Phillips Brook
Watershed

Management Plan

Cumberland County Soil & Water Conservation District

Prepared for the Town of Scarborough
February 2018

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Restoring Phillips Brook will also benefit Scarborough Marsh and Scarborough's beautiful beaches.

Nine Elements for Watershed-Based Plans

This Watershed Management Plan (WMP) incorporates the US Environmental Protection Agency's guidelines published in 2013, which require development of nine-element watershed-based plans for nonpoint source pollution (NPS) impaired waters prior to implementing projects using Clean Water Act section 319 funds. This table provides a listing of the nine required elements and the sections of this plan where each is addressed.

Required Plan Element		WMP Section
a	Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions	Section 5: Concerns for Watershed Health
b	An estimate of the load reductions expected from management measures	Section 6.1: Pollutant Load Reduction Targets
c	A description of the nonpoint source management measures that will need to be implemented to achieve load reductions and a description of the critical areas in which those measures will be needed	Section 6: Possible Solutions; Appendices A-F: Structural Solutions and Non-Structural Solutions Tables
d	Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan	Appendices A-F: Structural Solutions and Non-Structural Solutions Tables; Section 11: Funding Opportunities
e	An information and education component used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented	Section 6.3: Non-Structural Solutions: Education and Outreach; Section 9: Restoration Strategy and Timeline
f	Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious	Section 8: Restoration Strategy and Timeline
g	A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 10: Measures of Success and Interim Measurable Milestones
h	A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards	Section 9: Monitoring Plan; Section 10: Measures of Success and Interim Measurable Milestones
i	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above	Section 9: Monitoring Plan

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Acknowledgements

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Saltmarsh Sparrow (Audubon)
Phillips Brook flows into Scarborough Marsh, which is home to 43 endangered, threatened, rare, or declining species.

Executive Summary

Watershed Location

The Phillips Brook Watershed (Figure 1) covers 838 acres (1.3 square miles) in the Dunstan Corner area of Scarborough, Maine. A small portion of the upper watershed is within the neighboring community of Saco. The upper watershed is primarily forested land with some residential development. The lower watershed is primarily dominated by commercial development with more heavily traveled roads. The open water of Phillips Brook itself runs 2.77 miles from headwater wetlands through a residential area, across Broadturn Road and Payne Road, and then behind the commercial development along US Route 1 in Dunstan Corner before entering Scarborough Marsh northeast of Pine Point Road.

A **WATERSHED** is the land area that drains to a lake, river, stream, or other body of water.

The Dunstan area is a designated growth area in Town. The Dunstan Revitalization Strategy was developed in 2006 and was updated in 2014. The vision for the Dunstan area is to build upon the traditional 19th century down-town experience with clustered and attached housing and a variety of amenities, including commercial development, trail connectivity, and farmland preservation. In 2008, the area was re-zoned to allow mixed-use development and build-out analysis, based on available land area and redevelopment, estimates up to 400 new households and 150,000 square feet of additional commercial development.

Stream Water Quality & Habitat

Phillips Brook does not currently meet its designated Class C water quality standards for aquatic habitat use and dissolved oxygen and has been listed on the 303(d) list of impaired waters. In developing this watershed-based management plan, the causes for these impairments were investigated.

Reviewing all available information for the Phillips Brook Watershed, technical staff were able to identify one principal issue affecting watershed health: altered hydrology resulting in severe bank erosion and excessive sedimentation within the stream channel creating unsuitable habitat and further reducing already depleted dissolved oxygen.

Excessive sediment transport associated with flow alterations can be the result of decreased groundwater infiltration and increased amounts of and faster moving stormwater from existing and increasing impervious cover within the watershed. Undersized and misaligned culverts contribute to stream channel instability and alteration of flow. Where roads cross the stream channel, culverts restrict and alter the stream flow. These altered flows have resulted in severe bank erosion and the transportation of sediment from unstable banks to areas downstream. This is problematic for both habitat and water quality as the sediment aggraded downstream coats the natural stream bottom, directly damaging habitat and reducing dissolved oxygen by creating a smooth stream channel with little aeration.

Reestablishing stability and a natural flow regime in the Phillips Brook Watershed will help improve dissolved oxygen levels. However, it is critical to protect the system from further reductions in available dissolved oxygen in the future. Excess nutrients in a stream system can result in an overgrowth of algae, which would severely deplete available dissolved oxygen. A likely potential for increased nutrients in Phillips Brook would be improper fertilizer use and disposal of yard waste.

Impervious cover consists of any hardened surface such as roads, parking lots, driveways, sidewalks, and buildings which prevents rain water or snow melt from soaking into the ground, often causing it to discharge at higher rates into a nearby stream channel. Water quality and aquatic habitat can begin to show signs of stress when impervious cover in a watershed reaches 8-10% because of increased amounts of polluted stormwater runoff or snow melt related to increasing development. The current impervious cover for Phillips Brook is 9%. In 2005, the Maine Department of Environmental Protection (DEP) completed a Total Maximum Daily Load (TMDL) that used impervious cover as a surrogate of a suite of pollutants commonly found in urban stormwater runoff (Appendix I).

Heightened conductivity readings suggest that road salt in the watershed should be carefully monitored in the freshwater portion of the watershed and cautiously used to limit potential future effects on water quality. Increased chloride levels in freshwater streams, indicated by conductivity readings, can be the result of winter maintenance activities within the watershed. Road salt application results in chloride compounds running off into the water, which can be toxic to freshwater stream organisms. When chloride gets into the ground water supply it is especially damaging to stream health. In drier months, streams are primarily fed by ground water. If ground water is chloride loaded, it results in a higher concentration of the toxin in the water column since there is little dilution effect from rainwater.

Management Plan Goals

The overall purpose of this locally-supported, watershed-based plan is to identify specific actions needed to improve Phillips Brook's water quality and aquatic habitat to attain Class C standards. The specific actions identified herein address three goals identified by Phillips Brook Watershed stakeholders through the Phillips Brook Watershed Management Plan (WMP) development process:

- **Goal #1 - Restore water quality and stream habitat** to help ensure Phillips Brook meets its Class C state water quality standards
- **Goal #2 - Protect water quality and stream habitat** from potential degradation associated with future land use activities within the watershed
- **Goal #3 - Build and sustain community support** for the protection and restoration of the land and water resources of the Phillips Brook Watershed

Restoration and Protection Actions

This WMP outlines specific steps needed to achieve plan goals by reducing impacts and threats to water quality within the Phillips Brook Watershed. The ten-year plan (2019-2029) consists of five phases and includes plans for 17 structural solutions and six non-structural solutions. The structural solutions consist of stream crossing, in-stream restoration, and structural retrofit sites and are estimated to cost a total of $1.7 million. The non-structural solutions consist of education and outreach programs and policy, ordinance, and development standard reviews and have a total estimated cost of $15K.

The WMP, including the Restoration Strategy and Timeline (Section 8) and the Action Plan Table and Timeline (Appendix X) describe the actions in detail, which address these primary areas of focus:

- **Stream Crossing Sites** – Habitat and water quality degradation associated with improperly sized and/or placed roadway culverts will be addressed by pursuing culvert upgrade projects throughout the watershed. As funding and other project parameters allow, culverts will strive to meet standards, such as aquatic organism passage standards, that go above and beyond current requirements.
- **Stream Habitat Restoration** – Restoration efforts will be completed at stream bank erosion sites as detailed in the WMP Action Plan. These sites should be addressed concurrently with associated stream crossing improvement projects wherever possible, to ensure that in-stream work is protected from future damage at undersized or improperly sized culverts.
- **Stormwater Treatment and Impervious Cover Reduction** – Through non-structural solutions focusing on municipal ordinance language and design standards, the impact of impervious cover will be reduced. The effect of existing impervious can be minimized by requiring upgrades to stormwater management systems with redevelopment. The potential effects of new development can be minimized by holding stormwater planning and management to a higher, more protective standard than current practices.
- **Nutrient Reduction –** Redevelopment and new development will be encouraged to employ stormwater management practices such as vegetated filter strips and bioretention systems which directly address nutrient (i.e.,

phosphorus) inputs. Education and outreach efforts will help address residential nutrient sources.

- **Chloride Reduction** – Efforts to reduce chlorides will target municipal, state, commercial, and residential salt storage and application, and will include winter maintenance best management practice (BMP) training. The potential for groundwater contamination will be reduced by limiting the use of infiltration BMPs in areas with higher salt use.
- **Citizen Outreach** – A comprehensive education and outreach plan will be implemented throughout the watershed. YardScaping workshops and Snow Pro workshops will be held. Stream crossing or watershed improvement project signs will be considered to highlight sensitive areas and/or high-visibility projects.

Adaptive Management Strategies

Adaptive management is the process by which new information informs current practice; plans shift and adapt to meet needs that are subsequently better defined or newly discovered. An adaptive management approach is widely recommended for restoring urban watersheds (CWP, 2003) and is critical to ensuring plans stay current and relevant. The adaptive management approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short-time frame. 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.

ADAPTIVE MANAGEMENT incorporates new data, information, or technology into the Plan.

The Phillips Brook Workgroup, which is expected to include members of the steering, technical advisory, and outreach committees, will oversee plan implementation and will continue to engage the local community to ensure adaptive management strategies are employed.

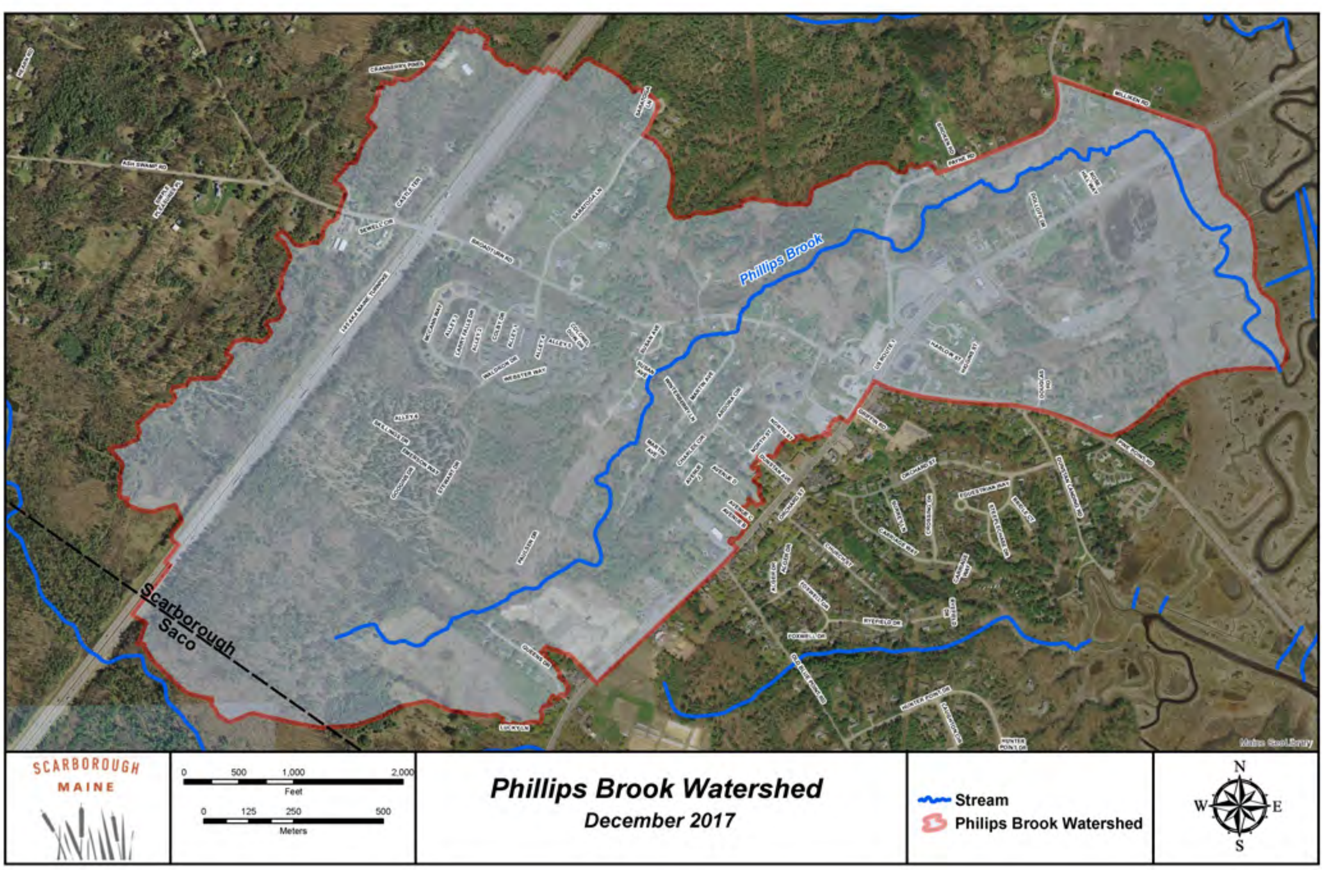


Figure 1. Phillips Brook Watershed

Funding Strategies

Phased implementation is expected to occur for many of the restoration projects identified in the plan. Many of the listed actions will be implemented by the Town of Scarborough and interested landowners. It is anticipated that some restoration efforts identified in this plan will be implemented using funding provided by the US Environmental Protection Agency (EPA) through Section 319 of the Clean Water Act as they are made available through the Maine DEP Non-Point Source program competitive process.

Project stakeholders recognize that grants alone cannot address the entire restoration process for Phillips Brook. The Town of Scarborough has identified development standards for new and redevelopment within the Phillips Brook Watershed which will, over time, help realize restoration goals. If milestones and goals are not met as anticipated, alternative funding sources will be explored due to the significantly higher levels of cost to implement large structural retrofits and stream crossing work.

1. Introduction

1.1 Watershed Management Planning

A watershed is an area that drains to a river, stream, or other body of water. The purpose of a Watershed Management Plan (WMP) is to evaluate a watershed that has shown signs of water quality impairments, document any sources of pollution, and provide a course of action to improve water quality.

The Phillips Brook WMP provides a holistic approach to management and restoration of the impaired waterbody. This WMP considers the unique conditions specific to the Phillips Brook Watershed and identifies suitable approaches to minimize future impacts to the brook due to human activities. Community stakeholders have played a critical role in plan development and the final plan reflects the community's goals for their watershed.

1.2 Plan Development

This WMP was developed over the course of two years (2015 – 2017) through a collaborative effort involving many local stakeholders. A Steering Committee was formed at the outset of the planning process and helped to guide efforts and assist with data collection, public involvement, and overall plan development. Steering Committee members divided into two subcommittees to allow more in-depth involvement with two major plan components. The Technical Advisory Committee (TAC) formed to collect and interpret biological and abiotic data evaluating stream health. The Outreach Committee formed to ensure local stakeholders and the public were widely engaged in the planning process.

Three public meetings were held during plan development and involved local residents, business owners, developers, regulators, and municipal board members. Management strategies suitable for the Town of Scarborough were selected and may be implemented in the future to address known issues in the watershed. This WMP incorporates the Environmental Protection Agency (EPA) guidelines published in 2013, which require development of nine-element watershed based plans for NPS-impaired waters prior to implementing projects using Clean Water Act section 319 funds.

1.3 Intended Audience

Any group that influences or is affected by water quality, habitat management, and land use decisions in the Phillips Brook Watershed would benefit from reading this report. Land owners and local groups in and around the Phillips Brook Watershed should use this plan as the foundation for local action and stream restoration. The Maine Department of Environmental Protection (DEP) and the EPA can use this plan to enhance their understanding of local watershed conditions and as a basis for future grant funding and other planning purposes.

2. Physical and Natural Features

2.1 Hydrology

Surface Water

The mainstem of Phillips Brook is 2.8 miles long, includes freshwater and tidal sections, and has a watershed of 838 acres. Phillips Brook originates in forested wetlands in the south of the Town of Scarborough and a small portion of the City of Saco. It then flows through a residential area in the Dunstan Corner neighborhood, then across Broadturn Road and Payne Road to the commercial development along US Route 1. Phillips Brook ultimately discharges to Scarborough Marsh northeast of Pine Point Road.

Phillips Brook is a low-gradient coastal stream with substrate consistent with its glaciomarine origins. The upper watershed is primarily evergreen and deciduous forest cover before flowing into areas of developed open space, pasture/hayland, and into the medium to high intensity residential and commercial development of the Route 1 commercial corridor. Portions of the stream in the lower watershed have been channelized in the past, resulting in sections of straightened, over-widened channel.

> Groundwater recharge area protection is critical to restoring and maintaining water quality within Phillips Brook and its tributaries.

Phillips Brook main stem is fed by two tributaries, referred to herein as the Dunstan Tributary and the Saratoga Tributary. The Dunstan Tributary flows southeasterly from the Webster Way section of the Dunstan Corner development to its confluence with the Phillips Brook main stem near the end of Susan Avenue. The Saratoga Tributary originates north of

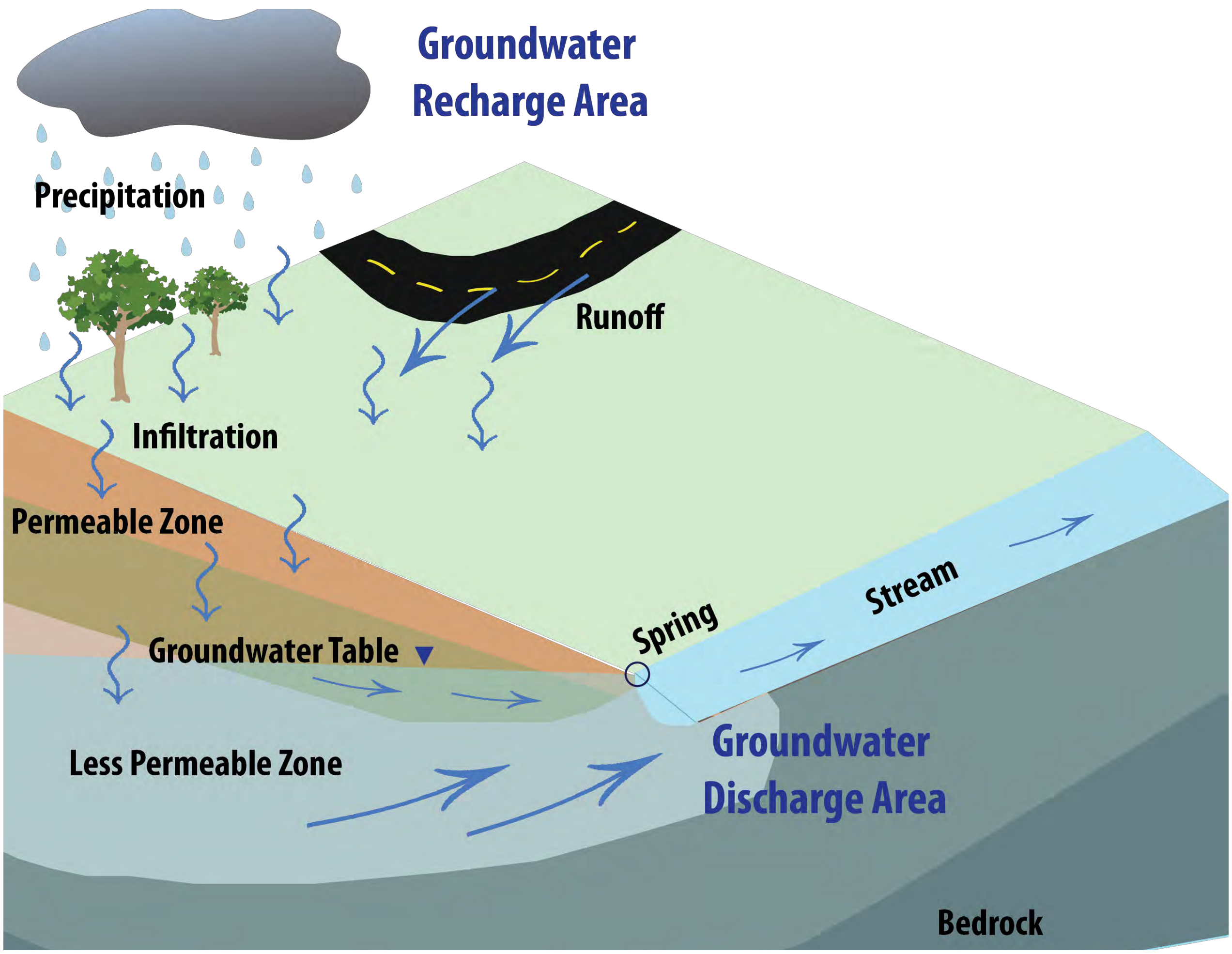


Figure 2. Groundwater Flow

the Maine Turnpike, Route 95, and flows southeasterly under Saratoga Lane, entering the main stem between Broadturn and Payne Roads.

Groundwater Resources

The Maine Geological Survey has not identified any significant sand and gravel aquifers within the Phillips Brook Watershed, and there is no current or anticipated future drinking water exploration within the watershed. Scarborough residents receive drinking water from Portland Water District, which sources its water from Sebago Lake in western Cumberland County.

In order to properly evaluate and protect surface water within the Phillips Brook Watershed, groundwater and subsurface hydraulic conditions must be considered. Groundwater and surface water interact in both recharge and discharge areas within the watershed (Figure 2). Groundwater recharge area protection is critical to restoring and maintaining water quality within Phillips Brook and its tributaries.

In general, groundwater recharge areas are located in the topographic high 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 Phillips Brook Watershed, groundwater recharge areas are assumed to be located southeast of the brook from Lucky Lane to Dunstan Avenue and north of the brook along US Route 95. Soils in these areas are outwash deposits of sand and gravel, which are more permeable than surrounding soils. A spring was observed adjacent to Martin Avenue, confirming groundwater recharge occurring from the zone southeast of the brook.

2.2 Topography and Soils

The topography of the Phillips Brook Watershed is that of a low-gradient stream. Elevations range from 80 feet in the upper watershed to 20 feet where the stream channel meets the Scarborough Marsh. There is one area of topographic interest east of Payne Road, where the stream channel drops 10 to 12 feet via a ledge outcrop waterfall.

Figure 3. Outcrop waterfall east of Payne Road

There is a wide diversity of soil types in the watershed with one dominant and two sub-dominant major soil series: Lamoine (~26% of total watershed area); Scantic (~10% of total watershed area); and Windsor (~15% of total watershed area).

The Lamoine series, formerly classified as Buxton, is a relatively deep and somewhat poorly drained soil with slopes of 3 to 8 percent. Parent material consists of fine glaciomarine deposits and it has a restrictive layer at greater than 60 inches. The Scantic series is a poorly drained soil with slopes of 0 to 3 percent. Parent material consists of glaciomarine deposits with a moderate restrictive layer at 60 inches. The Windsor is an excessively drained soil with varied slopes of 0 to 8 percent. Parent material consists of loose sandy glaciofluvial deposits with a restrictive layer greater than 60 inches.

The soil types in the watershed have a strong influence on the stream environment and its ability to support its designated uses in the face of external stressors. The watershed's soils allow for groundwater recharge into the stream and support stabilizing vegetation along the stream and within the floodplain. The soils along the Phillips Brook stream channel tend to be moderately to highly erodible and therefore are likely to enter the stream channel in disturbed conditions.

2.3 Surficial Geology

The 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 type in the watershed is the Presumpscot Formation, a fine-grained glaciomarine deposit with minor deposit 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 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. The watershed also has areas of marine regressive sand deposits southeast of the stream, which are coarser deposits left behind when the sea retreated from the coastal zone. As expected with this range in surficial geology, Phillips 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.

2.4 Climate

The Town of Scarborough is considered a humid continental climate according to the Köppen classification system, which indicates large seasonal temperature differences. Scarborough has an average low temperature of 13.2 degrees Fahrenheit in the winter to an average high of 78.1 degrees Fahrenheit in the summer months. While the annual average precipitation is 47.6 inches and the average yearly snowfall is approximately 64.4 inches, impacts of changing climate patterns will likely result in more intense weather events.

2.5 Habitat and Ecosystems

The riparian corridor along Phillips Brook is a unique ecosystem providing multiple environmental benefits, including reduction of nonpoint source pollution; providing food supply and cover to a wide variety of local wildlife; and reducing impacts of flood waters. Riparian habitat is widely protected and revered for its critical environmental niche.

Rare and Endangered Species

Birds

The Phillips Brook Watershed contains a small portion of Least Bittern (*Ixobrychus exilis*) habitat that is primarily associated with Scarborough Marsh. The habitat for this endangered species extends to include the tidal portion of the Phillips Brook Watershed. The Scarborough Marsh, to which Phillips Brook drains, also provides habitat for a species of special concern, the Saltmarsh Sparrow (*Ammodramus caudacutus*).

Figure 4. Least Bittern, USFWS

Mammals

The Scarborough Marsh, to which Phillips Brook drains, also provides habitat for the endangered New England Cottontail (*Sylvilagus transitionalis*).

Figure 5. New England Cottontail, USFWS

Fish

White suckers (*Catostomus commersonii*) and American eel (*Anguilla rostrata*) have been documented in Phillips Brook by Maine Department of Inland Fisheries and Wildlife (IFW). Brook Trout (*Salvelinus fontinalis*), present in neighboring streams, have not yet been documented in Phillips Brook but Maine IFW is planning upstream sampling to determine if they are present in the system.

Invasive Plants

Invasive plant species are non-native plants that are able to establish on many sites, grow quickly, and spread to the point of disrupting plant communities or ecosystems. All restoration activities within the watershed should consider invasive species management as part of the project. Invasive plant species were observed in the Phillips Brook Watershed, including but not limited to:

- Japanese knotweed (*Fallopia japonica*)
- Multiflora rose (*Rosa multiflora)*
- Common reed (*Phragmites australis*)
- Asiatic bittersweet (*Celastrus orbiculate*)

3. Population Characteristics and Land Use

3.1 Demographics

Scarborough is a town with approximately 20,000 residents as of 2017 data (Table 1). The total area of the Town is 70.6 square miles with a land area of 47.6 square miles. Scarborough is a suburb of the City of Portland and shares borders with Old Orchard Beach, Saco, Buxton, Gorham, Westbrook, South Portland, and Cape Elizabeth. One of the fastest growing communities in Maine, Scarborough is home to four popular sand beaches: Pine Point, Ferry Beach, Higgins Beach, and Scarborough Beach. The largest salt marsh in Maine is the Scarborough Marsh, which provides critical habitat for many threatened and endangered species. The marsh is roughly 3,200 acres, which provides many local and regional ecological benefits.

3.2 Historical Land Uses

Prior to European settlement, the area now known as Scarborough was inhabited by Sokokis Indians, who relied on the marsh for a steady supply of fish, shellfish, and wildlife. Land cover in the upper Phillips Brook Watershed consisted primarily of densely forested areas with the lower watershed transitioning to marshland. Fish and fur trading gave rise to European settlement in the 17th and 18th centuries. With settlement, forested land was converted to sparse habitations with small subsistence farms. Scarborough landowners along the marsh were sustained by the sale of salt marsh hay, resulting in dike and channel creation to increase productivity. By the early 1800s, the Cumberland Turnpike (now Route 1) was constructed to connect Dunstan to Portland. Construction of the Eastern Railroad in 1842 helped facilitate continued residential development in Scarborough. With the opening of the Maine Turnpike in 1948, population growth rose exponentially. Commercial development proliferated and supported heavy residential development through the 20th century.

3.3 Current Land Uses

Today, there is a mix of land use types in the Phillips Brook Watershed (Figure 5). The upper watershed still features large tracts of undeveloped forested land with intermittent residential development. There is considerable commercial development in the lower watershed along Route 1, which is the main commercial corridor through Town. A restaurant that opened within the tidal portion of the watershed in 1957, has an overboard discharge license, allowing discharge of sanitary wastewater into Phillips Brook, from the State.

Table 1. Population Demographics of the Town of Scarborough, 2017

Town	2017 Population	Population Aged 0-24	Population Aged 25-64	Population Aged 65+	Median Household Income	Per Capita Income
Scarborough	20,104	27.5%	51.5%	24.2%	$82,543	$44,747

Table 2. Development Summary

Development Type	Buildings & Pavement	Acres	Percent of Watershed
Low Intensity	20-49%	45	7%
Medium Intensity	50-79%	26	4%
High Intensity	80-100%	20	3%

Watershed properties include a mix of municipal sewer and private septic systems. A commercial business Table 2 summarizes the development intensity in the watershed. Most of the low intensity development occurs in the upper watershed and consists mainly of residences. The majority of high intensity development consists mainly of public roads and commercial land uses mostly located in the lower watershed.

Forested areas in the Phillips Brook Watershed are presently the most prevalent land cover type and comprise approximately 417 acres (or 64%) of the watershed. Wetlands interspersed throughout the watershed cover approximately 78 acres (or 12%) of the watershed. Hayfields, which occupy about 52 acres (or 8%) of the watershed, are located in the headwaters west of Queen Drive.

3.4 Future Land Use

The Dunstan area of Scarborough, which is encompassed by the Phillips Brook Watershed, is a designated growth area in Town. The Dunstan Revitalization Strategy was developed in 2006 and updated in 2014. The vision for the Dunstan area is to build upon the traditional 19th century downtown experience with clustered and attached housing and a variety of amenities, including commercial development, trail connectivity, and farmland preservation. In 2008, the area was re-zoned to allow mixed-use development. The build-out analysis based on available land area and redevelopment is estimated to be up to 400 new households and 150,000 square feet of additional commercial development.

The most extensive approved, undeveloped project in the watershed is Dunstan Crossing. The first phases of development have been completed, consisting of residential uses, and construction of the subsequent phases of development continues with commercial mixed-use buildings along Route 1. In addition to the approved Dunstan Crossing development, there are additional large tracts of

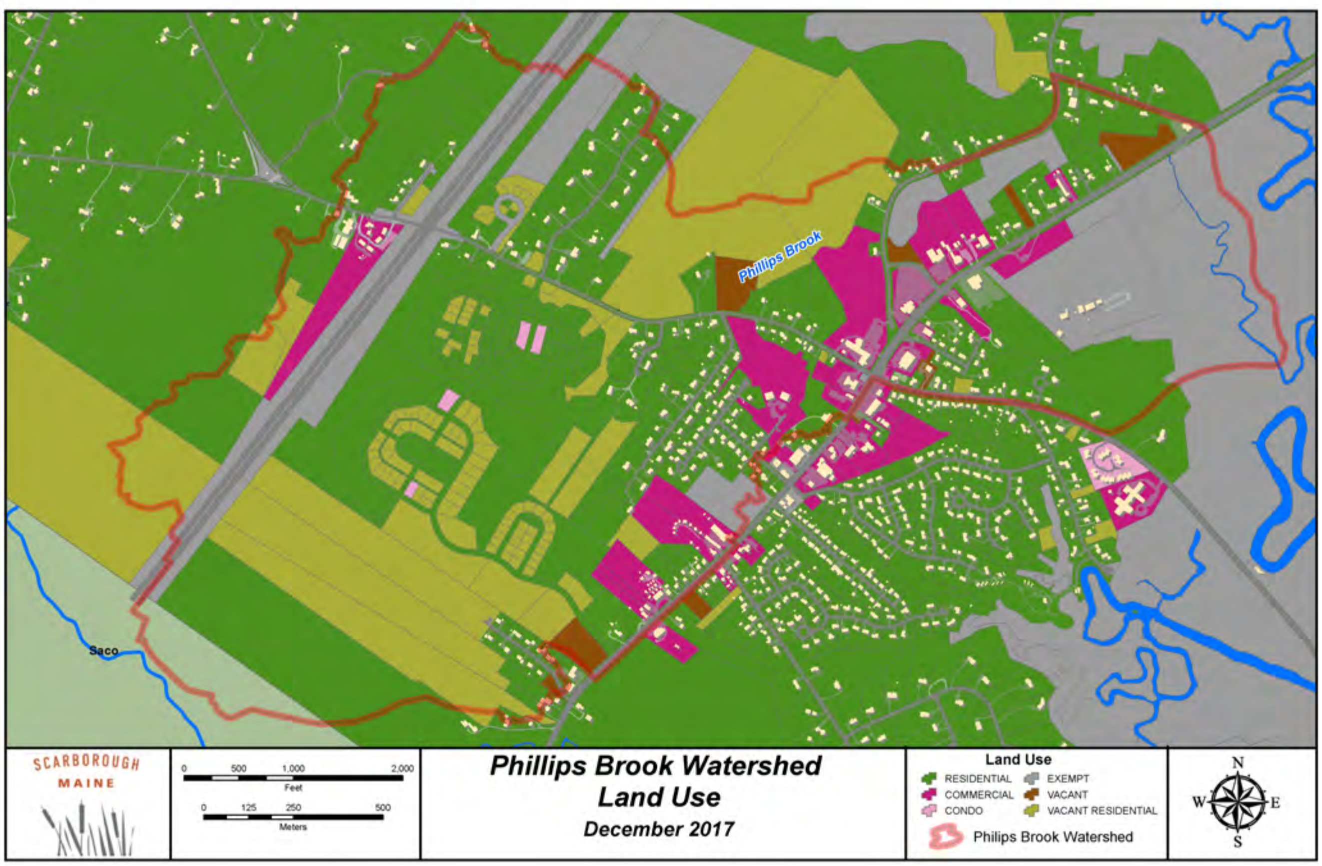


Figure 6. Phillips Brook Watershed land use

land under single-ownership which have been of interest to developers.

