach ID:** A3 **Recorder:** TT

Location: Kohls **Crew:** TT, IK, JF, WG

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars		✓	1
	2	Coarse materials in riffles embedded		✓	1
	3	Siltation in pools	✓		0
	4	Mid-channel bars	✓		0
	5	Deposition on point bars		✓	1
	6	Poor lateral sorting of bed materials		✓	1
	7	Soft, unconsolidated bed		✓	1
	8	Evidence of deposition in / around bank structures	✓		0
	9	Deposition in the overbank zone	✓		0
		Sum of Indices:			0.56
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed		✓	1
	3	Bank height increases	✓		0
	4	Absence of depositional features (no bars)	✓		0
	5	Cut face on bar forms		✓	1
	6	Head cutting due to knick point migration		✓	1
	7	Suspended armor layer visible in bank		✓	1
		Sum of Indices:			0.57
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	1
	2	Occurrence of large organic debris		✓	1
	3	Exposed tree roots		✓	1
	4	Basal scour on inside meander bends		✓	1
	5	Toe erosion on both sides of channel through riffle		✓	1
	6	Steep bank angles through most of subject reach		✓	1
	7	Length of bank scour >50% through subject reach		✓	1
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.88
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes	✓		0
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form		✓	1
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form	✓		0
	7	Bar forms poorly formed / reworked / removed	✓		0
		Sum of Indices:			0.14

Stability Index: 0.54

Condition: "in adjustment"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: A3

STREAM CORRIDOR SURVEY
Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Behind Kohls, intersects I-95

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	28 '	46 "	70 °	30 '	9.5 "		0 stream
End	43 °	28 '	42.3 "	70 °	30 '	2.8 "		0 stream

GPS Map Datum (e.g., NAD83, WGS84, etc.):

Site or Map Number (if applicable):

Date: 8/15/13 **Time:** 9:27 am

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	A3 - 01	View of upstream from starting location	43 ° 28 ' 46 "	70 ° 30 ' 9.5 "	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	A3 - 02	Small ditch line entering reach at street	° ' "	° ' "	
	A3 - 03	View downstream from start - organic pile up	° ' "	° ' "	
	A3 - 04	Upstream from start, constructed channel	° ' "	° ' "	
	A3 - 05	One shallow side, some fallen trees in stream	° ' "	° ' "	
	A3 - 06	Signs of erosion, exposed root	° ' "	° ' "	
	A3 - 07	Continuing upstream, log across water	° ' "	° ' "	
	A3 - 08	Continuing upstream taking notice of erosion	° ' "	° ' "	
	A3 - 09	Close up on erosion	° ' "	° ' "	
	A3 - 10	Raised bed of gravel, opposite side of A3-09	° ' "	° ' "	
	A3 - 14	First bank of cross section	° ' "	° ' "	
	A3 - 15	Second bank of cross section - exposed rock	° ' "	° ' "	
	A3 - 19	Mud bar	° ' "	° ' "	
	A3 - 21	Hard clay substrate	° ' "	° ' "	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	A3 - 11	Bride culvert lined with rip-rap protection	° ' "	° ' "	
	A3 - 12	Good habitat, vegetation and deep water, wildlife	° ' "	° ' "	
	A3 - 16	Aquatic vegetation	° ' "	° ' "	
	A3 - 17	Aquatic vegetation	° ' "	° ' "	
	A3 - 18	Aquatic vegetation	° ' "	° ' "	
End of reach: facing towards survey reach	A3 - 13	Stream channel becoming less defined	° ' "	° ' "	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

- ☐ Pool(s) ☐ Riffle(s) ☑ Run(s) ☐ Cascade(s)
- ☐ Rapid(s) ☐ Deadwater(s) ☐ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	>50%
Silt/Clay/Mud (< 0.002" in diam.)	☐	☐	☐	☑
Sand (0.002 – 0.08" in diam.)	☐	☑	☐	☐
Fine or Med [Pea] Gravel (0.08 – 0.6")	☐	☑	☐	☐
Coarse Gravel (0.6 – 2.5" in diam.)	☐	☑	☐	☐
Cobble (2.5 - 10" in diam.)	☐	☑	☐	☐
Rubble (10 – 20" in diam.)	☑	☐	☐	☐
Boulder (over 20" in diam.)	☑	☐	☐	☐
Bedrock (solid)	☑	☐	☐	☐

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

- ☑ Not embedded (0-5%) ☐ Somewhat (5-25%) ☐ Halfway (50%)
- ☐ Mostly embedded (75%) ☐ Completely (100%)

4. Presence of logs or large woody debris in stream

- ☐ None ☐ Few ☑ Many ☐ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

- ☐ None ☑ Occasional ☐ Plentiful

6. Water appearance:

- ☐ Clear ☑ Light brown ☐ Orange
- ☐ Milky ☐ Dark brown / tea ☐ Greenish
- ☐ Foamy ☐ Oily sheen ☐ Turbid
- ☐ Other Turns "mucky" after walking through

7. Water odor:

- ☐ Sewage ☐ Fishy ☑ None
- ☐ Chlorine ☐ Rotten eggs ☐ Other_____

8. Water temperature: _____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):
☐ < 1 ft ☐ 1-2 ft ☐ > 2 ft

(b) Average depth of pool(s):
☐ < 1 ft ☐ 1-2 ft ☐ > 2 ft

(c) Number of pool(s) >2 ft deep: _____

(d) Avg. distance between pools: _____ ft

10. Average width of stream channel:
_____ feet ☐ measured ☐ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:
- Vertical/undercut ☐
- Steeply sloping (> 30°) ☐
- Gradual/no slope (< 30°) ☐

(b) Extent of artificial bank modifications:
- Bank 0-25% covered ☐
- Bank 25-50% covered ☐
- Bank 50-75% covered ☐
- Bank 75-100% covered ☐

(c) Shape of the channel:
- ☐ Narrow, deep ☐ Wide, deep
- ☐ Narrow, shallow ☐ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	☐	☑	☐
Rootwads	☐	☑	☐
Overhanging vegetation	☑	☐	☐
Small woody debris	☑	☐	☐
Boulders/rocks	☐	☐	☑
Undercut banks	☐	☑	☐
Anthropogenic (manmade) structures	☑	☐	☐
Deep water, turbulence or foam	☑	☐	☐
Lawn	☑	☐	☐
Bare soil	☑	☐	☐

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	✓	☐	☐
Bushes, shrubs	☐	☐	☐
Tall grasses, ferns, etc.	☐	✓	☐
Lawn	✓	☐	☐
Boulders/rocks	✓	☐	☐
Gravel/sand	✓	☐	☐
Bare soil	☐	☐	☐
Pavement, structures	☐	✓	☐
Agricultural land	✓	☐	☐

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

☐ 0% ☐ 25% ✓ 50% ☐ 75% ☐ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	☐	☐	✓
Banks collapsed/eroded	✓	☐	☐
Garbage/junk adjacent to the stream	✓	☐	☐
Foam or sheen on bank	☐	☐	☐

Stream	0	1	2
Mud, silt, or sand in or entering the stream	✓	☐	☐
Garbage/junk in the stream	✓	☐	☐

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	✓	☐	☐
Livestock in or with unrestricted access to stream	✓	☐	☐
Actively discharging pipe(s)	✓	☐	☐
Other pipe(s) entering the stream	✓	☐	☐
Ditches entering the stream	☐	☐	☐

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
✓	☐	☐	Single-family housing
✓	☐	☐	Multifamily housing
✓	☐	☐	Lawns
☐	✓	☐	Commercial/institutional

0	1	2	**Roads, etc.**
☐	✓	☐	Paved roads or bridges
✓	☐	☐	Unpaved roads

0	1	2	**Construction underway on:**
✓	☐	☐	Housing development
☐	✓	☐	Commercial development
✓	☐	☐	Road bridge construction/repair

0	1	2	**Agricultural**
✓	☐	☐	Grazing land
✓	☐	☐	Feeding lots or animal holding areas
✓	☐	☐	Cropland
✓	☐	☐	Inactive agricultural land/fields

0	1	2	**Recreation**
✓	☐	☐	Power boating
✓	☐	☐	Golfing
✓	☐	☐	Camping
✓	☐	☐	Swimming/fishing/canoeing
✓	☐	☐	Hiking/paths

0	1	2	**Other**
✓	☐	☐	Mining or gravel pits
✓	☐	☐	Logging / industrial forest
✓	☐	☐	Industry
✓	☐	☐	Oil and gas drilling
✓	☐	☐	Trash dump
☐	☐	✓	Landfills
☐	✓		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

- ☑ Amphibians
- ☐ Waterfowl
- ☐ Reptiles
- ☑ Mammals
- ☐ Other wildlife / notes: _____

18. Fish in the stream? (Mark all that apply)

- ☐ No
- ☐ Yes, but rare
- ☐ Yes, abundant
- ☐ Small (1-2 in.)
- ☑ Medium (3-6 in.)
- ☐ Large (7 in. and above)

Are there any potential barriers to fish movement?

- ☐ Beaver dams
- ☐ Waterfalls > 1'
- ☑ None
- ☐ Dams
- ☐ Road barriers / culverts
- ☐ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

- ☐ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Attached
- ☐ Free-floating
- ☑ Stream margin
- ☐ Pools
- ☐ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

- ☐ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Light coating
- ☐ Heavy coating
- ☑ Brownish
- ☑ Greenish
- ☐ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ☑ None
- ☐ Occasional
- ☐ Plentiful
- ☐ Brownish
- ☐ Greenish
- ☐ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

- ☐ Rock-rubbing method: From cobbles and large stones selected from riffles.
- ☐ Stick-picking method: From woody objects in streams with sandy, silty bottoms.
- ☐ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

- ☐ No
- ☐ Yes, but rare
- ☐ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	☐ Occasional	☐ Plentiful
Snails/clamlike	☐ Occasional	☐ Plentiful
Insects	☐ Occasional	☐ Plentiful
Crayfish	☐ Occasional	☐ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

- ☐ Valley / flat (0 – 2 %)
- ☐ Hill / medium (3 – 4 %)
- ☐ Ridge / high (5 – 9 %)
- ☐ Mountain / very high (10 – 13 %)
- ☐ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

Rapid Geomorphic Assessment (RGA)

(Part of the Stream Corridor Survey [Level 1])

Date: 8/1/13 **Site/Reach ID:** A2 **Recorder:** TT

Location: Easy St. **Crew:** TT, IK, JF, WG

Form / Process	Geomorphic Indicator		Present		Score
	Num	Description	No	Yes	
Evidence of Aggradation (AI)	1	Lateral bars	✓		0
	2	Coarse materials in riffles embedded	✓		0
	3	Siltation in pools	✓		0
	4	Mid-channel bars	✓		0
	5	Deposition on point bars	✓		0
	6	Poor lateral sorting of bed materials	✓		0
	7	Soft, unconsolidated bed		✓	1
	8	Evidence of deposition in / around bank structures	✓		0
	9	Deposition in the overbank zone		✓	1
		Sum of Indices:			0.22
Evidence of Degradation (DI)	1	Channel incision into undisturbed overburden / bedrock	✓		0
	2	Elevated tree roots / root fan above channel bed	✓		0
	3	Bank height increases		✓	1
	4	Absence of depositional features (no bars)		✓	1
	5	Cut face on bar forms	✓		0
	6	Head cutting due to knick point migration	✓		0
	7	Suspended armor layer visible in bank	✓		0
		Sum of Indices:			0.29
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		0
	2	Occurrence of large organic debris		✓	1
	3	Exposed tree roots	✓		0
	4	Basal scour on inside meander bends	✓		0
	5	Toe erosion on both sides of channel through riffle	✓		0
	6	Steep bank angles through most of subject reach	✓		0
	7	Length of bank scour >50% through subject reach	✓		0
	8	Fracture lines along top of bank	✓		0
		Sum of Indices:			0.13
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chutes	✓		0
	2	Single thread to multiple channel	✓		0
	3	Evolution of pool-riffle form to low bed relief form	✓		0
	4	Cut-off channel(s)	✓		0
	5	Formation of island(s)	✓		0
	6	Thalweg alignment out of phase meander form	✓		0
	7	Bar forms poorly formed / reworked / removed	✓		0
		Sum of Indices:			0

Stability Index: 0.16

Condition: "in regime"

APPENDIX J-2b: Datasheets Longitude/Latitude

Reach ID: A2

STREAM CORRIDOR SURVEY
Level 1

Stream Name: Thatcher Brook

County: York **Town:** Biddeford

Investigators: TLT, JF, WG, IK

Site (description): Easy St.

GPS Location	Latitude (ex: 70° 16' 49.3")			Longitude (ex: 70° 23' 32.7")			Error (ex. 16')	Position in Reach: (Upstream or Downstream)
	Degree	Min	Sec	Deg	Min	Sec	Ft	
Start	43 °	28 '	12.2 "	70 °	30 '	15.1 "		up stream
End	43 °	28 '	13.5 "	70 °	30 '	17.7 "		down stream

GPS Map Datum (e.g., NAD83, WGS84, etc.):

Site or Map Number (if applicable):

Date: 8/15/13 **Time:** 11:15 am

Weather in past 24 hours:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Weather now:

- ☐ Storm (heavy rain)
- ☐ Rain (steady rain)
- ☐ Showers (intermittent rain)
- ☐ Overcast
- ☑ Clear/ Partly Sunny

Data sheets last revised: July 2007
LATITUDE/LONGITUDE VERSION

Photograph Log:

Take pictures of key features within your survey reach. Include the photo flip chart (with "Reach ID – Photo#) in each picture, if you have one. These photos are often very helpful in interpreting information, as well as accurate site referencing. Continue to log pictures in the "Comments" section of these datasheets if additional space is needed.

Suggested photos	Photo # (Reach ID—Photo#)	Description	GPS Latitude	GPS Longitude	Error (ft)
Start of reach: Facing direction of survey reach	A2 - 18	Low flow velocity, starts at bridge	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Problems / Land Uses: Pollution, erosion, sedimentation, riparian buffers or culverts in poor condition, dams, trail crossings, livestock in stream, etc.	A2 - 17	Ditch line, full of iron and oil sheen - thick	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 19	Moving downstream, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 20	Moving downstream, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 21	Moving downstream, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 23	Streamline ditch	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 24	Moving downstream, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 25	Cross section view	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 26	Cross section view	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 30	Moving downstream, low flow velocity	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 32	Substrate/woody	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 33	Abundant crawfish population	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	___ - ___		___ ° ___ ' ___ "	___ ° ___ ' ___ "	
Good things: Healthy buffers, wildlife, cold water seeps/springs, good habitat, etc.	A2 - 16	Bridge - great condition	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 22	Large boulder	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 27	More defined channel, riffles in stream	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 28	Moving downstream, riffles in stream	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
	A2 - 29	Moving downstream, riffles in stream	___ ° ___ ' ___ "	___ ° ___ ' ___ "	
End of reach: facing towards survey reach	A2 - 31	Open area	___ ° ___ ' ___ "	___ ° ___ ' ___ "	

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present:
(You can check more than 1 habitat)

❑ Pool(s) ❑ Riffle(s) ❑ Run(s) ❑ Cascade(s)
❑ Rapid(s) ❑ Deadwater(s) ❑ Other _____

2. Nature of particles in the stream bottom at site

	0%	1-10%	11-49%	>50%
Silt/Clay/Mud (< 0.002" in diam.)	❑	❑	❑	☑
Sand (0.002 – 0.08" in diam.)	☑	❑	❑	❑
Fine or Med [Pea] Gravel (0.08 – 0.6")	☑	❑	❑	❑
Coarse Gravel (0.6 – 2.5" in diam.)	☑	❑	❑	❑
Cobble (2.5 - 10" in diam.)	☑	❑	❑	❑
Rubble (10 – 20" in diam.)	☑	❑	❑	❑
Boulder (over 20" in diam.)	☑	❑	❑	❑
Bedrock (solid)	☑	❑	❑	❑

3. Pick the category that best describes the extent to which gravel, cobbles, rubble, and boulders on the stream bottom are embedded (covered by) in sand, silt, or mud. (Check "not embedded" if stream bottom is all bedrock, sand, or silt [i.e., it lacks any gravel, cobbles, rubble, or boulders].)

☑ Not embedded (0-5%) ❑ Somewhat (5-25%) ❑ Halfway (50%)
❑ Mostly embedded (75%) ❑ Completely (100%)

4. Presence of logs or large woody debris in stream

❑ None ☑ Few ❑ Many ❑ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream:

❑ None ❑ Occasional ☑ Plentiful

6. Water appearance:

☑ Clear ☑ Light brown ❑ Orange
❑ Milky ❑ Dark brown / tea ❑ Greenish
❑ Foamy ❑ Oily sheen ❑ Turbid
❑ Other _____

7. Water odor:

❑ Sewage ❑ Fishy ☑ None
❑ Chlorine ❑ Rotten eggs ❑ Other_____

8. Water temperature: _____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Average depth of run(s):
❑ < 1 ft ❑ 1-2 ft ❑ > 2 ft

(b) Average depth of pool(s):
❑ < 1 ft ❑ 1-2 ft ❑ > 2 ft

(c) Number of pool(s) >2 ft deep: _____

(d) Avg. distance between pools: _____ ft

10. Average width of stream channel:
_____ feet ❑ measured ❑ estimated

11. Stream velocity: _____ ft/sec. (optional)

12. Pick the description that best fits the shape of the stream banks and the channel.

(a) Stream bank:
Vertical/undercut ❑
Steeply sloping (> 30°) ❑
Gradual/no slope (< 30°) ☑

(b) Extent of artificial bank modifications:
Bank 0-25% covered ☑
Bank 25-50% covered ❑
Bank 50-75% covered ❑
Bank 75-100% covered ❑

(c) Shape of the channel:
❑ Narrow, deep ❑ Wide, deep
☑ Narrow, shallow ❑ Wide, shallow

13. Describe the streamside cover. Check "0" if absent, "1" if present, "2" if common

(a) Along water's edge and stream bank only:

	0	1	2
Logs, large woody debris	❑	☑	❑
Rootwads	❑	☑	❑
Overhanging vegetation	❑	❑	☑
Small woody debris	☑	❑	☑
Boulders/rocks	☑	❑	❑
Undercut banks	❑	❑	❑
Anthropogenic (manmade) structures	☑	☑	❑
Deep water, turbulence or foam	☑	☑	❑
Lawn	☑	☑	❑
Bare soil	☑	❑	❑

(b) From the top of the streambanks out to 25 yards.

	0	1	2
Trees, woodland	❑	❑	✓
Bushes, shrubs	❑	❑	✓
Tall grasses, ferns, etc.	❑	❑	❑
Lawn	❑	❑	❑
Boulders/rocks	❑	❑	❑
Gravel/sand	❑	❑	❑
Bare soil	❑	❑	❑
Pavement, structures	❑	❑	❑
Agricultural land	❑	❑	❑

14. Pick the category that best describes the extent to which vegetation shades the stream at your site.

❑ 0% ❑ 25% ❑ 50% ✓ 75% ❑ 100%

15. Note general conditions. Check "0" if absent, "1" if present, "2" if problem is clearly severe.

Stream Banks	0	1	2
Natural streamside plant cover degraded	✓	❑	❑
Banks collapsed/eroded	✓	❑	❑
Garbage/junk adjacent to the stream	❑	✓	❑
Foam or sheen on bank	✓	❑	❑

Stream	0	1	2
Mud, silt, or sand in or entering the stream	✓	❑	❑
Garbage/junk in the stream	❑	✓	❑

Other	0	1	2
Yard waste on bank (grass, clippings, etc.)	✓	❑	❑
Livestock in or with unrestricted access to stream	✓	❑	❑
Actively discharging pipe(s)	✓	❑	❑
Other pipe(s) entering the stream	✓	❑	❑
Ditches entering the stream	❑	✓	❑

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "0" if absent, "1" if present, "2" if clearly having an impact on the stream.

0	1	2	**Residential**
❑	✓	❑	Single-family housing
❑	❑	❑	Multifamily housing
❑	✓	❑	Lawns
❑	❑	❑	Commercial/institutional

0	1	2	**Roads, etc.**
❑	✓	❑	Paved roads or bridges
❑	✓	❑	Unpaved roads

0	1	2	**Construction underway on:**
✓	❑	❑	Housing development
✓	❑	❑	Commercial development
✓	❑	❑	Road bridge construction/repair

0	1	2	**Agricultural**
✓	❑	❑	Grazing land
✓	❑	❑	Feeding lots or animal holding areas
✓	❑	❑	Cropland
✓	❑	❑	Inactive agricultural land/fields

0	1	2	**Recreation**
✓	❑	❑	Power boating
✓	❑	❑	Golfing
✓	❑	❑	Camping
✓	❑	❑	Swimming/fishing/canoeing
✓	❑	❑	Hiking/paths

0	1	2	**Other**
✓	❑	❑	Mining or gravel pits
✓	❑	❑	Logging / industrial forest
✓	❑	❑	Industry
✓	❑	❑	Oil and gas drilling
✓	❑	❑	Trash dump
✓	❑	❑	Landfills
✓	❑		Natural woodland (natural woodlands usually don't have an impact on streams)

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? (Mark all that apply)

- ❑ Amphibians ❑ Waterfowl ❑ Reptiles ❑ Mammals
- ❑ Other wildlife / notes: _____

18. Fish in the stream? (Mark all that apply)

- ❑ No ❑ Yes, but rare ❑ Yes, abundant
- ❑ Small (1-2 in.) ❑ Medium (3-6 in.) ❑ Large (7 in. and above)

Are there any potential barriers to fish movement?

- ❑ Beaver dams ❑ Waterfalls > 1' ❑ None
- ❑ Dams ❑ Road barriers / culverts ❑ Other _____

19. Aquatic plants in the stream. (Mark all that apply)

- ❑ None ❑ Occasional ❑ Plentiful
- ❑ Attached ❑ Free-floating
- ❑ Stream margin ❑ Pools ❑ Near riffle

20. Extent of algae in the stream. (Mark all that apply)

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Light coating ❑ Heavy coating
- ❑ Brownish ❑ Greenish ❑ Other _____

(b) **Are there any filamentous (string-like) algae?**

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Brownish ❑ Greenish ❑ Other _____

(c) **Are any detached "clumps" or "mats" of algae floating on the water's surface?**

- ✓ None ❑ Occasional ❑ Plentiful
- ❑ Brownish ❑ Greenish ❑ Other _____

MACROINVERTEBRATE SURVEY

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected?

- ❑ Rock-rubbing method: From cobbles and large stones selected from riffles.
- ❑ Stick-picking method: From woody objects in streams with sandy, silty bottoms.
- ❑ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present?

- ❑ No ❑ Yes, but rare ❑ Yes, abundant

23. If present, describe the types of macroinvertebrates found.

(Mark all that apply)

Wormlike	❑ Occasional	❑ Plentiful
Snails/clamlike	❑ Occasional	❑ Plentiful
Insects	❑ Occasional	❑ Plentiful
Crayfish	❑ Occasional	❑ Plentiful

Notes:

24. What is the approximate slope of your stream reach?

- ❑ Valley / flat (0 – 2 %) ❑ Hill / medium (3 – 4 %)
- ❑ Ridge / high (5 – 9 %) ❑ Mountain / very high (10 – 13 %)
- ❑ Waterfall / very steep (> 14 %) [don't work in these reaches]

COMMENTS: *(Note changes or potential problems such as spills, construction, type of discharging pipes)*

Site has a ditch with evidence of iron oxides. Water quality measurements were taken. Site has a dense scrub-shrub layer. Almost no flow, very murky.

Map/Sketch of Site

Please attach USGS 7.5" topo map of your site (photocopy is OK).
Please note the start and stop points of your stream habitat survey and any features you encountered that require further illustration or clarification.
Also, please draw a sketch of your reach, and any important features, in the space provided below.

APPENDIX B

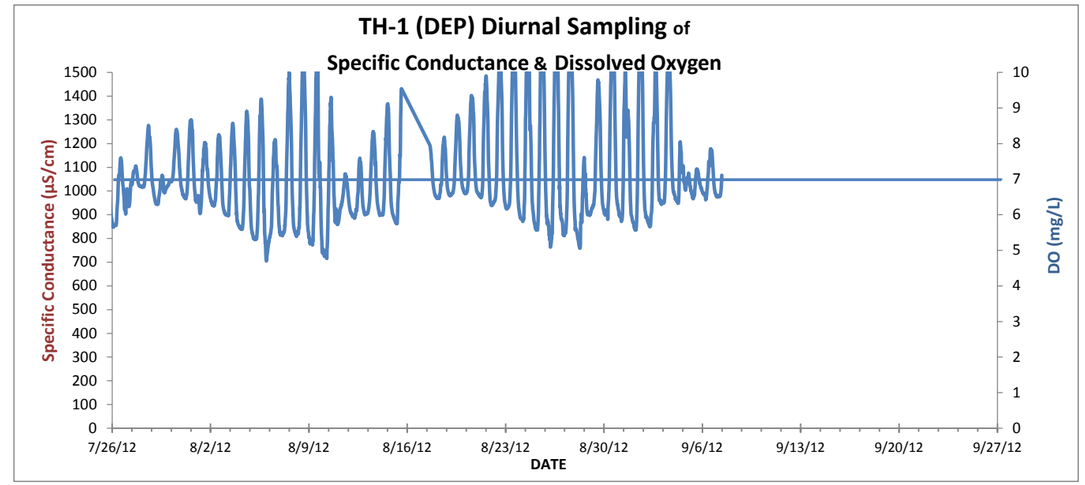
WATER QUALITY DATA

2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number TH 1			
Site Photo	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located downstream from previous DEP sampling STA 746 and DEP Screening Station 19 within Thatcher Brook.	7/18/12 minutes: • Previous data in general vicinity (STA 746) • Previous STA746 location was sandy – new location to identify more solid surface • Available data from 2004 (water quality and flow) - limited to Temp, DO (low), SPC (high) • Influence of IC (commercial development) may be demonstrated • Confluence of Richardson and Upper Thatcher tributaries • Proximate to wetland and downgradient / in vicinity of development	Maine DEP performing biological monitoring (rock bags) and Maine DEP data sonde

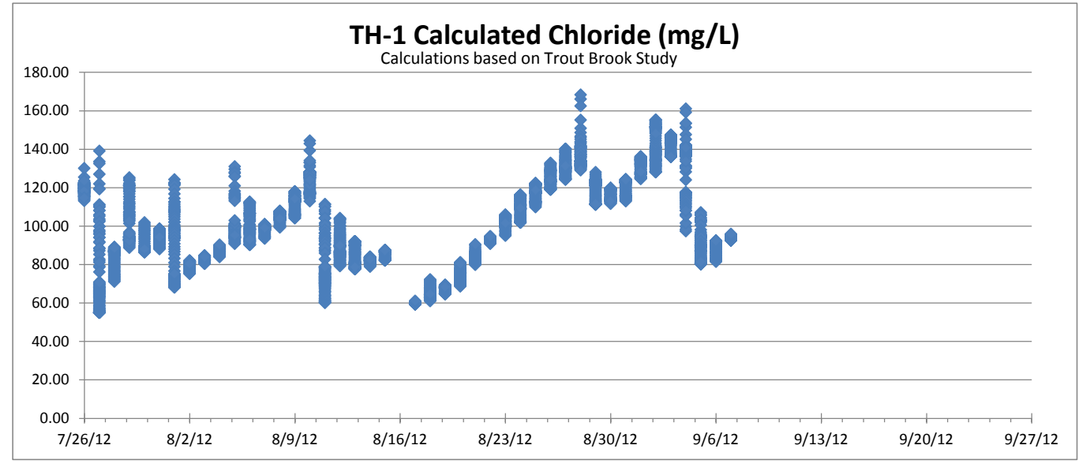
	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	21.205	0.464	101.141	7.095	80.184
Maximum	27.100	0.731	168.297	12.200	147.600
Minimum	16.420	0.281	55.037	4.700	54.600



Precipitation (inches)	
7/26/2012	0
7/27/2012	0.69
7/28/2012	0
7/29/2012	0.16
7/30/2012	0.21
7/31/2012	0
8/1/2012	0.64
8/2/2012	0.03
8/3/2012	0
8/4/2012	0
8/5/2012	0
8/6/2012	0.25
8/7/2012	0
8/8/2012	0
8/9/2012	0
8/10/2012	0.05
8/11/2012	0.78
8/12/2012	0.08
8/13/2012	0.3
8/14/2012	0.38
8/15/2012	0

Baseline Data (first 30 of 4,021 records)