3.5 Land Use Effects on Phillips Brook

Over the past few decades, extensive research has established a very strong relationship between development intensity and adverse impacts to water resources. Beyond a certain critical threshold, landscape conversion from natural areas to more highly developed human land uses generally results in a deterioration of water quality and aquatic habitat. One of the primary drivers for this degradation is impervious cover (IC), which consists of any hardened surface that prevents rain water or snow melt from soaking into the ground prior to connecting to the surface waters. Common examples of IC include roads, parking lots, driveways, sidewalks and buildings. The types of pollutants that can be picked up from these surfaces during rain and snow melt events and carried to nearby surface waters include petroleum products, weed and bug killers, fertilizers, bacteria, and soil, among many others (Figure 6). Water quality and aquatic habitat can begin to show signs of stress when IC in a watershed reaches 8-10% because of increased

> Areas with **IMPERVIOUS COVER (IC)** do not allow water to soak into the ground. These areas include roads, parking lots, sidewalks, and rooftops.

Figure 7. Many common activities can contribute pollutants to Phillips Brook

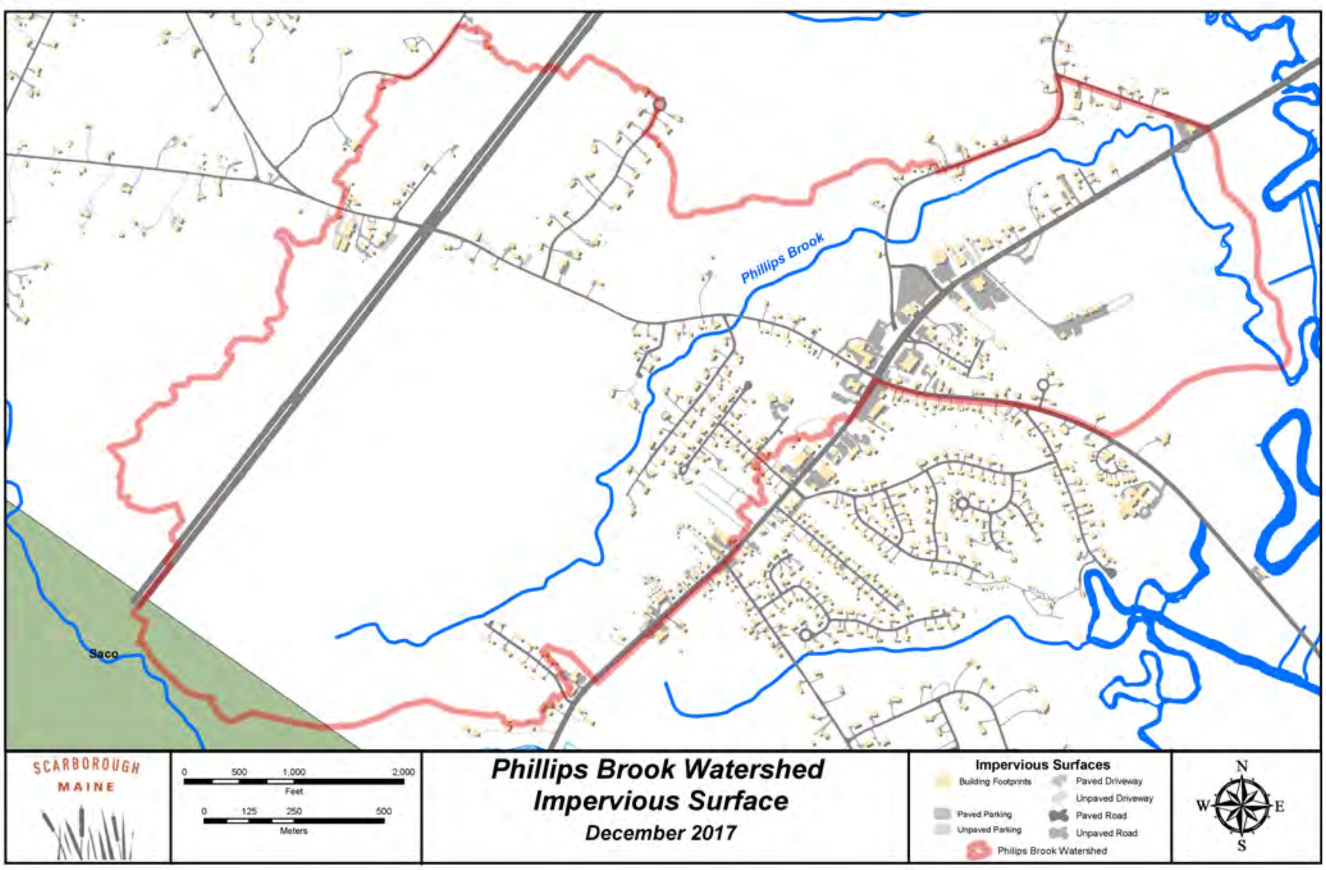


Figure 8. Phillips Brook Watershed impervious cover

amounts of polluted stormwater runoff or snow melt related to increasing development.

The current IC for Phillips Brook is 9% (Figure 7). Since the Phillips Brook Watershed is poised for considerable additional development, a variety of strategies can be employed to minimize the amount of pollutants generated from future and existing land uses. These strategies will be discussed in greater detail below, but for the most part they generally consist of reducing the amount of concentrated runoff and pollutants generated at the source and creating landscape features that allow developed areas to mimic the natural functions of undeveloped areas. For example, a homeowner might use less (or no) weed killer on a residential lawn and establish a vegetated buffer between the lawn and an adjacent stream or drainage way. Areas intended for future development or redevelopment also represent potential threats to water quality and aquatic habitat. State and local regulations now require that many new development / redevelopment projects must be designed to maintain pre-development conditions for the amount of pollutants and stormwater runoff generated from a particular project site. Ultimately, how and where landscape alterations occur is critically important for water resource protection.

Figure 9. Road salt is becoming a concern in freshwater streams like Phillips Brook because of its impact on stream life.

3.6 Transportation Infrastructure

Public roads represent a significant proportion of IC in the Phillips Brook Watershed. They are also an essential component of the built environment and closely linked to adjacent land use development patterns. Much of the polluted stormwater runoff generated in the watershed is conveyed along transportation corridors, either through underground stormwater systems or roadside ditches. Public roads can also be a source of pollutants from vehicles (e.g., petroleum products, heavy metals, etc.) and winter maintenance activities (e.g., road salt and sand). There is a rough correspondence between traffic volumes and the amount of pollutants potentially generated from public roads. Increases in traffic volumes also increase the likelihood of pollutants from vehicles and winter maintenance activities. Road salt is becoming a particular concern in freshwater streams due to its adverse impacts on aquatic organisms. Heavily traveled roads generally receive more salt applications to meet public expectations for safety and driveability in the winter.

There are currently just over 6.15 miles of public roads in the Phillips Brook Watershed and approximately 3.8% of them have relatively low traffic volumes (less than 10,000 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). New development and redevelopment in the region will potentially increase the amount of traffic on the roads that traverse the watershed.

In addition to winter maintenance activities on the area roadways, the Town is responsible for maintaining all of the public roads in Town. These maintenance activities include:

- Street sweeping and catch basin cleaning
- Minor road surface repair
- Underground drainage infrastructure repair
- Surface drainage repair and maintenance (ditching)
- Signage and pavement markings
- Traffic signal repair and maintenance
- Road side grass and weed control

Table 3. Maine Class C Streams, Designated Uses, and Criteria

Designated Uses	Numeric Criteria	Habitat Narrative Criteria	Aquatic Life (Biological) Narrative Criteria
Aquatic Life; Drinking Water; Fishing; Recreation; Navigation, Hydropower; Industrial Discharge	Dissolved Oxygen 5 ppm and 60% saturation E. coli 126/100 ml (g.m.*) or 236/100 ml (inst.*)	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community. **
* "g.m." means geometric mean and "inst." means instantaneous level **Determined using numeric bicriteria through DEP's Biological Monitoring Program			

Many of these activities can help control and reduce the amount of pollutants in stormwater. Routine street sweeping and catch basin cleaning are of particular importance in removing the pollutants that accumulate on public roads and in the stormwater piping systems before these materials reach nearby surface waters.

4. Watershed Analysis and Stream Monitoring

4.1 Stream Class and Criteria

The Maine Legislature (Title 38 MRSA 464-468) established water quality classification standards for all surface waters in the State of Maine, which provide water quality goals and criteria for classified waters. Although all water bodies must meet fishable and swimmable goals in the Federal Clean Water Act, four classes of freshwater streams (AA, A, B and C) have been established to reflect differences in risk. This ranges from Class AA streams, which are in the most natural condition and highest water quality criteria, to Class C streams, which are still good quality but have a higher risk of degradation.

Phillips Brook is designated Class C by the DEP (MRSA Title 38, Chapter 3). Class C streams must support aquatic life and allow for other designated uses such as drinking water, fishing and recreation. In addition, Class C streams must meet specific criteria for dissolved oxygen (DO), bacteria, habitat, and aquatic life.

According to the Integrated Water Quality Monitoring and Assessment Report (DEP, 2010), Phillips Brook does not meet Class C designated uses and criteria. Specifically, it is listed as impaired because it does not provide for aquatic life based on habitat and dissolved oxygen. The

Table 4. Assessments Conducted in the Phillips Brook Watershed

Assessment Type	Completed By	Date
Aquatic Macroinvertebrate Assessment	DEP	2010, 2015, 2016
Comprehensive Stream Corridor Assessment	CCSWCD, DEP, Town of Scarborough	2016
Water Quality Assessment	DEP, Town of Scarborough	2006, 2010, 2016, 2017

Table 5. Summary of Macroinvertebrate Assessments in the Phillips Brook Watershed

Year	S 953 (Payne Rd)	S 1066 (Broadturn Rd)	(Susan Ave)
2010	Indeterminate	Not sampled	Not sampled
2015	Met standards	Met standards	Not sampled
2016	Indeterminate	Met standards	Non-attaining

following table summarizes the Water Quality standards that are applicable to Phillips Brook.

Over the past several years, several assessments have been conducted in the Phillips Brook Watershed. Table 4 provides a list of the assessments conducted to inform this WMP.

4.2 Aquatic Macroinvertebrate Assessment

AQUATIC MACROINVERTEBRATES are insects that live in water.

DEP's Biological Monitoring Program (also known as the Biomonitoring Program) collects and analyzes aquatic macroinvertebrate samples from Maine's rivers and streams. The Program uses a statistical model to determine if rivers and streams are meeting the aquatic life criteria associated with their assigned legislative water quality classification (described in section 4.1).

In 2010, Maine DEP lead a biomonitoring effort in Phillips Brook. While there was diversity of organisms in the samples, there weren't enough macroinvertebrates to determine stream health. In 2015, Phillips Brook was again sampled, and while more macroinvertebrates were found, the overall diversity was lower than what was found in 2010. This indicates a stream under stress.

4.3 Comprehensive Stream Corridor Assessment

Fluvial geomorphology is the study, assessment, and classification of the shape and stability of stream systems. Fluvial geomorphology uses a classification system of different stream types and information about land uses within the watershed to evaluate stream system stability. Although all streams change over time, human disturbance can destabilize the natural equilibrium in stream systems. In-stream and bank erosion can increase dramatically with significant increases in the stream flow (by increasing impervious surfaces and runoff) or increases in the amount of sediment reaching the stream. This instability also directly affects stream habitat conditions. In addition, past alterations to stream channels (e.g., straightening and widening) can slow down stream flow, which can also impact stream habitat and dissolved oxygen (DO) levels.

FLUVIAL GEOMORPHOLOGY is the study of the shape and stability of stream systems.

In 2016, a fluvial geomorphic assessment was conducted in Phillips Brook by CCSWCD, DEP, and the Town of Scarborough. The fluvial geomorphic assessment surveyed the brook from its headwaters to its tidal water influence (approximately 7,500 feet). A reconnaissance-level assessment (Level I) bank erosion study was performed to estimate erosion rates along the entire 7,500 feet of brook. A more detailed survey (Level II) was completed within 380 feet of an unstable section of the upper part of the brook. This Level II survey included a longitudinal profile and several cross-section profiles, as well as setting of bank pins and scour chains for future analysis. The Bank Assessment for Non-Point Source Consequences of Sediment (BANCS) method was used to predict stream erosion rates for the entire brook. The assessment divided the brook into 34 separate study areas based on their bank erosion rate prediction. An overall estimate of erosion was then calculated by multiplying the length and height of each bank type by the specific bank erosion term, and then summing the estimates of erosion.

The survey found reaches of Phillips Brook which are in a state of accelerated bank erosion. The instream analysis revealed that many of the extreme and very high bank erosion rates were located upstream of point bars on the inside banks. Point bars are a sign of active channel migration and horizontal instability which develop in the stream's effort to reduce the width/depth ratio, reduce slope and eventually develop a stable stream type. The highest bank erosion rates were just downstream of culvert crossings and downstream of the Dunstan tributary confluence (Figure 10).

An estimated 0.7 tons/year/foot or a cumulative 83 tons/year of sediment are being transported from the surveyed reaches to the Scarborough Marsh (Figure 11). The quantity of sediment being distributed into the stream is currently filling in the stream bed gravels which results in macro-invertebrate habitat loss. The assessment found that culverts and stormwater infrastructure are contributing to the instability, mainly due to the changes made to the way rainfall historically infiltrated the watershed versus how current stormwater runoff intensity, duration, and frequency discharge to the stream. For more detail on the survey methods and results, see the report “A Study of Bank Erosion Rates in Phillips Brook: Headwater to Tidal Reaches (CCSWCD, 2017)” in Appendix G.

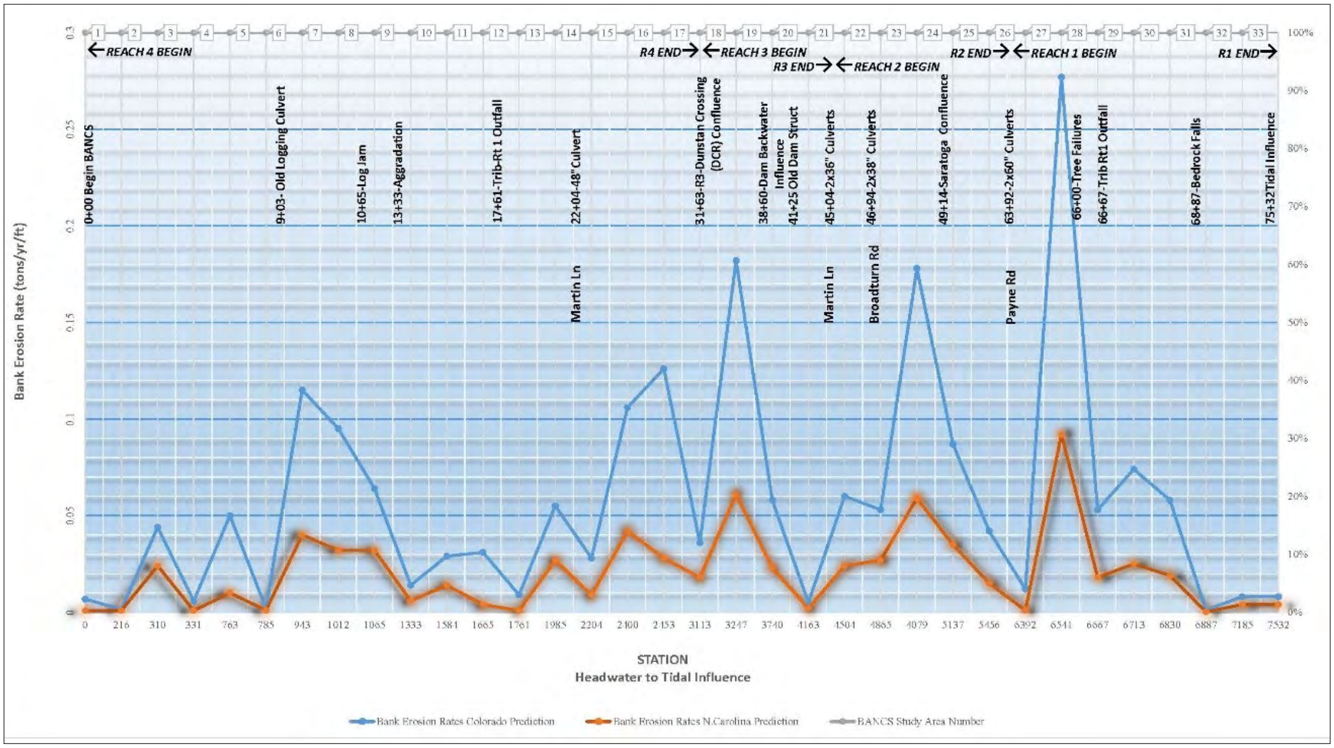


Figure 10: Phillips Brook bank erosion rate prediction from headwaters to the tidally influenced area.

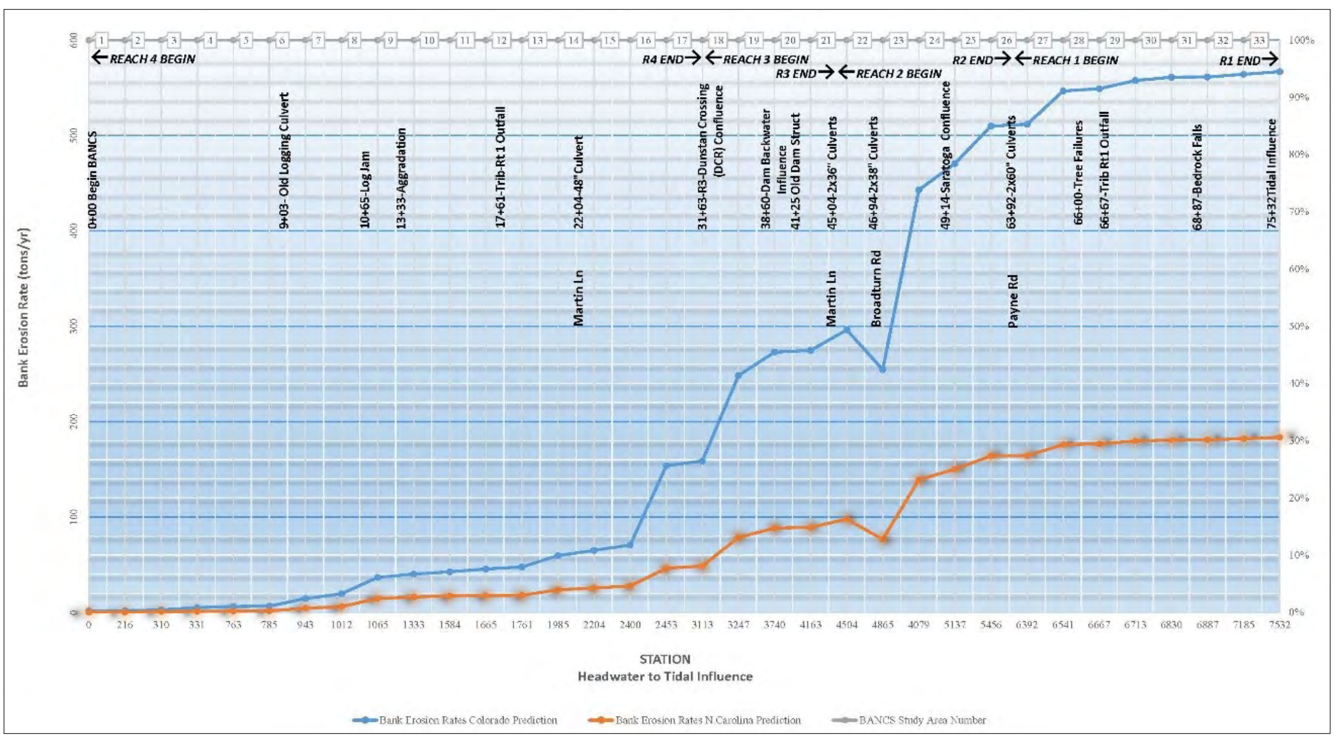


Figure 11: Phillips Brook cumulative bank erosion prediction from headwaters to the tidally influenced area.

4.4 Water Quality Assessment

Dissolved Oxygen

Dissolved oxygen (DO) was assessed by DEP with a continuous monitoring device deployment in 2010. The diurnal DO was assessed by the Town of Scarborough throughout the watershed during 2016. Data show DO dipped below parameters twice during monitoring device deployment and once during diurnal data collection. In 2017, DEP deployed continuous monitoring devices in several locations in the brook. There were several periods of low DO, not showing a strong diurnal influence. These dips are thought to be caused by extreme low flow conditions and DO should continue to be monitored.

Figure 12. Altered flow patterns have caused severe bank erosion in Phillips Brook.

Specific Conductance

The specific conductance data suggest that there may be a chloride source located hydrogeologically upgradient of Saratoga Lane. Specific conductance is the ability of water to conduct an electrical current at 25 degrees C. 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.

Specific conductance data collected during summer 2016 suggests conductivity continues to be a concern in the Saratoga Tributary to Phillips Brook. These data suggest that this tributary likely exceeds the chloride criterion during some summer baseflow conditions. In addition to summer chloride issues, it is likely that runoff from winter salt application to state and municipal roads and private driveways causes elevated chloride in the late winter/early spring runoff period.

5. Causes of Stream Impairment

> Phillips Brook is impaired for aquatic life. The primary reason is the stream's altered hydrology.

Reviewing all available information for the Phillips Brook Watershed, technical staff were able to identify one principal issue affecting watershed health: altered hydrology resulting in severe bank erosion and excessive sedimentation within the stream channel creating unsuitable habitat and further reducing already depleted dissolved oxygen. Additionally, heightened conductivity readings suggest that road salt in the watershed should be carefully monitored and cautiously used to limit potential future effects on water quality. With dissolved oxygen levels already depleted, it will also be critical to limit the runoff of nutrients into the brook, which can cause excessive algal growth and reduce available oxygen even more.

5.1 Altered Flow

Changes in the flow rates and pattern within Phillips Brook have caused significant physical alterations to the stream channel.

Biomonitoring in Phillips Brook shows a stream under stress. A comprehensive fluvial geomorphic assessment shows severely altered flow rates and patterns within the watershed. These altered flow patterns have caused severe bank erosion with undercuts causing vegetation to topple. The deeply incised stream channel is disconnected from the adjacent floodplain, causing higher velocity storm flows within the stream. The study also found significant areas of deposition, where eroded materials have accumulated in the stream channel. This deposited material directly degrades habitat and further limits natural flow patterns.
These altered flows are the direct result of:

- increased impervious cover (IC), including

parking lots, roads, rooftops, and other paved areas which increase the rate and amount of stormwater runoff; and
- stream crossings, where a road or driveway crosses a stream, which restrict the flow of water both up- and down-stream of the crossing.

Studies in Maine and around the country show strong connection between stream health and the amount of development in a watershed. A direct correlation has been established between IC and the health of aquatic ecosystems; as IC increases above 10%, there is a corresponding increase in stormwater flows and degradation in water quality, stream habitat, and diversity of aquatic life (CWP, 2003). Phillips Brook's total IC was found to be 9%. The highest amount of impervious cover is associated with commercial development along Route 1, with the Dunstan Crossing smart growth residential development, and with municipal roadways. An inventory of stream crossing sites is included in Appendix F.

5.2 Low Dissolved Oxygen

Low and altered stream flow causes low levels of available dissolved oxygen.

Data show that dissolved oxygen (DO) levels are a potential concern for the health of Phillips Brook. The flow alterations discussed in section 5.2 above, can also reduce DO levels within the water column. Deposited sediment fills voids between rocks in the stream beds, reducing the stirring and bubbling of the water, which reduces available DO.

Excessive nutrients within the stream can also deplete the system of DO. While data collected did not show excessive nutrients are a major concern at this time, protecting the brook from any additional future dissolved oxygen demands is critical. Therefore, nutrient enrichment was identified as an issue that should be addressed as a protective measure for the stream. Given the limited agricultural sites within the watershed, it is critical to address alternative sources of nutrient loading: commercial and residential use of fertilizers.

5.3 Chloride

Historical and continued use of road salt have caused chloride to enter the system from both surface and groundwater flow.

Runoff from winter salt application on state highways, municipal roads, and private driveways causes elevated chloride in the late winter/early spring runoff period. However, data suggest that chloride is also entering the system during the summer months from groundwater sources. The high conductivity found in the Saratoga Tributary suggests chloride is entering the system from a source adjacent to this channel.

Broadturn Road and Saratoga Lane are the municipal roadways from which stormwater discharges to this tributary. There are a limited number of residential sites in the Saratoga Development that also contribute runoff to the stream. The Maine Turnpike crosses the headwaters of this tributary and, since it was built in 1947, there is a long history of road salt application in this area. Reducing salt use, wherever safe and practical, and limiting infiltration in areas of higher salt use will be critical to help protect the stream from further degradation.

6. Potential Solutions

Phillips Brook is dealing with many of the same impairments impacting other urban streams in Maine. However, given its small watershed size, opportunities for on-the ground restoration and improvement projects are not as numerous as in neighboring watersheds. To develop the most effective and targeted restoration plan possible, this plan explores both structural and non-structural solutions to address the issues affecting watershed health. Structural solutions tend to focus on restoring or correcting damage already done, whereas non-structural solutions tend to focus on protecting the stream from further degradation. Given that Phillips Brook Watershed is, in many regards, a watershed on the edge of significant impairment, the non-structural solutions are of critical importance.

To ensure that the solutions recommended within this plan are those most suitable for Phillips Brook, the Town engaged area conservation groups; regional and state technical experts; watershed residents and landowners; municipal boards and staff including the Long-Range Planning Committee, Conservation Commission, and Planning Board; and the Scarborough Economic Development Corporation to help identify solutions with the highest potential impact and highest likelihood of successful implementation. The structural and non-structural solutions are discussed below and detailed in Appendices A through F.

6.1 Structural Solutions

Using a multi-tiered approach to protect and restore habitat conditions within the Phillips Brook Watershed, the Town explored structural solutions to 1) stabilize flows into and within Phillips Brook and its tributaries and 2) to restore the stream corridor to natural conditions.

A variety of structural solutions will help address the severely altered flow regime within Phillips Brook and its tributaries. Those determined to be most likely to succeed and positively influence stream health are:

- Retrofits of existing stormwater infrastructure
- In-stream restoration projects to reconnect floodplain and slow the water in the system
- Stream crossing improvement projects

Retrofit Opportunities

Potential retrofit opportunities were identified by reviewing existing and proposed stormwater infrastructure on developed and permitted sites. The overall goals of the stormwater retrofit analysis were to identify structural stormwater retrofit opportunities that could attenuate the primary contributors of untreated stormwater pollution in the watershed. Projects that could be implemented with limited impact on existing infrastructure and in a cost-effective manner were prioritized.

The proponent of the largest single development site, Dunstan Crossing, has been in regular communication with Town staff and has recently updated their State and local permits to reflect current water quality and quantity standards for the portion of the development that has not been constructed.

Additional retrofit opportunities were sought in the areas with the highest amount of impervious cover (IC), which is along the Route 1 corridor. Following the goals of the retrofit analysis detailed above, the following four sites were identified:

1. **Route 1** (SR-1)
   Stormwater runoff causing sink holes and erosion to stream. Locate, restore and stabilize stormwater discharge.
2. **Dunstan Reach** (SR-2)
   Increased stormwater runoff from Dunstan Crossing results in severe bank erosion. Stormwater pond retrofits are underway to address this issue.
3. **Saratoga Reach** (SR-3)
   Increased stormwater runoff from results in bank failures. Assess source of runoff and address cause.
4. **Saratoga Reach** (SR-4)
   Flow regime changes from Maine Turnpike stormwater results in bank failures. Assess solutions with MTA.

In-stream Restoration Sites

A critical component to stabilizing the flow regime in Phillips Brook is reconnecting the stream channel with the adjacent floodplain. Over time, as high volume and high rate discharges flowed through the system, the stream channel became incised as the banks eroded. This deepening of the channel results in surface water that is unable to enter the floodplain. Reconnection of the stream channel to the floodplain will slow the flow of water through the system and help prevent further bank instability and erosion.

The following sites were identified for in-stream restoration efforts (Appendix E):

1. **Downstream of Stewart Drive** (IS-1)
   Incised stream bed, log jam and bank failures. Reconnect stream to floodplain and construct riffles.
2. **Martin Avenue near Broadturn** (IS-2)
   Clogged culvert with invasive plants. Reshape and stabilize slopes by culvert and establish native plants.

3. **Between Martin Ave. and Susan Ave.** (IS-3)
Bank failures. Stabilize with log and/or boulder cross vane structures.
4. **Old Mill Dam** (IS-4)
Creates upstream aggradation and downstream bank failures. Consider dam removal or modification to allow better stream connectivity and then restore stream banks.
5. **Broadturn Road Crossing** (IS-5)
Accumulated trash and debris. Remove for better stream flow.
6. **Scarborough Staging Yard** (IS-6)
Floodplain fill impacting stream and severe bank erosion evident. Work with Public Works to modify site, remove floodplain fill and stabilize banks.
7. **Susan Ave. Culvert and Dunstan Reach** (IS-7)
Bank failures and incised bed. Reconnect floodplain using log and/or boulder cross vane structures.
8. **Dunstan Crossing Ponds to Confluence** (IS-8)
Bed degradation and aggradation with high sediment loading. Adjust detention pond release rates and install instream structures to dissipate energy and accommodate higher velocities.