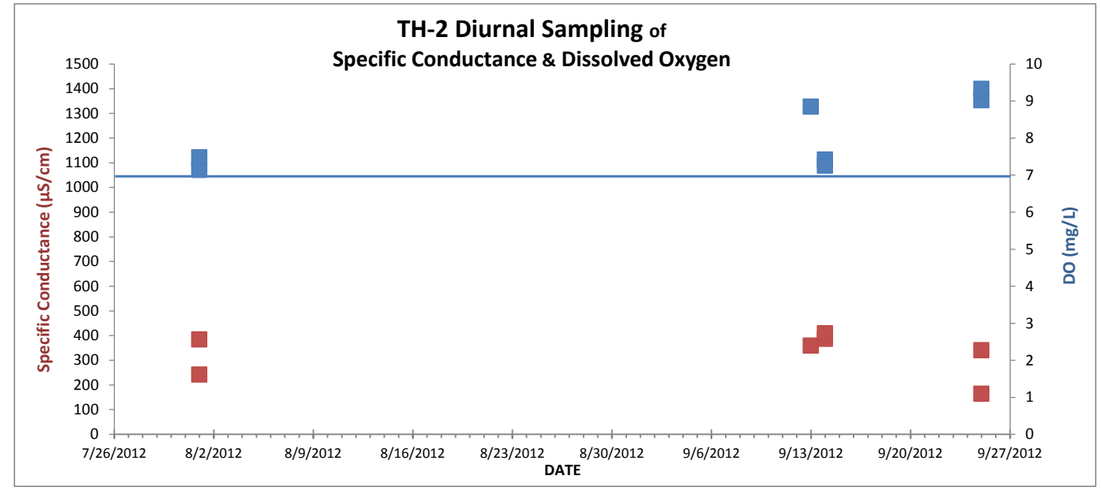
Date Time	Date	Time	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
7/25/2012 12:24	7/25/2012	12:24:31	22.23	0.431	92.79	7.97	91.6
7/25/2012 12:39	7/25/2012	12:39:31	22.54	0.435	93.80	8.01	92.7
7/25/2012 12:54	7/25/2012	12:54:31	22.87	0.439	94.80	8.11	94.4
7/25/2012 13:09	7/25/2012	13:09:31	23.23	0.443	95.81	8.09	94.9
7/25/2012 13:24	7/25/2012	13:24:31	23.43	0.447	96.82	8.13	95.6
7/25/2012 13:39	7/25/2012	13:39:31	23.62	0.45	97.57	8.15	96.2
7/25/2012 13:54	7/25/2012	13:54:31	23.75	0.453	98.33	8.16	96.5
7/25/2012 14:09	7/25/2012	14:09:31	23.83	0.456	99.08	8.14	96.5
7/25/2012 14:24	7/25/2012	14:24:31	23.93	0.459	99.84	8.13	96.6
7/25/2012 14:39	7/25/2012	14:39:31	24.06	0.461	100.34	8.11	96.6
7/25/2012 14:54	7/25/2012	14:54:31	24.14	0.463	100.84	8.11	96.7
7/25/2012 15:09	7/25/2012	15:09:31	24.19	0.464	101.10	8.06	96.2
7/25/2012 15:24	7/25/2012	15:24:31	24.23	0.466	101.60	8.01	95.6
7/25/2012 15:39	7/25/2012	15:39:31	24.22	0.467	101.85	7.96	95
7/25/2012 15:54	7/25/2012	15:54:31	24.2	0.469	102.35	7.9	94.3
7/25/2012 16:09	7/25/2012	16:09:31	24.18	0.471	102.86	7.83	93.4
7/25/2012 16:24	7/25/2012	16:24:31	24.17	0.472	103.11	7.78	92.8
7/25/2012 16:39	7/25/2012	16:39:31	24.14	0.474	103.61	7.72	92.1
7/25/2012 16:54	7/25/2012	16:54:31	24.11	0.474	103.61	7.66	91.3
7/25/2012 17:09	7/25/2012	17:09:31	24.06	0.475	103.86	7.6	90.5
7/25/2012 17:24	7/25/2012	17:24:31	24.03	0.475	103.86	7.53	89.5
7/25/2012 17:39	7/25/2012	17:39:31	24	0.477	104.37	7.46	88.7
7/25/2012 17:54	7/25/2012	17:54:31	23.96	0.478	104.62	7.38	87.7
7/25/2012 18:09	7/25/2012	18:09:31	23.9	0.479	104.87	7.27	86.3
7/25/2012 18:24	7/25/2012	18:24:31	23.84	0.48	105.12	7.16	84.9
7/25/2012 18:39	7/25/2012	18:39:31	23.77	0.481	105.37	7.05	83.4
7/25/2012 18:54	7/25/2012	18:54:31	23.71	0.482	105.63	6.96	82.3
7/25/2012 19:09	7/25/2012	19:09:31	23.64	0.483	105.88	6.85	81
7/25/2012 19:24	7/25/2012	19:24:31	23.55	0.485	106.38	6.76	79.7
7/25/2012 19:39	7/25/2012	19:39:31	23.46	0.486	106.63	6.7	78.9



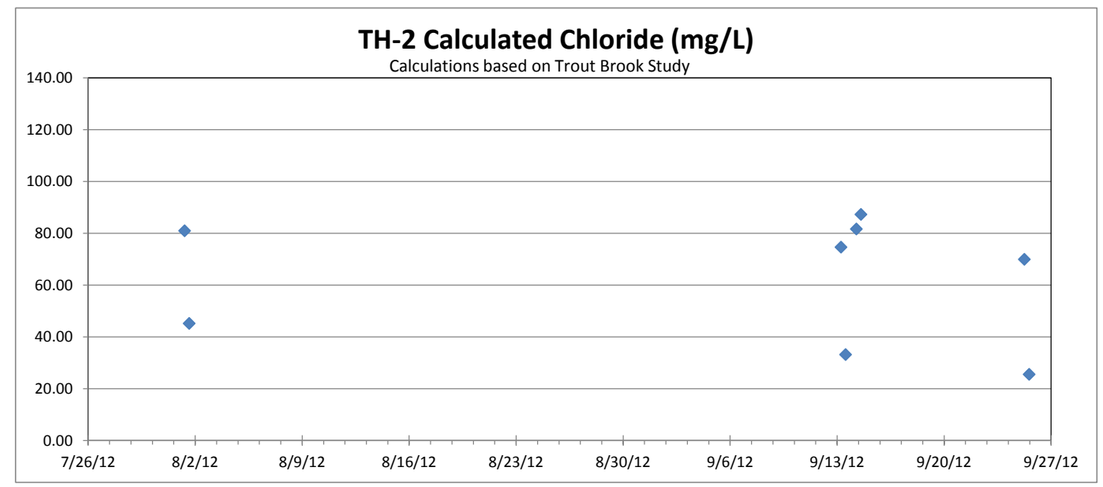
2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number TH 2 Site Photo	Monitoring Location	Rationale for Monitoring Site Location	Type of Monitoring
	Located on Richardson Brook upstream of the Medical Center Drive/Mountain Road crossing.	7/18/12 minutes: • No previous data for Richardson Tributary • Optimal site to characterize Richardson Tributary • Rule out wetland impacts (aeration from falls), unless lingering toxic effects • Capture non-wetland impacts of developed area and contributions from Richardson tributary before confluence with Lower tributary/Main Stem • Demonstrate typical water quality for habitat	GZA Field Monitoring DO, SPC, Temperature and Maine DEP performing biological monitoring (rock bags)



	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.133	0.310	62.323	8.039	79.251
Maximum	21.560	0.409	87.278	9.330	87.600
Minimum	11.400	0.164	25.564	7.140	71.000



Baseline Data

Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
8/1/2012	0.48	overcast, 68	7:42	8	19.70	0.384	80.96	7.14	77.89
8/1/2012	0.48	partly cloudy 69	14:47	8	21.56	0.242	45.22	7.48	84.32
9/13/2012	0.00	clear, 54	6:21	5	14.7	0.359	74.64	8.85	87.6
9/13/2012	0.00	clear, 73	13:30	5	16.0	0.194	33.24	7.82	76.4
9/14/2012	0.00	clear, 56	6:15	5	16.4	0.387	81.69	7.42	75.4
9/14/2012	0.00	clear, 73	13:30	5	17.1	0.409	87.28	7.25	71.0
9/25/2012	0.06	clear, 42	6:00	4	11.4	0.340	69.99	9.02	77.6
9/25/2012	0.06	clear, 64	13:30	4	12.2	0.164	25.56	9.33	83.8

2012 Baseline Monitoring Results

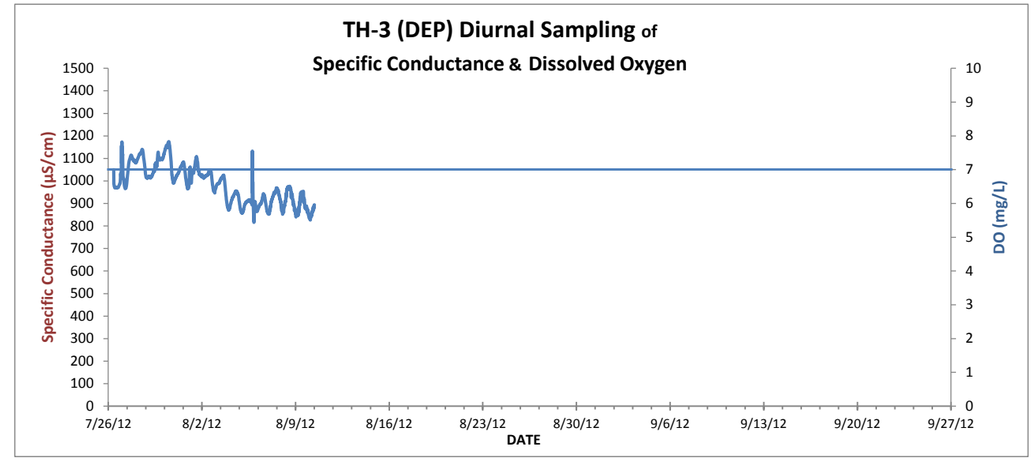
Thatcher Brook Watershed

Site Number TH 3			
Site Photo	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located in Richardson Brook subwatershed, upstream of TH 2, in close proximity to DEPs SS-2 (Rope Factory).	7/18/12 minutes: • Data found from previous DEP efforts • Melissa Evers sonde data from 2011 • Wendy Garland watershed survey data from 2011 • Optimal site to identify IC impacts and upstream from wetland	Maine DEP performing biological monitoring (rock bags) and Maine DEP data sonde

Potential Retrofit

Retrofit Type	Location	Source	Observations
Drainage structures	Rope Factory	Sheetflow from parking lot	

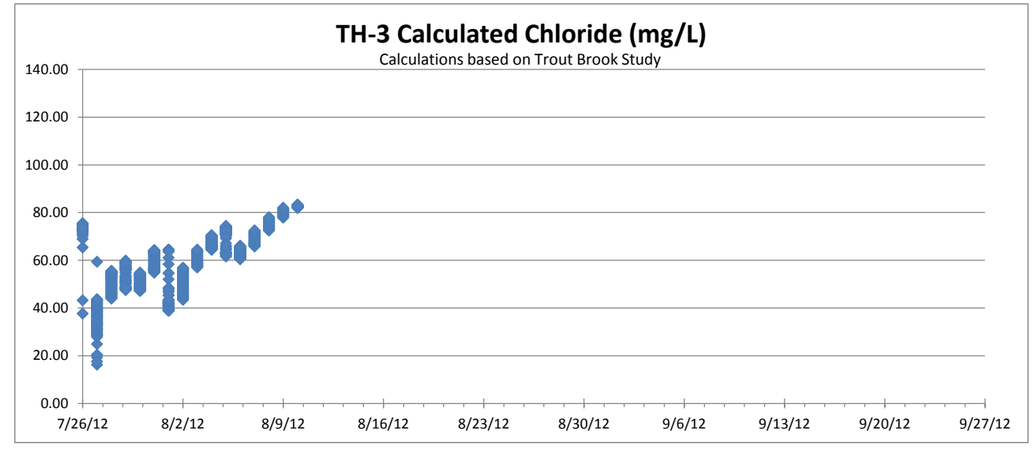
	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	21.203	0.302	60.430	6.55	73.729
Maximum	24.950	0.393	83.226	7.83	91.000
Minimum	16.890	0.127	16.277	5.44	63.3



Baseline Data (first 30 of 1,441 records)

Precipitation (inches)	
7/26/2012	0
7/27/2012	0.69
7/28/2012	0
7/29/2012	0.16
7/30/2012	0.21
7/31/2012	0
8/1/2012	0.64
8/2/2012	0.03
8/3/2012	0
8/4/2012	0
8/5/2012	0
8/6/2012	0.25
8/7/2012	0
8/8/2012	0
8/9/2012	0
8/10/2012	0.05
8/11/2012	0.78
8/12/2012	0.08
8/13/2012	0.3
8/14/2012	0.38
8/15/2012	0

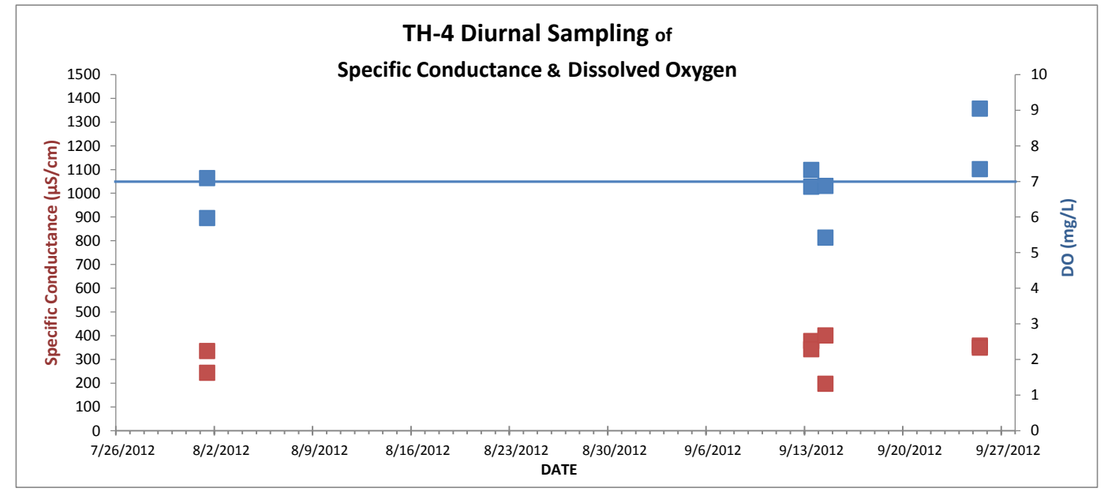
Date Time	Date	Time	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
7/26/2012 9:45	7/26/2012	9:45:33	20.22	0.344	70.89	7	77.4
7/26/2012 10:00	7/26/2012	10:00:33	19.91	0.347	71.65	6.59	72.5
7/26/2012 10:15	7/26/2012	10:15:33	19.88	0.347	71.65	6.56	72
7/26/2012 10:30	7/26/2012	10:30:33	19.86	0.348	71.90	6.53	71.7
7/26/2012 10:45	7/26/2012	10:45:33	19.87	0.349	72.15	6.51	71.5
7/26/2012 11:00	7/26/2012	11:00:33	19.87	0.35	72.40	6.5	71.4
7/26/2012 11:15	7/26/2012	11:15:33	19.87	0.35	72.40	6.5	71.3
7/26/2012 11:30	7/26/2012	11:30:33	19.85	0.351	72.66	6.47	71.1
7/26/2012 11:45	7/26/2012	11:45:33	19.84	0.351	72.66	6.46	70.9
7/26/2012 12:00	7/26/2012	12:00:33	19.82	0.351	72.66	6.46	70.9
7/26/2012 12:15	7/26/2012	12:15:33	19.81	0.351	72.66	6.46	70.9
7/26/2012 12:30	7/26/2012	12:30:33	19.8	0.351	72.66	6.46	70.8
7/26/2012 12:45	7/26/2012	12:45:33	19.79	0.351	72.66	6.46	70.8
7/26/2012 13:00	7/26/2012	13:00:33	19.79	0.351	72.66	6.46	70.8
7/26/2012 13:15	7/26/2012	13:15:33	19.8	0.351	72.66	6.46	70.8
7/26/2012 13:30	7/26/2012	13:30:33	19.8	0.351	72.66	6.46	70.9
7/26/2012 13:45	7/26/2012	13:45:33	19.8	0.351	72.66	6.46	70.8
7/26/2012 14:00	7/26/2012	14:00:33	19.81	0.351	72.66	6.47	71
7/26/2012 14:15	7/26/2012	14:15:33	19.81	0.351	72.66	6.47	71
7/26/2012 14:30	7/26/2012	14:30:33	19.81	0.351	72.66	6.47	71
7/26/2012 14:45	7/26/2012	14:45:33	19.81	0.351	72.66	6.47	71
7/26/2012 15:00	7/26/2012	15:00:33	19.82	0.351	72.66	6.47	71
7/26/2012 15:15	7/26/2012	15:15:33	19.82	0.352	72.91	6.48	71
7/26/2012 15:30	7/26/2012	15:30:33	19.82	0.352	72.91	6.48	71.1
7/26/2012 15:45	7/26/2012	15:45:33	19.81	0.352	72.91	6.47	71
7/26/2012 16:00	7/26/2012	16:00:33	19.81	0.352	72.91	6.48	71.1
7/26/2012 16:15	7/26/2012	16:15:33	19.81	0.353	73.16	6.48	71
7/26/2012 16:30	7/26/2012	16:30:33	19.81	0.353	73.16	6.47	71
7/26/2012 16:45	7/26/2012	16:45:33	19.81	0.353	73.16	6.48	71.1
7/26/2012 17:00	7/26/2012	17:00:33	19.81	0.354	73.41	6.48	71.1



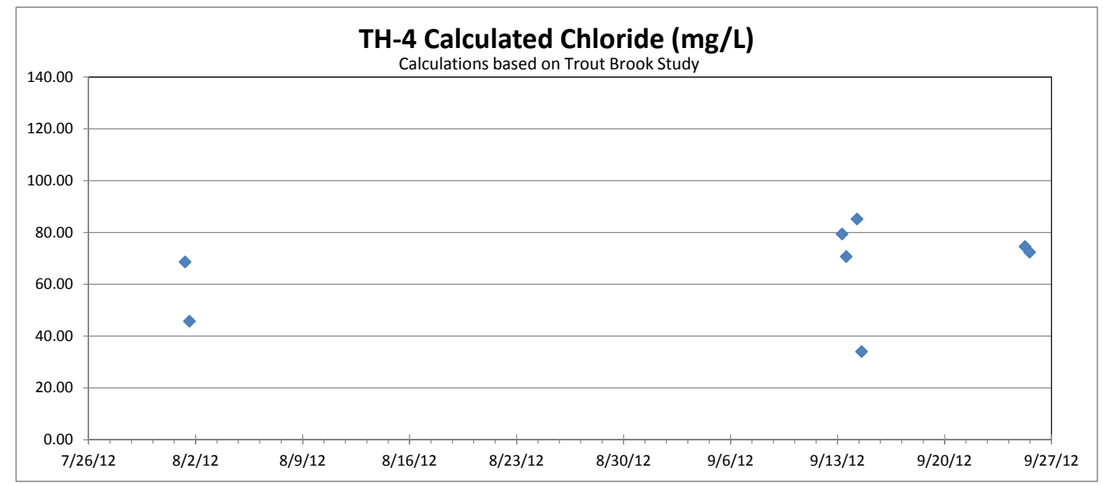
2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number TH 4	Monitoring Location	Rationale for Monitoring Site Location	Type of Monitoring
Site Photo	Located on Richardson Brook upstream of TH2, downstream of Biddeford spur, near DEP SS-2	7/18/12 minutes: • Above Screen Sampling Site 2, before the falls, in Richardson tributary • SS-2 data disregarded since diurnal temps reversed, but DO expected to be low • Close proximity to wetland before the falls Field observation: Emergent wetland upstream of sampling location and falls downstream of sampling station.	GZA Field Monitoring DO, SPC, Temperature



	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.818	0.326	66.309	6.988	66.039
Maximum	21.850	0.401	85.164	9.040	85.500
Minimum	10.700	0.197	33.996	5.420	50.700



Baseline Data

Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
8/1/2012	0.48	overcast, 68	7:33	6	19.79	0.335	68.63	5.97	65.22
8/1/2012	0.48	partly cloudy 69	14:34	6	21.85	0.244	45.72	7.09	80.69
9/13/2012	0.00	clear, 54	7:03	5	14.5	0.378	79.38	6.85	55.1
9/13/2012	0.00	clear, 73	13:41	5	18.8	0.343	70.69	7.32	64.8
9/14/2012	0.00	clear, 56	6:36	5	15.5	0.401	85.16	5.42	50.7
9/14/2012	0.00	clear, 73	13:49	5	19.8	0.197	34.00	6.87	65.6
9/25/2012	0.06	clear, 42	6:30	4	10.7	0.358	74.52	7.34	60.7
9/25/2012	0.06	clear, 64	13:45	4	13.6	0.350	72.38	9.04	85.5

2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number TH 5			
Site Photos	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located within the unnamed tributary that flows along the south easterly limits of the Kohl's parking lot and in close proximity of DEP Screening Station 18. These stations will be identified as 5A, 5B and 5C respectively (see below)	This site was chosen in the field on 7/25/12 (not on the original list of sites on 7/18/12). The rationale for this triple location is to capture date from each influent tributary as well as the confluence.	GZA Field Monitoring DO, SPC, Temperature
	TH 5A Upstream of unnamed tributary confluence with Thatcher Brook	Influent tributary expected to contribute runoff from a large portion of upgradient IC (including Kohl's and drainage from under Rt111/car wash)	GZA Field Monitoring DO, SPC, Temperature
	TH 5B Thatcher Brook upstream of confluence with unnamed tributary	Combined influent from Richardson and Upper Thatcher tributaries, before confluence to Lower Thatcher Brook (also upgradient from juncture w/Rt111). Field observation: Low flow on 9/25/12 compared to 8/1/12 observations	GZA Field Monitoring DO, SPC, Temperature
	TH 5C The downstream location will be approximately 30 feet below the discharge point to allow a reasonable mixing zone before data monitoring	Confluence into Lower Thatcher from Richardson/Upper Thatcher (TH5B) and unnamed tributary (TH5A) Field observation: Fairly high flow area	GZA Field Monitoring DO, SPC, Temperature

TH 5A	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	17.554	0.400	93.944	6.830	70.010
Maximum	23.650	1.377	330.889	8.180	88.300
Minimum	9.000	0.001	0.000	5.350	56.400

TH 5B	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.526	0.453	98.208	7.835	74.845
Maximum	22.040	0.533	118.463	9.620	83.500
Minimum	10.700	0.379	79.703	6.160	61.800

TH 5C	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.656	0.478	104.702	7.709	77.755
Maximum	22.180	0.559	125.007	9.670	91.100
Minimum	10.500	0.267	51.589	5.770	63.550

2012 Baseline Monitoring Results

Thatcher Brook Watershed

Baseline Data

Site	Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
TH 5A	8/1/2012	0.48	overcast, 68	7:00	6	20.28	0.793	183.90	5.35	59.00
TH 5A	8/1/2012	0.48	partly cloudy 69	13:56	6	23.65	1.003	236.76	6.69	79.08
TH 5A	9/13/2012	0.00	clear, 54	7:39	7	12.9	0.013	0.00	7.38	69.9
TH 5A	9/13/2012	0.00	clear, 73	14:27	7	21.4	0.001	0.00	6.82	67.9
TH 5A	9/14/2012	0.00	clear, 56	7:10	7	13.9	0.004	0.00	5.94	56.4
TH 5A	9/14/2012	0.00	clear, 70	14:22	7	21.6	0.004	0.00	6.23	69.2
TH 5A	9/25/2012	0.06	clear, 42	7:12	6	9.0	1.377	330.89	8.05	70.3
TH 5A	9/25/2012	0.06	clear, 64	14:10	6	17.7	0.006	0.00	8.18	88.3
TH 5B	8/1/2012	0.48	overcast, 68	7:08	4	20.07	0.533	118.46	6.16	67.65
TH 5B	8/1/2012	0.48	partly cloudy 69	14:01	4	22.04	0.379	79.70	7.26	82.61
TH 5B	9/13/2012	0.00	clear, 54	7:44	2	14.6	0.453	98.28	8.33	83.1
TH 5B	9/13/2012	0.00	clear, 73	14:36	2	17.4	0.452	98.03	8.47	79.7
TH 5B	9/14/2012	0.00	clear, 56	7:20	2	15.9	0.486	106.68	6.73	61.8
TH 5B	9/14/2012	0.00	clear, 73	14:32	2	18.4	0.496	109.25	7.64	67.0
TH 5B	9/25/2012	0.06	clear, 42	7:18	2	10.7	0.415	88.71	8.47	73.4
TH 5B	9/25/2012	0.06	clear, 68	14:20	2	13.1	0.406	86.55	9.62	83.5
TH 5C	8/1/2012	0.48	overcast, 68	7:15	7	20.17	0.559	125.01	5.77	63.55
TH 5C	8/1/2012	0.48	partly cloudy 69	14:05	7	22.18	0.403	85.74	7.01	79.79
TH 5C	9/13/2012	0.00	clear, 54	7:50	6	14.6	0.536	119.24	8.22	79.8
TH 5C	9/13/2012	0.00	clear, 73	14:48	6	18.0	0.541	120.48	8.62	90.1
TH 5C	9/14/2012	0.00	clear, 56	7:30	6	15.8	0.556	124.25	6.59	65.6
TH 5C	9/14/2012	0.00	clear, 73	14:41	6	18.8	0.267	51.59	7.45	78.0
TH 5C	9/25/2012	0.06	clear, 42	7:26	5	10.5	0.489	107.34	8.34	74.1
TH 5C	9/25/2012	0.06	clear, 68	14:28	5	13.2	0.475	103.97	9.67	91.1

793
1003
12.8
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1377
5.6

533
379
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451.8
486.2
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406.2

559
403
536.1
541
556
267.3
488.8
475.4

2012 Baseline Monitoring Results

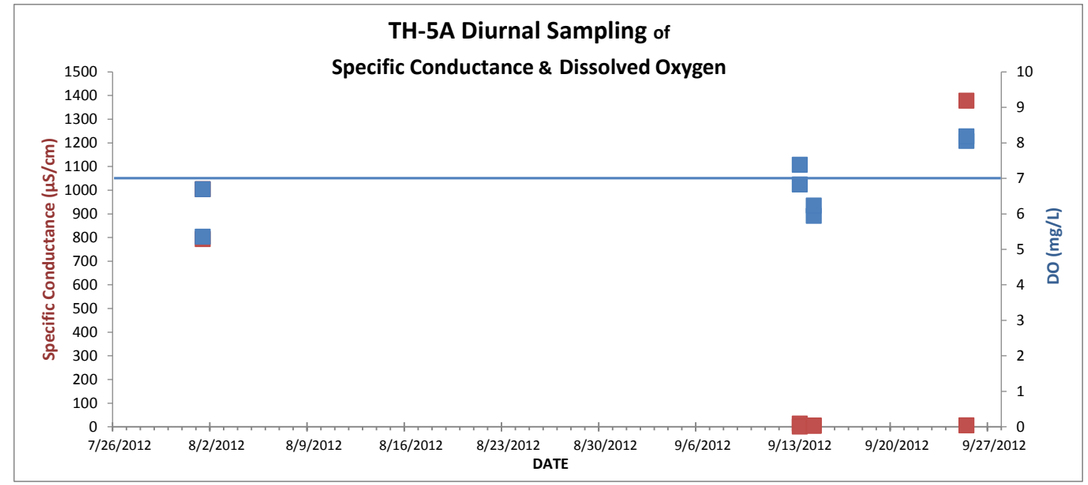
Thatcher Brook Watershed

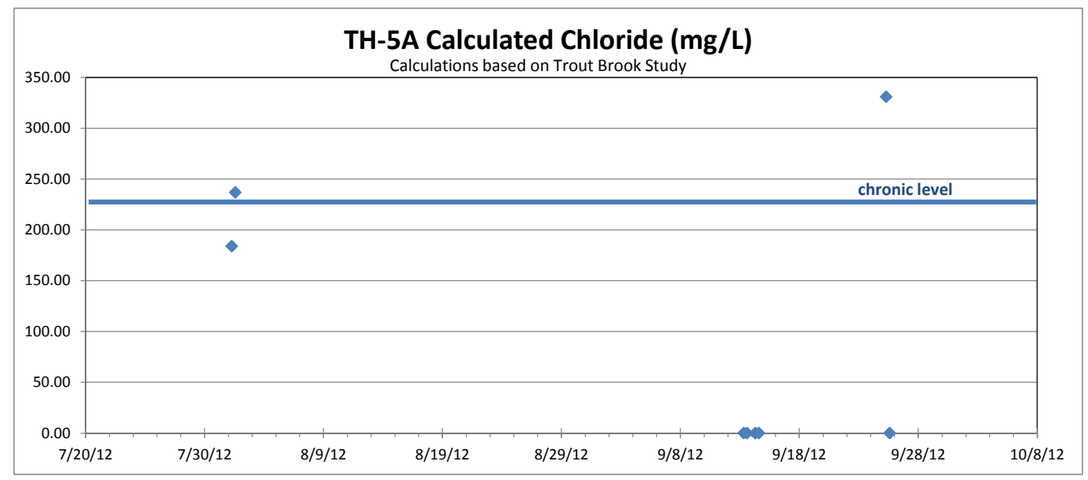
Site Number	TH 5A		
Site Photos	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located within the unnamed tributary that flows along the south easterly limits of the Kohl's parking lot and in close proximity of DEP Screening Station 18. These stations will be identified as 5A, 5B and 5C respectively (see below)	This site was chosen in the field on 7/25/12 (not on the original list of sites on 7/18/12). The rationale for this triple location is to capture date from each influent tributary as well as the confluence.	GZA Field Monitoring DO, SPC, Temperature
	TH 5A Upstream of unnamed tributary confluence with Thatcher Brook	Influent tributary expected to contribute runoff from a large portion of upgradient IC (including Kohl's and drainage from under Rt111/car wash)	GZA Field Monitoring DO, SPC, Temperature

	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	17.554	0.400	93.944	6.830	70.010
Maximum	23.650	1.377	330.889	8.180	88.300
Minimum	9.000	0.001	0.000	5.350	56.400

Baseline Data

Site	Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
TH 5A	8/1/2012	0.48	overcast, 68	7:00	6	20.28	0.793	183.90	5.35	59.00
TH 5A	8/1/2012	0.48	partly cloudy 69	13:56	6	23.65	1.003	236.76	6.69	79.08
TH 5A	9/13/2012	0.00	clear, 54	7:39	7	12.9	0.013	0.00	7.38	69.9
TH 5A	9/13/2012	0.00	clear, 73	14:27	7	21.4	0.001	0.00	6.82	67.9
TH 5A	9/14/2012	0.00	clear, 56	7:10	7	13.9	0.004	0.00	5.94	56.4
TH 5A	9/14/2012	0.00	clear, 70	14:22	7	21.6	0.004	0.00	6.23	69.2
TH 5A	9/25/2012	0.06	clear, 42	7:12	6	9.0	1.377	330.89	8.05	70.3
TH 5A	9/25/2012	0.06	clear, 64	14:10	6	17.7	0.006	0.00	8.18	88.3