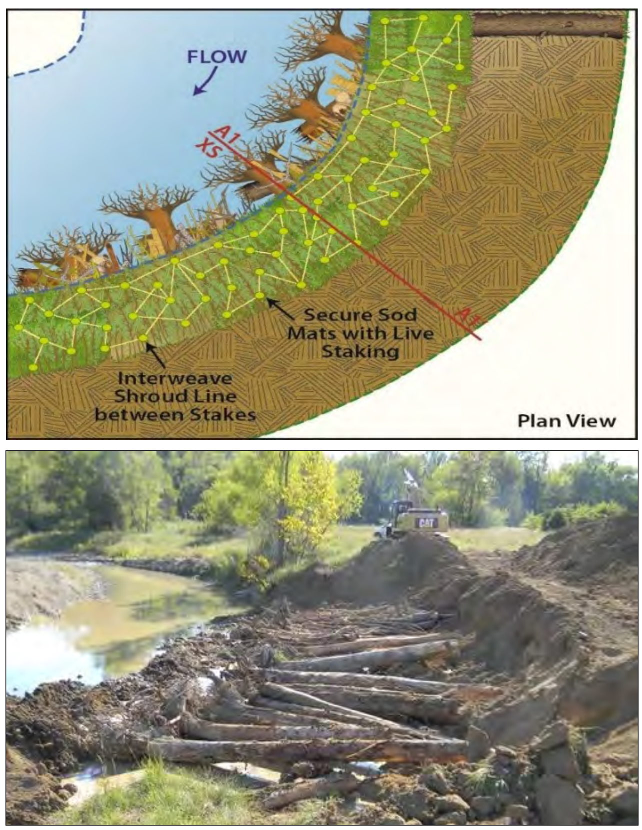
These sites were found to have unstable banks, an incised channel disconnected from the floodplain, or significant deposition of eroded materials.

In-stream restoration projects will improve the hydraulic and geomorphic stability and habitat. Features will be constructed of natural materials commonly used in channel design. These structures include, but are not limited to, bankfull benches, wood toe, vanes, step pools, and constructed riffles.

Log J-Hook Structures
Log J-hook structures are log, root wad, and boulder structures constructed on the outside of stream bends where strong helical flows, high boundary stress, and high velocity gradients create high stress in the near-bank region. Log J-hook structures reduce accelerated streambank erosion on the outside of meander bends by reducing near-bank slope, velocity, velocity gradient, stream power, and shear stress. They also redirect flows away from the outside bend and provide opportunities for overhead cover for fish.

Figure 13: J-Hook log vane

Wood Toe Structures
Wood toe structures (Figures 14 & 15) are relatively inexpensive, easy to construct structures which utilize a combination of woody debris, live cuttings, fill, and sod mats (materials readily available on most stream restoration projects). Wood toe structures serve to protect vulnerable and unstable banks while also providing a roughness element to help ensure pool habitat remains viable. Wood toe structures are a cover feature for numerous aquatic species.



Figures 14 & 15: Wood toe structures

Constructed Riffles
Boulder/cobble constructed riffles serve as vertical grade control while allowing fish passage. Constructed riffle features create a range of velocities and depths, providing habitat for a host of aquatic species. Riffle structures can be modified to include pocket pools, woody debris, and the occasional boulder cluster to further provide habitat diversity while meeting the project needs.


Figure 16: Constructed riffle

Step-pool Structures
Step-pool structures are a series of pools with sequential drops in elevation. These provide grade control and energy dissipation for high gradient channel sections. Scour holes created in each pool provide habitat for aquatic life. Step pools may be constructed with rocks or trees. Step-pool structures are commonly used to connect small, intermittent tributary channels with project streams. Large woody debris, and boulder clusters may also be placed in the channel to enhance in-stream habitat and to mimic variability found in natural stream systems.


Figure 17: Step-pools

Bankfull Bench Structures
Bankfull bench structures (Figure 18) are relatively flat topographic features constructed at the base of steep slopes to increase the distance between stream shear forces and readily erodible bank materials. Such benches are typically vegetated with a suite of deep rooting woody shrubs and herbaceous species adept at surviving in flood plains. Bankfull benches are relatively easy to construct and have been successfully utilized on stream restoration projects for decades.

Stream Crossing Improvement Sites

Where roads and driveways cross streams, culverts and bridges are sized to meet development standards. However, development standards aren't always sufficient for the protection of the stream. Culverts that are insufficiently sized or that improperly placed (either too high or too low in the stream channel) are barriers to the flow of water and to aquatic wildlife. Scour pools are commonly found adjacent to improperly sized or placed culverts. Culverts that are too small constrict the flow of water, which results in increased velocity downstream during high-flow periods and can cause significant erosion to stream banks.

The following stream crossing sites surveyed within the Phillips Brook Watershed were found to have some negative impact to the stream channel (Appendix F).

1. **Dunstan Crossing Stewart Drive** (SC-1)
   Culvert failure with scour pool and stream plugging. Town replaced with properly sized culvert meeting aquatic organism passage (AOP) standards.
2. **Martin Avenue Extension** (SC-2)
   48" culvert is undersized and results in driveway flooding. Explore public private partnership options to replace.
3. **Martin Avenue** (SC-3)
   36" culverts are undersized and result in scour pool, bank erosion and flooding. Replace and stabilize banks with boulders and/or wood.
4. **Broadturn Road** (SC-4)
   Two 48" culverts are undersized and result in scour pool, bank erosion and flooding. Replace

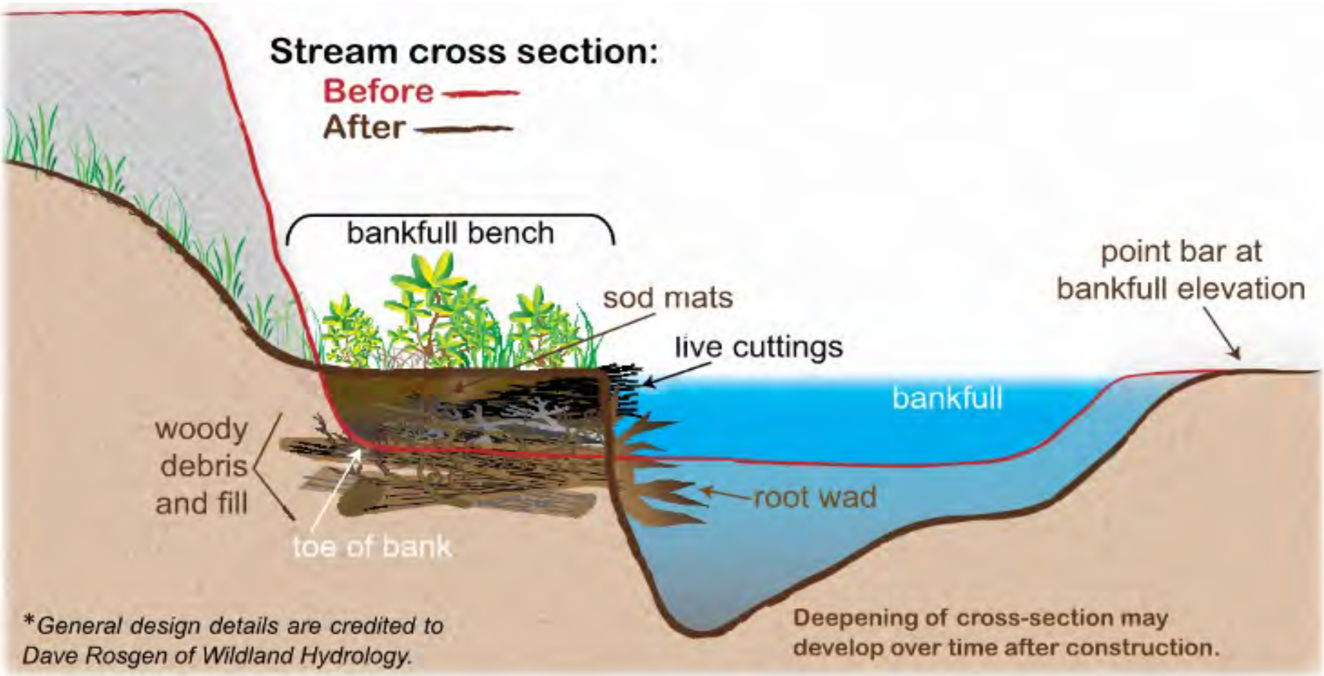


Figure 18: Bankfull bench structure

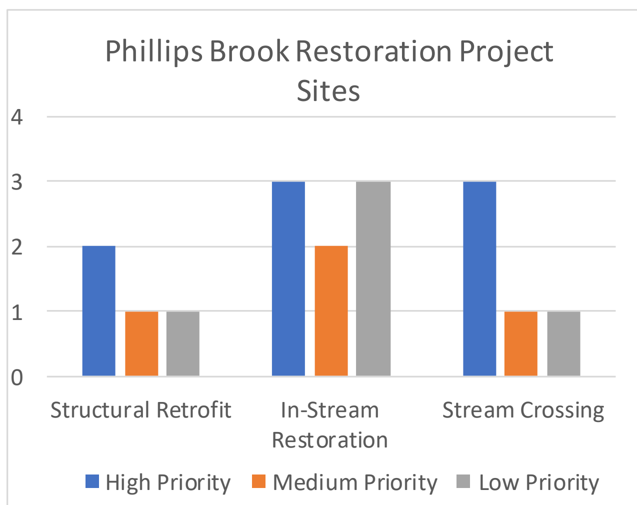
and stabilize stream banks with log and/or boulder cross vane structures.

5. **Payne Road (**SC-5)
   Two 60" culverts are undersized and result in scour pool, severe bank erosion and flooding. Replace and stabilize stream with log and/or boulder cross vane structures.
6. **Susan Avenue** (SC-6)
   Undersized culvert on private road results in bank failures in tributary. Replace and stabilize slopes and banks with boulders and/or wood.

In order to protect and restore the physical and biological integrity of the stream, future road construction projects and replacement of existing culverts should strive to utilize stream crossing standards that allow for aquatic organism passage.

Figure 19: Payne Road culverts, 2015

These standards seek to simulate the natural stream corridor, ensuring habitat connectivity, and do not restrict stream flows during large storm events.



6.2 Non-Structural Solutions

The Town of Scarborough explored a variety of non -structural solutions to help better protect all of Scarborough's fragile natural resources and potentially help to restore Phillips Brook and other impaired streams within Town. **Education and outreach** efforts are critical to the success of a

Watershed Management Plan. Reducing nutrient loading and chloride levels within the stream will be the focus of outreach campaigns in the Phillips Brook Watershed. Additional non-structural solutions were organized into three categories: **ordinance and policy changes**; **design standards**; and **funding strategies**. The highest ranked solutions for each category are summarized below in order of priority.

Education and Outreach

Reducing Nutrient Loading

Commercial and residential use of fertilizer is a primary source of excess nutrients in urban stream systems. Additionally, commercial and residential landscaping and yard waste is often disposed of in the riparian zone, including the bordering floodplain wetlands immediately adjacent to the stream channel. This waste leaches concentrated nutrients into the system, resulting in eutrophic conditions and excess algae growth. Education and outreach to residential and commercial landowners to encourage proper fertilizer application, appropriate yard waste disposal, and alternatives to chemical fertilizers is a critical component to successful watershed management.

YardScaping, an existing outreach program, will be employed to reduce the use of fertilizers and pesticides, to reduce yard waste dumping incidents, and to teach landowners about rain garden and vegetated buffer installation. The campaign will include customized outreach methodologies, such as: neighborhood presentations; rain garden installation workshops; "Green Neighbor" pledge drive; or establishing a Youth Conservation Corps program to carry out conservation work.

Figure 20. The YardScaping program promotes the use of healthy lawn care practices.

Winter Maintenance Guidelines

The Town will engage in an education campaign targeting landowners, private snow removal contractors, and Public Works personnel on appropriate salt application processes. This campaign will encourage reduced salt use where appropriate and will promote targeted application. The general guidelines provided by the University of New Hampshire's Green SnowPro program will serve as the basis of the outreach. Signs indicating areas of "reduced salt" application will be installed areas where the water table is close to the surface (within 5 feet of grade) or where conditions suggest a direct pathway to groundwater (sand and gravel deposits).

Figure 21: New Hampshire's Green SnowPro Program will serve as the basis for winter maintenance outreach.

Ordinance and Policy Changes

Development Review/Authority

The Town will seek capacity to review projects triggering Site Location of Development Law. This authority will allow the Town maximum flexibility in the review process and will allow more effective municipal guidance of development within Town. Obtaining and maintaining this authority requires the Town have an extremely knowledgeable and engaged staff. The Town Engineer, Town Planner, and the Scarborough Economic Development Corporation are already well-versed in comprehensive development review to state standards.

Expand Stream Protection Zones

The Town will expand the Stream Protection Zones, which provides the opportunity for additional and enhanced requirements to better protect streams and rivers. Stream Protection Zones are already in place for the main stem of Red Brook (applies within 75' of the stream) and for the Nonesuch River (applies within 250' of the river). Since the framework is already in place to allow the Town to establish Stream Protection Zones, expanding this zone to include all streams in Town will be prioritized.

Refine Stormwater Requirements
The Town will refine existing stormwater standards to eliminate or minimize barriers to implementing:

- Best Management Practices
- Green Infrastructure
- Low Impact Development techniques
- Other beneficial / innovative measures

For Phillips Brook specifically, and other watersheds where chlorides are of concern, the Town will assess subsurface geology in areas where infiltration BMPs are proposed. The Town will avoid infiltrating in areas of higher salt use (from roadways, parking lots, and driveways); in areas where the water table is close to the surface (i.e., within 5 feet of grade); or where conditions suggest a direct pathway to groundwater (i.e., sand and gravel deposits or permeable strata).

There is a regional effort underway with the Regional Clean Water Collaborative, and the Town will continue to participate in these discussions while pursuing improvements to local standards.

Refine Stream Crossing Requirements
The Town will refine stream crossing requirements for development and redevelopment, maximizing the protections for streams and ensuring infrastructure will not impede flow. Current culvert design recommendations for stream crossings suggest a culvert at least 1.2 times larger than the banks of the stream. This recommendation could become a requirement, or the Town could require even more clearance to better prepare for the increasing number of large rain and flooding events. Guidance for aquatic organism passage standards already exist (Massachusetts, Vermont, USDA Forest Service, Maine DOT) and could be easily adapted for Scarborough. These requirements, and the overall impact to the Phillips Brook Watershed, will be taken into consideration when the road proposed to connect Payne and Broadturn roads is constructed.

Design Standards

Develop a Credit/Exchange for Developers to Increase Flexibility
The Town intends to establish a program that will allow the Town maximum flexibility to work with developers to find the best site-specific solutions. Stormwater solutions can be targeted for the specific impairments and issues in the watershed capitalizing on local knowledge to help direct and preserve to the greatest extent practicable. This effort will focus on Urban Impaired Stream (UIS) Watersheds, such as Phillips Brook, as a first step, establishing a track record for success, before Town-wide implementation.

Enhance Floodplain Protection/Restoration
Facing more frequent and intense storm events, the Town will be seeking enhanced floodplain protections to allow a greater degree of control over impacts to floodplains. Focusing first on UIS watersheds, the Town will expand these additional protections to other watersheds and to apply to redevelopment projects in the future.

Establish Enhanced Redevelopment Requirements
Recognizing the potential for planned and carefully regulated redevelopment to help improve conditions within a watershed, the Town will be seeking enhanced redevelopment requirements. These requirements will provide the Town authority to require improvement on redevelopment sites that would otherwise not be improved. These requirements provide for the potential to reduce or disconnect existing impervious area and will be established throughout the municipality.

Develop Stricter Requirements for Stormwater Management for New Development
The Town will be developing stricter requirements for stormwater management on new development sites throughout Town. The Town will be able to address specific concerns in different watersheds and will consider looking at infrastructure to manage runoff from more significant storms than is currently required.

6.3 Pollutant Load Reduction Targets

The goal of this watershed management plan is to restore the brook's water quality and habitat to attain Class C standards. As has been detailed in Section 5, the primary concerns, or stressors, are related to the alteration of flow rates and physical alterations to the stream channel, resulting in excessive sediment transport. One way to measure the impact of this stressor is to estimate the current rate of sediment transport and compare to stable streams. The fluvial geomorphic assessment calculated an average bank erosion rate of 0.27 feet per year. This is an estimated 0.7 tons per year per foot, or approximately 83 tons per year being transported from the brook to the Scarborough Marsh each year. Stable alluvial streams generally demonstrate bank erosion rates of 0.001 to 0.005 feet per year. While this natural erosion rate would be an ideal target, Class C standards would likely be attainable with a somewhat lower target. Since the current erosion rate would need to be reduced by 98% to reach the natural erosion rate, the target reduction rate from the structural solutions is 80%. This is an estimated reduction of 0.216 feet per year, or 66.4 tons per year total erosion. As structural and nonstructural solutions are implemented, load reductions are calculated, and the health of the brook is assessed, load reduction targets will be updated accordingly.

Figure 22: Reducing stream bank erosion will help restore Phillips Brook's water quality and habitat.

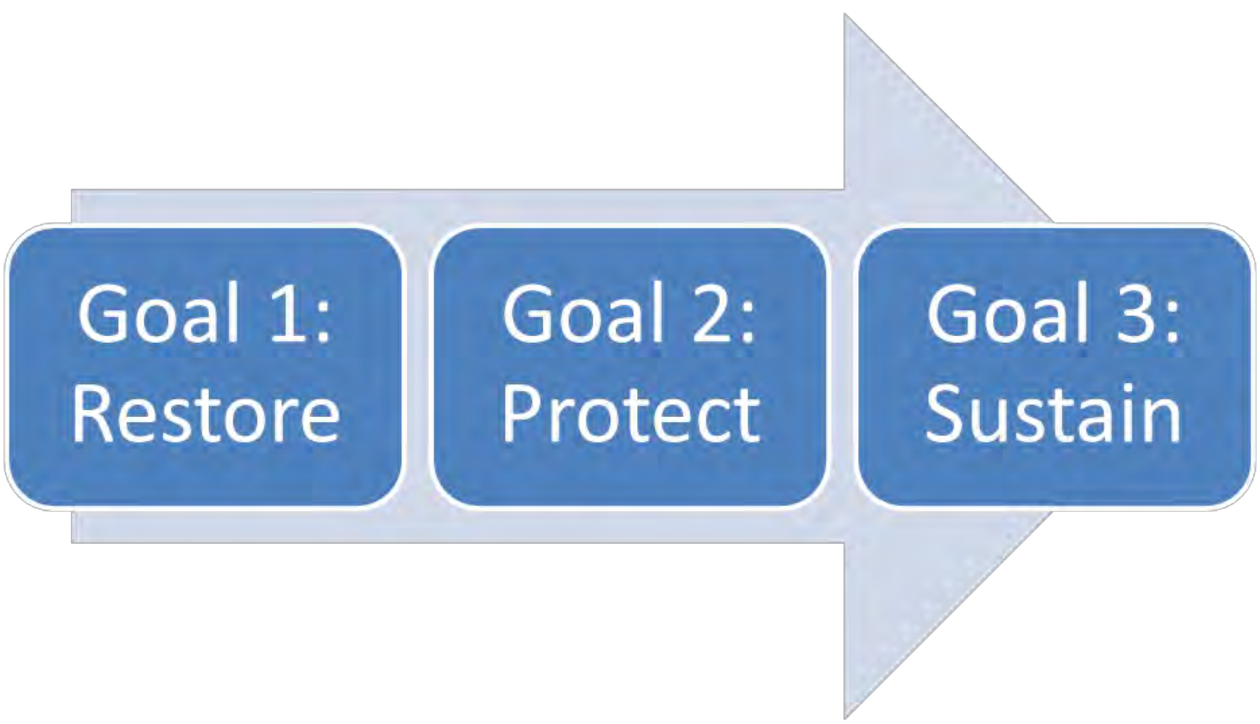
7. Watershed Management Plan Goals

The primary goal of the Phillips Brook Watershed Management Plan is to restore Phillips Brook to its Class C statutory classification. To ensure Phillips Brook meets Class C standards, the Phillips Brook Watershed Management Plan aims to restore and protect the watershed through improved water quality and aquatic habitat and by increasing community involvement.

The following goals and objectives were established by the project steering committee and stakeholders at several public meetings:

- **Goal #1 - <u>Restore</u> water quality and stream habitat** to help ensure Phillips Brook meets its Class C state water quality standards
- **Goal #2 - <u>Protect</u> water quality and stream habitat** from potential degradation associated with future land use activities within the watershed
- **Goal #3 - Build and <u>sustain</u> community support** for the protection and restoration of the land and water resources of the Phillips Brook Watershed

Figure 23: Scarborough Marsh
Restoring Phillips Brook will also benefit Scarborough Marsh.



8. Restoration Action Plan and Timeline

The primary goal of the Phillips Brook WMP is to have the stream support aquatic organisms and habitat that meets Class C water quality standards by 2028. The primary driver of watershed stress is flow alterations causing habitat degradation, elevated levels of nutrients, and reduced DO levels. Elevated chloride also appears to be affecting stream health, primarily in the Saratoga Tributary.

8.1 Adaptive Management

Adaptive management is the process by which new information about the health of the watershed is incorporated in the WMP. An adaptive management approach is widely recommended for restoring urban watersheds (CWP, 2003). This approach recognizes that the entire watershed cannot be restored with a single restoration action or within a short time frame. 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. As previously discussed, the restoration priorities were identified based on relative stressor and problem site rankings. The Action Plan proposes to complete work in five phases. Work within each phase may change as new and updated information becomes available. Continued monitoring and additional analyses are recommended to further refine restoration efforts.

8.2 Plan Oversight

It is important for the community within Phillips Brook Watershed to work together to restore water quality and stream habitat. The Phillips Brook WMP will be carried out by the Town of Scarborough with extensive involvement from stakeholders within the watershed, who will form the Phillips Brook Workgroup. The Town of Scarborough will take the lead role in the Phillips Brook Workgroup. Other participants serving on the workgroup may include CCSWCD, DEP, Scarborough Economic Development Corporation, local environmental nonprofits, and watershed landowners.

The Workgroup will meet at least twice per year to oversee progress toward meeting the goals of the WMP. The larger community will be provided with periodic updates about Phillips Brook and implementation projects through outreach channels such as: the Phillips Brook Restoration webpage; periodic press releases to local newspapers; newsletters; and public meetings. The Workgroup will be responsible for overall WMP updates and any changes to the phasing or monitoring plans as new and updated information becomes available. The Workgroup will partner to seek funding to support restoration efforts within the Phillips Brook Watershed.

8.3 Action Plan Summary

The Phillips Watershed Management Plan timeline is intended to help focus restoration efforts on the highest priority projects. The Action Plan Table and Timeline (Appendix X) details which structural solution projects and non-structural solutions are planned to be completed during each phase of restoration. Seven in-stream restoration sites, six stream crossing sites, and four structural retrofit sites are planned over the next ten years, with an estimated cost of $1.7 million. The installation of retrofit and stream restoration projects will also be made on an opportunistic basis to take advantage of available funding, landowner interest and other considerations. Similarly, the pursuit of the non-structural solutions (ordinance, policy, and design standards) may also be made on an opportunistic basis as staffing, funding, and political climate allow. Following is a summary of each phase of the Action Plan.

Phase I: 2019-2020

Phase I prioritizes education and outreach efforts, which help to ensure public involvement and cooperation in subsequent phases of restoration. Additionally, Phase I includes critical projects addressing flow regime alternations and projects that will reconnect the stream channel to the adjacent floodplain.

- YardScaping campaign
- Winter maintenance education campaign
- One (1) structural retrofit site
- Two (2) in-stream restoration sites
- Two (2) stream crossing improvement sites

Phase II: 2021-2022

Phase II includes additional solutions aimed at restoring a natural flow regime and invasive species eradication. Education and outreach efforts will also be completed during Phase II, continuing public involvement and support of restoration efforts.

- YardScaping campaign
- Winter maintenance education campaign
- One (1) structural retrofit site
- One (1) stream crossing improvement site
- Two (2) in-stream restoration sites
- Investigation and evaluation of potential solutions for the overboard discharge

Phase III: 2023-2024

Phase III includes critical projects addressing flow regime alternations.

- One (1) structural retrofit site
- One (1) stream crossing improvement site

Phase IV: 2025-2026

Phase IV includes additional solutions aimed at restoring a natural flow regime and erosion control. Education and outreach efforts will also be completed during Phase IV, continuing public involvement and support of restoration efforts.

- YardScaping campaign
- Winter maintenance education campaign
- Two (2) in-stream restoration sites
- One (1) structural retrofit site
- One (1) stream crossing improvement site

Phase V: 2026-2027

Phase V focuses on those issues where additional analysis is needed. The stream crossing site is on private land and it is possible improvements might be achieved through the development approval process.

- One (1) in-stream restoration site and any additional in-stream site identified through the adaptive management process
- One (1) stream crossing improvement site and any additional stream crossing improvement site identified through the adaptive management process

9. Monitoring Plan

The ultimate goal of this WMP is to restore the stream conditions so that Phillips Brook and its tributaries support aquatic life at its designated classifications. The sampling design presented herein will continue to evaluate stream hydrology, water chemistry, and habitat and their impacts on the macroinvertebrate community. Ongoing monitoring within these focus areas is needed to determine whether the actions identified in the WMP are effectively moving Phillips Brook toward restoration and eventual removal from 303(d) list.

9.1 Macroinvertebrate Community

Currently DEP's macroinvertebrate monitoring (or biomonitoring) program is the primary means used to assess whether Maine rivers and streams meet their designated uses. Benthic macroinvertebrates are useful indicators of the effects of a wide range of stresses on streams and are also used to determine whether Maine streams meet their aquatic life criteria. DEP's past macroinvertebrate monitoring indicates that the stations in Phillips Brook do not meet the Class C standards for aquatic life. Since benthic macroinvertebrate sampling is DEP's primary indicator for 303(d) listing, future monitoring in the watershed should include additional macroinvertebrate monitoring.

DEP'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

Figure 24. Caddisfly larvae are aquatic macroinvertebrates that indicate a healthy stream ecosystem.

Table 6. Biomonitoring Program Summary

Sample Frequency	Conducted by	Number of Sites	Protocol	Notes
Annual	Volunteers	up to 5	Kick-netting	Locations to be determined
5-year	DEP	3	Rock bags	DEP Sites: S-454, S-675, & S-795

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]. This process will be followed by DEP staff at five-year intervals.

In addition, this WMP proposes to complete annual macroinvertebrate monitoring events using volunteers, such as local high school students, the Ecos Club, plover monitors, and/or Maine Healthy Beaches volunteers. These results will be used as screening level results to monitor stream recovery. If the screening data suggests that the stream is achieving its cleanup goals and could be de-listed, then additional sampling can be conducted following the complete DEP protocol for sample collection and invertebrate identification.

9.2 Stream Flow and Channel

When the macroinvertebrate sampling is conducted, field staff should also monitor stream hydrology conditions. Specifically, stream discharge can be calculated at each monitoring station using the cross-sectional flow method. Additionally, stream channel geomorphology conditions can be monitored in order to assess changes over the monitoring period. Examples of stream channel conditions include width, depth profile, and presence or absence of habitat for invertebrates or fish. This portion of the monitoring program can be done in conjunction with other monitoring efforts, provides valuable information for minimal time investment. Photo points should be established at each monitoring site to track hydrologic and geomorphologic changes. Bank chains and pins, used for the initial geomorphological assessment, may be used in subsequent years to perform additional comprehensive analyses of sediment transport through the system.

9.3 Water Chemistry

Chloride

Chloride levels will be assessed throughout the Saratoga Tributary, above and below the Route 95 crossing. To ensure that higher levels are limited to the Saratoga Tributary and are not affecting other areas, chloride will also be assessed at sampling locations throughout the watershed. Monitoring will occur during summer base flow conditions, typically July through September. Additionally, samples will be taken at all sampling sites during two targeted high-flow events per year: spring snow melt and a summer storm event with >0.25" of rain.

Figure 25. Fishing boats at Pine Point in Scarborough. The health of Phillips Brook impacts the health of our coastal waters and fisheries.

Dissolved Oxygen and Temperature

Dissolved oxygen and temperature will be taken at existing sample sites throughout the watershed during Summer base flow conditions, typically July through September. If Sonde data loggers are available from Maine DEP, continuous data collection will be employed at sites to be determined.

9.4 Restoration Site Monitoring

Monitoring is recommended for all in-stream restoration projects to make sure the projects are functioning as designed. Large wood placed in the stream should be regularly inspected to make sure it is stable and providing habitat benefits as planned. Photo points may be established at each restoration site. Upstream and downstream photos may be taken at each point before construction, immediately after construction and then annually to document effects on Phillips Brook. Estimates of sediment load reduction as a result of in-stream restoration projects will be calculated as appropriate estimation methods are available. DEP staff may be included in habitat restoration project development and consulted about how and when to conduct a follow up stream habitat assessment to determine if the stream is progressing toward or meeting stream habitat criteria.

10. Measures of Success/Interim Measurable Milestones

Phillips Brook does not currently meet its Class C state water quality standards due to and aquatic life use impairments. The goal of this plan is for Phillips Brook to meet State water quality standards by 2028. It is proposed that this goal 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 impervious cover. Since it may take ten or more years for Phillips Brook to meet state water quality standards, interim targets may also be tracked to measure progress on WMP implementation. Interim and long term measurable targets are listed in Table 7.

Figure 26. Phillips Brook tributary

Table 7. Measurable Milestones

	Interim Targets		
	2020 (Phase I)	**2024 (Phase II & III)**	**2028 (Phase IV & V)**
Water Quality Benchmarks			
Enhance macroinvertebrate type, abundance, and distribution GOAL: Meet Class C Standards (based on probabilities of meeting)	25%	50%	100%
Structural Benchmarks			
Reduction of erosion in stream GOAL: 6.64 tons reduction of sediment erosion	25% of goal (1.66 tons)	50% of goal (3.32 tons)	100% of goal (6.64 tons)
Amount of funding secured for structural elements of plan implementation (include contributions from town, fees, donations, and grants) GOAL: $1,700,000	$785,000	$420,000	$495,000
Improvement of the stream channel and corridor through instream restoration and stream crossing improvements GOAL: 13 sites	4	4	5
Number of areas installed with structural retrofits GOAL: 4 sites	1	2	1
Non-Structural Benchmarks			
Amount of funding secured for non-structural elements of plan implementation (include contributions from town, fees, donations, and grants) GOAL: $15,000	$5,000	$5,000	$5,000
Number of design standards, ordinances, and financial solutions implemented GOAL: 6 non-structural solutions	2	2	2
Number of watershed residences reached through YardScaping outreach GOAL: All watershed residences reached	25%	50%	100%
Number of stream abutters reached through direct outreach GOAL: All stream abutters reached	25%	50%	100%
Number of watershed residences pledged to be "Green Neighbors" GOAL: 20% of watershed residences	5%	10%	20%
Number of Public Works staff trained in winter maintenance BMPs GOAL: All appropriate staff	50% (10 people)	75% (15 people)	100% (20 people)
Number of local contractors reached regarding winter maintenance BMPs GOAL: 10 winter maintenance contractors in watershed	25%	50%	100%

11. Funding Opportunities

11.1 Funding Strategies

The Town, as a general approach, will prioritize establishing incentives over fees to help fund the watershed improvement projects identified in this WMP and additional efforts to protect and restore natural resources throughout Town.

Incentives

The Town will explore modifying ordinance and/or design language to promote conservation and protection of natural landscape. The Town will also explore allowing Tax Increment Financing (TIF) for specific developers/developments or general environmental infrastructure improvements.