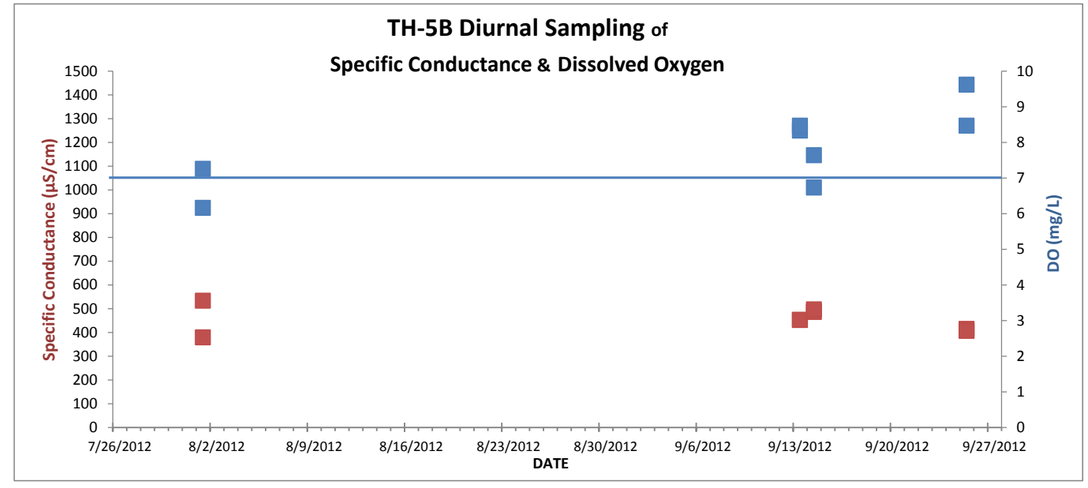




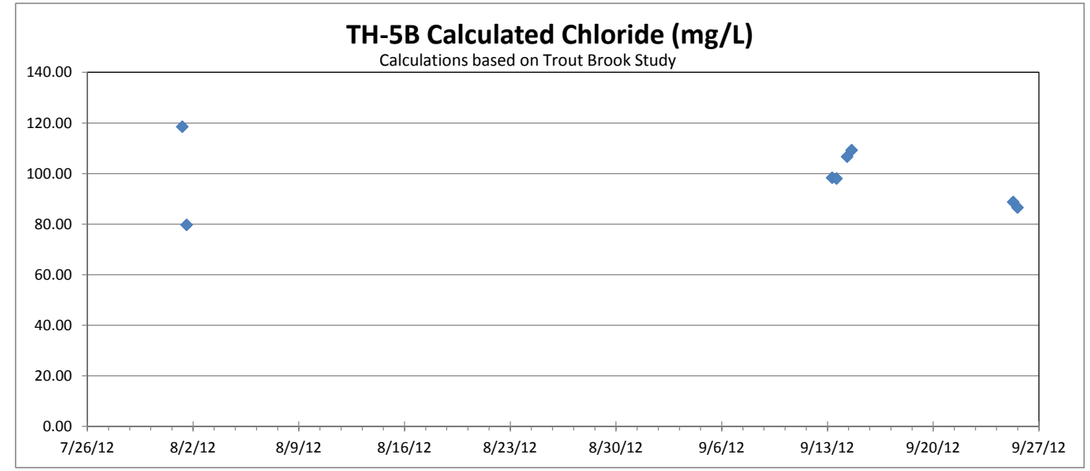
2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number	TH 5B		
Site Photos	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located within the unnamed tributary that flows along the south easterly limits of the Kohl's parking lot and in close proximity of DEP Screening Station 18. These stations will be identified as 5A, 5B and 5C respectively (see below)	This site was chosen in the field on 7/25/12 (not on the original list of sites on 7/18/12). The rationale for this triple location is to capture date from each influent tributary as well as the confluence.	GZA Field Monitoring DO, SPC, Temperature
	TH 5B Thatcher Brook upstream of confluence with unnamed tributary	Combined influent from Richardson and Upper Thatcher tributaries, before confluence to Lower Thatcher Brook (also upgradient from juncture w/Rt111). Field observation: Low flow on 9/25/12 compared to 8/1/12 observations	GZA Field Monitoring DO, SPC, Temperature



	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.526	0.453	98.208	7.835	74.845
Maximum	22.040	0.533	118.463	9.620	83.500
Minimum	10.700	0.379	79.703	6.160	61.800



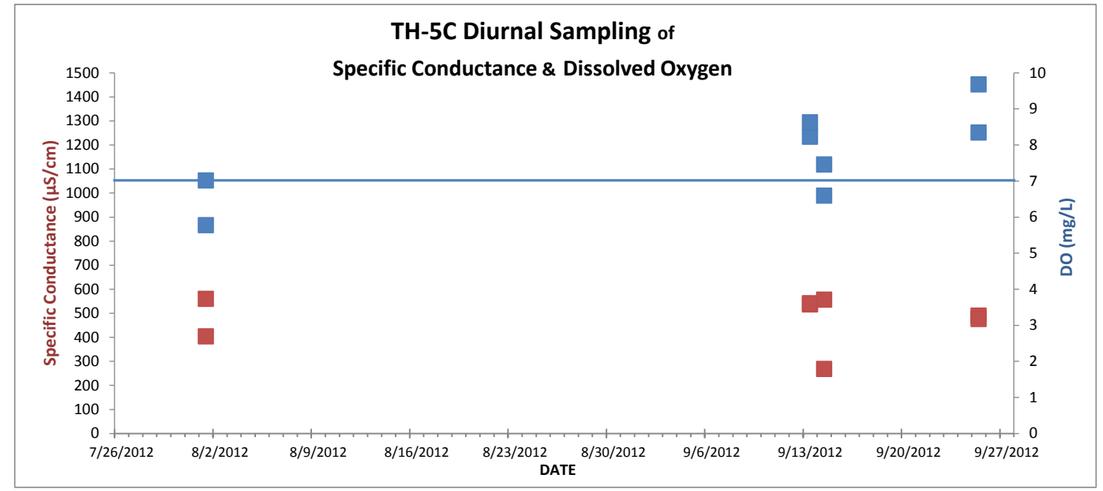
Baseline Data

Site	Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
TH 5B	8/1/2012	0.48	overcast, 68	7:08	4	20.07	0.533	118.46	6.16	67.65
TH 5B	8/1/2012	0.48	partly cloudy 69	14:01	4	22.04	0.379	79.70	7.26	82.61
TH 5B	9/13/2012	0.00	clear, 54	7:44	2	14.6	0.453	98.28	8.33	83.1
TH 5B	9/13/2012	0.00	clear, 73	14:36	2	17.4	0.452	98.03	8.47	79.7
TH 5B	9/14/2012	0.00	clear, 56	7:20	2	15.9	0.486	106.68	6.73	61.8
TH 5B	9/14/2012	0.00	clear, 73	14:32	2	18.4	0.496	109.25	7.64	67.0
TH 5B	9/25/2012	0.06	clear, 42	7:18	2	10.7	0.415	88.71	8.47	73.4
TH 5B	9/25/2012	0.06	clear, 68	14:20	2	13.1	0.406	86.55	9.62	83.5

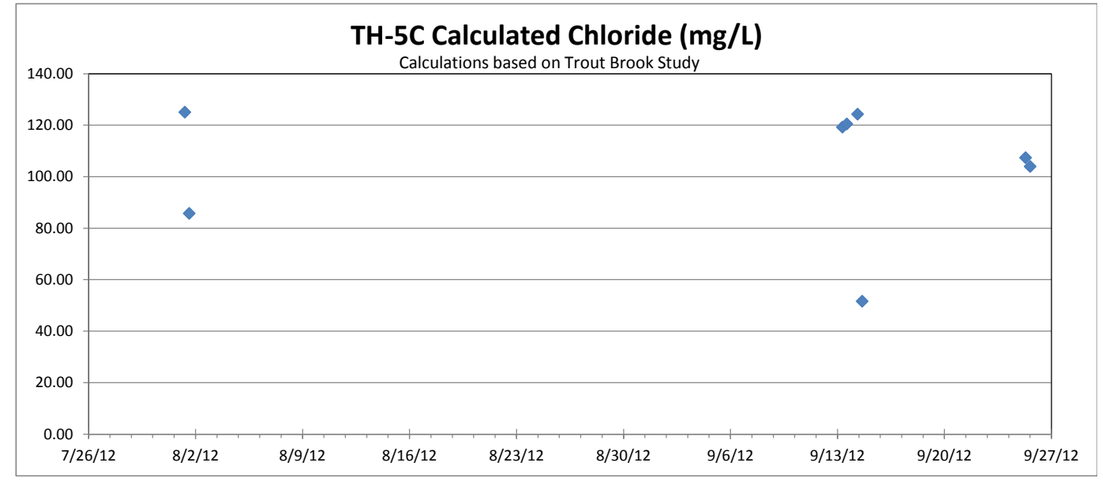
2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number	TH 5C		
Site Photos	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located within the unnamed tributary that flows along the south easterly limits of the Kohl's parking lot and in close proximity of DEP Screening Station 18. These stations will be identified as 5A, 5B and 5C respectively (see below)	This site was chosen in the field on 7/25/12 (not on the original list of sites on 7/18/12). The rationale for this triple location is to capture date from each influent tributary as well as the confluence.	GZA Field Monitoring DO, SPC, Temperature
	TH 5C The downstream location will be approximately 30 feet below the discharge point to allow a reasonable mixing zone before data monitoring	Confluence into Lower Thatcher from Richardson/Upper Thatcher (TH5B) and unnamed tributary (TH5A) Field observation: Fairly high flow area	GZA Field Monitoring DO, SPC, Temperature



	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.656	0.478	104.702	7.709	77.755
Maximum	22.180	0.559	125.007	9.670	91.100
Minimum	10.500	0.267	51.589	5.770	63.550



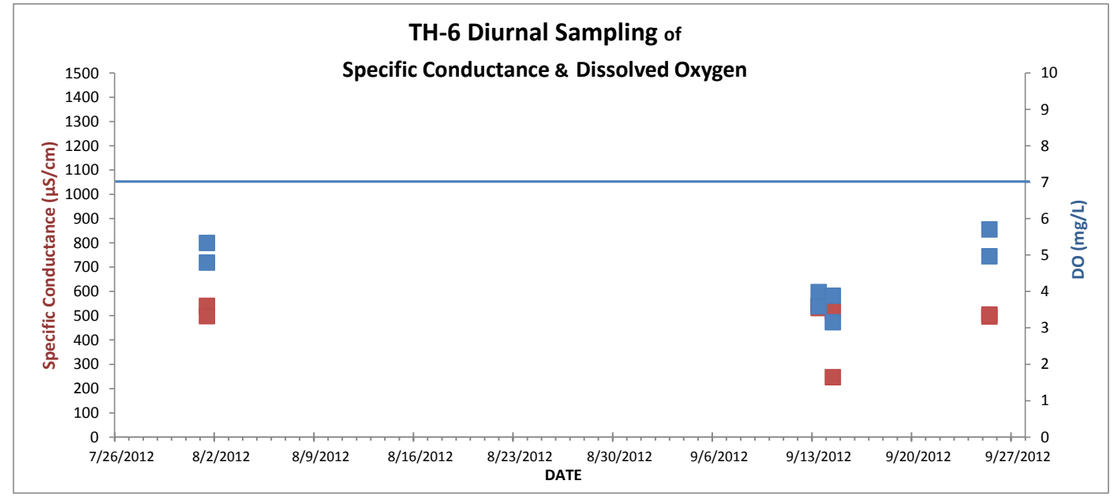
Baseline Data

Site	Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
TH 5C	8/1/2012	0.48	overcast, 68	7:15	7	20.17	0.559	125.01	5.77	63.55
TH 5C	8/1/2012	0.48	partly cloudy 69	14:05	7	22.18	0.403	85.74	7.01	79.79
TH 5C	9/13/2012	0.00	clear, 54	7:50	6	14.6	0.536	119.24	8.22	79.8
TH 5C	9/13/2012	0.00	clear, 73	14:48	6	18.0	0.541	120.48	8.62	90.1
TH 5C	9/14/2012	0.00	clear, 56	7:30	6	15.8	0.556	124.25	6.59	65.6
TH 5C	9/14/2012	0.00	clear, 73	14:41	6	18.8	0.267	51.59	7.45	78.0
TH 5C	9/25/2012	0.06	clear, 42	7:26	5	10.5	0.489	107.34	8.34	74.1
TH 5C	9/25/2012	0.06	clear, 68	14:28	5	13.2	0.475	103.97	9.67	91.1

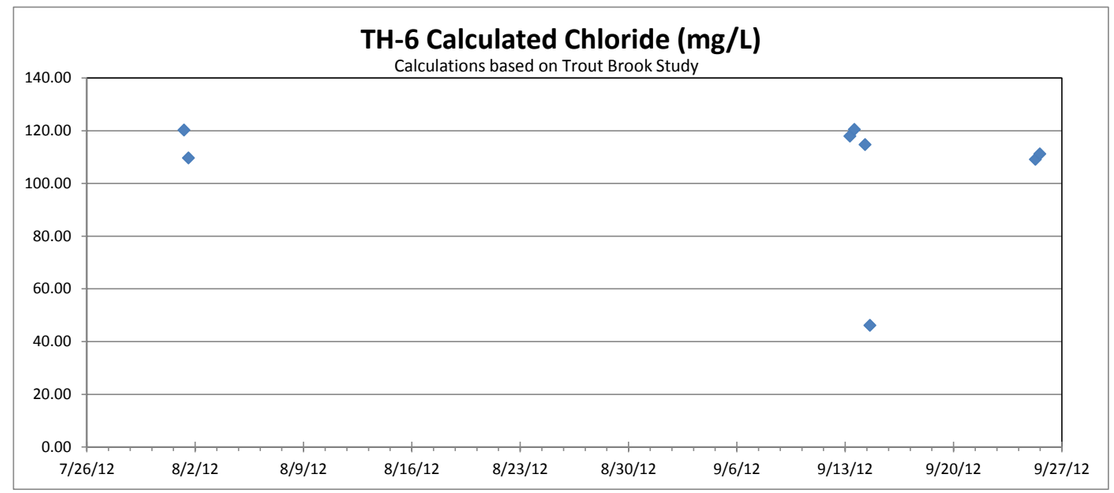
2012 Baseline Monitoring Results

Thatcher Brook Watershed

Site Number TH 6			
Site Photo	**Monitoring Location**	**Rationale for Monitoring Site Location**	**Type of Monitoring**
	Located within Upper Thatcher Brook upstream of the Route 111 crossing.	This site was identified in the field on 7/25/12 (not on original list of sites of planned 7/18/12). The rationale for this location was to assess conditions proximate to DEP monitoring location W-043 (wetland). It is also the only site monitored in Upper Thatcher as part of WMP development. Field observations: Dense aquatic vegetation with a presumably high BOD and low DO due to wetland effects (PEM/PSS wetland upstream).	GZA Field Monitoring DO, SPC, Temperature



	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.535	0.484	106.17	4.423	38.819
Maximum	23.080	0.541	120.48	5.700	62.010
Minimum	8.500	0.246	46.15	3.150	25.100



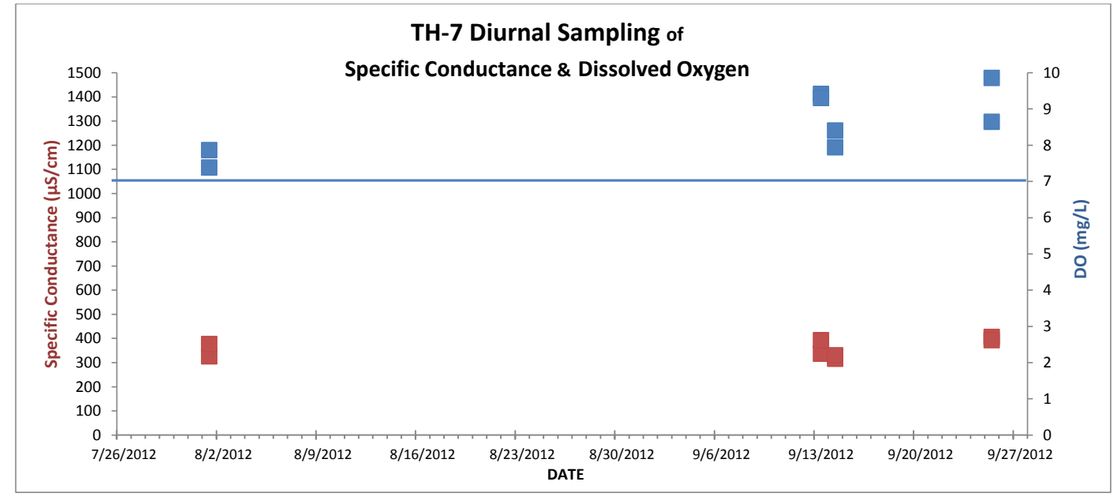
Baseline Data

Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
8/1/2012	0.48	overcast, 68	6:32	4	20.70	0.540	120.22	4.79	53.24
8/1/2012	0.48	partly cloudy, 69	13:35	4	23.08	0.498	109.65	5.33	62.01
9/13/2012	0.00	clear, 54	7:21	1	12.8	0.531	117.96	3.59	29.3
9/13/2012	0.00	clear, 73	14:10	1	18.8	0.541	120.48	3.98	32.8
9/14/2012	0.00	clear, 56	6:50	1	14.3	0.518	114.69	3.15	25.1
9/14/2012	0.00	clear, 73	14:08	1	20.0	0.246	46.15	3.88	30.9
9/25/2012	0.06	clear, 42	6:50	1	8.5	0.496	109.07	4.96	35.4
9/25/2012	0.06	clear, 64	13:53	1	14.1	0.504	111.16	5.70	41.8

2012 Baseline Monitoring Results

Thatcher Brook Watershed

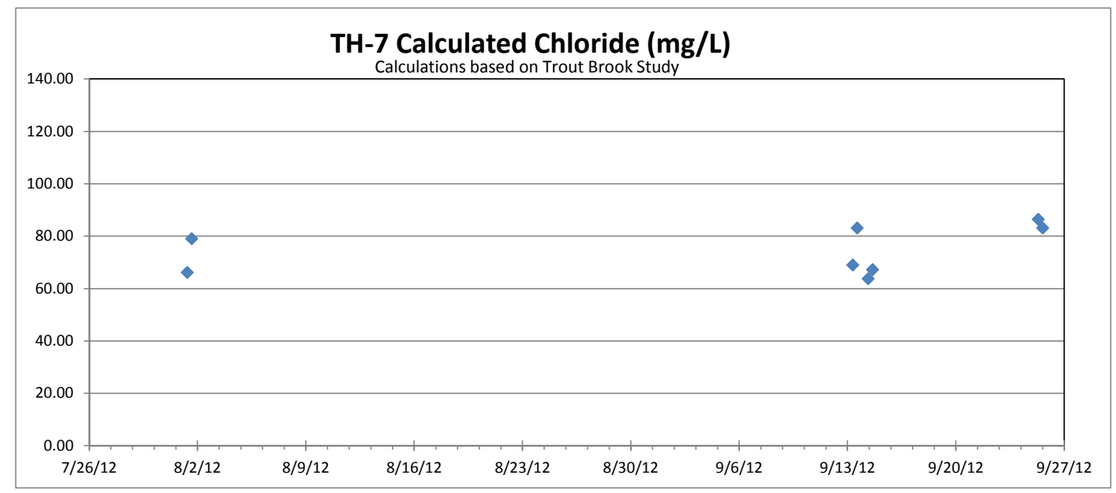
Site Number TH 7	Monitoring Location	Rationale for Monitoring Site Location	Type of Monitoring
Site Photo	Located within Thatcher Brook upstream of the large culvert under South Street.	7/18/12 minutes: • Previous data collected downstream at TB27 • Optimal site to identify IC impacts and characterize conditions before confluence with Saco River	GZA Field Monitoring DO, SPC, Temperature



Potential Retrofit

Retrofit Type	Location	Source	Observations
Drainage swale	South Street	Unstable drainage swale	Increased turbidity after inputs from the swale

	Temp	SPC	Chloride	DO (mg/L)	DO (%)
Average	16.858	0.359	74.67	8.598	87.414
Maximum	21.840	0.406	86.40	9.850	97.400
Minimum	10.900	0.315	63.70	7.380	74.300



Baseline Data

Date	Rain w/n 48 hrs (in)	Weather and Temperature (°F)	Time	Estimated Flow Rate (in/sec)	Temperature (°C)	Specific Conductance (mS/cm)	Calculated Chloride (mg/L)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%)
8/1/2012	0.48	overcast, 68	8:08	4	19.82	0.325	66.11	7.38	80.66
8/1/2012	0.48	partly cloudy 69	15:00	4	21.84	0.376	78.95	7.86	89.35
9/13/2012	0.00	clear, 54	8:19	8	14.9	0.336	68.93	9.41	93.4
9/13/2012	0.00	clear, 73	15:05	8	18.7	0.392	83.08	9.30	97.4
9/14/2012	0.00	clear, 53	7:55	8	15.8	0.315	63.70	7.94	80.5
9/14/2012	0.00	clear, 73	14:52	8	19.0	0.329	67.14	8.40	90.1
9/25/2012	0.06	clear, 42	7:48	2	10.9	0.406	86.40	8.64	74.3
9/25/2012	0.06	clear, 64	14:48	2	13.9	0.392	83.08	9.85	93.6

2012 Baseline Monitoring Results

Thatcher Brook Watershed

Summary of 2012 Baseline Data

Site Number	Temperature (°C)			Specific Conductance (mS/cm)			Calculated Chloride (mg/L)			Dissolved Oxygen (mg/L)			Dissolved Oxygen (%)		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
TH 1	27.100	16.420	21.205	0.731	0.281	0.464	168.297	55.037	101.141	12.200	4.700	7.095	147.600	54.600	80.184
TH 2	21.560	11.400	16.133	0.409	0.164	0.310	87.278	25.564	62.323	9.330	7.140	8.039	87.600	71.000	79.251
TH 3	24.950	16.890	21.203	0.393	0.127	0.302	83.226	16.277	60.430	7.830	5.440	6.554	91.000	63.300	73.729
TH 4	21.850	10.700	16.818	0.401	0.197	0.326	85.164	33.996	66.309	9.040	5.420	6.988	85.500	50.700	66.039
TH 5A	23.650	9.000	17.554	1.377	0.001	0.400	330.889	0.000	93.944	8.180	5.350	6.830	88.300	56.400	70.010
TH 5B	22.040	10.700	16.526	0.533	0.379	0.453	118.463	79.703	98.208	9.620	6.160	7.835	83.500	61.800	74.845
TH 5C	22.180	10.500	16.656	0.559	0.267	0.478	125.007	51.589	104.702	9.670	5.770	7.709	91.100	63.550	77.755
TH 6	23.080	8.500	16.535	0.541	0.246	0.484	120.476	46.152	106.174	5.700	3.150	4.423	62.010	25.100	38.819
TH 7	21.840	10.900	16.858	0.406	0.315	0.359	86.397	63.695	74.672	9.850	7.380	8.598	97.400	74.300	87.414

	Temperature (°C)			Specific Conductance (mS/cm)			Calculated Chloride (mg/L)			Dissolved Oxygen (mg/L)			Dissolved Oxygen (%)		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Maximum	27.100	16.890	21.205	1.377	0.379	0.484	330.889	79.703	106.174	12.200	7.380	8.598	147.600	74.300	87.414
Minimum	21.560	8.500	16.133	0.393	0.001	0.302	83.226	0.000	60.430	5.700	3.150	4.423	62.010	25.100	38.819

Thatcher Brook Summary Data
Biddeford, Maine

		Richardson (13% IC)												Upper Thatcher (6% IC) above Richardson confluence				
Parameter	**standard and/or data info**	**Eastern Trail Trib** Bacteria Site 1	**Sterling Rope** Bacteria Site 7 S-978 TH3 Geomorph B1	**Biddeford Spur (above falls)** TH4	**Small Trib** TH4A	**Medical Center Dr.** S-979 TH2 Geomorph B2	**Route 111** TH8	**Ditch (near Route 111)** TH8A	**Biddeford Spur** TH9	**Route 1** TH10	**Iron Trail Road** TH11	**Above Landry** TH12	**Park and Ride**	**Old Alfred Rd** Bacteria Site 5 S-450	**Mountain Road** Bacteria Site 2	**Easy Street** Geomorph A2	**Wal-Mart wetland** W-43	**Route 111** TH6
Macroinvertebrates																		
DEP biomonitoring	Statistical model		Indeterminant (2012)			Indeterminant (2012)											Nonattainment (2013)	
2013 kicknetting	EPA score		see Table 2, 2013 Macroinvertebrate Metrics			see Table 2, 2013 Macroinvertebrate Metrics										see Table 2, 2013 Macroinvertebrate Metrics		
Habitat/Geomorph																		
RGA score	0-0.2 = in regime 0.21-0.4 = in transition >.4 = stressed		0.29			0.41										0.16		
RGA high parameters			degradation, widening			aggradation, widening, planiform adjustment										NA		
EPA Habitat Score			127			106										133		
EPA Parameters < 10			riparian width, pool substrate			epifaunal and pool substrate, channel sinuosity										epifaunal substrate, pool variability, channel sinuosity		
Substrate			1/2 silt, 1/4 gravel, 1/4 boulder			1/3 silt, 1/3 sand, 1/3 gravel										>50% silt, clay, mud	dense mat of aquatic plants	
Bankful & wetted width (ft)			9', 9'			14', 13'										12', 5.5'		
Baseflow Water Depth		7 inches	10 inches			11 inches							8 inches	4 inches	10 inches	5 inches	12 inches	
Dissolved Oxygen																		
Early a.m.	7 mg/L																	
	n		15	4		3							1	1	1		3	
	mean		5.63	5.84		7.80							6.45	5.83	5.76		3.84	
All D.O. Values	7 mg/L																	
	n	5	25	10		13	1	1	1	2	1	2	7	7	6	2	7	8
	min	2.31	5.54	5.11		6.95	7.09	3.48	7.27	5.35	8.72	6.07	6.16	5.11	2.3	5.77	1.12	3.15
	max	7.79	8.63	9.04		9.52				6.01		6.66	8.58	8.13	6.69	6.28	7.38	5.7
	mean	5.78	6.55	6.68		7.93				5.70		6.40	7.00	6.39	4.40	6.03	4.19	4.42
Diurnal Swing (average)	2 mg/L swing		1.4 (sonde)	-0.2		-0.3							0.8	0.0	-0.3			0.55
Nutrients																		
Total Phosphorus	30 ppb (ug/L)		19**, 21, 140, 170, 220*****	36**, 20, 21, 83, 140*****	18, 300, 260, 240******					24**, 10, 17, 160, 230*****	13****	12**	78, 61**, 16, 26, 77, 220*****	57			51, 33	
Total Nitrogen	0.71 mg/L																0.862, 0.60	
Bacteria (E. coli)																		
instantaneous	236	133, 81, 159, 86, 52, 121	435, 2420, 1986, 582, 311, 517, 325.5**, 2419.6****	410.6**, 579.4***			235.9****	1111.9****	248.1****	816.4**, > 2419.6****	686.7****	2419.6**, 27.5****	260, 214, 122, 411, 219, 93, 1203.3**, 275.5****	186, 34, 162, 2, 6, 145	120, 173, 201, 461, 1011, 99		48, 129, 31, 102, 20, 16	
geometric mean	64	99	762										196	35	240		43	
Conductivity	CCC -860 us/cm																	
	n	5	12	11		13	1	1	1	1	1	2	8	6	5	2	7	8
	max	74	546	471		438	450	1900	447	2470	534	878	332	538	141	186	246	541
	mean	55.08	364	331		294						656	351	299	75	172	177	484
Temperature	> 25° C trout impacts																	
	n	5	12	11		13	1	1	1	2	1	2	8	6	5	2	7	8
	max	25.3	21.7	21.85		21.56	21.3	19.8	20.9	19.6	21.6	21.5	25	26.6	22.5	20.8	24.5	23.08
	mean	19.90	18.60	18.00		17.17				18.50		21.10	20.50	20.83	19.08	20.45	20.46	16.54
Metals																		
Aluminum																	107	
Iron	1000 CCC													3487				
Lead	0.41 CCC													0.808				
Zinc	30.6 ug/L													16.3				
Chloride	230 mg/L									140****							41	

* High values during baseflow conditions

Note: Draft data summary provided by MaineDEP on 3/6/14 and formatted by GZA on 3/7/14 for Thatcher Brook Technical Committee Meeting on 3/12/14

Thatcher Brook Summary Data
Biddeford, Maine

		Lower Thatcher (17% IC)										below Richardson confluence					
Parameter	**standard and/or data info**	**Below Kohls** S-746 TH1	**Kohls trib** TH5A	**Above Kohls trib** TH5B Geomorph A3		**Below Kohls trib** Bacteria Site TH5C	**Aroma Joe's** TH5D					**Springbrook Dr.** Bacteria Site 6	**Geomorph C2**	**S-451**	**South Street** TH7	**Main Street** TB27	
Macroinvertebrates																	
DEP biomonitoring	Statistical model	Nonattainment (2012)												Attained (2000, 2005, 2010)			
2013 kicknetting	EPA score			see Table 2, 2013 Macroinvertebrate Metrics									see Table 2, 2013 Macroinvertebrate Metrics				
Habitat/Geomorph																	
RGA score	0-0.2 = in regime 0.21-0.4 = in transition >.4 = stressed			0.54									0.19				
RGA high parameters				aggradation, degradation, widening									widening				
EPA Habitat Score				105									110				
EPA Parameters < 10				pool variability, channel sinuosity, bank stability									epifaunal and pool substrate, channel sinuosity				
Substrate				>50% silt, clay, mud									80% silt, 20% cobble, boulder				
Bankful & wetted width (ft)		20', 11'	3', 3'	18', 14.5'									29', 26'				
Baseflow Water Depth		13 inches	10 inches	15 inches		10 inches						7 inches	12 inches				
Dissolved Oxygen																	
Early a.m.	7 mg/L																
	n	4	3	4										1	4	1	
	mean	5.92	7.07	6.75										8.24	8.12	6.63	
All D.O. Values	7 mg/L																
	n	4	10	8		15						5	2	7	9	1	
	min	4.9	5.01	6.16		5.5						5.71	6.47	6.7	7.38	6.63	
	max	8.61	8.18	9.62		9.67						8.17	6.7	8.7	9.85	6.63	
	mean	6.83	6.66	7.84		7.27						7.08	6.59	7.89	8.50	6.63	
Diurnal Swing (average)	2 mg/L sw	2.7 (sonde)	1.02 (one reading with 3.0 change)	0.72		0.83								-0.15	0.235	0.08	
Nutrients																	
Total Phosphorus	30 ppb		31^, 77^, 28^, 120^, 19**, 29****	22^, 32^, 61^, 38**, 23, 28****		25^, 48^, 22^, 79^, 35**, 22,	18**					36****		4, 27, 31, 33 , 25			
Total Nitrogen	0.71 mg/L													.3, .6, .5, .2			
Bacteria (E. coli)																	
instantaneous	236		579.4**	1413.6**		160, 152, 150, 162, 435, 219, 1413.6** , 298.7***	1046.2**					649, 131, 214, 152, 73, 99				548, 1120, 142, 348, 328, 148, 70, 70, 166, 140, 127, 166, 411, 161, 127	
geometric mean	64					196						165				199	
Conductivity	CCC -860 us/cm																
	n	4	9	12		19	1					5	2	5	8		
	min	367	736	364		157.8	1245					130	367	180	315		
	max	1410	1377	678		830						459	413	279	406		
	mean	670	951	458		458						291	390	224	359		
Temperature	> 25° C trout impacts																
	n	4	9	8		14						5	2	5	8	0	
	min	17.4	9	10.7		10.5						14.1	20.1	18.6	10.9	0	
	max	21.8	23.65	22.04		22.8						24.2	22.4	23.6	21.84	0	
	mean	19.88	17.64	16.53		18.10						19.86	21.25	20.88	16.86		
Metals																	
Aluminum																	
Iron	1000 CCC													792			
Lead	0.41 CCC																
Zinc	30.6 ug/L													2.7			
Chloride	230 mg/L		260****			130***, 150****											

* High values during baseflow conditions
^ Collected on 5/17/14 before and during a storm, ** Collected on 7/1/2014, ***Collected on 7/29/2014, ****Collection ed on 8/6/2014
Note: Draft data summary provided by MaineDEP on 3/6/14 and formatted by GZA on 3/7/14 for Thatcher Brook Technical Committee Meeting on 3/12/14