Fees

The Town will explore establishing **recurrent annual fees** for new and existing development. These fees, typically created for stormwater mitigation, will allow the Town to get out ahead of future development and protect non-impaired waterbodies. Establishing a stormwater fee will equalize the burden across all sectors and is the most egalitarian of all potential fee structures.

The Town will also consider **one-time impact fees** for new and re-development. These fees are not meant to eliminate a developer's responsibility to mitigate stormwater impacts. Impact fees are best when coupled with Town-delegated review to: maximize local control; maintain consistency for the developers (in case standards "contradict" DEP rules); and allow stormwater credit exchange on and off site within the watershed. Establishing impact fees will require the Town to: reinvest funds from fees, such as with a Compensation Fee Utilization Plan; communicate to the public where the reinvestments are going (i.e., services provided); and to anticipate costs and timeline.

11.2 Grant Funding

Casco Bay Estuary Partnership (CBEP) Habitat Restoration Grants

Description: CBEP is part of the National Open to non-profit conservation groups (land trusts, watershed groups), towns, and state and federal conservation agencies. Project criteria includes land protections, acquisition of high value habitat, public access, level of threat, size of project, cost effectiveness, community support, matching funds and likelihood of implementation. Applications are processed when received with no deadlines. Submit electronic copies of proposal, budget and letters of support.

- Grant range from $1000—$20,000 but larger amounts are considered.
- In-stream habitat restoration projects, buffer enhancements.

US EPA 5 Star Grants

Description: Open to any public or private entity engaging in community-based restoration. Projects must include a strong on-the-ground wetland, riparian or coastal habitat component and must also include a strong training, education, community stewardship and/or outreach component. Projects must involve diverse partnerships that contribute funding, technical assistance, workforce support and in-kind services.

- Urban Waters Focus Area grants available.
- 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 Environmental Protection Agency Clean Water Act Section 319 grants

Description: The primary objective of NPS projects is 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 DEP, which administers the grant program in partnership with EPA.

- Annual grant RFP issued by DEP in April with project commencing following April
- Town Roadway retrofits, private facility retrofits, stream enhancement-buffers, regional facilities.

Wildlife Habitat Incentive Program (WHIP)

The USDA Natural Resources Conservation Service administers the Wildlife Habitat Incentive Program (WHIP) which is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land. Provides funding to:

- Promote the restoration of declining or important native fish and wildlife habitats.
- Protect, restore, develop or enhance fish and wildlife habitat to benefit at-risk species.
- Reduce the impacts of invasive species on fish and wildlife habitats.
- Protect, restore, develop or enhance declining or important aquatic wildlife species' habitats.
- Protect, restore, develop or enhance important migration and other movement corridors for wildlife.

WHIP funds could be used for habitat restoration and protection within Phillips Brook, invasive species removal and buffer restoration, and preserve other wildlife habitat within the stream corridor.

Environmental Quality Incentives Program (EQIP)

The USDA Natural Resources Conservation Service administers the Environmental Quality Incentives Program (EQIP) is a voluntary program 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).

Community Development Block Grant

Community Development Block Grants must meet one of the following objectives:

- Benefit to low and moderate income persons;
- Prevention and/or elimination of slum and blight conditions; and
- Meeting community development needs having a particular urgency.

And also:

- Are part of a long-range community strategy;
- Improve deteriorated residential and business districts and local economic conditions;
- Provide the conditions and incentives for further public and private investments;
- Foster partnerships between groups of municipalities, state and federal entities, multi -jurisdictional organizations, and the private sector to address common community and economic development problems; and
- Minimize development sprawl consistent with the State of Maine Growth Management Act and support the revitalization of downtown areas.

The most likely use for Community Development Block Grants in the Phillips Brook Watershed would be for public infrastructure or public facilities grants.

11.3 Private Foundation Funding

Davis Conservation Foundation

Description: 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. 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
- Funding possible for monitoring Program, YardScaping, Outreach Programs, Town Roadway retrofits, and stream enhancement-buffers.

John Sage Foundation

Description: 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

Description: 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

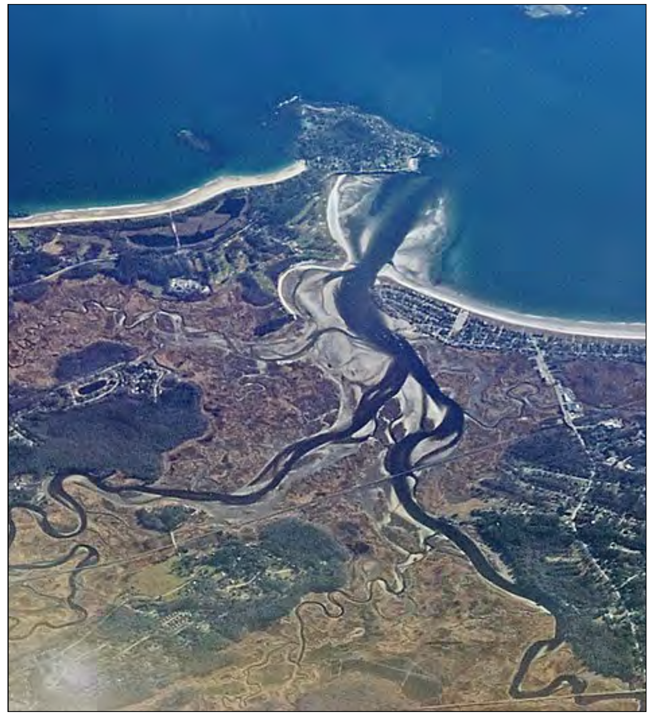


Figure 27. Phillips Brook flows into the Scarborough Marsh and Saco Bay.

12. Acronyms

BMPs	Best Management Practices
CBEP	Casco Bay Estuary Partnership
CCC	Criterion Chronic Concentration
CCSWCD	Cumberland County Soil & Water Conservation District
CFUP	Compensation Fee Utilization Plan
CMC	Criterion Maximum Concentration
CSO	Combined Sewer Overflow
CWP	Center for Watershed Protection
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
DEP	Maine Department of Environmental Protection
mg/L	milligrams per liter
mS/cm	milliSiemens per centimeter
MS4	Municipal Small Separate Stormwater System
Plan	Watershed Management Plan
RHA	Rapid Habitat Assessment
SCA	Stream Corridor Assessment
STEPL	Spreadsheet Tool for Estimating Pollutant Load
TMDL	Total Maximum Daily Load
WHIP	Wildlife Habitat Incentive Program
WMP	Watershed Management Plan

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Appendix A: **Structural Retrofit Opportunities**

This table lists locations where **stormwater management infrastructure** within the Phillips Brook watershed is potentially problematic for continued stream health. Recommendations for retrofit upgrades to infrastructure are offered as an opportunity for improvement.

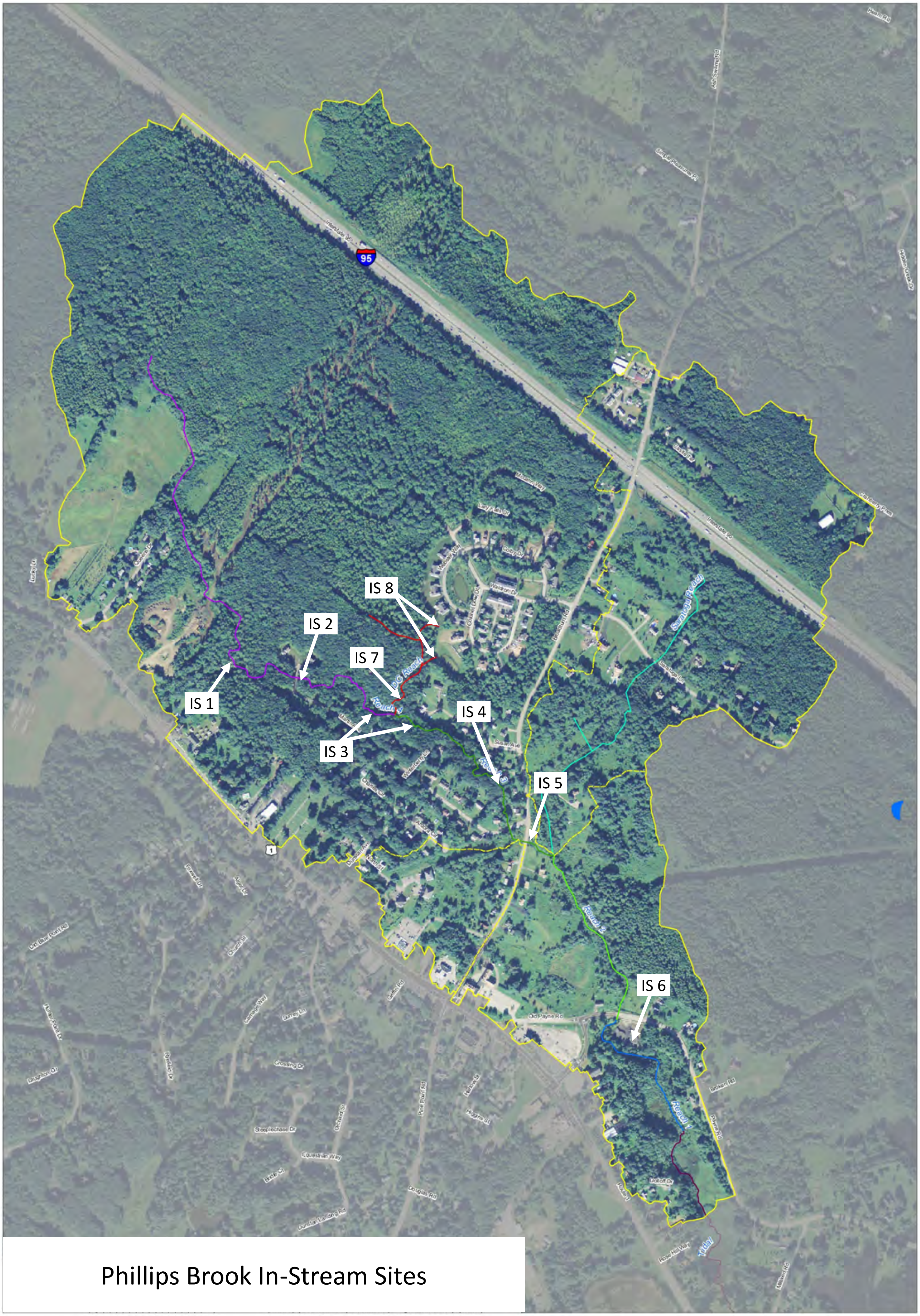
Site ID	Reach	Parcel ID	Location Description	Description of Issue	Recommendations	Priority	Cost Estimate
SR-1	Reach 4	R046003B	Erosion located in rear yard of residence; discharge believed to be to the left of Dr. Stereo on Route 1	Stormwater runoff from Route 1 causing sink holes and erosion into Phillips Brook	Camera work needed to locate discharge point; restore and stabilize outfall with rip rap and plunge pool as needed	Medium/MDOT	$75 - 100K
SR-2	Dunstan Reach	U031083A; U031069; U031071A	Confluence of Dunstan tributary with main channel	Flow regime changes from stormwater runoff from Dunstan Crossing resulting in severe bank erosion	Stormwater pond retrofits at Dunstan Crossing property are underway; and will address flow rate and velocity	High	$50 - 75K
SR-3	Saratoga Reach	Assumed U029004	Above and below confluence of Saratoga tributary with main channel	Possible Flow regime changes from stormwater runoff from Maine Turnpike (Saratoga); bank failures	Reach was not part of the study. A reach assessment is recommended to understand the potential cause of flow regime changes	High	$10 - 20K
SR-4	Saratoga Reach	R047005A	East of Route 95 / Maine Turnpike	Possible Flow regime changes from stormwater runoff from Maine Turnpike (Headwaters); bank failures	Reach was not part of the study. A reach assessment is recommended to understand the potential cause of flow regime changes	Low/Study/MTA	$10-20K

Phillips Brook Structural Retrofit Sites

Appendix B: **In-Stream Restoration Sites**

This table lists locations **within the channel** and on **land immediately adjacent** to the stream where conditions are problematic for continued stream health and which present an opportunity for stream, wetland, and floodplain restoration.

Site ID	Reach	Parcel ID	Location Description	Description of Issue	Recommendations	Priority	Cost Estimate
IS-1	Reach 4	U030002V	Downstream of Stewart Drive	Incised bed; log jam; aggradation of eroded sediment; and bank failures	Reconnect floodplain using log and/or boulder cross vane structures; dredge aggraded materials; construct riffles with suitable native materials	Low	$30 - 40K
IS-2	Reach 4	Parcels R046003B; R046003C; R046003D	Martin Avenue near Broadturn Road	Invasive species potentially clogging culvert	Slopes adjacent to culvert may need to be re-worked to establish native vegetation; alternatively, slopes can be covered with a non-woven geotextile and riprap for stabilization without vegetative cover	High	$15 - 20K
IS-3	Reach 3	U031065	Between Martin Avenue and Susan Avenue	Bank seepage evident; bank failures	Stabilize banks with log and/or boulder cross vane structures	Low	$20 - 30K
IS-4	Reach 3	TBD	Old mill dam between Susan Ave and Martin Ave	Associated upstream aggradation of sediments; associated downstream bank failures	Consider removal/modification of dam to allow enhanced stream connectivity; evaluate for historical significance; conduct comprehensive feasibility study including hydrological analysis; follow with stream bank restoration and dredging of aggraded materials	Low/Study	$100 - 150K
IS-5	Reach 2	R047008	Broadturn Road crossing	Accumulated trash and debris	Town to remove accumulated trash and debris	High	$200
IS-6	Reach 1	U034032	Scarborough staging yard on Payne Road	Floodplain fill impacting flow; severe bank erosion evident	Work with Scarborough Public Works to identify acceptable modifications to the layout of the property to allow fill to be pulled out of the floodplain; employ bankfull bench structure at slopes; stabilize banks in place with boulders, woody debris, or similar	High	$200 - 300K
IS-7	Dunstan Reach	TBD	Between Susan Ave culvert and Dunstan Reach	Bank failures; Incised bed	Reconnect floodplain using log and/or boulder cross vane structures	Medium	$20 - 30K
IS-8	Dunstan Reach	TBD	Dunstan Crossing detention ponds downstream to confluence	Bed degradation and aggradation; sediment load exceeding natural rates	Work with release rates from detention ponds; instream structures like log/boulder cross vanes and energy dissipation to accommodate higher velocities during detention pond runoff release	Medium	$30 - 40K-

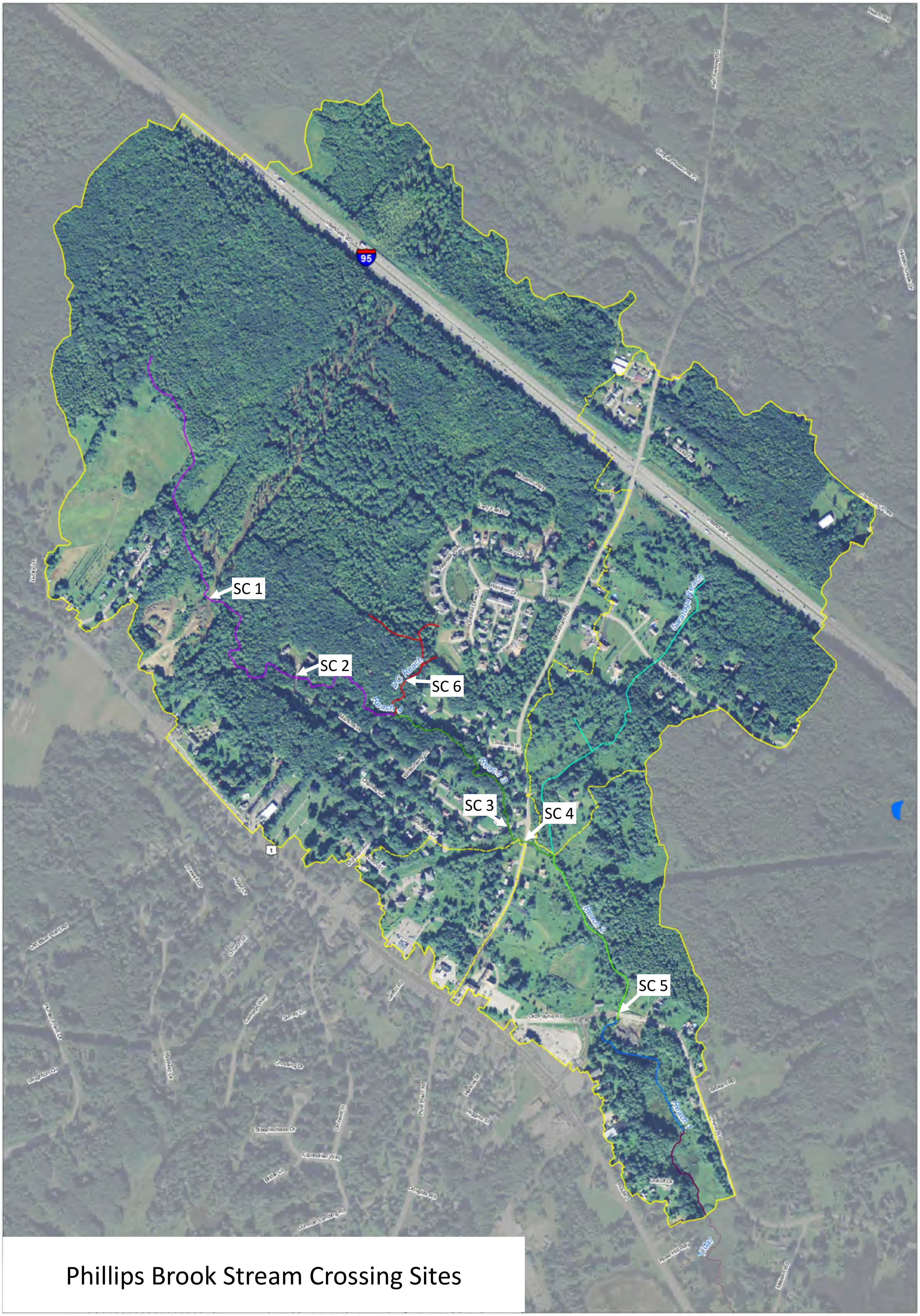


Phillips Brook In-Stream Sites

Appendix C: **Stream Crossing Improvement Projects**

This table lists locations where a **roadway or driveway** that **crosses** Phillips Brook is problematic for stream health and presents an opportunity for improvement. Any recommendation for replacement offers the best possible solution. If replacing the structure is not feasible, stabilization measures should still be implemented.

Site ID	Reach	Responsible Party	Crossing Street	Crossing Infrastructure	Description of Issue	Recommendations	Priority	Cost Estimate
SC-1	Reach 4	Dunstan Crossing / TBD	Stewart Drive	Private / logging road	Culvert failure evident; scour pool present; stream plugging occurring	Replace with properly-sized structure meeting Aquatic Organism Passage (AOP) standards; stabilize stream banks with log and/or boulder cross vane structures	High	$150 - 200K
SC-2	Reach 4	Parcels R046003B; R046003C; R046003D	Private drive / Martin Avenue Extension	48" diameter culvert	Culvert undersized; reported driveway flooding in larger storm events	Explore public/private partnership to replace with properly-sized structure meeting AOP standards.	Low	$75 - 100K
SC-3	Reach 3	Town	Martin Avenue	36" diameter culvert	Undersized culverts resulting in scour pool and bank erosion; reported roadway flooding in larger storm events	Replace with properly-sized structure meeting AOP standards; stabilize banks in place with boulders and/or woody debris	Medium	$30 - 50K
SC-4	Reach 3	Town	Broadturn Road	Two 48" diameter culverts	Undersized culverts resulting in scour pool and bank erosion; reported roadway flooding in larger storm events	Replace with properly-sized structure meeting AOP standards; stabilize stream banks with log and/or boulder cross vane structures	High	$150 - 200K
SC-5	Reach 2	Town	Payne Road	Two 60" diameter culverts	Undersized culverts resulting in scour pool and severe bank erosion; reported roadway flooding in larger storm events	Replace with properly-sized structure meeting AOP standards; stabilize stream with log and/or boulder cross vane structures	High	$175 - 225K
SC-6	Dunstan Reach	Parcels U031083D and U031083	Susan Avenue/Dunstan Reach	Private / logging road	Undersized culvert resulting in bank failures in tributary	Stabilize slopes; replace with properly sized structure meeting AOP standards; stabilize banks in place with boulders and/or woody debris	High	$75 - 100K



Phillips Brook Stream Crossing Sites

Appendix D: Policy: Ordinance

Potential Solution	Issues Addressed			Cost Estimate	Timeline	Implications	Priority
	Sediment	Habitat	Chlorides				
Seek Development Review Authority / Capacity	✓	✓	✓	$$	Short-term*	• BENEFIT: allows Town maximum flexibility for review and direction of development • Requires extremely knowledgeable and engaged staff (Engineer, Planner, Economic Department) • Happening already in the region • Has not "scared off" or halted development in Portland	1
Expand stream protection zones	✓	✓	✓	$	Mid-term*	• BENEFIT: allows Town more say in activities within the protection zone • Defines set back area for protection zone • Already in place for main stem of Red Brook (75') and Nonesuch River (250')	2
Refine Stormwater standards for sites not triggering CH500	✓	✓	✓	$$	Short-term*	• BENEFIT: allows Town to eliminate or minimize barriers to implementing: o Best Management Practices o Green Infrastructure o Low Impact Development techniques o Other beneficial / innovative measures • Regional effort underway with Regional Clean Water Collaborative (RCWC)	3
Refine standards for all stream crossings	✓	✓		$$$	Short-term*	• BENEFIT: maximizes protections for stream, habitat, etc. • Require 1.2 bankfull width (currently only a recommendation) • Happening already in region • AOP standards exist; Maine DOT spec • Require with geomorphic analysis	4
Limit impervious cover in watershed / sensitive zone	✓	✓	✓	$ - $$$	Short-term*	• BENEFIT: allows Town to direct growth (up vs. out), prioritize open space, spark innovative design, and address impervious cover TMDL (pollution budget for water body) • See Center for Watershed Protection model • Eventually run out of impervious cover (places for development) • Existing development in Long Creek already pays $3K annually for each acre of impervious cover • Staff commitment needed, heavy reliance on accurate GIS data • Develop a chloride minimization strategy to explore options for reducing chlorides	5
Improve ordinances to address climate change and resiliency	✓	✓		$$	Short-term*	o BENEFIT: allows Town to improve resilience and overall sustainability	6
Encourage conservation of undeveloped land	✓	✓	✓	$$$	ongoing	• BENEFIT: allows Town to coordinate with partners (SLT, FoSM, etc.) to prioritize conservation and protections	7
Address (over board discharge) OBDs and aging septic systems	✓	✓	✓	$	Mid-term*	• BENEFIT: reduces direct discharges of pollutants to streams and wetlands	8

* short-term= 1-4 years; mid-term=4-8 years; long-term=8-10+ years

Appendix E: Development Standards / Design

Potential Solution	Issues Addressed			Cost Estimate	Timeline	Implications	Priority
	Sediment	Habitat	Chlorides				
Allow credits/exchange to developers to increase flexibility	✓	✓	✓	$$	Mid-term*	• BENEFIT: With Delegated Review Authority and capacity; allows Town flexibility to work with developers to find best possible solutions for specific sites • BENEFIT: Will allow “development-friendly” flexibility while still engaging in site design that best protects the environment	**1**
Enhance floodplain protection/restoration on all levels of development	✓	✓	✓	$	Mid-term*	• BENEFIT: Allows Town control over floodplain impacts • Already required for new development o expand to redevelopment • Relevant to resiliency in the face of climate change	**2**

Require improvement to site conditions for re-development	✓	✓	✓	$	Mid-term*	• BENEFIT: Allows Town authority to require improvement while allowing flexibility to determine what's best for the site, such as:
						  o Increased buffer
						  o Less impervious
						  o Additional treatment
						• Reduction of grandfather status
							3

Stricter requirements for stormwater management for new development	✓	✓	✓	$	Mid-term*	• Address rate & velocity • Current language requires no adverse impacts; should it be more specific? o Could require zero increase in rate & velocity	**4**
Require low-impact development (LID) techniques	✓	✓	✓	$	Mid-term*	• Proposed through CH500 • DEP cautions in watersheds already stressed by chlorides • Already happening in region o LID standard in York	**Not prioritized**
Enhance post-construction O&M standards for new and re-development	✓	✓	✓	$	Short-term*	• BENEFIT: Encourages Town oversight and follow-up on O&M actions • Draft done for Red Brook landowners • Already required for sites >1 acre	**Not prioritized**

* short-term= 1-4 years; mid-term=4-8 years; long-term=8-10+ years

Appendix F: Policy: Financial

Potential Solution	Issues Addressed			Cost Estimate	Timeline	Implications	Priority
	Sediment	Habitat	Chlorides				
Stormwater Impact Fees	✓	✓	✓	$	Short-term*	• BENEFIT: allows reinvestment in improvement projects and collective protection efforts, such as: o Land acquisition (headwaters, stream corridor) o Culverts and other structural upgrades • Happening already in the region • Outreach to developers and landowners needed	**Low**
Wetlands Impact fees	✓	✓		$	Short-term*	• BENEFIT: allows Town to develop flood mitigation bank to reinvest or self-insure properties • Happening already in the region • Outreach to developers and landowners needed	**Low**
Compensation Fee Utilization Plan (CFUP)	✓	✓	✓	$	Short-term*	• BENEFIT: allows Town to reinvest in-lieu fees in impaired watersheds to fund prioritized list of restoration and protection projects • Happening already in the region • Guidance available on this DEP Program	**Medium**
Tax Increment Financing (TIF)	✓	✓	✓	$$	Mid-term*	• BENEFIT: provides subsidy for redevelopment to incorporate stormwater infrastructure or address structural retrofits • BENEFIT: promotes public-private partnership (P3) • Happening already in the region o Falmouth has been very successful (TIFs, P3)	**High**
Incentives for conservation and protection of natural landscape (land, water, flora, fauna, etc.)	✓	✓	✓	$	Mid-term*	• BENEFIT: provide mechanism for conserving / protecting: o Headwaters o Floodplain o riparian corridor o wetlands o other vital areas that maintain watershed health (e.g., vernal pools)	**High**
Stormwater Utility Fee	✓	✓	✓	$$$	Mid-term*	• BENEFIT: provides a self-generating revenue source for the Town to comprehensively address: o All retrofits of stormwater infrastructure, in-stream corridor, stressors, and water quality monitoring needs o Other stormwater permit requirements and impairment issues throughout the Town • Happening already in the region • Outreach to entire community needed	**Medium**
Vernal Pool SAMP	✓			$$	Long-term*	• BENEFIT: allows Town to self-designate VP areas • Happening already in region: Orono, Topsham • Collaborate with land trusts • VP inventory in progress by Conservation Commission	**Low**
Pursue P3 to promote additional BMPs, LID, GI	✓	✓	✓	$	Mid-term*	• BENEFIT: Work with existing partnerships	**Low**

* short-term= 1-4 years; mid-term=4-8 years; long-term=8-10+ years

A STUDY OF BANK EROSION RATES IN PHILLIPS BROOK: HEADWATER TO TIDAL REACHES

Cumberland County Soil & Water Conservation District

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1.0 INTRODUCTION

The Town of Scarborough is in the process of developing a Watershed Management Plan (WMP) with the inclusion of a Stream Corridor Survey. This survey evaluated the health of Phillips Brook from its headwaters to its tidal water influence. This document describes the geomorphic findings for approximately 7,500 feet of the stream. Phillips Brook was broken down into four (4) distinct main stem reaches and two (2) tributary reaches (**Figure 1**). The four (4) main stem reaches were divided into thirty-four (34) study areas based on their bank erosion rate prediction.

- The survey, a reconnaissance-level assessment (RLA) level I bank erosion study, was performed to estimate erosion rates along the entire 7500ft of the stream.
- A level II survey was completed within 381 feet in the upper part of Reach 3. This included a longitudinal (long) profile and cross-section survey through riffles, two pools, two runs and two glides' stream bed features.

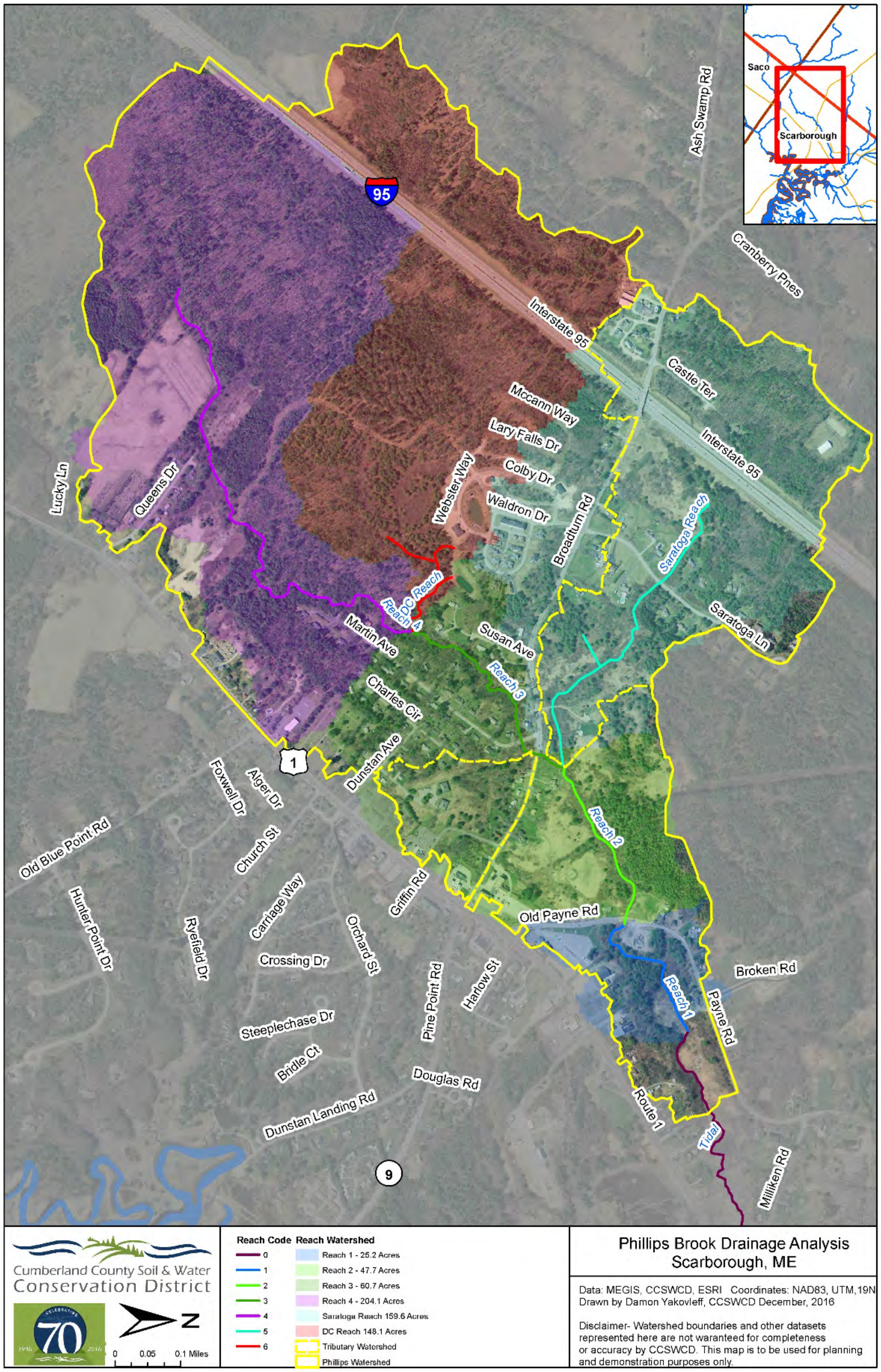
These surveys along with water quality data will inform the conceptual stabilization methodologies considered in the Phillips Brook WMP.

Streambank erosion rates can be predicted using the Bank Assessment for Non-Point Source Consequences of Sediment (BANCS; Rosgen 2006). This BANCS method was used to provide:

- an estimate of the rate of erosion and the amount of bank material being released from streambanks into Phillips Brook, and
- a visual assessment tool that, when combined with the quantitative studies completed in other states, reasonably estimates erosion rates.

The survey for Phillips Brook provided an overall estimate of erosion, calculated by multiplying the length and height of each bank type by the specific bank erosion term, and then summing the estimates of erosion. This provides an estimate of cubic yards and/or tons of sediment that erode per year per foot of stream.

Figure 1: Phillips Brook Watershed Study Area



2.0 SITE DESCRIPTION

Phillips Brook is located primarily in the Town of Scarborough and covers 653 acres (1.02 square miles) in the Dunstan Corner area. The watershed's 2.77 miles of brook was divided into the following reaches (**Figure 1**):

- **Reach 1** begins at the double 60"-diameter Payne Road culverts (station 63+92) and ends at the tidal influenced boundary (station 75+32) at the lower end of the watershed. It is bound to the north by Route 1 and the south by Payne Road.
- **Reach 2** begins at the double 48"-diameter Broadturn Road culverts (station 46+94) and ends at the Payne Road Culverts (station 63+92). This reach has some large instability downstream of the Broadturn Road culverts.
- **Reach 3** is defined as the section of Phillips Brook beginning at the confluence with the Dunstan Crossing Reach (station 31+63) and continues downstream until it intersects with the Broadturn Road culverts (station 46+94).
- **Reach 4** begins in the headwaters of the watershed (station 0+00) and ends at the Dunstan Crossing Reach confluence (station 31+63). This reach show signs of instability in and around the culvert failure in the upper watershed as well as the 48" diameter culvert where the upper Martin Ave crosses the stream.
- **Dunstan Crossing Reach** begins above Dunstan Crossing and ends at the confluence with Reach 3.
- **Saratoga Reach** begins above Interstate 95 and ends at the confluence with Reach 2.

Additional level II and level III studies were completed in Reach 3 which began at the confluence with the Dunstan Crossing Reach (DCR) and continued downstream 381 feet. Reach 3 exhibits signs of instability including bank erosion, vegetation loss, and channel incision resulting in an abandoned floodplain. Historic land use practices along this reach include deforestation in the headwaters, floodplain encroachment, the installation of numerous stream crossings including a legacy mill dam site.

The watershed is a mix of new growth forest and large areas deforested to facilitate land development with limited vegetated buffers along stream reaches. There are agricultural fields from the Reach 4 headwaters through the end of Reach 3. The watershed changes to a wider mixed brush and grass floodplain beginning in Reach 2 to the tidal boundary of Reach 1**.**

2.1. DRAINAGE BASIN AREA and STRESSORS

Phillips Brook's six reaches have a total watershed area of 645.4 acres.

- Reach 1, which begins at the Payne Road Culvert and ends at the tidal influence, consists of 25.2 acres.
- Reach 2, which begins at Broadturn Road and ends at Payne Road, consists of 47.7 acres.
- Reach 3, which begins at the confluence with the DCR and ends at Broadturn Road culvert, consists of 60.7 acres without inclusion of the DCR watershed.

- Reach 4, which begins in the headwaters above Queens Drive and ends at the DCR/Reach 3 confluence, consists of 204.1 acres.
- Dunstan Crossing Reach, which begins above Dunstan Crossing and ends at the confluence with Reach 3, consists of 148.1 acres.
- Saratoga Reach, which begins above Interstate 95 and ends at the confluence with Reach 2, consists of 159.6 acres.

Reach 1 challenges include contraction scour below the Payne Road culverts and floodplain fill from the Scarborough staging yard. Reach 2 challenges include runoff changes from Interstate 95 and contraction scour below the Broadturn culverts. Reach 3 has several challenges including increased flows due to watershed changes, contraction scour from culverts, and an abandoned mill dam. Reach 4 challenges include increased runoff from Interstate 95 to the headwater wetlands, the contraction scour below the Martin Lane culvert, and scour and stream plugging at the failing old logging access culvert. See **Appendix A**.

2.2. PHYSIOGRAPHY, GEOLOGY, AND SOILS

Phillips Brook is located in the Coastal Lowlands physiographic ecoregion (Toppan, 1935) along the southern boundary of the Town of Scarborough. The geology of the Coastal Lowlands ecoregion is highly varied. The landscape's broad ridges and valleys have a strong northeast alignment that parallels the underlying trend of faults and bedrock lineaments (Maine Geological Survey, 1985). This region has an average elevation of little over 100 feet above high tide elevation.

The dominant bedrock lithology in the project vicinity is comprised of sedimentary and metasedimentary rocks of Silurian-Delvonian and Carboniferous age (Soil Conservation Service, 1974). Soils within this ecoregion are typically thin, granular till deposits occurring frequently with rock outcroppings. Water infiltration capacity is moderate and runoff can be rapid until marine clay lenses are encountered.

3.0 METHODOLOGY

During the weeks of June 20 to June 28, 2016, bank erosion surveys were performed on Phillips Brook for the entire stream, starting in the headwaters and ending at the tidal influence. During the month of July, qualitative surveys were conducted in the Dunstan Crossing Reach (DCR). These included long profile, cross-section survey, bank profiles and bank pin installation and scour chains at two riffles. Survey monuments were set that will allow the reach to be analyzed for change over time with future surveys. Bank Pins and scour chains that were installed will provide the ability of future analysis regarding change that is occurring vertically and horizontally in the stream reach.

The BANCS method uses two bank erodibility estimation tools: Bank Erosion Hazard Index

(BEHI) and Near Bank Stress (NBS). The application involves evaluating the bank characteristics and flow distribution along river reaches, mapping the location and extent of each bank feature, and developing risk ratings per bank feature. The BEHI and NBS surveys were conducted along the entire stream consisting of thirty-four (34) BANCS study area sites. The BANCS data set used for predicting stream erosion rates was not collected in the Saratoga reach or DCR as part of this work.

3.1. BANK EROSION HAZARD INDEX (BEHI)

BEHI provides an indication of streambank susceptibility to erosion, while NBS provides an indication of the erosive forces acting on the streambank. BEHI included photo documentation of existing conditions and notes and assigned numerical erosion values to stressed or unstable areas. Field surveys of bank erosion were not included for evaluation in this project for the Saratoga reach or DCR, the BEHI and NBS values began to decline below the DCR confluence of Reach 3. Representative photographs of banks (**Appendix B**) were taken to visually document BEHI conditions and factors contributing to NBS. It is highly possible the runoff effect and the discharge manner of DCR stormwater ponds are contributing to this affect.

During field surveys, the left and right banks of study areas 1 through 34 were classified based on both the BEHI and NBS. D1, D2 and D3 of **Appendix D** show example BEHI, NBS and BANCS data forms, respectively. As part of classification, stream bank study areas were divided into segments and inventoried based on the changes in physical bank characteristics and the applied shear stress (e.g., bank height), root depths, root density, bank angle, and amount of surface protection. The locations of bank segments and sampling locations were marked on aerial photographs during the field survey.

In the BANCS model, there are seven methods that can be used to assess energy distribution against streambanks, which is referred to as NBS. Method 1 was used during this survey as it is the most rapid method when the channel pattern consists of central and transverse bars and the stream has high slope (velocity gradient). Method 1, which is completed in the field is performed by identifying stream deposition, degradation and unstable banks was utilized NBS values range from High, Very High to Extreme for Method 1. The location of the thalweg was analyzed in the field for central and transverse bar deposition zones to assist the indication of the NBS rating.

Maine does not currently have a streambank erosion rate BEHI and NBS curve. Streambank erosion rates for BEHI/NBS were therefore predicted using the relationships derived from two of the three regional curves that have been validated for various soil density and streambank failure mechanisms. The three curves used in North America are the:

- Colorado, for sedimentary and/or metamorphic geology
- Yellowstone National Park, for glaciation and/or volcanic geology
- North Carolina, for piedmont/alluvial geology

BANCS study areas 1 and 34 were converted to bank erosion rates using graphs for the North Carolina Piedmont Region (North Carolina State University Stream Restoration Program 1989) and the South Central Colorado Region (USEPA 1989; **Figures 2** and 3, respectively). It should be noted that, based on soil cohesion and vegetation type, it is expected that the South Central Colorado Region data will over-predict bank erosion and the North Carolina Piedmont Region data will likely under-predict bank erosion for Phillips Brook. Although the North Carolina curve would likely reflect a more similar soil cohesion and vegetation type as is found in the coastal lowlands of Maine, both the North Carolina and Colorado curve numbers for streambank erosion rate prediction were used in predicting erosion rates for Phillips Brook.

3.2. LONGPROFILE AND CROSS SECTION SURVEY

The long profile characterizes average stream slopes and depths of riffles, pools, runs, glides and steps. The average water surface slope is required for delineating stream types and is used as a parameter for dimensionless ratios for restoration decisions. The water surface slopes of individual bed features can be compared using longitudinal data. In addition, the long profile can be used during the design stages to obtain maximum depths of individual bed features as well proper design bed feature spacing. See **Appendix C**.

Cross-section data at riffle locations provides the morphological parameters required for classifying the stream. The cross-sections also provide quantitative parameters that are used during the design stage for restoration. These parameters include: bankfull cross-sectional area; bankfull width; width/depth ratio and entrenchment ratio. Two cross-sections were obtained at separate riffles and pools within Reach 3. Only one cross-section was obtained from the other individual glide and run bed features, See Appendix C. The Rosgen stream classification is calculated from long profile and cross-section data, see Appendix D.

The long profile and cross-sections were permanently monumented in the field with rebar so that the surveys can be repeated in the future. This provides a procedure to compare the measured stream channel dimensions from one year to changes that may occur in the future. The documented changes in channel dimensions, pattern, profile and materials, as well as streambank erosion sediment relations can be used as overlays to reflect temporal change. The BANCS prediction methodology can also be validated with a new survey capturing the measured channel response vs. the predicted erosion rates. These all provide confidence when determining appropriate conceptual design application with the goal of channel stability.

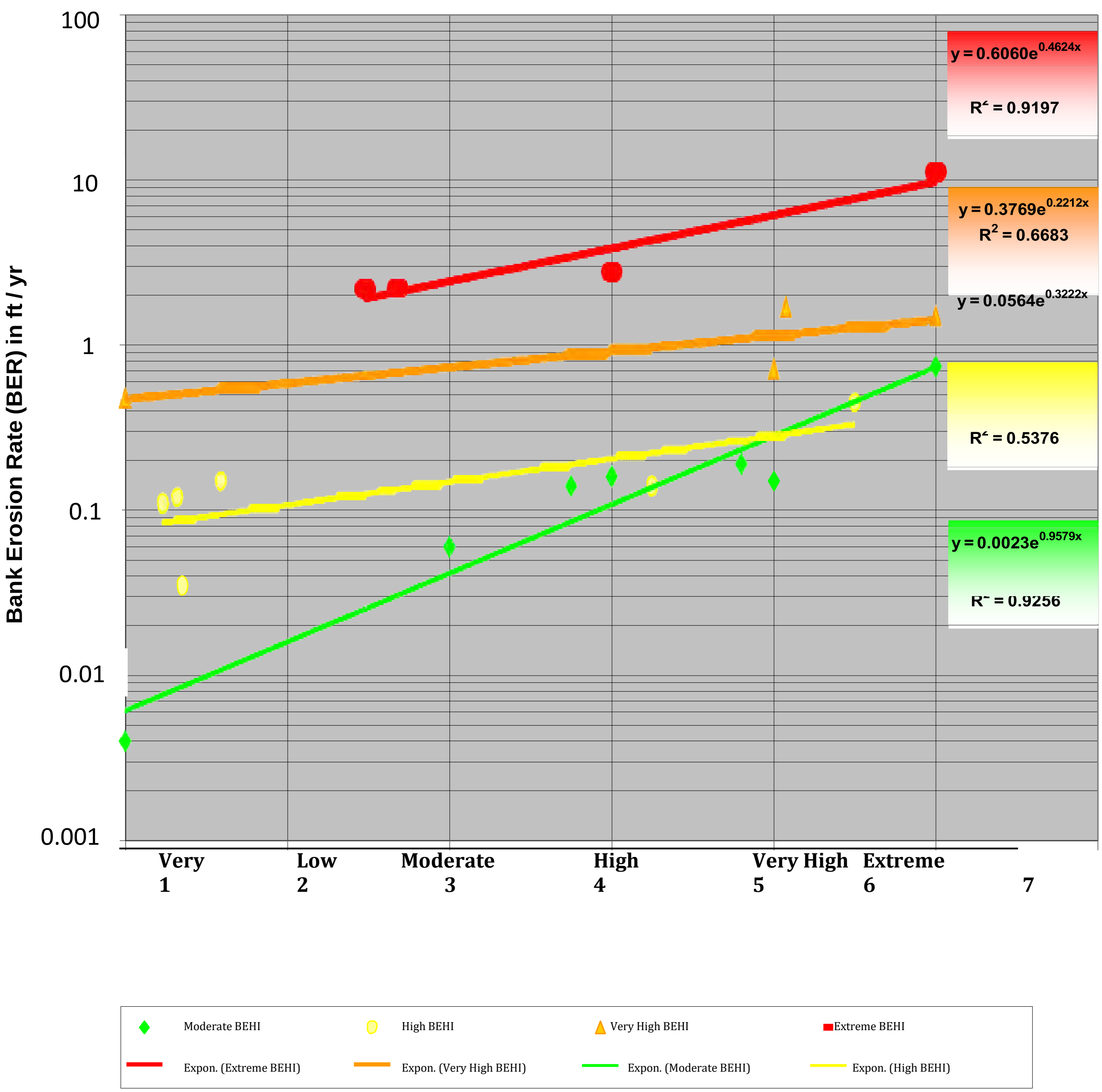
The bank pins installed in the long profile reach should be revisited by DEP after peak spring runoff occurs. The bank soil loss measured at the pins will be calculated as a volume of material and then converted to tons/foot/year. The volume of material (cubic feet) lost from the streambank each year can be converted to pounds based on a density of 40 pounds/cubic foot (lbs/cft).[1]

[1] Density estimated based on a particle density of 165 lbs/cft and bulk density of a sand soil of 105 lbs/cft (Jury and Horton 2004).

Figure 2. North Carolina Region Bank Erosion Prediction Curve

North Carolina Streambank Erodibility

Produced by NRCS and NCS



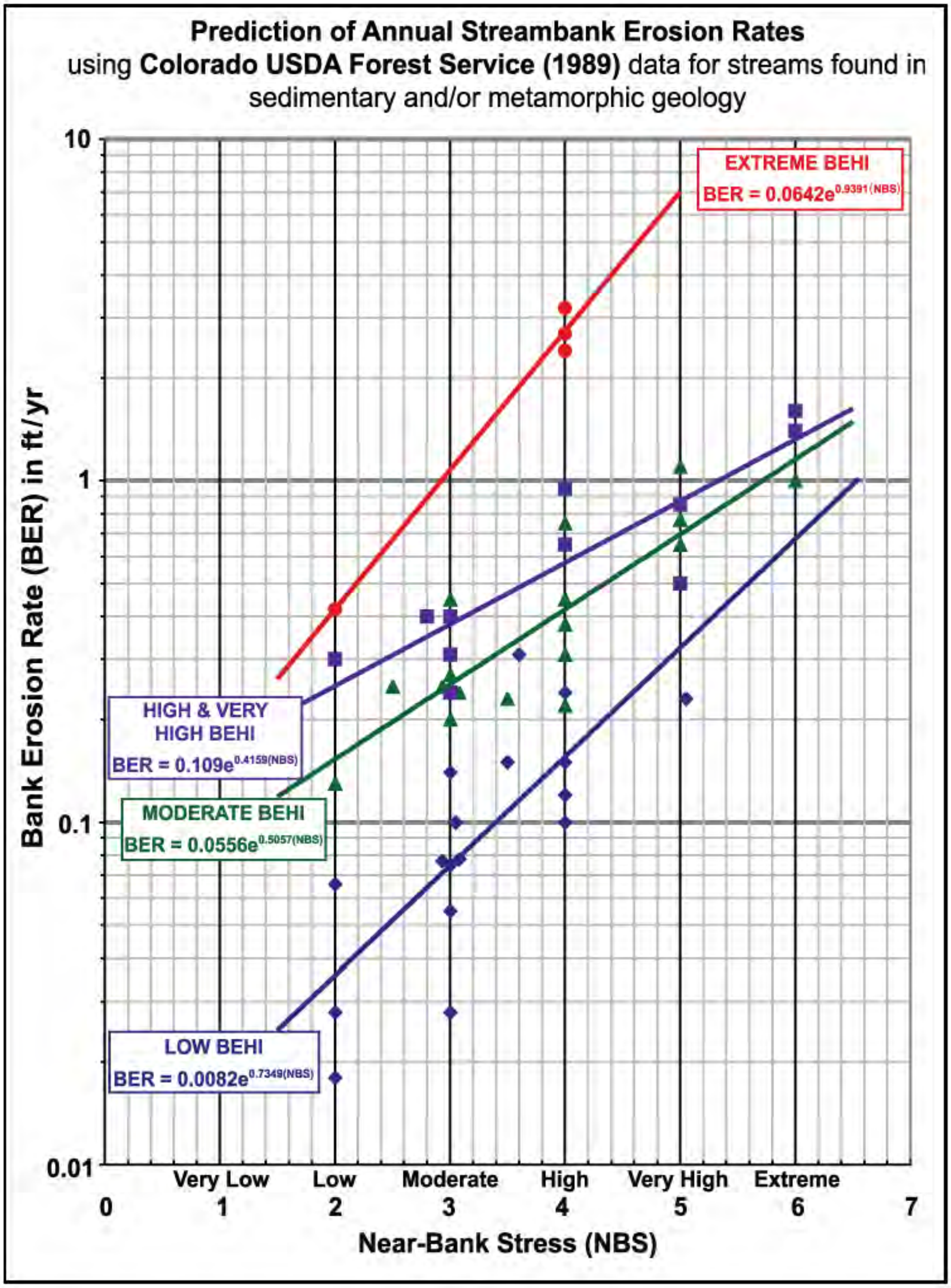


Figure 3. South Central Colorado Region Bank Erosion Prediction Curve

3.0 RESULTS

Phillips Brook in its entire BEHI and NBS assessment resulted in 34 separate surveyed bank erosion study areas. The BEHI and NBS data for study areas 1 and 34 are discussed. The study areas ranged from 22 to 936 feet in length. The longitudinal and cross-section surveys total 381 feet for BEHI and NBS study areas 18 and 19. The long profile and cross-section survey data was analyzed to provide the Rosgen stream classification.

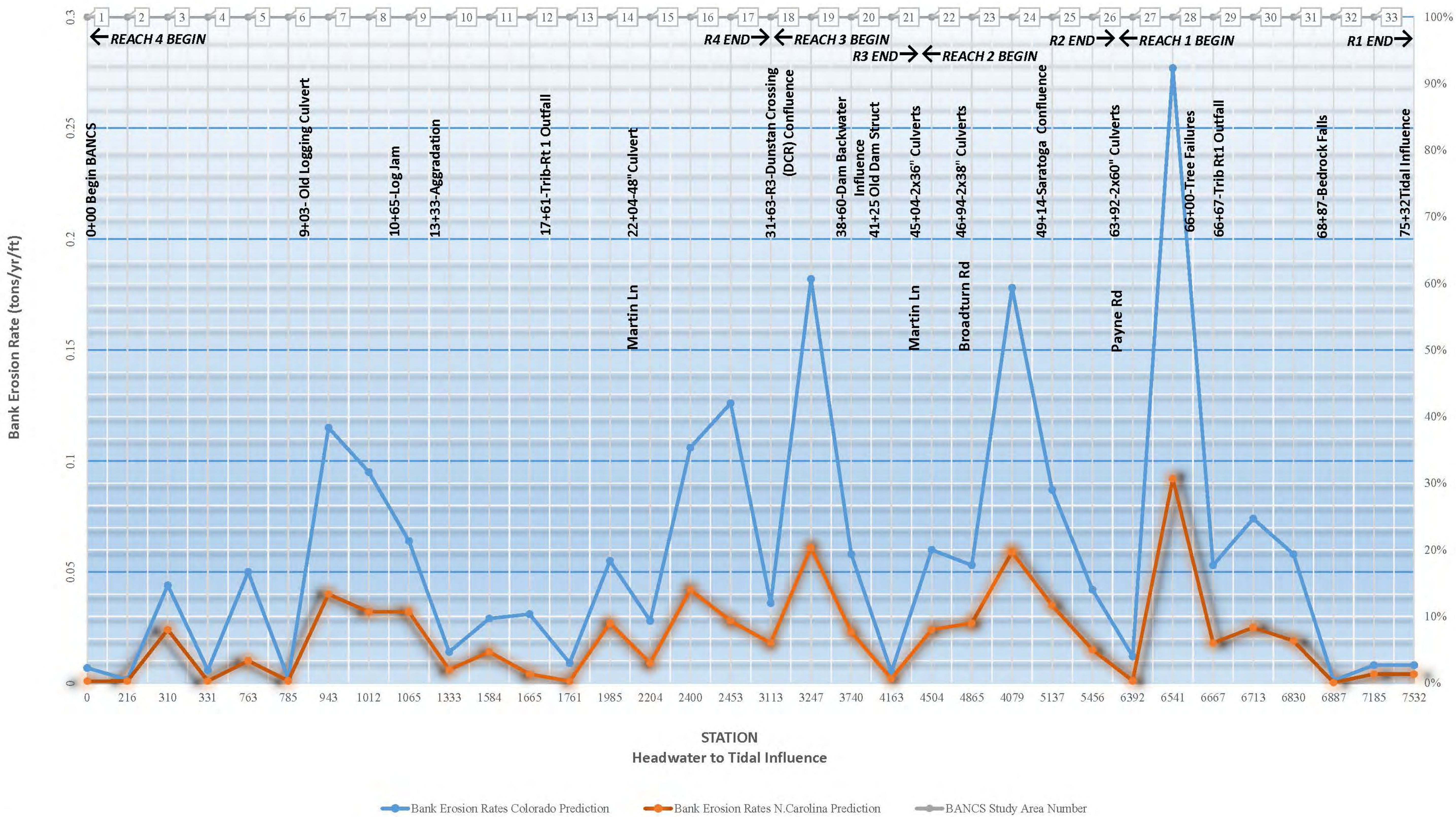
The curves shown in **Figures 2** and **3** were used to estimate yearly bank erosion based on BEHI and NBS values generated from the field survey. The BEHI and NBS numbers for the bank segments were converted to sediment in tons/foot/year by multiplying bank erosion rates (North Carolina and Colorado) by the bank height and the length of bank assessed.

The annual streambank erosion rates for BEHI and NBS were summarized for the Phillips Brook study areas. Study areas 1 through 34 have average bank erosion rates of 0.4 ft/year (Colorado curve) and 0.14 ft/year (North Carolina curve). Both curves provide a prediction two orders of magnitude higher than the rates of 0.001-0.005 feet/year documented for stable streams in similar valley systems in North Carolina (unpublished data). Even when considering that North Carolina rivers probably have lower rates of bank erosion than rivers in the northeast, the data from Phillips Brook clearly indicates that nearly all study areas are in a state of accelerated bank erosion. Only four (4) of the 34 study areas (13, 14, 33, and 34) have low predicted bank erosion rates and would be considered stable.

The total bank erosion predicted from the 7,500 linear feet of streambank surveyed was estimated to be about 234.8 tons/year (Colorado curve) (**Figure 3**) and 82.8 tons/year (North Carolina curve) (**Figure 2**). The conditions found along Phillips Brook are likely somewhere between the those found in North Carolina and Colorado, leading to the conclusion that erosion rates would fall somewhere between the rates calculated. The actual rate is based on conditions such as soil cohesion and vegetation, which can change depending on specific location.

The North Carolina and Colorado rates both show increased bank erosion rates are elevated downstream of culverts that are not sized adequately. This can be seen at the culverts located at station 9+03, 22+04 (upper Martin Ave), 45+04 (lower Martin Ave), 46+94 (Broadturn Road), and 63+29 (Payne Rd). Downstream from the culverts at Payne Road the bank erosion is the highest in the watershed at 0.09 tons/year/foot, see **Figure 4**. Similarly, downstream of the DCR station 31+63 has a predicted erosion rate of 0.061 tons/year/foot, the second highest erosion rate in the RLA.

Figure 4: Phillips Brook Bank Erosion Rate Prediction
Scarborough, ME



4.0 SUMMARY

Streambank erosion rates for study areas 1 and 34 of Phillips Brook, assessed in June 2016, were completed during a period of below average flow. Together, these two factors provide a good indication of streambank erosion. Using bank erosion prediction curves from North Carolina and Colorado, the BEHI and NBS scores were converted to erosion rates that averaged 0.27 feet/year over the 34 BANCS study areas surveyed. Stable alluvial streams generally demonstrate erosion rates of 0.001 to 0.005 feet/year. Based on this comparison, reaches of Phillips Brook are in a state of accelerated bank erosion. Culverts and stormwater infrastructure are attributing with the instability, mainly due to the changes made to the manner in which rainfall historically infiltrated the watershed versus how current stormwater runoff intensity, duration, and frequency discharge to the stream.

When combined with measurements of streambank height, the rates of erosion can be converted into a weight of sediment being distributed into the stream. Approximately 0.7 tons/year/foot or approximately 83 tons/year of sediment are being transported from these reaches to the Scarborough Marsh. The instream analysis revealed that many of the extreme and very high bank erosion rates were located upstream of point bars on the inside banks. Point bars are a sign of active channel migration and horizontal instability which develop in the stream's effort to reduce width/depth ratio, reduce slope and eventually develop a stable stream type. The quantity of sediment being distributed into the stream is currently filling in the stream bed gravels which results in macro-invertebrate habitat loss.

5.0 RESTORATION DESIGN METHODOLOGY

Design methodology for restoration can be done in several ways and are often determined by the type of stream and the type of restoration considered. The alluvial design method of restoration uses a stable reference stream as a template to restore an impaired stream. A reference stream is of the same Rosgen stream type and valley type as the stream to be restored. Geomorphic measurements from such a reference stream are used to develop dimensionless ratios, used to calculate the dimensions of the design stream such as the conceptual riffle and pool design cross sections and stream pattern. Data from reference reaches will be used to develop the final restoration design. Using Rosgen parameters, B4/1, B3c, and C3b stream types located in a Valley Type VII should be surveyed by CCSWCD and be considered when preparing a final design to repair the F2/3 channel in Phillips Brook.

Following development of a design using alluvial design methodology, the restoration design is validated using sediment competence calculations to determine if the design channel can produce enough shear stress to transport the largest particle made available from its upstream reach during a bankfull event. This validation procedure assumes that sediment supply for the design reach includes bedload sediment that can replace riffle substrate transported downstream during a bankfull event. This helps to ensure stream facets are sustainable.

The threshold design method of stream restoration uses shear stress calculations to design riffle features using material too large to be moved during a specified design flow. This method is used when the sediment supply for a design reach is composed only of suspended sediment with no bedload supply to replace riffle substrate transported downstream during a bankfull event. Threshold design is an appropriate method for streams that receive clear-water, or “hungry water”, discharges such as those located downstream of dams, stormwater detention ponds, or culverts, and for those streams with limited flood plain access.

Preferred conceptual alternatives need to be determined in the WMP. However, dividing Phillips Brook into restoration areas based on the stressors is a solid place to begin this process. **Figure 4** clearly reveals five (5) areas of increased erosion rates. The five highest erosion areas are in all four reaches of Phillips Brook, and if restored should be based on individual restoration priority and methodology. The restoration areas that are located below a higher gradient reach, with apparent excess bedload and flows through a constrained valley, the project alternatives here should consider using alluvial design and threshold design methods. Due to the anticipated slopes and constrained valley, Rosgen stream types that are typical for this region (B4/1, B3c, and C3b) are recommended for use on this project.

Type 1 Restoration would involve replacing the incised channel with a new, stable stream at a higher elevation – essentially restoring the stream to original elevations and conditions. The new channel is typically an E or C. Type 2 Restoration would create a new, stable stream and floodplain at the existing channel-bed elevation – recreating natural conditions but at the lower elevation. The new channel is typically an E or C stream. Type 3 Restoration reconnects floodplain using boulder cross vane structures that support and protect the streambanks, provide grade control, and support scour pools for habitat between the structures. Type 3 Restoration projects will not require extensive changes to the surroundings but will require locally sources material for structure. Type 4 Restorations use various stabilization techniques to stabilize the banks in place. These techniques do not attempt to correct problems with dimension, pattern or profile.

Reaches 1, 2 and 3 are the most impacted reaches from stormwater infrastructure. Reach 1 is challenged by culverts and floodplain fill. This reach could be restored with the re-establishment of floodplain, Type 1 Restoration. This would establish bankfull stage and historical floodplain elevation below the Payne Road culverts. Reach 2 also has potential for Type 1 Restoration utilizing natural channel design methods to raise the bed through aggradation allowing the bankfull stage and floodplain connectivity to occur. Reach 3 (Sta. 31+13 to 46+94) could be restored as a B3/1 meandering stream type using threshold and natural channel design methods described in the following sections following Type 3 Restoration protocols. Reach 2 (Sta. 46+94 to 63+92) could be restored as a B3c moderately meandering stream type by similar methods. Reach 4 (Sta. 5+40 to Martin Ave) could be stabilized in place to a C3b meandering stream type following Type 4 Restoration protocols.

Restoration in selected reaches should propose to use structures including but not limited to cross vanes, J-hook vanes, and constructed riffles to aggrade the channel, decrease the width to depth ratio, increase the entrenchment ratio, and increase the low-flow water depth throughout the restored reach. Materials will be locally balanced to the extent practical such as to limit construction expenditures associated with hauling of material.

6.0 ECOLOGICAL OBJECTIVES

Phillips Brook historically provided habitat for anadromous Brook Trout (*Salvelinus fontinalis*). The proposed designs will accomplish several ecologically beneficial objectives within each restoration reach. By relocating the channel away from infrastructure and steep embankments, restructuring the stream pattern and profile, and changing the stream type, it will be possible to reduce bank erosion that is a source of sediment to Phillips Brook. While sand and fine gravel substrates will still be present within the reach, especially in lower energy areas such as glides and along point bars, the overall composition of bed substrates will shift such that gravels and cobbles will comprise a greater proportion of the surface area, which will increase the macro-invertebrate production (and therefore overall productivity) within the project reach.

Structural enhancements result in the formation of localized scour pools with the intent of increasing the frequency of pools that are an important, but rare, overwintering habitat in the reach. Another restoration objective in all restored reaches is to reduce lateral erosion on meander bends using log vane/rootwad combination structures. This structure will also serve as in-stream cover and high flow refugia for fish species present in the reach.