DO Average

	Richardson (13% IC)										
Dates	Eastern Trail Trib Bacteria Site 1	S-978, TH3, Geomorph B1 and Bacteria Site 7 Sterling Rope	TH4 and Geomorph B2 Biddeford Spur (above falls)	S-979 and TH2 Medical Center Dr.	TH8 Route 111	TH8A Ditch near Route 111	TH9 Biddeford Spur	TH10 Route 1	TH11 Iron Trail Road	TH12 Above Landry	Park and Ride
8/1/2000											
6/14/2001											
7/14/2004											
8/12/2004											
6/13/2005											
7/18/2005											
8/15/2005											
7/19/2010											
7/22/2010											
8/24/2010											
7/5/2012		6.75	5.11								6.45
7/25/2012		6.88		7.7							
8/21/2012		6.76		7.54							
9/17/2012		8.54		9.52							
8/1/2012		*sonde from 7/26/12 - 8/15/12	5.97	7.14							
8/1/2012			7.09	7.48							
9/13/2012			6.85	8.85							
9/13/2012			7.32	7.82							
9/14/2012			5.42	7.42							
9/14/2012			6.87	7.25							
9/25/2012			7.34	9.02							
9/25/2012			9.04	9.33							
5/29/2013											
6/13/2013											
7/8/2013											
7/16/2013	5.86	6.38									6.61
7/25/2013	6.79	7.17									8.07
8/1/2013		6.89	5.74	6.95							
8/8/2013	6.15	6.75									6.98
8/15/2013		7.22		7.12							
8/21/2013	2.31	6.39									6.16
9/17/2013	7.79	8.63									8.58
7/1/2014		6.53	5.53					5.35		6.07	6.39
7/29/2014											
8/6/2014		6.74	5.8		7.09	3.48	7.27	6.01	8.72	6.66	6.73
N	5	12	10	13	0	0	0	0	0	0	7
min	2.31	6.38	5.11	6.95	7.09	3.48	7.27	5.35	8.72	6.07	6.16
max	7.79	8.63	9.04	9.52	7.09	3.48	7.27	6.01	8.72	6.66	8.58
mean	5.8	7.0	6.5	7.9	7.1	3.5	7.3	5.7	8.7	6.4	7.0

	Upper Thatcher (6% IC) above Richardson confluence				
Dates	S-450 and Bacteria Site 5 Old Alfred Rd	Bacteria Site 2 Mountain Road	Easy Street Geomorph A2 (upstream end)	W-43 Wal-Mart wetland	TH6 Route 111
8/1/2000	7.3				
6/14/2001				7.38	
7/14/2004					
8/12/2004					
6/13/2005				5.9	
7/18/2005					
8/15/2005					
7/19/2010					
7/22/2010					
8/24/2010					
7/5/2012	5.83	5.76			
7/25/2012					
8/21/2012					
9/17/2012					
8/1/2012					4.79
8/1/2012					5.33
9/13/2012					3.59
9/13/2012					3.98
9/14/2012					3.15
9/14/2012					3.88
9/25/2012					4.96
9/25/2012					5.7
5/29/2013				6	
6/13/2013					
7/8/2013				2	
7/16/2013	5.11	2.3			
7/25/2013	6.74	4.5		4.04	
8/1/2013			6.28		
8/8/2013	6.24	3.36		2.87	
8/15/2013			5.77		
8/21/2013	5.4	3.78		1.12	
9/17/2013	8.13	6.69			
7/1/2014					
7/29/2014					
8/6/2014					
N	7	6	2	7	8
min	5.11	2.3	5.77	1.12	3.15
max	8.13	6.69	6.28	7.38	5.7
mean	6.4	4.4	6.0	4.2	4.4

	Lower Thatcher (17% IC) Richardson confluence								below	
Dates	S-746 and TH1 below Kohls	TH5A Kohls trib	TH5B above Kohls trib	TH5C & Bacteria Site below Kohls trib	TH5D Aroma Joe's	Springbrook Dr. Bacteria Site 6	Geomorph C2 (upstream end)	S-451	TH7 South Street	TB27 Main Street
8/1/2000								8.7		
6/14/2001										
7/14/2004	6.3									
8/12/2004	4.9									
6/13/2005										
7/18/2005								7.7		
8/15/2005								7.9		
7/19/2010								6.7		
7/22/2010								7.8		
8/24/2010								8.2		
7/5/2012		5.01		6.43				8.24	7.76	6.63
7/25/2012	7.51									
8/21/2012	8.61									
9/17/2012										
8/1/2012	*sonde from 7/26/12 - 8/15/12	5.35	6.16	5.77					7.38	
8/1/2012		6.69	7.26	7.01					7.86	
9/13/2012		7.38	8.33	8.22					9.41	
9/13/2012		6.82	8.47	8.62					9.3	
9/14/2012		5.94	6.73	6.59					7.94	
9/14/2012		6.23	7.64	7.45					8.4	
9/25/2012		8.05	8.47	8.34					8.64	
9/25/2012		8.18	9.62	9.67					9.85	
5/29/2013					7.7					
6/13/2013										
7/8/2013					5.5					
7/16/2013					7.68		5.71			
7/25/2013					6.98		7.38			
8/1/2013		6.93			6.95			6.47		
8/8/2013					6.16		7.21			
8/15/2013								6.7		
8/21/2013							6.91			
9/17/2013							8.17			
7/1/2014		7.31	6.13	6.58		6.38				
7/29/2014				6.82						
8/6/2014		6.53		6.7						
N	4	10	8	15	0	5	2	7	9	1
min	4.9	5.01	6.13	5.5	6.38	5.71	6.47	6.7	7.38	6.63
max	8.61	8.18	9.62	9.67	6.38	8.17	6.7	8.7	9.85	6.63
mean	6.8	6.7	7.6	7.2	6.4	7.1	6.6	7.9	8.5	6.6

	2012 sonde
n	1441
min	5.44
max	7.83
mean	6.55

Sonde (21 days)	
average min	5.9
average max	8.57

Provided by MaineDEP on 3/6/14

Conductivity

Dates	t											Richardson confluence					Lower Thatcher (17% IC)					below Richardson confluence			
	Eastern Trail Trib Bacteria Site 1	S-978, TH3, Geomorph B1 and Bacteria Site 7 Sterling Rope	TH4 and Geomorph B2 Biddeford Spur (above falls)	S-979 and TH2 Medical Center Dr.	TH8 Route111	TH8A Ditch Near Rt 111	TH9 Biddeford Spur	TH10 Route 1	TH11 Iron Trail Road	TH12 Above Landry	Park and Ride	S-450 and Bacteria Site 5 Old Alfred Rd	Bacteria Site 2 Mountain Road	Easy Street Geomorph A2 (upstream end)	W-43 Wal-Mart wetland	TH6 Route 111	S-746 and TH1 below Kohls	TH5A Kohls trib	TH5B above Kohls trib	TH5C & Bacteria Site below Kohls trib	TH5D Aroma Joe's	Springbrook Dr. Bacteria Site 6	Geomorph C2 (upstream end)	S-451	TH7 South Street
8/1/2000												293												279	
6/14/2001															246										
7/14/2004																	511								
8/12/2004																	1410								
6/13/2005															137										
7/18/2005																								180	
8/15/2005																								279	
7/22/2010																								197	
8/24/2010																								185	
7/25/2012		329		255													367								
8/21/2012		351		296													393								
9/17/2012		300		438																					
8/1/2012		*sonde from 7/26/12 - 8/15/12	335	384												540	*sonde from 7/26/12 - 8/15/12	793	533	559					325
8/1/2012			244	242												498		1003	379	403					376
9/13/2012			378	359												531		*	453	536					336
9/13/2012			343	194												541		*	452	541					392
9/14/2012			401	387												518		*	486	556					315
9/14/2012			197	409												246		*	496	267					329
9/25/2012			358	340												496		1377	415	489					406
9/25/2012			350	164												504		*	406	475					392
5/7/2013																		754	364						
5/29/2013															160					197					
6/13/2013																									
7/8/2013															189					254					
7/16/2013	65	275.4									210	285	80.7									267			
7/25/2013	41.4	179.3									103.9	154.7	50.1		140					157.8		167.4			
8/1/2013		384	193	195										157				930		367			413		
8/8/2013	58	448									530	398	62		172					530		432			
8/15/2013		388		164										186									367		
8/21/2013	74	496									418	538	141		194					418		459			
9/17/2013	37	150									94	126	43									130			
5/16/2014											494							736	399	445.3					
7/1/2014		527	370					2470		633	424							920	430	500	1245				
7/29/2014																				546					
8/6/2014		546	470.5		450	1900	447		534	678	532							1084		622					
8/13/2014																		965	678	830					
N	5	12	11	13	1	1	1	1	1	2	8	6	5	2	7	8	4	9	12	19	1	5	2	5	8
min	37	150	193	164	450	1900	447	2470	534	633	94	126	43	157	137	246	367	736	364	158	1245	130	367	180	315
max	74	546	471	438	450	1900	447	2470	534	678	532	538	141	186	246	541	1410	1377	678	830	1245	459	413	279	406
mean	55	364	331	294	450	1900	447	2470	534	656	351	299	75	172	177	484	670	951	458	458	1245	291	390	224	359

	2012 sonde
N	1441
min	127
max	393
mean	302

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Temp

	Richardson (13% IC)											Upper Thatcher (6% IC) above Richardson confluence					Lower Thatcher (17% IC)									below Richardson confluence
Dates	Eastern Trail Trib Bacteria Site 1	S-978, TH3, Geomorph B1 and Bacteria Site 7 Sterling Rope	TH4 and Geomorph B2 Biddeford Spur (above falls)	S-979 and TH2 Medical Center Dr.	TH8 Route 111	TH8A ditch (Near Rt 111)	TH9 Biddeford Spur	TH10 Route 1	TH11 Iron Trail Road	TH12 Above Landry	Park and Ride	S-450 and Bacteria Site 5 Old Alfred Rd	Bacteria Site 2 Mountain Road	Easy Street Geomorph A2 (upstream end)	W-43 Wal-Mart wetland	TH6 Route 111	S-746 and TH1 below Kohls	TH5A Kohls trib	TH5B above Kohls trib	TH5C below Kohls trib	TH5D Aroma Joe's	Springbrook Dr. SSATH19	Geomorph C2 (upstream end)	S-451	TH7 South Street	TB27 Main Street
8/1/2000												19.3												18.6		
6/14/2001															22.7											
7/14/2004																	17.4									
8/12/2004																	20.4									
6/13/2005															20.8											
7/18/2005																								23.6		
8/15/2005																								21.3		
7/22/2010																								22.2		
8/24/2010																								18.7		
7/25/2012		19.8		20.9													21.8									
8/21/2012		20.1		20.2													19.9									
9/17/2012		12.5		13																						
8/1/2012			19.79	19.7												20.7	*sonde from 7/26/12 - 8/15/12	20.28	20.07	20.17					19.82	
8/1/2012			21.85	21.56												23.08		23.65	22.04	22.18					21.84	
9/13/2012			14.5	14.7												12.8		12.9	14.6	14.6					14.9	
9/13/2012			18.8	16												18.8		21.4	17.4	18					18.7	
9/14/2012			15.5	16.4												14.3		13.9	15.9	15.8					15.8	
9/14/2012			19.8	17.1												20		21.6	18.4	18.8					19	
9/25/2012			10.7	11.4												8.5		9	10.7	10.5					10.9	
9/25/2012			13.6	12.2												14.1		17.7	13.1	13.2					13.9	
5/29/2013															14.5					14.2						
6/13/2013																										
7/8/2013															24.5					22.8						
7/16/2013	25.3	21.7									25	26.6	22.5									24.2				
7/25/2013	20.4	18.4									20	20.7	19.1		21.2					20.6		19.7				
8/1/2013		18.9	21.4	20.8										20.8				18.3		19.8			22.4			
8/8/2013	20.1	18.9									20.5	20.8	18.7		19.9					20.5		19.4				
8/15/2013		18.4		19.2										20.1									20.1			
8/21/2013	19.6	20.5									22.2	23.1	21.5		19.6					22.2		21.9				
9/17/2013	14.1	12.9									14.2	14.5	13.6									14.1				
5/16/2014											18.6							16.9	18.9	18.7						
7/1/2014		20.4	21.9					17.3		21.5	23.2							20	22.2	22.2	20.6					
7/29/2014																				20.7						
8/6/2014		20.2	20.7		21.3	19.8	20.9	19.6	21.6	20.7	20.6							20.1		20.3						
8/13/2014																			19.7							
N	5	12	11	13	1	1	1	2	1	2	8	6	5	2	7	8	4	12	11	18		5	2	5	8	0
min	14.1	12.5	10.7	11.4	21.3	19.8	20.9	17.3	21.6	20.7	14.2	14.5	13.6	20.1	14.5	8.5	17.4	9.0	10.7	10.5		14.1	20.1	18.6	10.9	0.0
max	25.3	21.7	21.9	21.6	21.3	19.8	20.9	19.6	21.6	21.5	25.0	26.6	22.5	20.8	24.5	23.1	21.8	23.7	22.2	22.8		24.2	22.4	23.6	21.8	0.0
mean	19.9	18.6	18.0	17.2	21.3	19.8	20.9	18.5	21.6	21.1	20.5	20.8	19.1	20.5	20.5	16.5	19.9	18.0	17.5	18.6		19.9	21.3	20.9	16.9	#DIV/0!

	2012 sonde
N	1441
min	16.9
max	25
mean	21.2

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Diurnal DO

Early a.m.

Dates	Richardson (13% IC)					Upper Thatcher (6% IC) above Richardson confluence				
	Eastern Trail Trib Bacteria Site 1	S-978, TH3, Geomorph B1 and Bacteria Site 7 Sterling Rope	TH4 and Geomorph B2 Biddeford Spur (above falls)	S-979 and TH2 Medical Center Dr.	Park and Ride	S-450 and Bacteria Site 5 Old Alfred Rd	Bacteria Site 2 Mountain Road	Easy Street Geomorph A2 (upstream end)	W-43 Wal-Mart wetland	TH6 Route 111
7/4/2012		6.75	5.11		6.45	5.83	5.76			
8/1/2012			5.97	7.14						4.79
9/13/2012			6.85	8.85						3.59
9/14/2012			5.42	7.42						3.15
9/25/2012*			7.34	9.02						4.96
N		1	4	3	1	1	1			3
min		6.75	5.11	7.14	6.45	5.83	5.76			3.15
max		6.75	7.34	9.02	6.45	5.83	5.76			4.96
mean		6.75	5.8375	7.803333	6.45	5.83	5.76			3.843333
Diurnal Swing										
7/4/2012		0.21	-3.9		0.8	-0.02	-0.26			
8/1/2012			1.12	0.34						0.54
9/13/2012			0.47	-1.03						0.39
9/14/2012			1.45	-0.17						0.73
9/25/2012			1.7	0.31						0.74
Average		0.21	-0.22	-0.29	0.80	-0.02	-0.26			0.55

Dates	Lower Thatcher (17% IC) below Richardson confluence								
	S-746 and TH1 below Kohls	TH5A Kohls trib	TH5B above Kohls trib	TH5C & Bacteria Site below Kohls trib	Springbrook Dr. Bacteria Site 6	Geomorph C2 (upstream end)	S-451	TH7 South Street	TB27 Main Street
7/4/2012		5.01		6.43			8.24	7.76	6.63
8/1/2012	sonde	5.35	6.16	5.77				7.38	
9/13/2012		7.38	8.33	8.22				9.41	
9/14/2012		5.94	6.73	6.59				7.94	
9/25/2012*		8.05	8.47	8.34				8.64	
N		4	3	4			1	4	1
min		5.01	6.16	5.77			8.24	7.38	6.63
max		8.05	8.47	8.34			8.24	9.41	6.63
mean		5.92	7.073333	6.7525			8.24	8.1225	6.63
Diurnal Swing									
7/4/2012	sonde high	3.02		0.82			-0.15	0.11	0.32
8/1/2012		1.34	1.1	1.24				0.48	0
9/13/2012		-0.56	0.14	0.4				-0.11	0
9/14/2012		0.29	0.91	0.86				0.46	0
9/25/2012		0.13	1.15	1.33				1.21	0
Average		1.02	0.72	0.83			-0.15	0.24	0.08

Afternoon

Dates	Richardson (13% IC)					Upper Thatcher (6% IC) above Richardson confluence				
	Eastern Trail Trib Bacteria Site 1	S-978, TH3, Geomorph B1 and Bacteria Site 7 Sterling Rope	TH4 and Geomorph B2 Biddeford Spur (above falls)	S-979 and TH2 Medical Center Dr.	Park and Ride	S-450 and Bacteria Site 5 Old Alfred Rd	Bacteria Site 2 Mountain Road	Easy Street Geomorph A2 (upstream end)	W-43 Wal-Mart wetland	TH6 Route 111
7/4/2012		6.96	1.21		7.25	5.81	5.5			
8/1/2012			7.09	7.48						5.33
9/13/2012			7.32	7.82						3.98
9/14/2012			6.87	7.25						3.88
9/25/2012*			9.04	9.33						5.7
N		1	5	4	1	1	1			4
min		6.96	1.21	7.25	7.25	5.81	5.5			3.88
max		6.96	9.04	9.33	7.25	5.81	5.5			5.7
mean		6.96	6.306	7.97	7.25	5.81	5.5			4.7225

Dates	Lower Thatcher (17% IC) below Richardson confluence								
	S-746 and TH1 below Kohls	TH5A Kohls trib	TH5B above Kohls trib	TH5C & Bacteria Site below Kohls trib	Springbrook Dr. Bacteria Site 6	Geomorph C2 (upstream end)	S-451	TH7 South Street	TB27 Main Street
7/4/2012		8.03		7.25			8.09	7.87	6.95
8/1/2012		6.69	7.26	7.01				7.86	
9/13/2012		6.82	8.47	8.62				9.3	
9/14/2012		6.23	7.64	7.45				8.4	
9/25/2012*		8.18	9.62	9.67				9.85	
N		5	4	5			1	5	1
min		6.23	7.26	7.01			8.09	7.86	6.95
max		8.18	9.62	9.67			8.09	9.85	6.95
mean		7.19	8.2475	8			8.09	8.656	6.95

*Did not include the 9/25/12 data in calculations. Very late in season and no longer worst condition

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APPENDIX C

CHLORIDE REGRESSION ANALYSIS

Long Creek Chloride – Conductivity Data with Thatcher Brook Data Overlay

Date	*Location*	*SpC (ms/cm)*	*Chloride (mg/L)*
7/29/14	*TH5A (Kohl's trib)*	*0.546*	*130*
8/6/14	*TH5C (mainstem)*	*0.622*	*150*
8/6/14	*TH5A (Kohl's trib)*	*1.084*	*260*

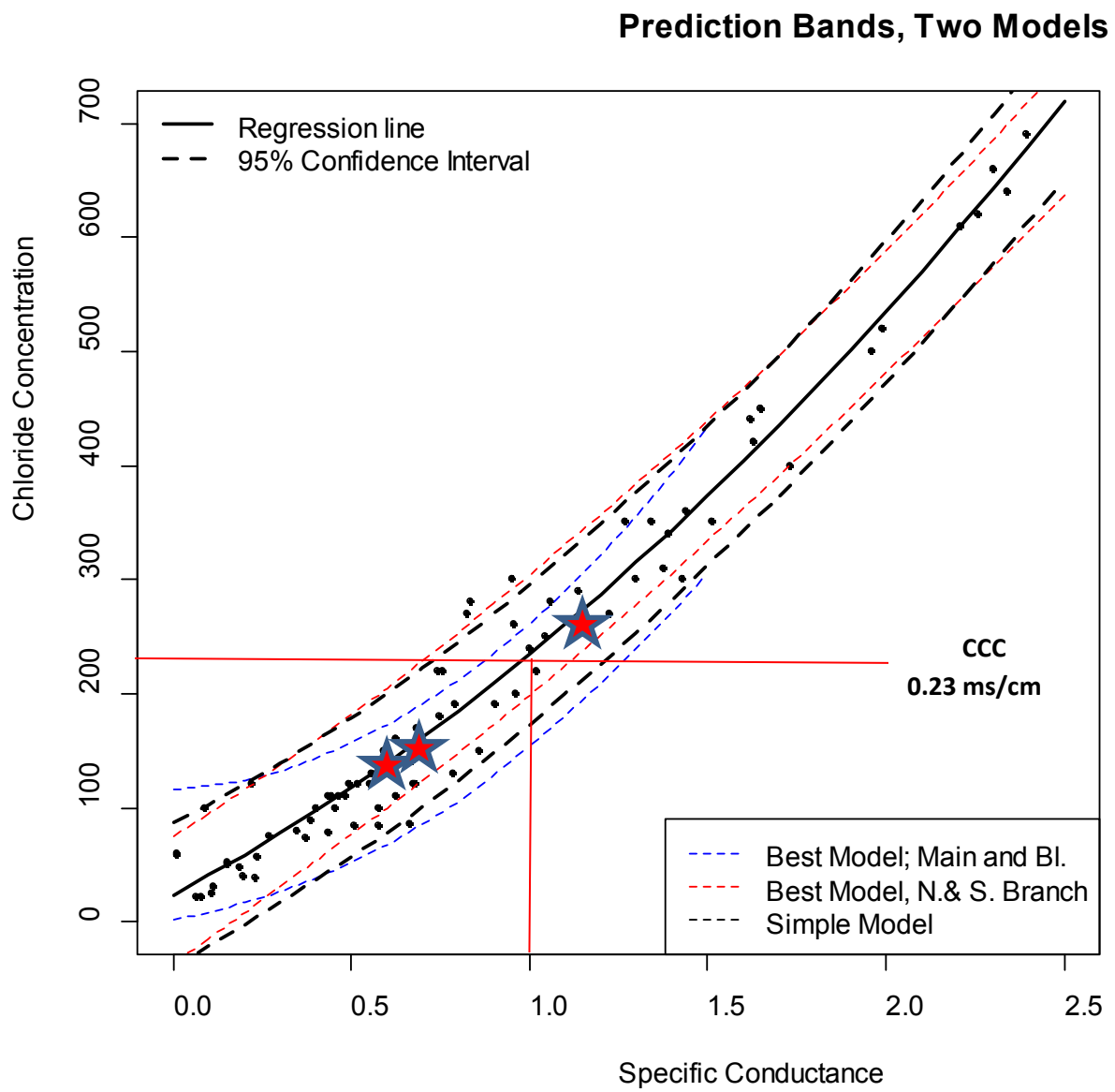
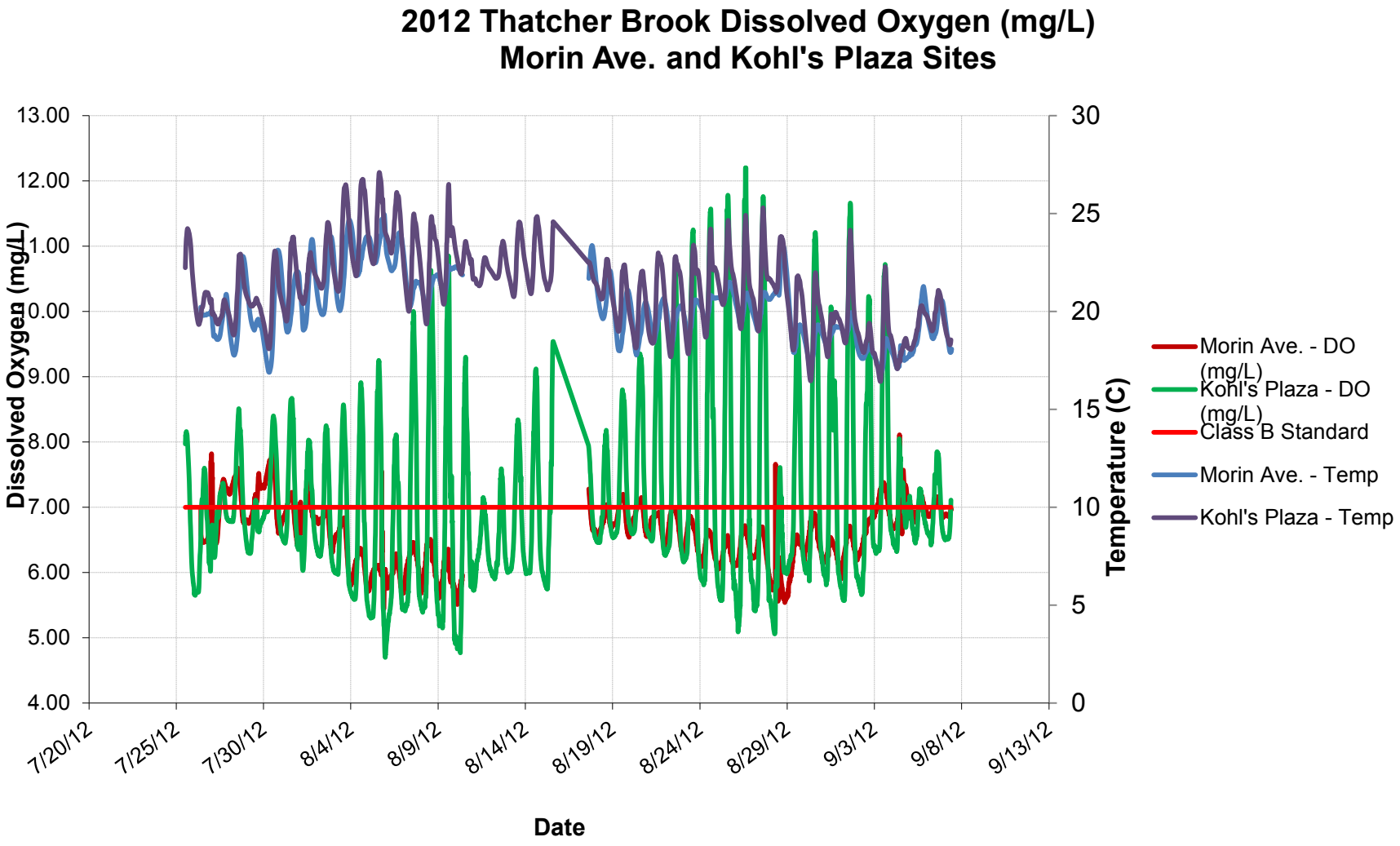
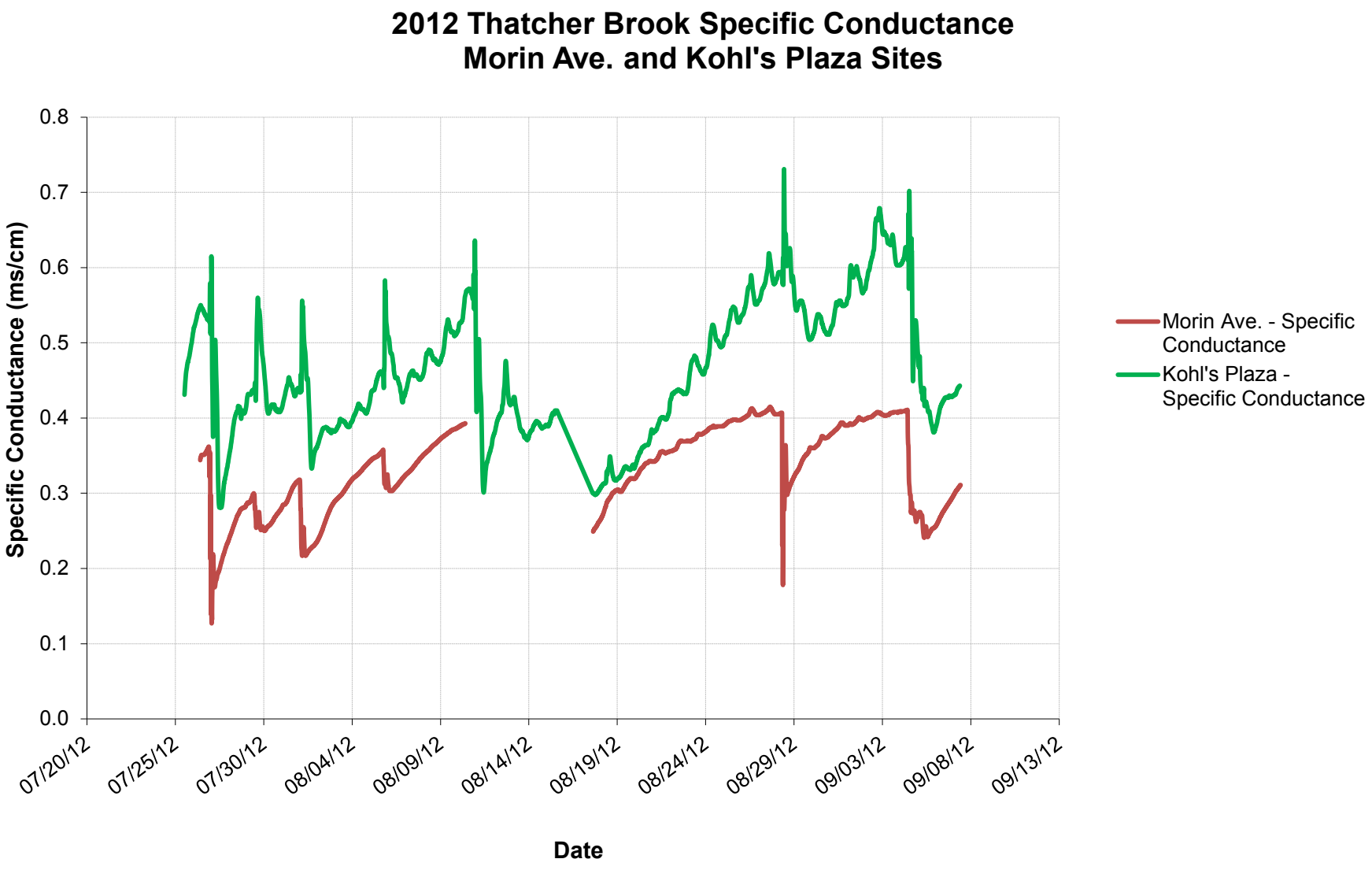


Figure 4: Comparison of prediction intervals between the best model (color) and a simpler alternative (black). About 95% of all observations are expected to fall within the prediction band shown. Differences are slight, suggesting there is little practical advantage to using the more complex model, even if it is somewhat better supported statistically.


2012 Thatcher Brook Dissolved Oxygen (mg/L)
Morin Ave. and Kohl's Plaza Sites
Dissolved Oxygen (mg/L)
13.00
12.00
11.00
10.00
9.00
8.00
7.00
6.00
5.00
4.00
Temperature (C)
30
25
20
15
10
5
0
7/20/12
7/25/12
7/30/12
8/4/12
8/9/12
8/14/12
8/19/12
8/24/12
8/29/12
9/3/12
9/8/12
9/13/12
Date
Morin Ave. - DO (mg/L)
Kohl's Plaza - DO (mg/L)
Class B Standard
Morin Ave. - Temp
Kohl's Plaza - Temp



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