The food web within restored reaches is primarily driven by adjacent riparian vegetation which stimulates production through leaf litter fall. Enhancement of riffle surface area is expected to produce a measurable shift in the abundance of individuals within the various functional feeding groups toward those designed to process coarse particulate organic materials. Because many of the ecological processes that contribute to the integrity of aquatic ecosystems (leaf litter, wood recruitment, etc.) are intact within Phillips Brook, as the channel adjusts to further reduce the sediment supply, enhancement of the ecological quality of the stream is anticipated.

7.0 WATER QUALITY

One of the goals of any stream restoration projects in Phillips Brook is to improve water quality within the project reach. The proposed design will increase low-flow water depths in the project reach by reconstructing the stream channel to decrease the width to depth ratio, relocating the channel away from large sediment sources, restoring riffle-pool-run-glide morphology, and in some reaches restoring access to available floodplain habitat for flood flows. Increased low-flow water depths will result in cooler water temperatures and increased dissolved oxygen in the proposed channel. The aeration provided by riffle-pool-run-glide morphology as well as associated structures such as J-hook, log vane, step pool, and cross vane structures will also increase dissolved oxygen in the proposed channel. The restoration will also improve water quality by reducing sediment inputs from streambank erosion.

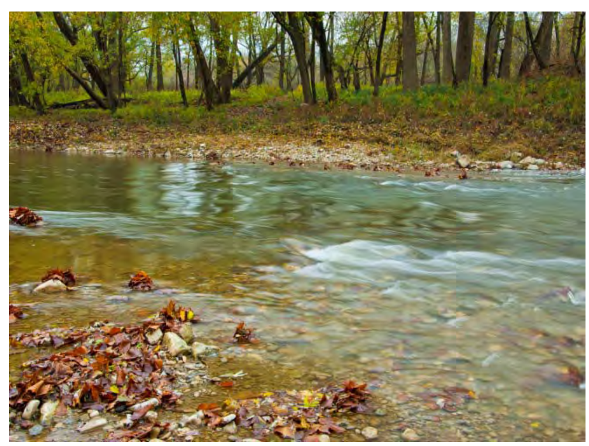
8.0 CONCEPTUAL DESIGN

8.1. STRUCTURES

The WMP will look to incorporate several features in the stream channel to improve the hydraulic and geomorphic stability and habitat. Features should be constructed of natural materials commonly used in natural channel design. These structures include, but are not limited to, bankfull benches, wood toe, vanes, step pools, and constructed riffles.

Bankfull Bench Structures Bankfull bench structures are relatively flat topographic features constructed at the base of steep slopes to increase the distance between stream shear forces and readily erodible bank materials. Such benches are typically vegetated with a suite of deep rooting woody shrubs and herbaceous species adapt at surviving in flood plain, near-stream situations. Bankfull benches mimic the effects of a naturally occurring flood plain and allow modification of channel geometry into a stable form that possesses the width and depth necessary to transport in-stream sediment load over time without aggrading or degrading. The overall sediment transport capacity of a channel is increased while shear stresses applied onto adjacent banks are decreased through use of the bankfull bench. Bankfull benches are relatively easy to construct and may be modified to include other features, such as wood toe. Bankfull benches have been successfully utilized on stream restoration projects for decades, but also occur naturally.

Wood Toe Structures Wood toe structures are relatively inexpensive, easy to construct structures which utilize a combination of woody debris, live cuttings, fill, and sod mats (materials readily available on most stream restoration projects). Wood toe serves to protect vulnerable and unstable banks while also providing a roughness element to help ensure pool habitat remains viable. Wood toe structures are a cover feature for numerous aquatic species and also serve as a long-term in-stream carbon source. Wood toe structures can be modified to provide additional overhead cover for native and resident fish species, simulating the presence of under-cut bank habitat on stable streams. Wood toe structures can also be incorporated into bankfull benches. Wood toe structures have been built for over 15 years and have proven to be effective.



Log J-Hook Structures Log J-hook structures are log, root wad, and boulder constructed structures constructed on the outside of stream bends at the head of pools where strong helical flows, high boundary stress, and high velocity gradients create high stress in the near-bank region. Log J-hook structures are designed to reduce accelerated streambank erosion on the outside of meander bends by reducing near-bank slope, velocity, velocity gradient, stream power, and shear stress. They also redirect flows away from the outside bend, and provide opportunities for overhead cover for native and resident fish species.
Log J-hook structures have been installed for over 10 years have proven to be a cost-effective solution to reducing streambank erosion along meander bends.

Constructed Riffles Boulder/cobble constructed riffles serve as vertical grade control while allowing sediment transport and fish passage. Boulder/cobble constructed riffles are constructed of large anchor boulders as well as a moveable bed in the low-flow region of the cross-section. Typically, materials are harvested from existing reaches that are armored with natural substrate. Constructed riffle features create a large range of velocity and depth combination, providing habitat for a host of aquatic species and serve as a veritable grocery store for native and resident fish species. Riffle structures can be modified to include low-low meanders, pocket pools, woody debris, and the occasional boulder cluster to further provide habitat diversity while meeting the project needs. Boulder/cobble constructed riffles have been built for over 10 years and have shown great resilience. Constructed riffles can also be designed to provide holding cover for fish.

Step-pool Structures Step-pool structures are a series of pools with sequential drops in elevation. These provide grade control and energy dissipation for high gradient channel sections. Scour holes created in each pool provide habitat for aquatic life. Step pools may be constructed with rock or trees. Step-pool structures are commonly used to connect small, intermittent tributary channels with project streams. Large woody debris, and boulder clusters may also be placed in the channel to enhance in-stream habitat and to mimic variability found in natural stream systems.

9.0 LITERATURE CITED

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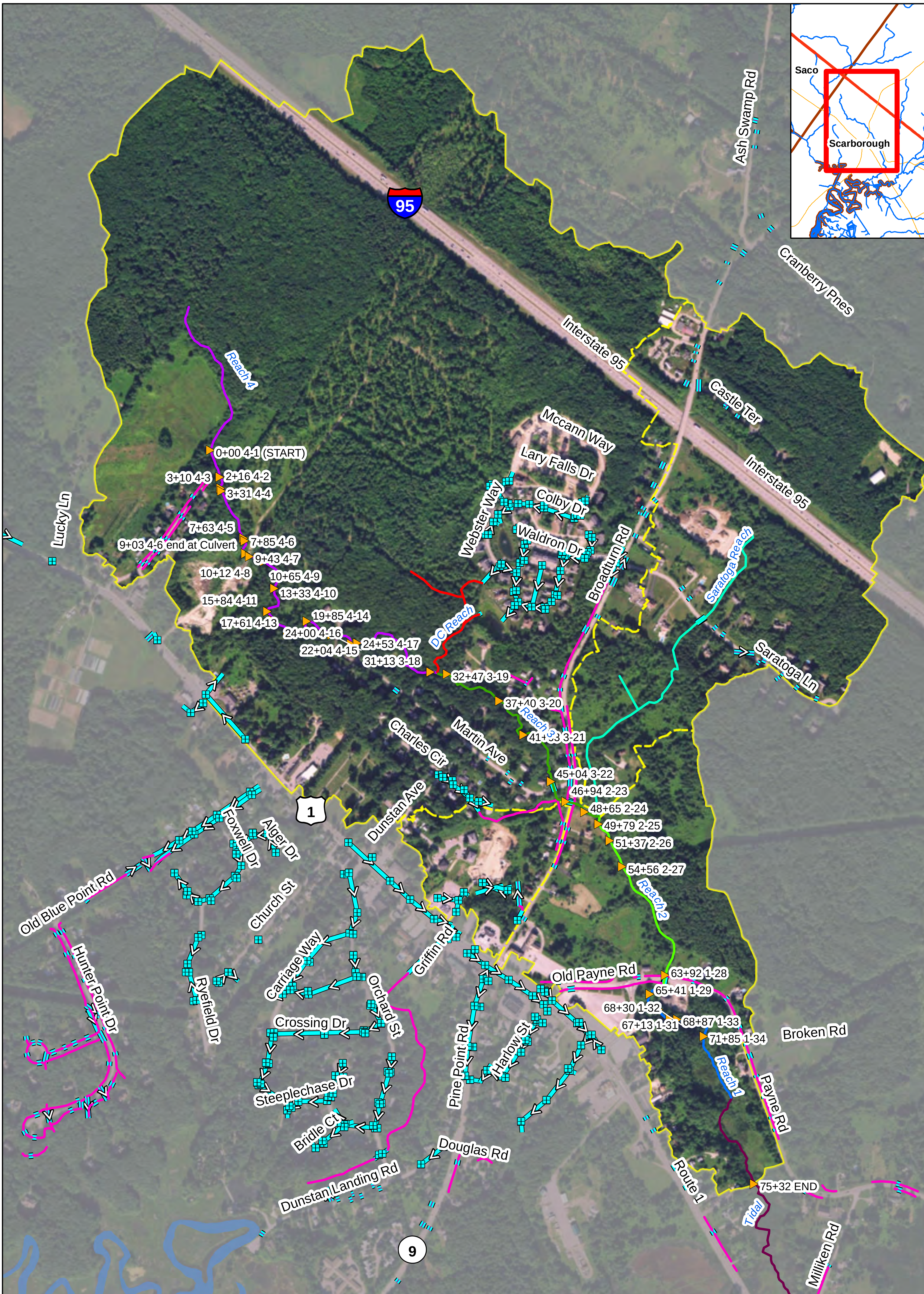
APPENDIX A

GIS Maps



Cumberland County Soil & Water Conservation District

CELEBRATING 70 1946 2016

N

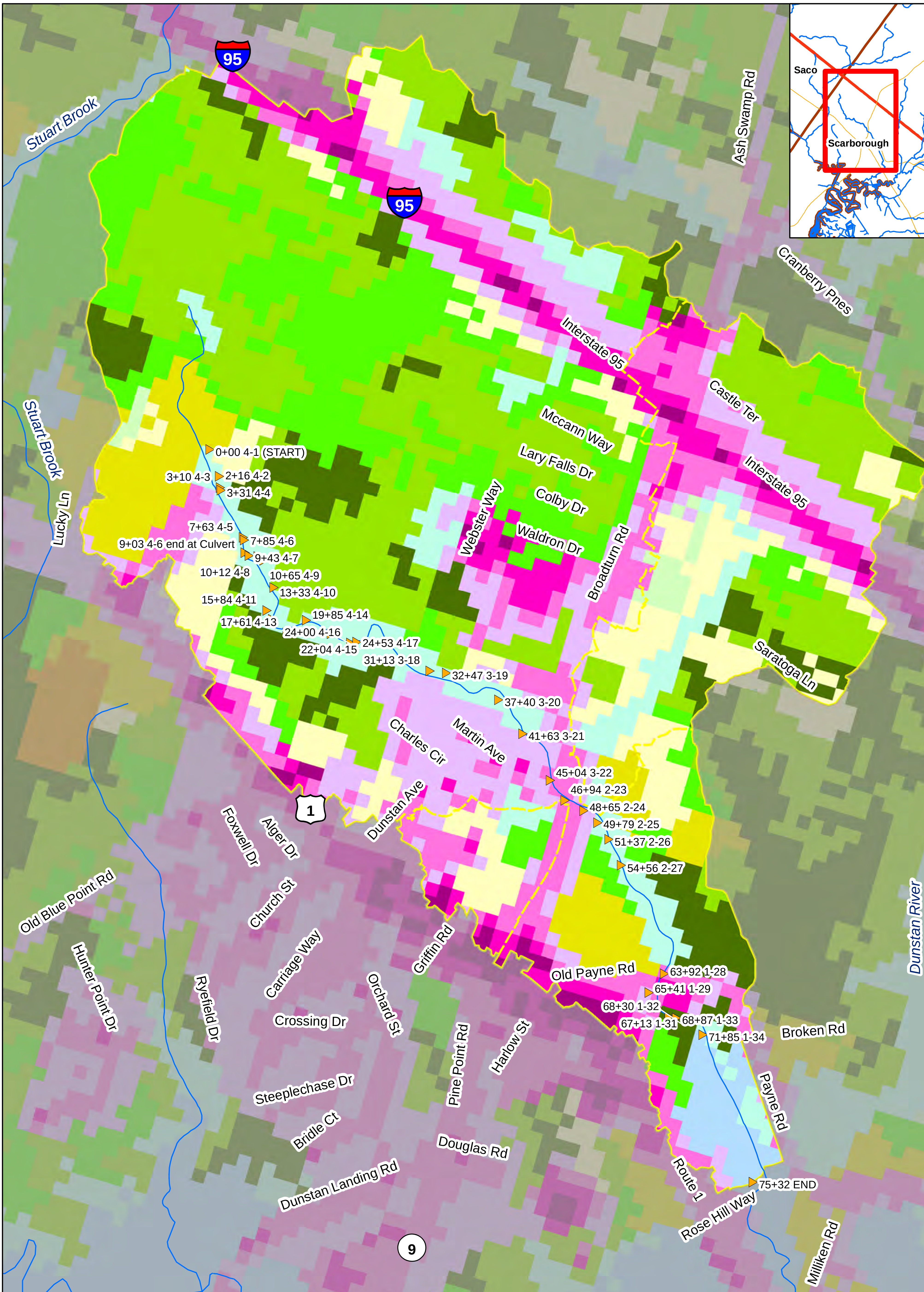
BANCS Study Area	**Reach Code**
Catch Basin	0
Ditches	1
Drain Pipes	2
Culverts	3
Tributary Watershed	4
Phillips Watershed	5
	6

0 0.05 0.1 0.2 Miles

A2 Phillips Brook SW Structures
Scarborough, ME

Data: MEGIS, CCSWCD, ESRI Coordinates: NAD83, UTM,19N
Drawn by Damon Yakovleff, CCSWCD Jan. 2017

Disclaimer- Watershed boundaries and other datasets represented here are not waranteed for completeness or accuracy by CCSWCD. This map is to be used for planning and demonstration purposes only.



Cumberland County Soil & Water Conservation District

CELEBRATING 70 1946 2016

N

BANCS Study Area
Phillips Watershed
Tributary Watershed
Stream

Land Cover

0 - Other
11 - Water
12 - Ice / Snow
21 - Dev'p Open Space
22 - Developed, Low
23 - Developed, Medium
24 - Developed, High
31 - Bare Areas
41 - Deciduous Forest
42 - Evergreen Forest
43 - Mixed Forest
52 - Scrubland
71 - Grassland
81 - Pasture
82 - Agriculture
90 - Wetland, woody
95 - Emergent Wetland

0 0.05 0.1 0.2 0.3 Miles

A3: Phillips Brook Land Use Scarborough, ME

Data: MEGIS, CCSWCD, ESRI Coordinates: NAD83, UTM,19N
Drawn by Damon Yakovleff, CCSWCD Jan. 2017

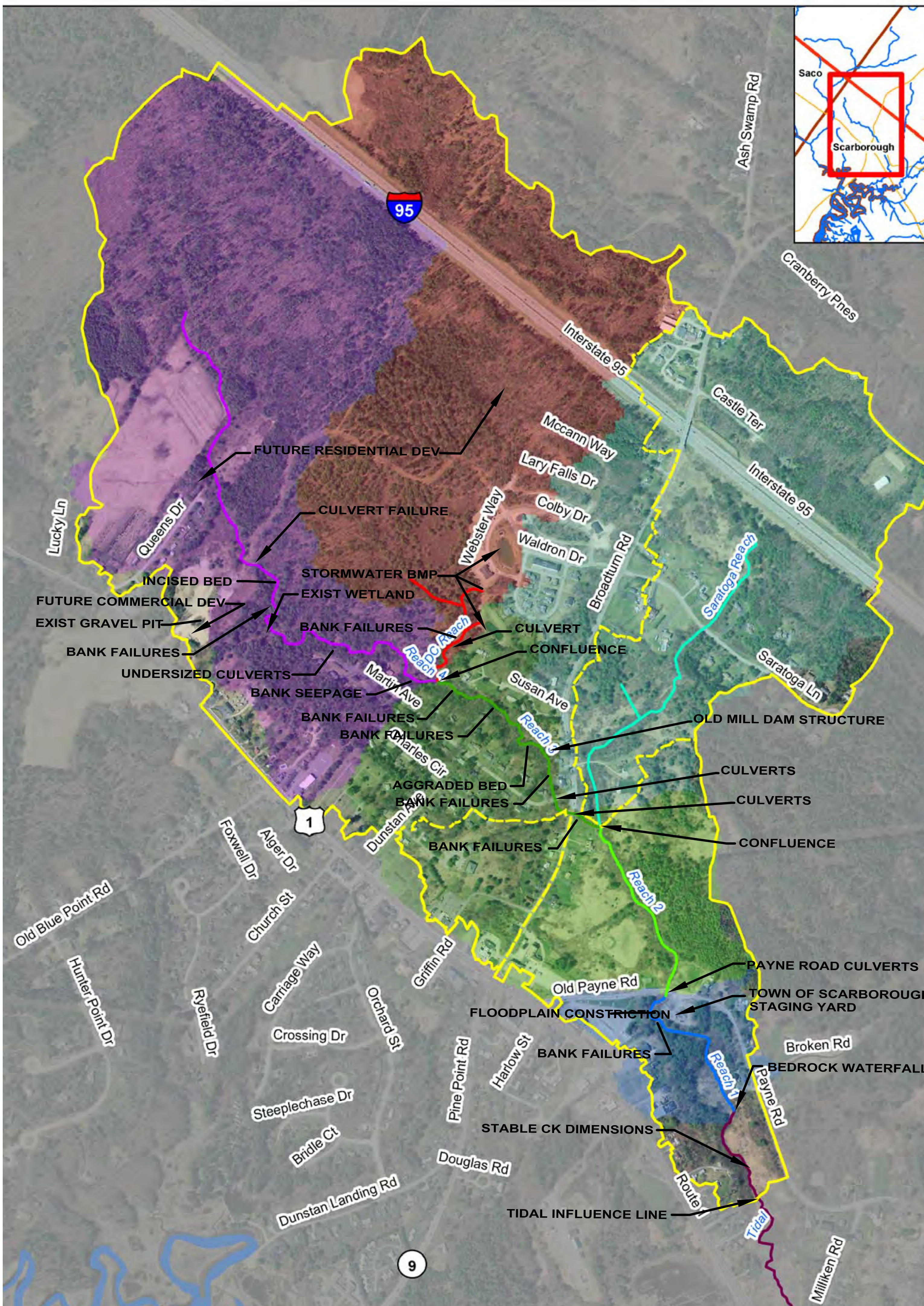
Disclaimer- Watershed boundaries and other datasets represented here are not waranteed for completeness or accuracy by CCSWCD. This map is to be used for planning and demonstration purposes only.

Reach Code	Reach Watershed
0	Reach 1 - 25.2 Acres
1	Reach 2 - 47.7 Acres
2	Reach 3 - 60.7 Acres
3	Reach 4 - 204.1 Acres
4	Saratoga Reach 159.6 Acres
5	DC Reach 148.1 Acres
6	Tributary Watershed
	Phillips Watershed

Phillips Brook Drainage Analysis
Scarborough, ME

Data: MEGIS, CCSWCD, ESRI Coordinates: NAD83, UTM,19N
Drawn by Damon Yakovleff, CCSWCD December, 2016

Disclaimer- Watershed boundaries and other datasets represented here are not waranteed for completeness or accuracy by CCSWCD. This map is to be used for planning and demonstration purposes only.



TITLE: REACHES AND OVERVIEW OF PHILLIPS BROOK WATERSHED SELECT IDENTIFIED STREAM STRESSORS

PROJECT: BANK EROSION RATES - PHILLIPS BROOK

LOCATION: REACHES ABOVE TIDAL

BY: T.BARRY

TRIBUTARY: PHILLIPS BROOK

DATE: 12/30/2016

SCALE: 1" = 800'

REVISIONS:

1

2

3

Cumberland County Soil & Water Conservation District

SHEET:

A-1

APPENDIX B

Representative Bank Photographs

Photo 1: Phillips Bk with bank conditions with a BEHI rating of Very Low

Photo 2: Phillips Bk with bank conditions with a BEHI rating of Low

Photo 3: Phillips Bk with bank conditions with a BEHI rating of Moderate/High

Photo 4: Phillips Bk with bank conditions with a BEHI rating of High/Extreme

Photo 5: Phillips Bk with bank conditions with a BEHI rating of very high

Photo 6: Phillips Bk with bank conditions with a BEHI rating of extreme

APPENDIX C

Longitudinal Profile & Cross Sections

FIG C-1: LONGPROFILE STA 0+00 - 3+81

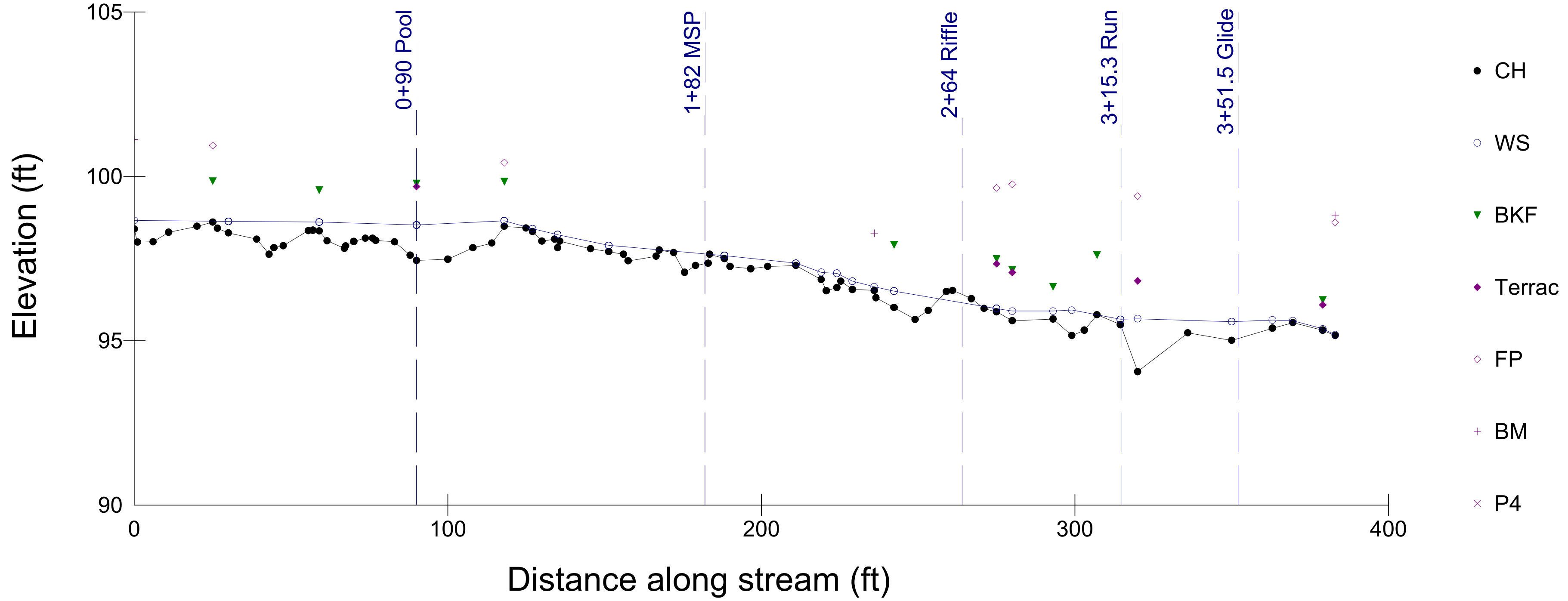
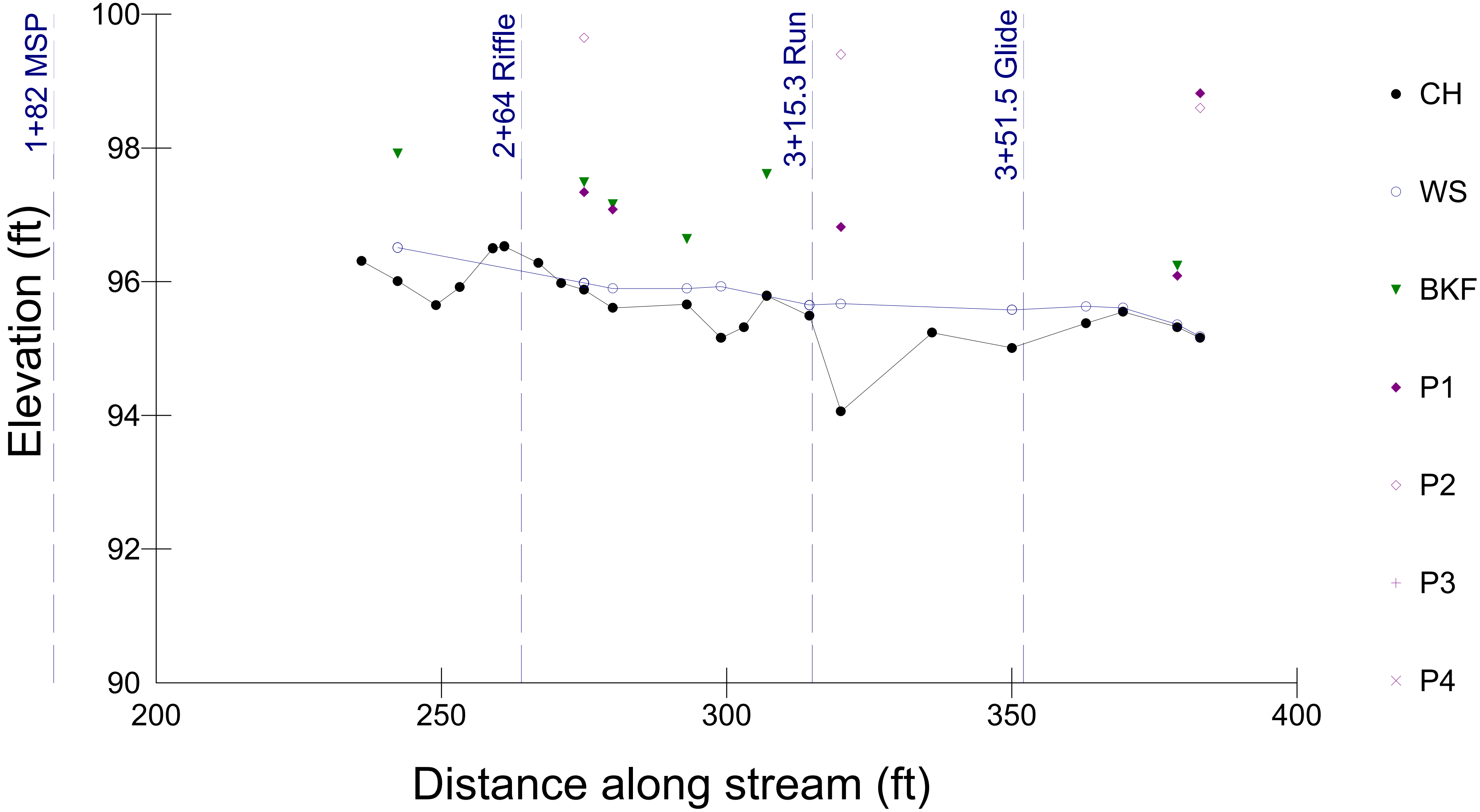


FIG C-2: LONGPROFILE STA 2+36-3+81



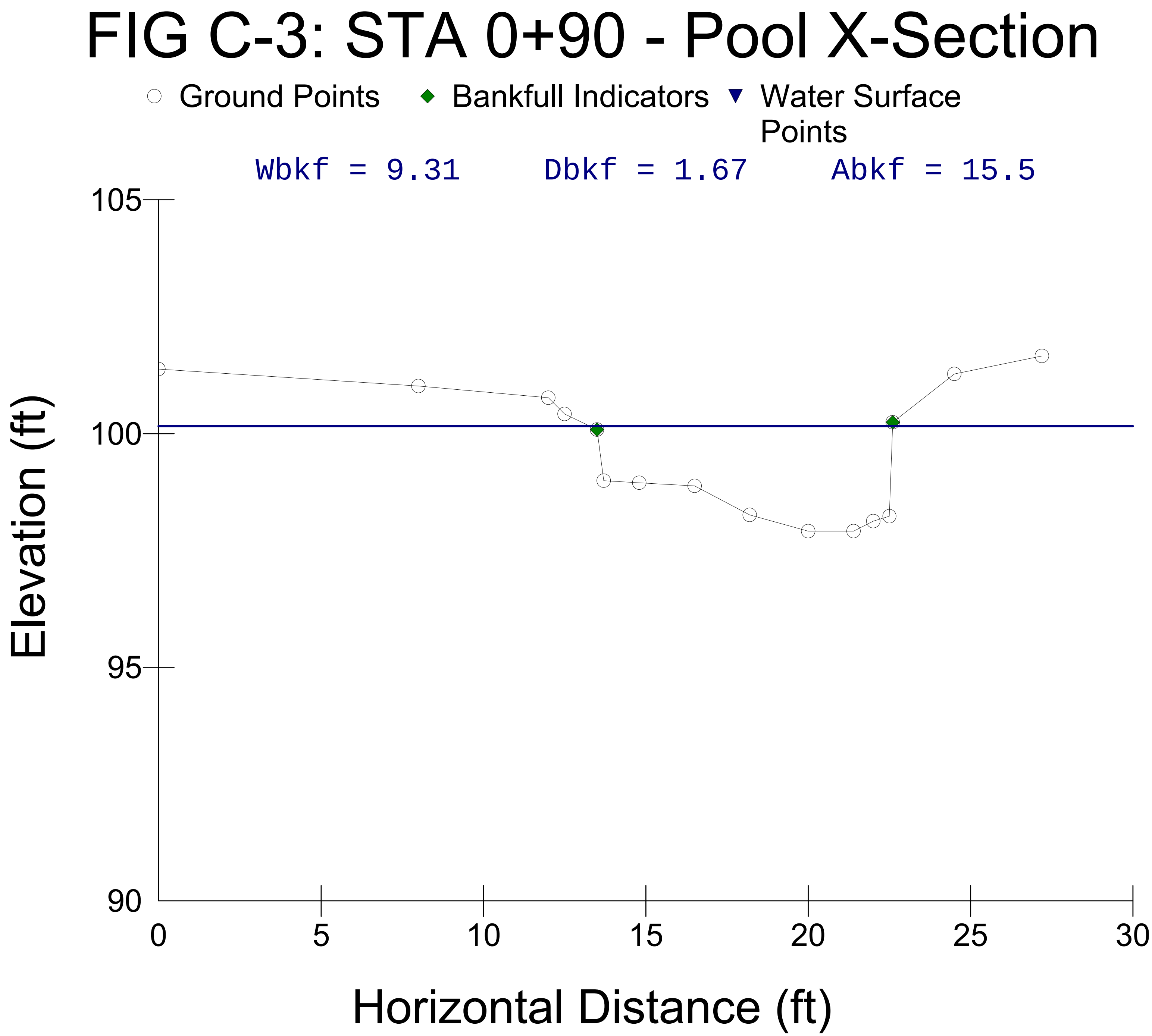


FIG C-3: STA 0+90 - Pool X-Section
Ground Points
Bankfull Indicators
Water Surface Points
Wbkf = 9.31
Dbkf = 1.67
Abkf = 15.5
105
100
95
90
0
5
10
15
20
25
30
Elevation (ft)
Horizontal Distance (ft)

FIG C-4: STA 1+82 Mini Step Pool X-Section

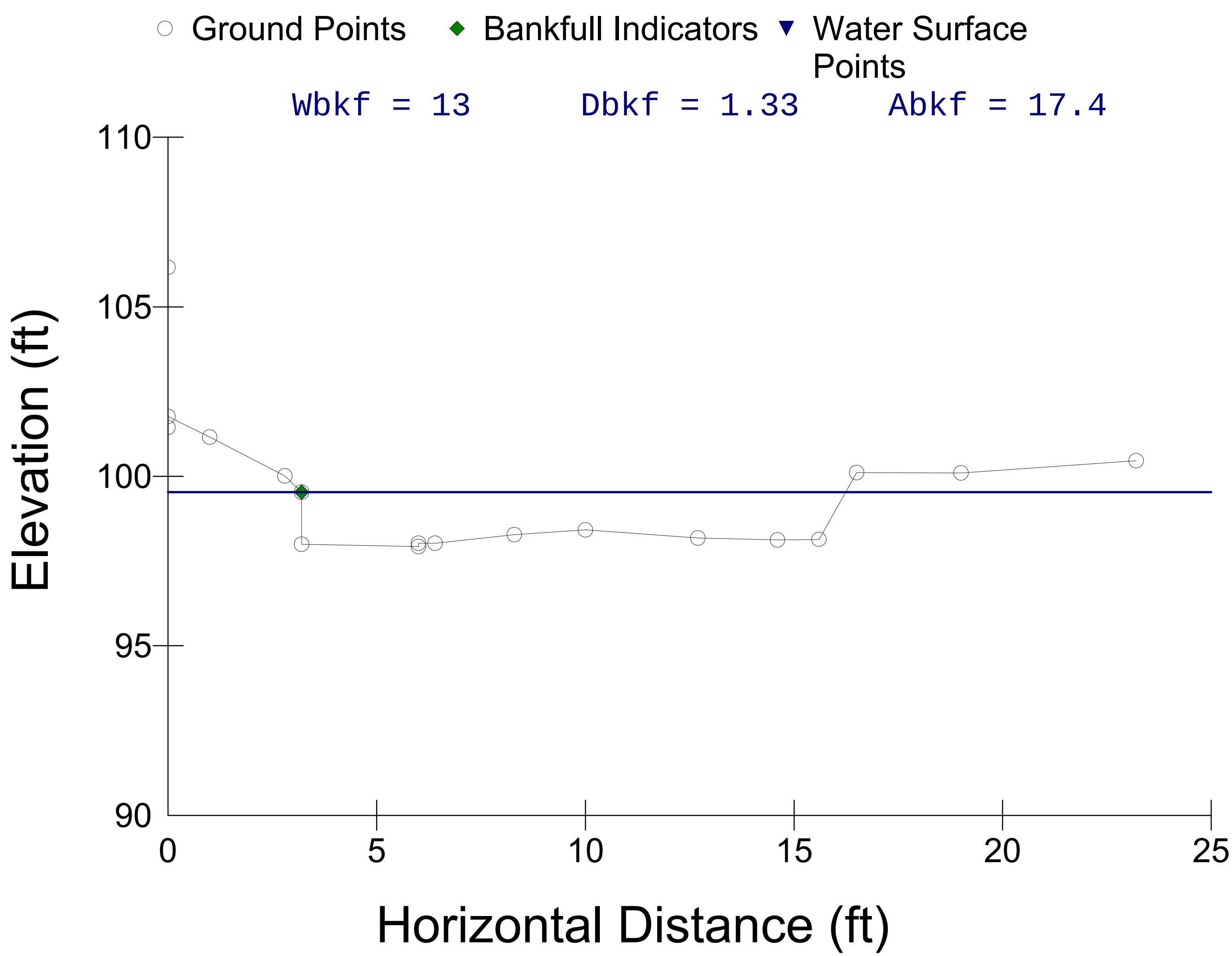


FIG C-5: STA 2+64 Riffle X-Section

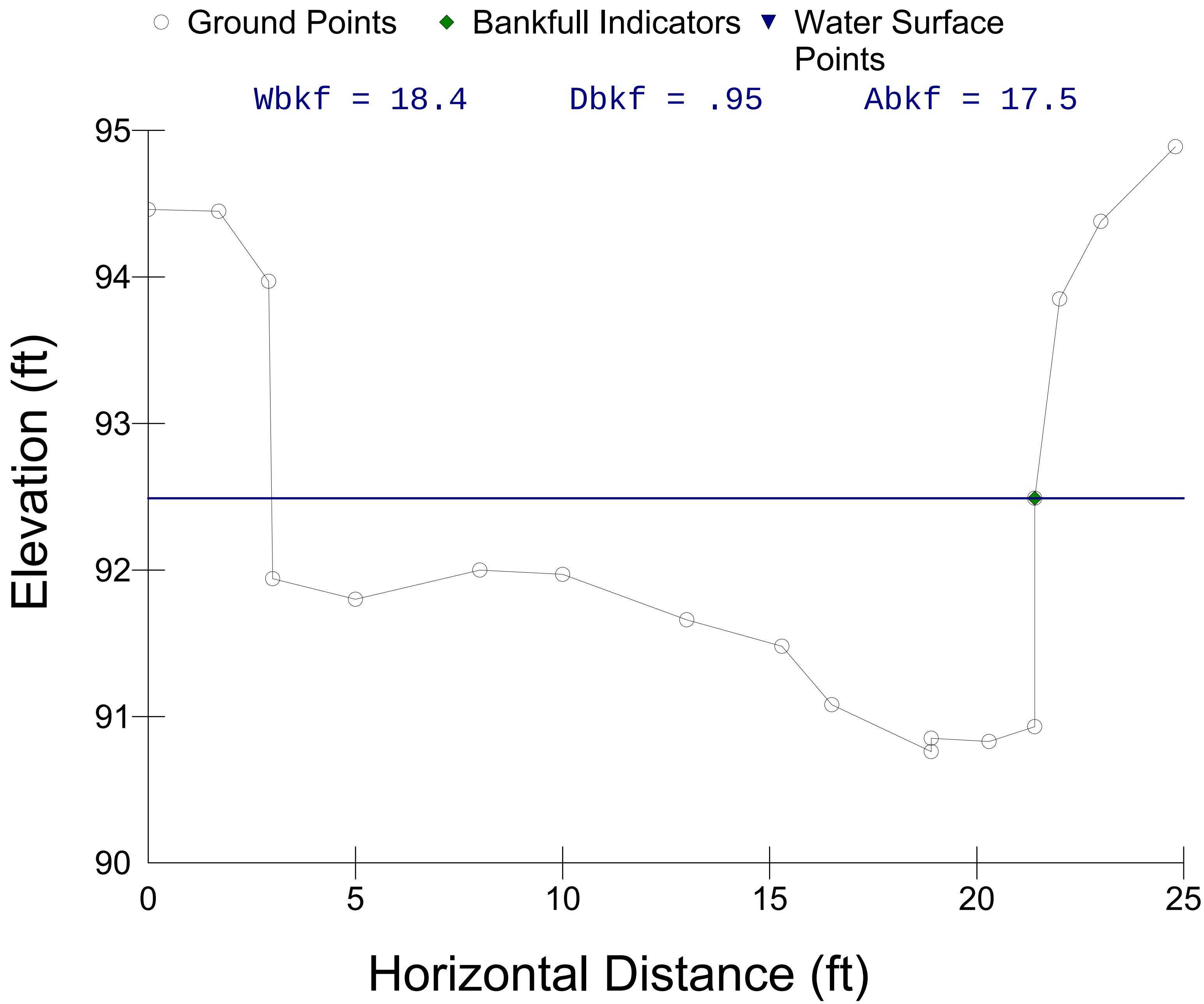


FIG C-6: STA 3+15.3 Run X-Section

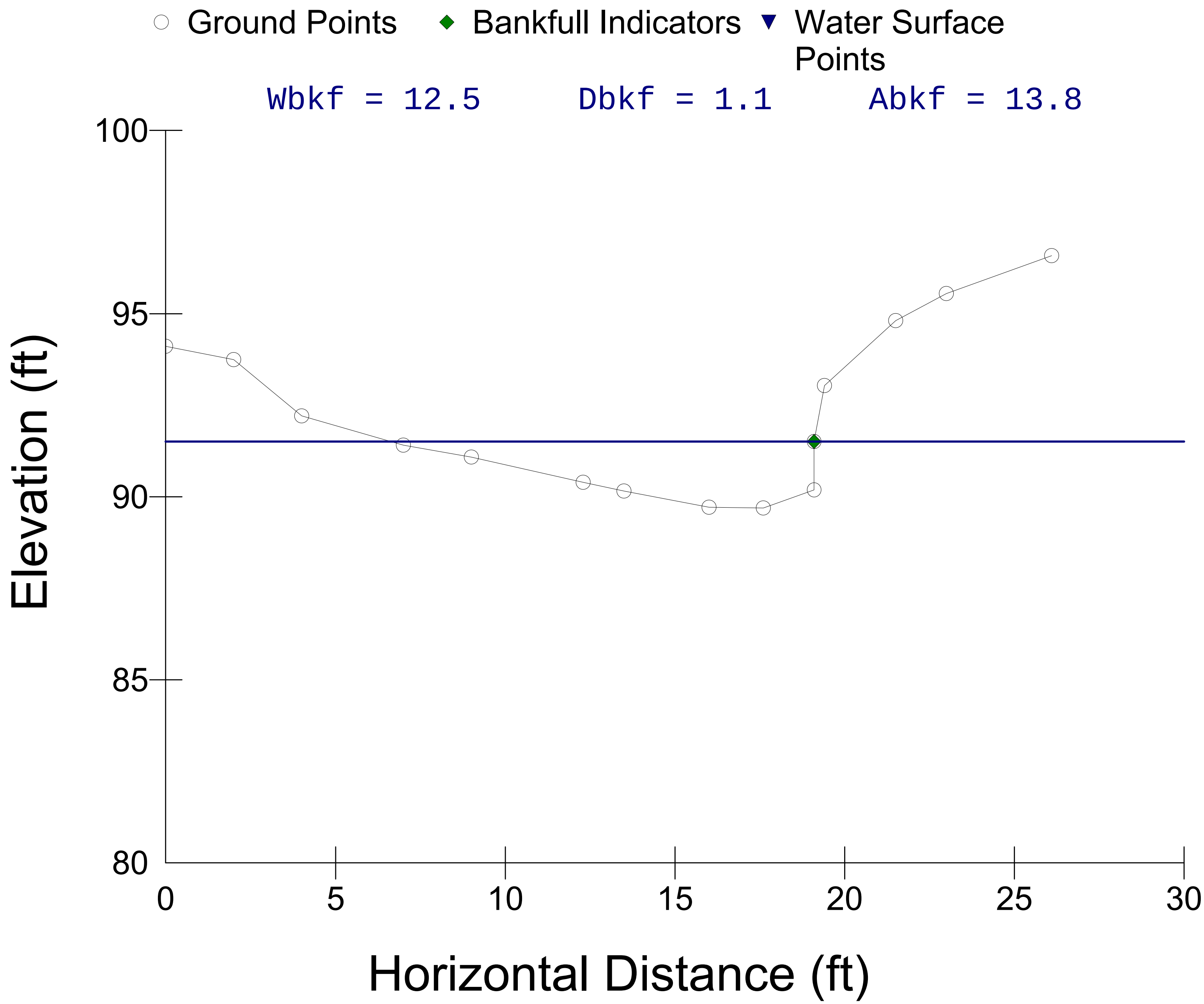
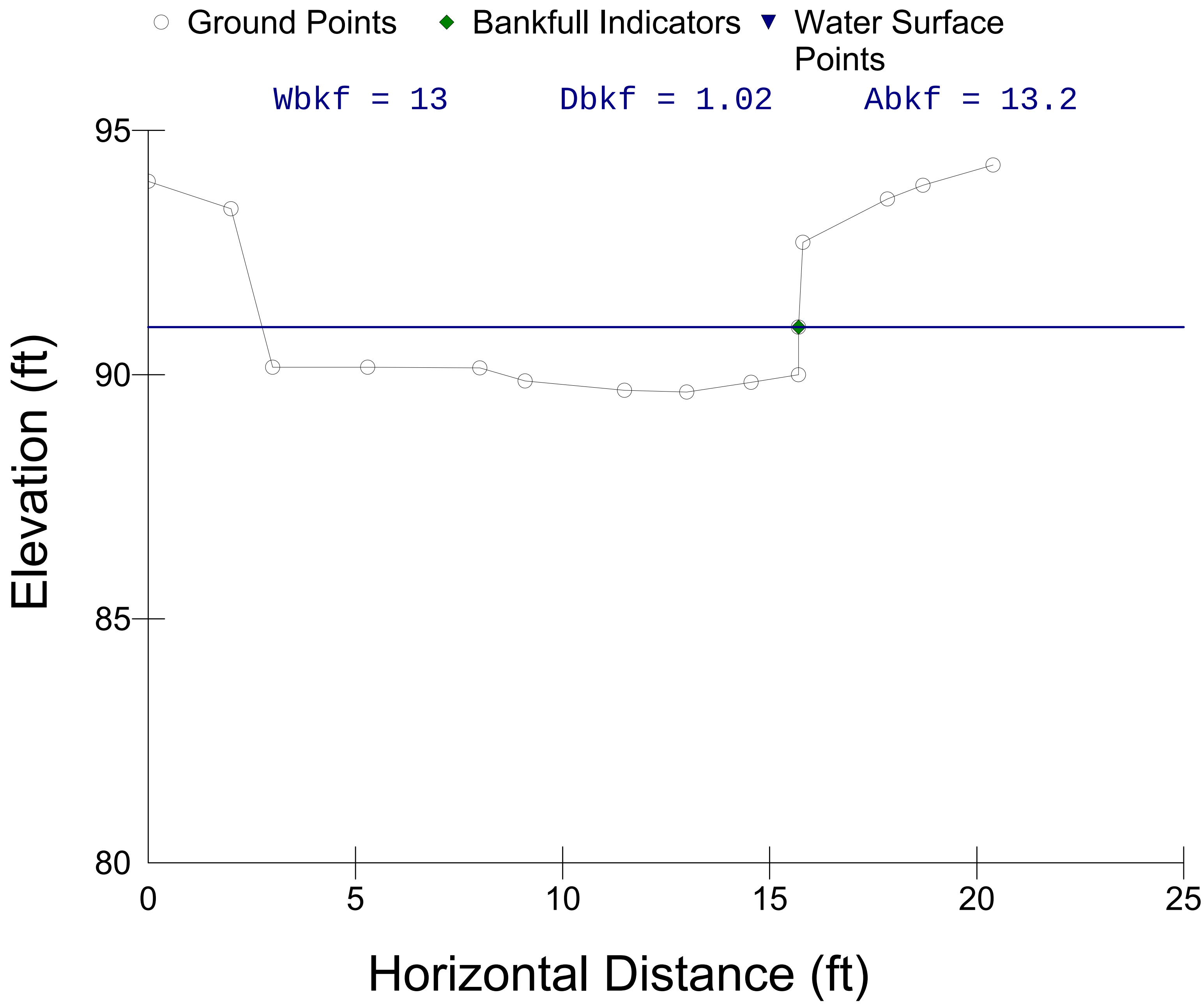


FIG C-7: STA 3+51.5 Glide X-Section



APPENDIX D

BEHI, NBS, BANCS, Rosgen Stream Classification & Pfankuch

Stream: **Phillips Brook Example Bank**	Location: **Example Bank for Report**	
Station: Upstream of Martin Ave	Observers: **TWB/KF**	**BEHI Score** (Fig. 3-7)
Date: **6-19-2016**	Stream Type: **C4/5** Valley Type: **VIII**	

StudyBank Height / Bankfull Height (C)

Study Bank Height (ft) =	**16 (A)**	**Bankfull Height** (ft) =	**5 (B)**	(A) / (B) =	**3.2 (C)**	9

Root Depth / Study Bank Height (E)

Root Depth (ft) =	**0. 5 (D)**	**Study Bank Height** (ft) =	**16 (A)**	(D) / (A) =	**0.03125 (E)**	9

Weighted Root Density (G)

Root Density as % =	**25% (F)**	(F) x (E) =	**0.00781 (G)**	9

Bank Angle (H)

Bank Angle as *Degrees* =	**85 (H)**	7

Surface Protection (I)

Surface Protection as % =	**20% (I)**	7

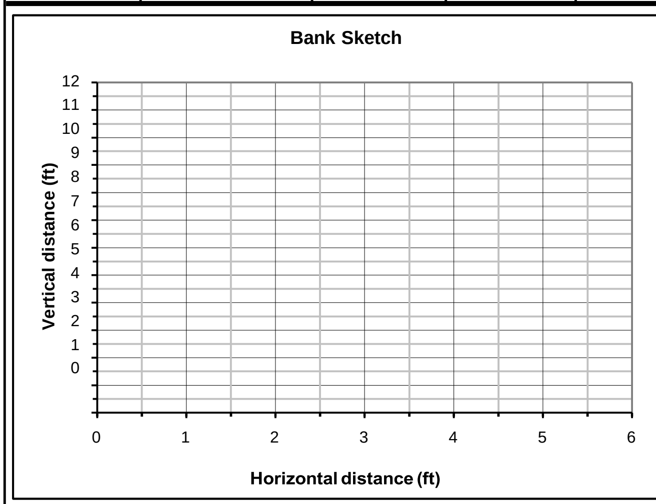
Bank Material Adjustment:

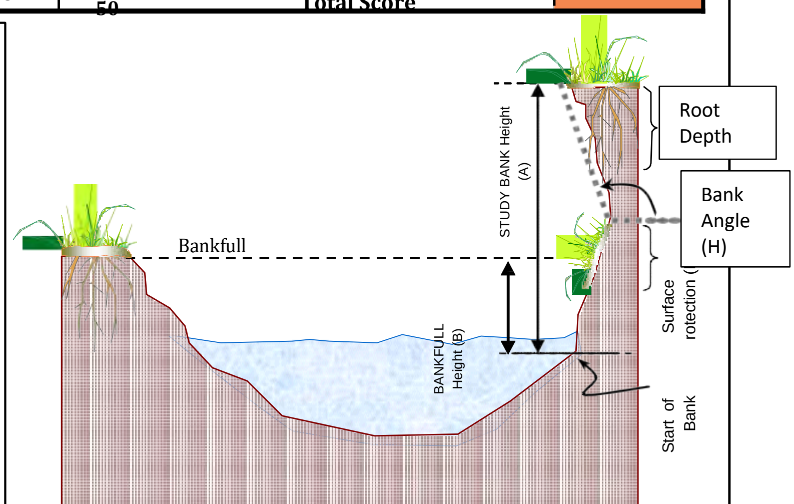
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment	0
Stratification Adjustment Add 5–10 points, depending on position of unstable layers in relation to bankfull stage	0

Very Low	Low	Moderate	High	Very High	Extreme 46
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	50

Adjective Rating and **Total Score**: 41





D1. Example BEHI Form

D2. Example NBS Form

Estimating Near-Bank Stress (NBS)

Stream: **Phillips Brook**	Location: **Example**	
Station:	Stream Type:	Valley Type:
Observers: **DAB**		Date:

Methods for Estimating Near-Bank Stress (NBS)

(1) Channel pattern, transverse bar or split channel/central bar creating NBS..........	Level I	Reconaissance
(2) Ratio of radius of curvature to bankfull width (R_c / W_{bkf})...	Level II	General prediction
(3) Ratio of pool slope to average water surface slope (S_p / S).......................................	Level II	General prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})...	Level II	General prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})......................	Level III	Detailed prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (□$_{nb}$ / □$_{bkf}$)........................	Level III	Detailed prediction
(7) Velocity profiles / Isovels / Velocity gradient..	Level IV	Validation

Level I	(1)	Transverse and/or central bars-short and/or discontinuous............ ....NBS = High / Very High Extensive deposition (continuous, cross-channel).. ....NBS = Extreme Chute cutoffs, down-valley meander migration, converging flow...................................NBS = Extreme

Level	Method				
Level II	(2)	Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*tio* R_c / W_{bkf}	ear-Bank Stress (NBS)
Level II	(3)	Slope S_p	Average Slope S	*Ratio* S_p / S	ear-Bank Stress (NBS)
Level II	(4)	Slope S_p	e Slope S_{rif}	*io* S_p / S_{rif}	ear-Bank Stress (NBS)
Level III	(5)	Near-Bank Max Depth d_{nb} (ft)	an Depth d_{bkf} (ft)	*o* d_{nb} / d_{bkf}	ear-Bank Stress (NBS)

Dominant Near-Bank Stress

Level	Method								
Level III	(6)	Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress □$_{nb}$ (lb/ft^2)	an Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress □$_{bkf}$ (lb/ft^2)	Ratio □$_{nb}$ / □$_{bkf}$	Near-Bank Stress (NBS)

Level	Method		
Level IV	(7)	Velocity Gradient (ft / sec / ft)	ear-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See (1)	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme		< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating	

Level III: River Stability Prediction Forms & Worksheets

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches (Rosgen, 2006b).

Stream:				Location:			
Graph Used:			Total Bank Length (ft):			Date:	
Observers:				Valley Type:		Stream Type:	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI Rating (Worksheet 3-11) (adjective)	NBS Rating (Worksheet 3-12) (adjective)	Bank Erosion Rate (Figure 3-9 or 3-10) (ft/yr)	Length of Bank (ft)	Study Bank Height (ft)	Erosion Subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total Erosion (ft^3/yr)		
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					Total Erosion (yds^3/yr)		
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					Total Erosion (tons/yr)		
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					Total Erosion (tons/yr/ft)		

River Stability Field Guide Page 3-89

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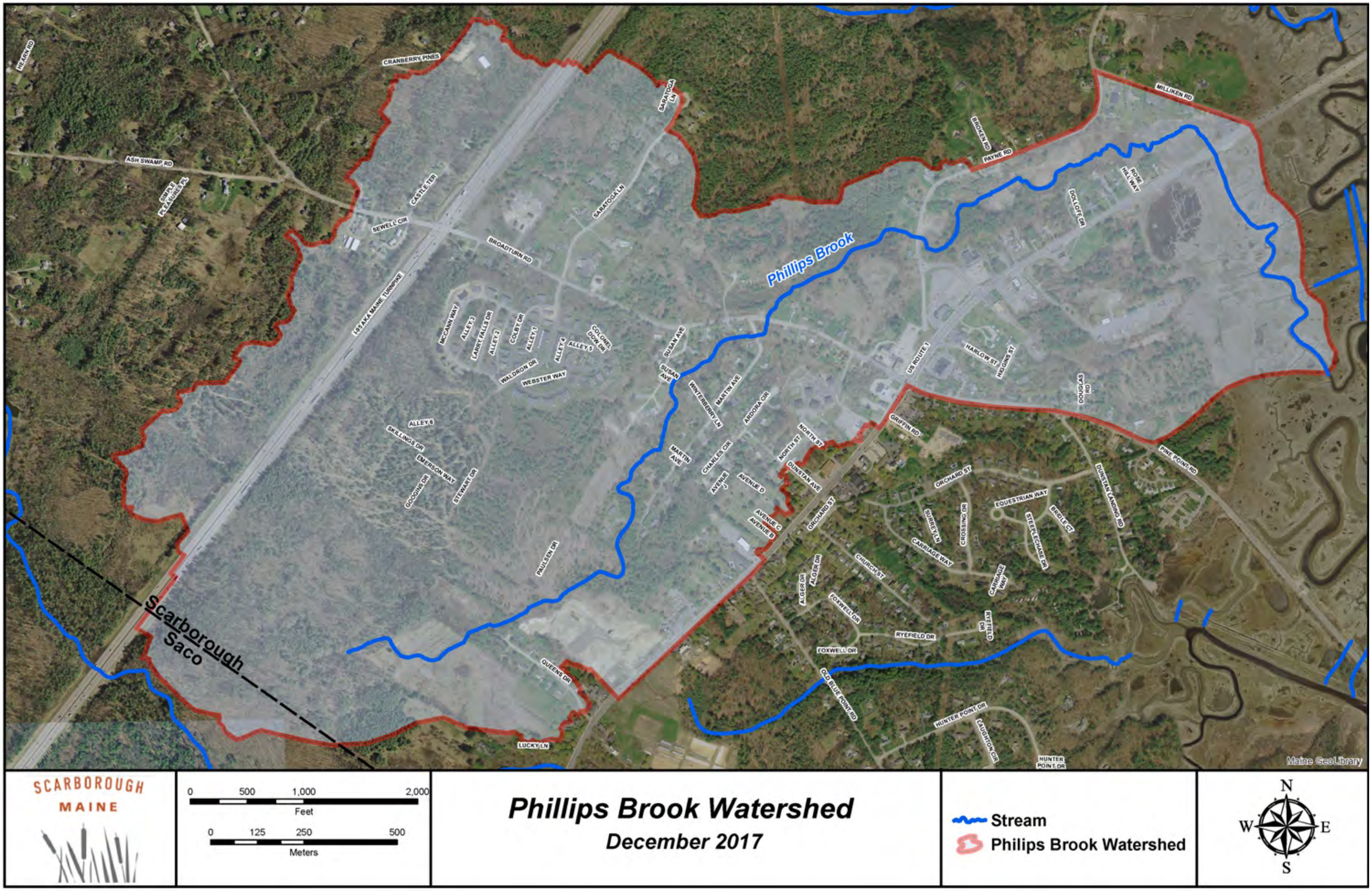
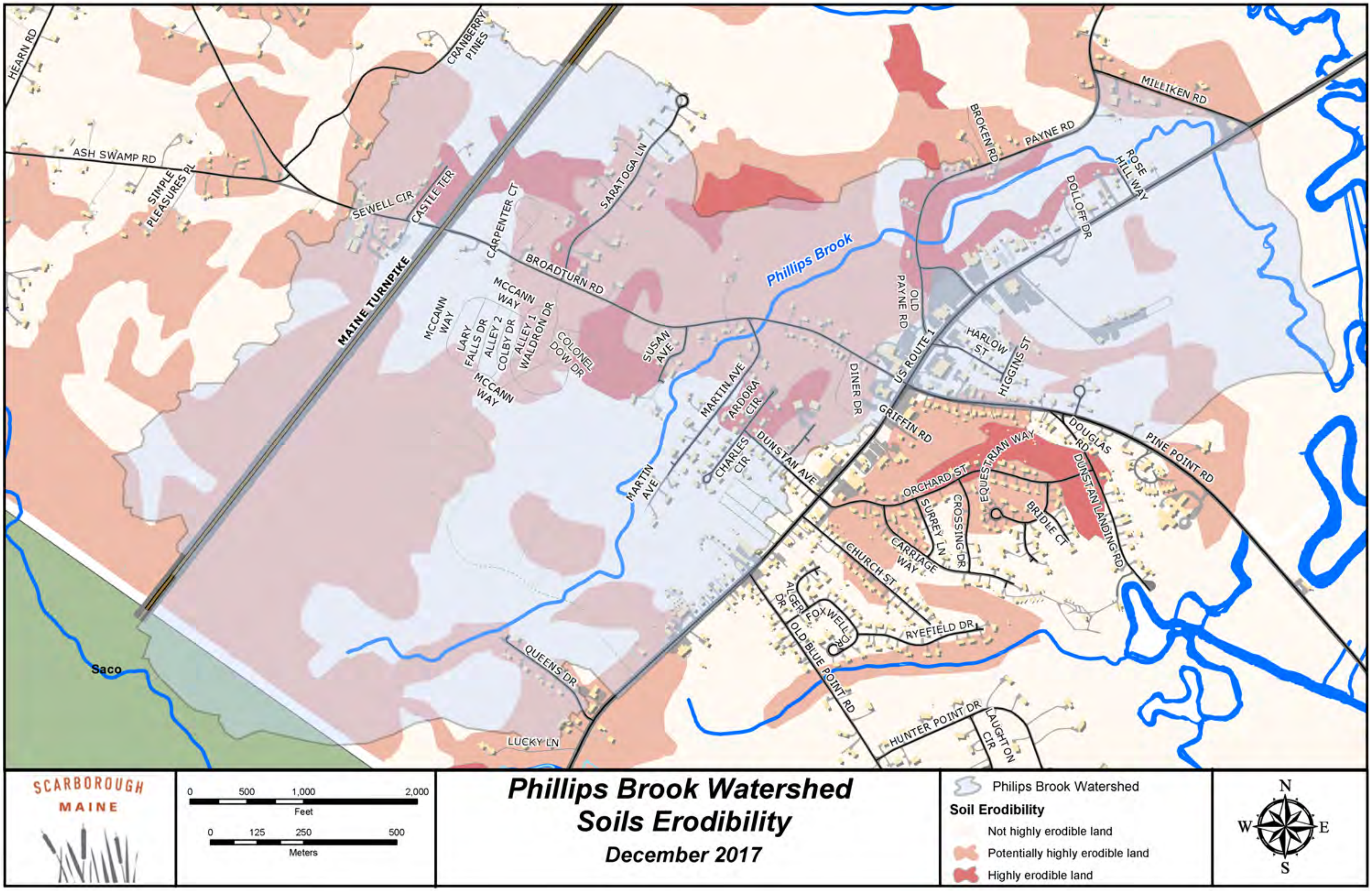
D3. Example Annual Streambank Erosion Estimate Form (BANCS)

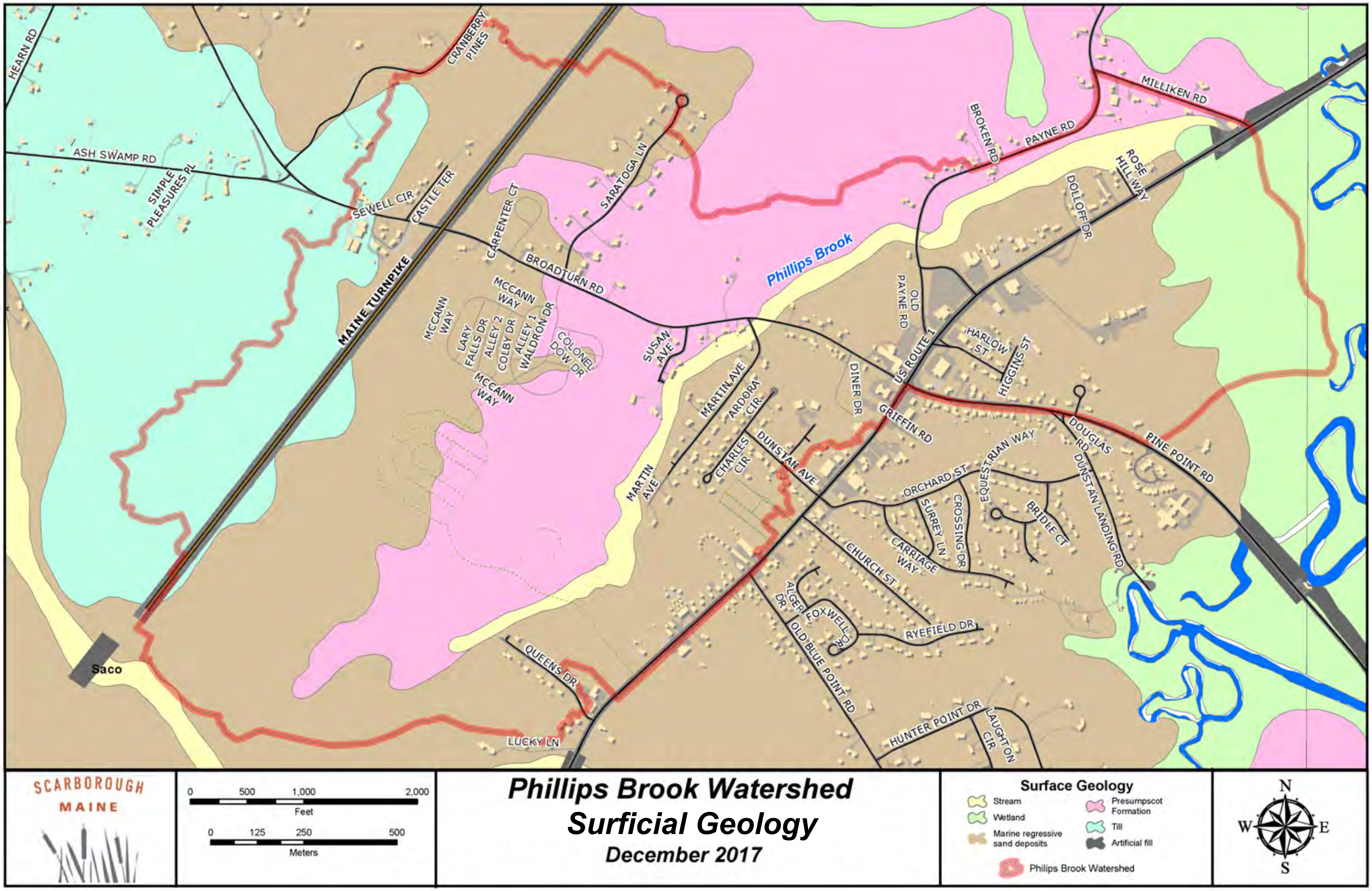
Map 1: Phillips Brook Watershed, Main Stem, and Tributaries



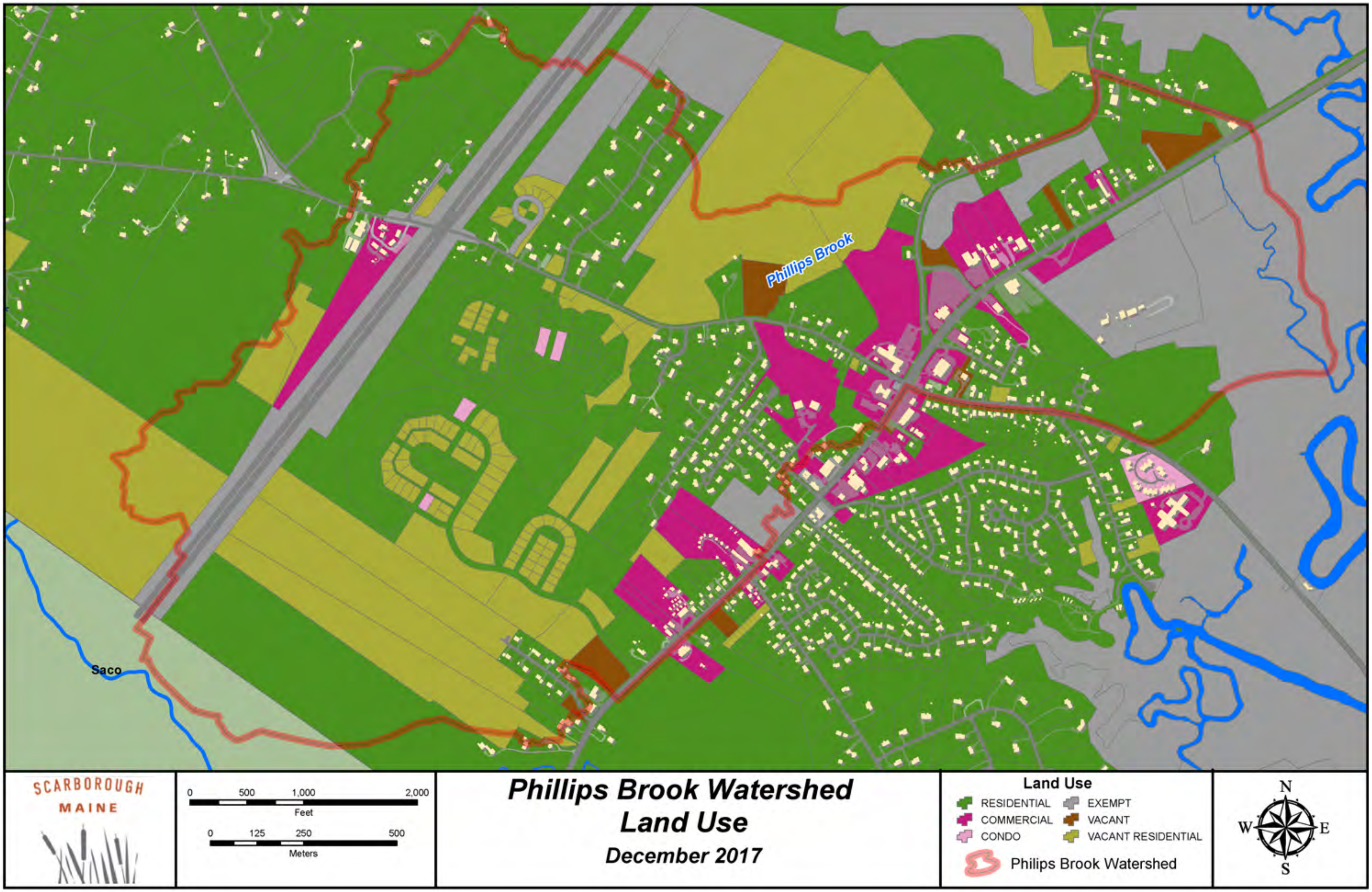
Map 2: Phillips Brook Watershed Soils



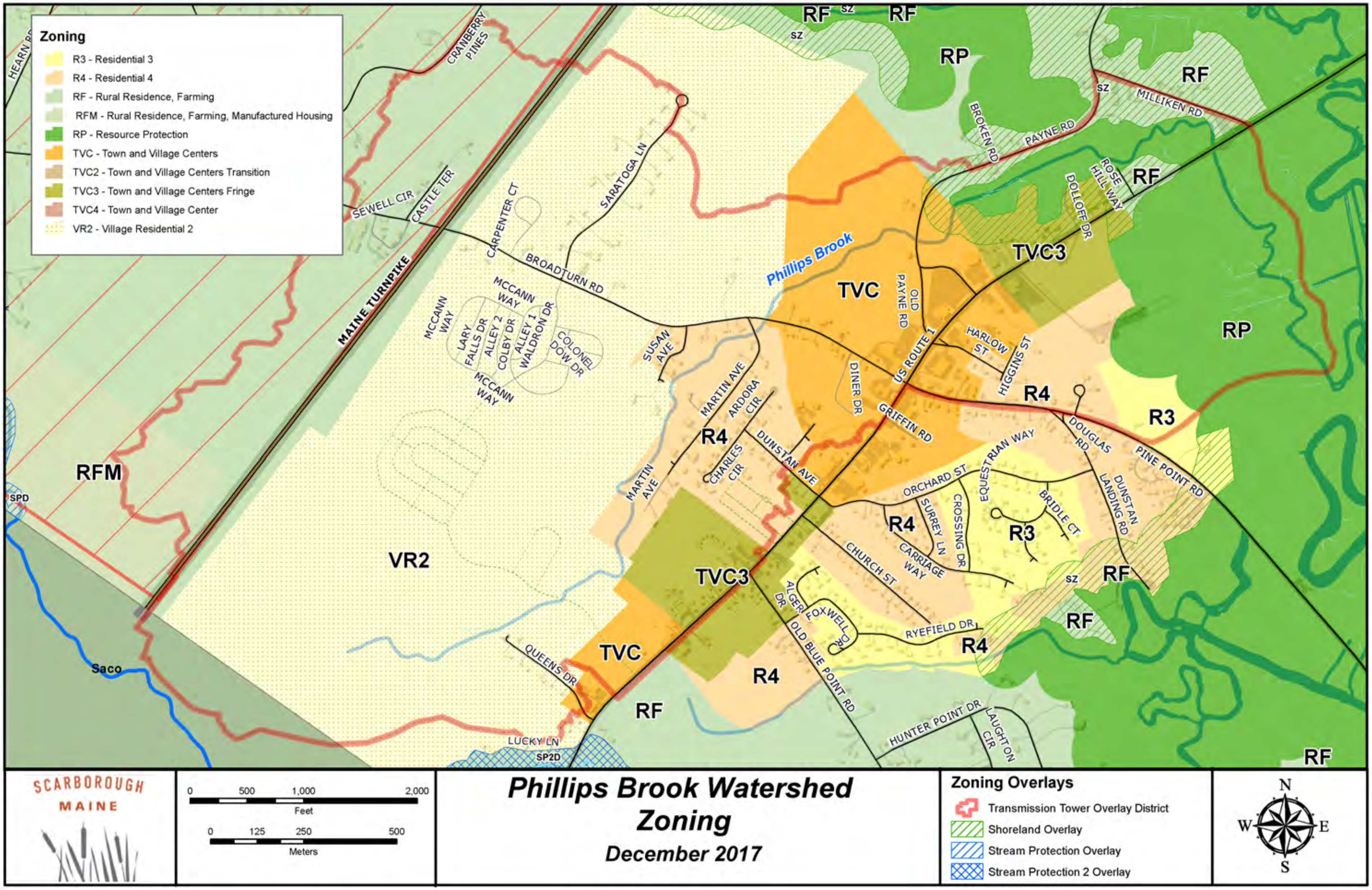
Map 3: Phillips Brook Watershed Surficial Geology



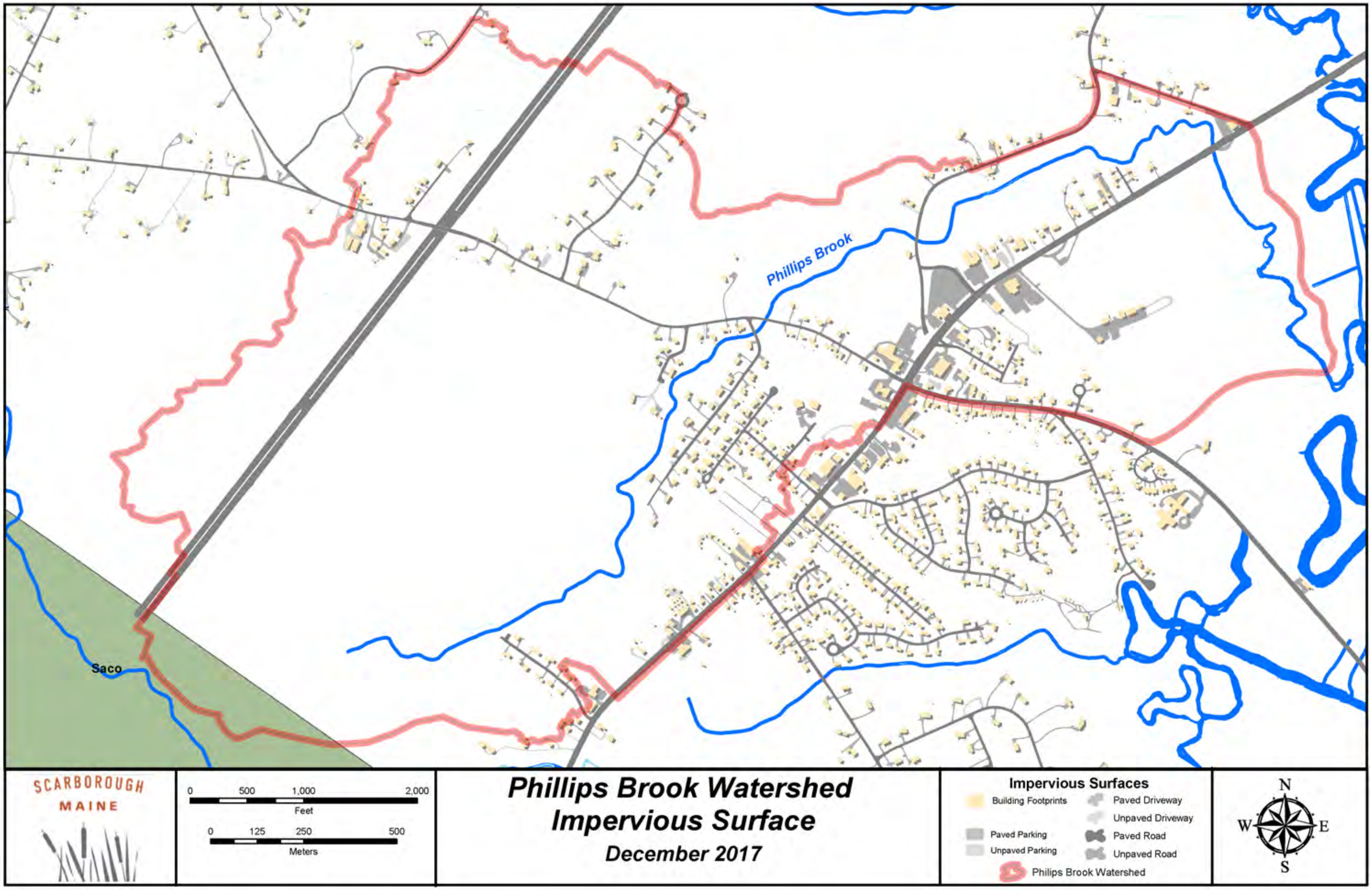
Map 4: Phillips Brook Watershed Land Use



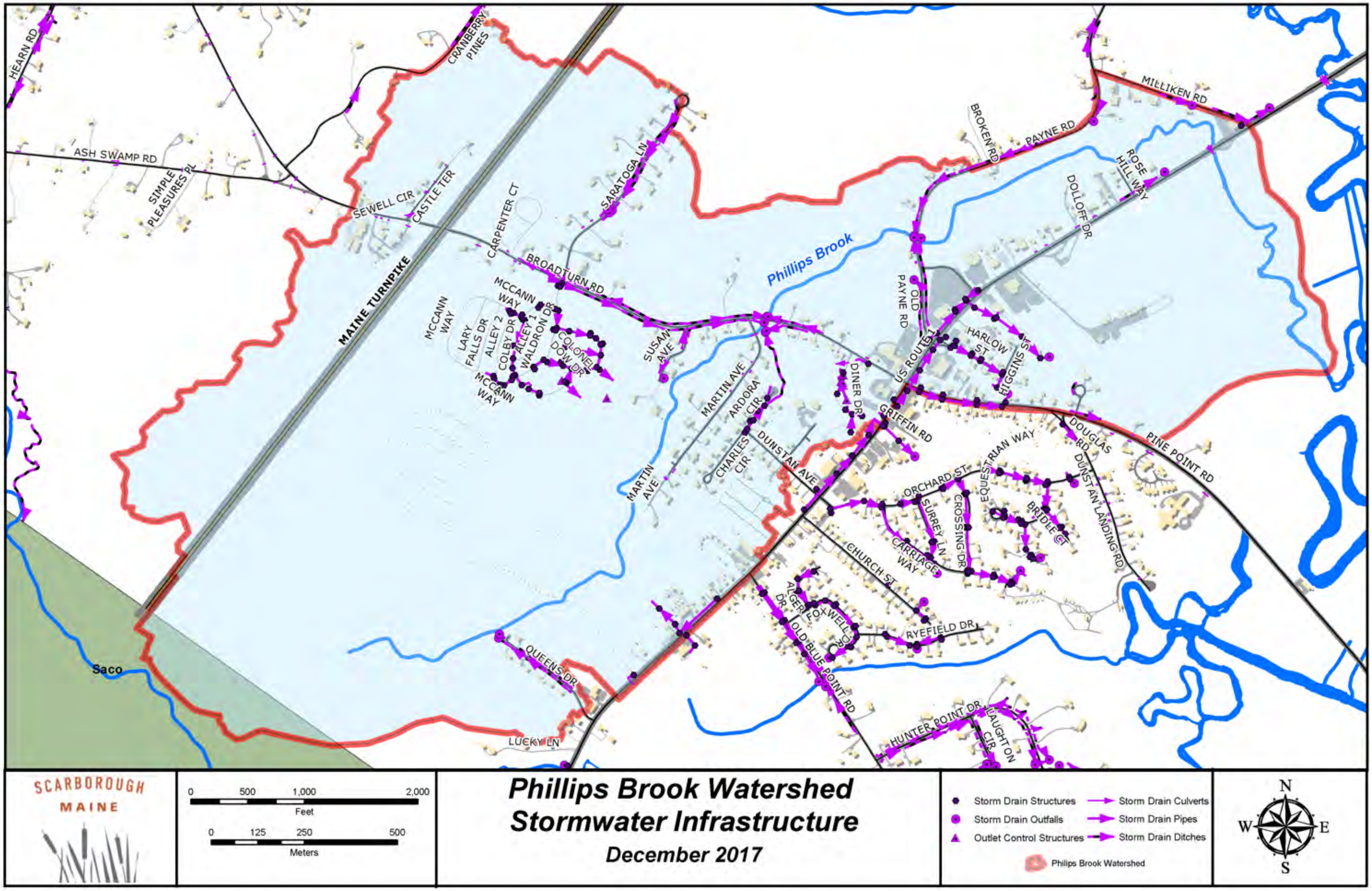
Map 5: Phillips Brook Watershed Municipal Zoning



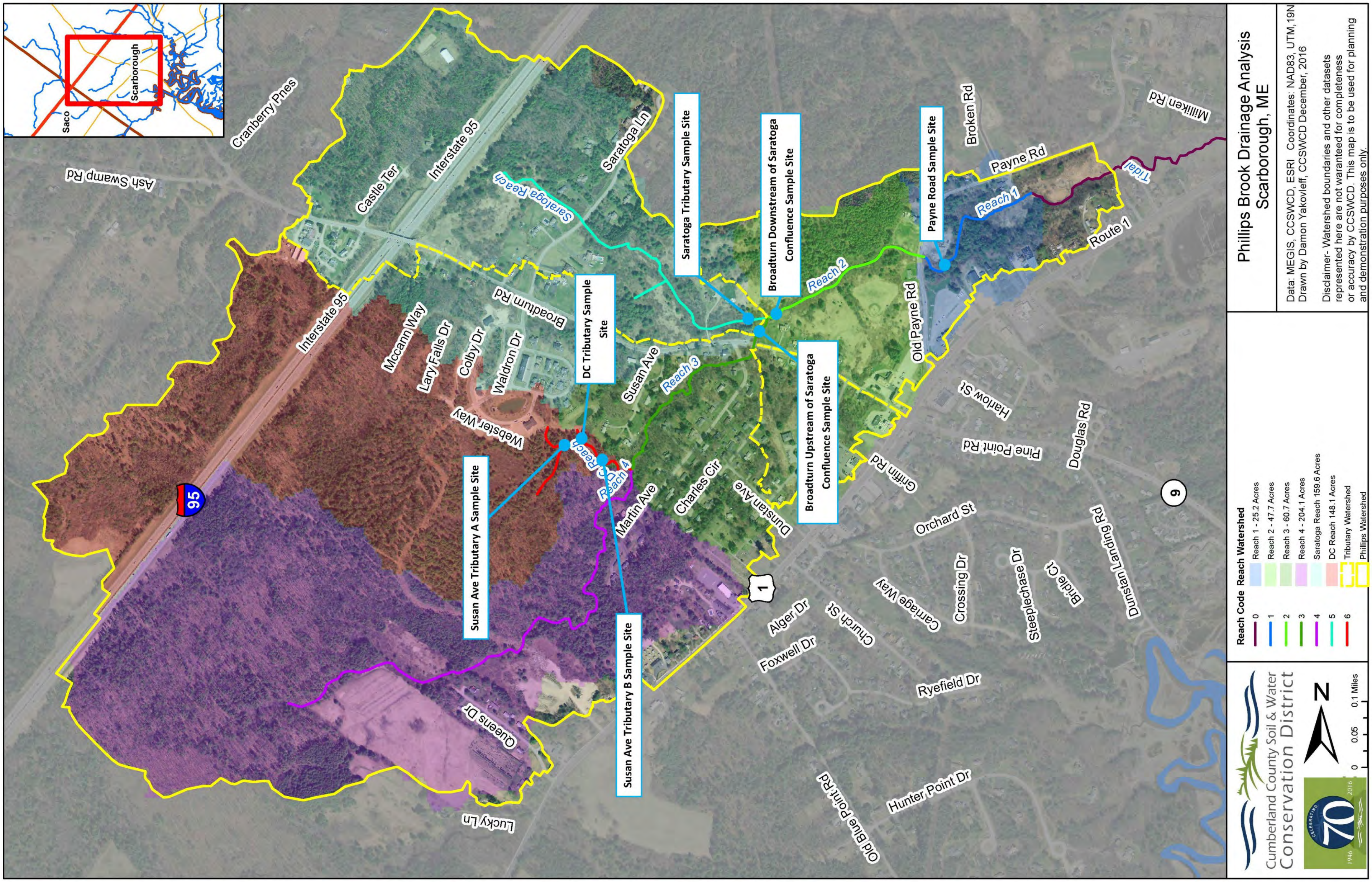
Map 6: Phillips Brook Watershed Impervious Cover



Map 7: Phillips Brook Watershed Stormwater Infrastructure



Map 8: Phillips Brook Watershed Monitoring Sites



TMDL Assessment Summary

Phillips Brook

Watershed Description

This **TMDL** assessment summary applies to Phillips Brook, a 2.77-mile stream located in the Town of Scarborough, Maine. Phillips Brook, a small tributary to Scarborough Marsh, begins in a mixed forest area between the Maine Turnpike and US Route 1 in Scarborough. The stream flows parallel to U.S. Route 1 and through a field before passing under Broadturn Road. It then flows under Payne Road near the road's intersection with US Route 1. Shortly thereafter it flows into a very large wetland area where it passes under US Route 1. The brook then flows into Scarborough Marsh east of Pine Point Road in Scarborough. The Phillips Brook watershed covers 653 acres in the towns of Scarborough and Saco.

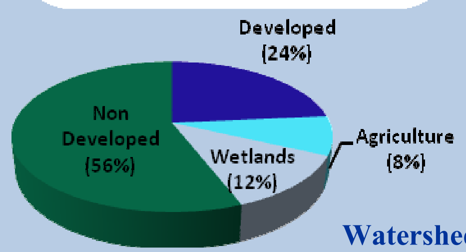
- Stormwater runoff from **impervious cover (IC)** is the largest source of pollution to Phillips Brook. Stormwater falling on roads, roofs and parking lots in developed areas flows quickly off impervious surfaces, carrying dirt, oils, metals, and other pollutants, and sending high volumes of flow to the nearest section of the stream.
- A number of Payne Road and US Route 1 storm drains and ditches, which are linked directly to Phillips Brook, funnel runoff from roads and parking lots down to the stream.
- Development has surrounded the stream near the end of its course around US Route 1 and Payne Road. This encroachment has removed important wetland areas and degraded the habitat around Phillips Brook in these areas.
- Remaining wetland and woodlands in a large portion of the lower Phillips Brook watershed absorb and filter stormwater pollutants, and help protect both water quality

Definitions

- **TMDL** *is an acronym for* ***Total Maximum Daily Load****, representing the total amount of a pollutant that a water body can receive and still meet water quality standards.*
- **Impervious cover** *refers to landscape surfaces (e.g. roads, sidewalks, driveways, parking lots, and rooftops) that no longer absorb rain and may direct large volumes of stormwater runoff into the stream.*

Waterbody Facts

- **Segment ID:** ME0106000104_611R02
- **City:** Scarborough, ME
- **County:** Cumberland
- **Impaired Segment Length:** 2.77 miles
- **Classification:** Class C
- **Direct Watershed:** 1.02mi^2 (653 acres)
- **Watershed Impervious Cover:** 9%
- **Major Drainage Basin:** Presumpscot River and Casco Bay Watershed



Watershed Land Uses

in the stream and stream channel stability.

Why is a TMDL Assessment Needed?

Phillips Brook upstream of site 953.
(Photo: FB Environmental)

Phillips Brook, a Class C freshwater stream, has been assessed by DEP as not meeting standards for aquatic life use, and has been listed on the 303(d) list of impaired waters. The Clean Water Act requires that all 303(d)-listed waters undergo a TMDL assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

The impervious cover TMDL assessment for Phillips Brook addresses water quality impairments for dissolved oxygen and aquatic life (stream habitat assessments). These impairments are associated with a variety of pollutants in urban stormwater as well as erosion, habitat loss and unstable stream banks caused by excessive amounts of runoff.

Sampling Results & Pollutant Sources

Due to development near the stream, the physical habitat in and around Phillips Brook has become degraded. Development has replaced natural forest and wetland areas with impervious cover around much of the stream. The new impervious cover increases the volume of water entering the stream shortly after rain, carrying pollutants and eroding the stream bank, further degrading the streams habitat (Varricchione, 2002). This impairment is based on DEP's stream habitat assessments. Phillips Brook was also sampled by DEP for macro-invertebrates for the first time in the summer of 2010, but the final results for that sampling event are not yet available (DEP, 2010b).

Sampling Station	Sample Date	Statutory Class	Model Results
S-953	8/16/2010	B	I

Phillips Brook was also sampled near Payne Road by DEP for aquatic life (instream macroinvertebrates) in the summer of 2010 and results indicate Phillips is "indeterminate" (I), meaning too few organisms were collected to meet the minimum needed to statistically determine classification (DEP, 2010b). DEP makes aquatic life use determinations using a statistical model that incorporates 30 variables of data collected from rivers and streams, including the richness and abundance of streambed organisms, to determine the probability of a sample meeting Class A, B, or C conditions. Biologists use the model results and supporting information to determine if samples comply with standards of the class assigned to the stream or river (Davies and Tsomides, 2002).

Impervious Cover Analysis

__6% IC__ represents an approximate __33% reduction__ in stormwater runoff volume and associated pollutants when compared to existing pollutant loads.

Increasing the percentage of impervious cover (%IC) in a watershed is linked to decreasing stream health (CWP, 2003). Because Phillips Brook's impairment is not caused by a single pollutant, %IC is used for this TMDL to represent the mix of pollutants and other impacts associated with excessive stormwater runoff. The Phillips Brook watershed has an impervious surface area of **9%** (Figure 1). DEP has found that in order to support Class C aquatic life use, the Phillips Brook watershed may require the characteristics of a watershed with **6%** impervious cover. The target for Phillips Brook is lower than the target recommended for Class C streams in, IC Guidance (Appendix 2), of the TMDL report. Not all watersheds are created equally and the guidance does include an option to apply Best Professional Judgment when choosing streams' targets. The development is concentrated in the most downstream portion of the watershed (Figure 1) and exerts a disproportionate effect on the lower impaired stream segment. This segment does exhibit some characteristics associated with impairment due to stormwater runoff, therefore a target was chosen to reduce the impact of IC and achieve water quality classification. The stream is a low gradient flow system with associated wetland areas, which may also influence the downstream portion of the stream. The relative contribution of the slow flow and wetland needs to be evaluated during the development of a Watershed Specific Plan, as recommended in the IC TMDL.

Impervious Cover GIS Calculations

The Impervious Cover Calculations are based on analysis of GIS coverage's presented in Figure 1. The impervious area is derived from 2007 1 meter satellite imagery and the watershed boundary is an estimation based on contours and digital elevation models.

This TMDL target is intended to guide the application of Best Management Practices (BMP) and Low Impact Development (LID) techniques to reduce the *impact* of impervious surfaces. Ultimate success of the TMDL will be Phillips Brook's compliance with Maine's criteria for habitat assessment.

Next Steps

Because Phillips Brook is an impaired water, stormwater runoff in the watershed should be considered during the development of a watershed management plan to:

- Encourage greater citizen involvement (e.g. through the Friends of Scarborough Marsh) to ensure the long term protection of Phillips Brook;
- Address existing stormwater problems in the Phillips Brook watershed by installing structural and applying non-structural best management practices (BMPs); and
- Prevent future degradation of Phillips Brook through the development and/or strengthening of local stormwater control ordinances.

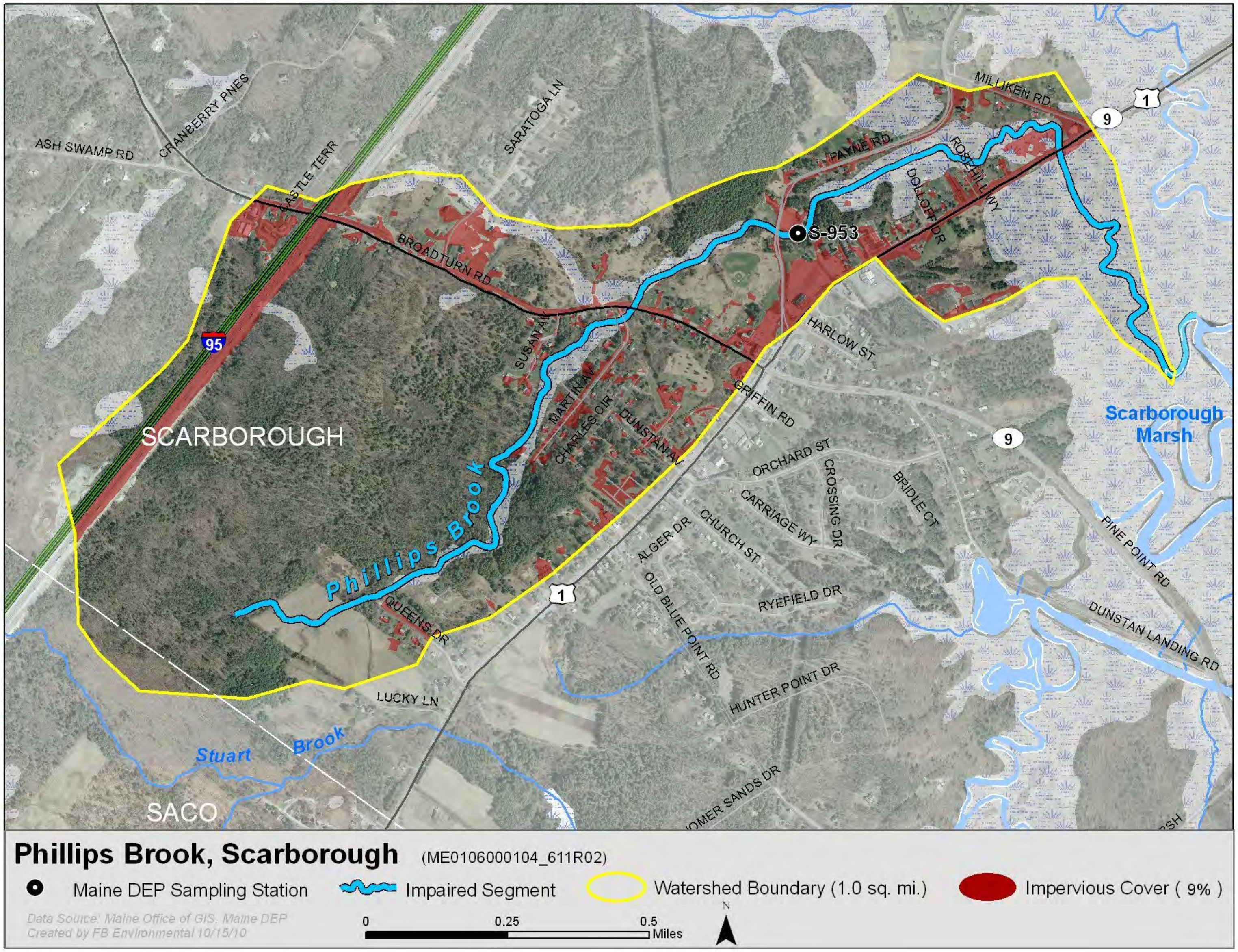


Figure 1: *Map of Phillips Brook watershed impervious cover.*

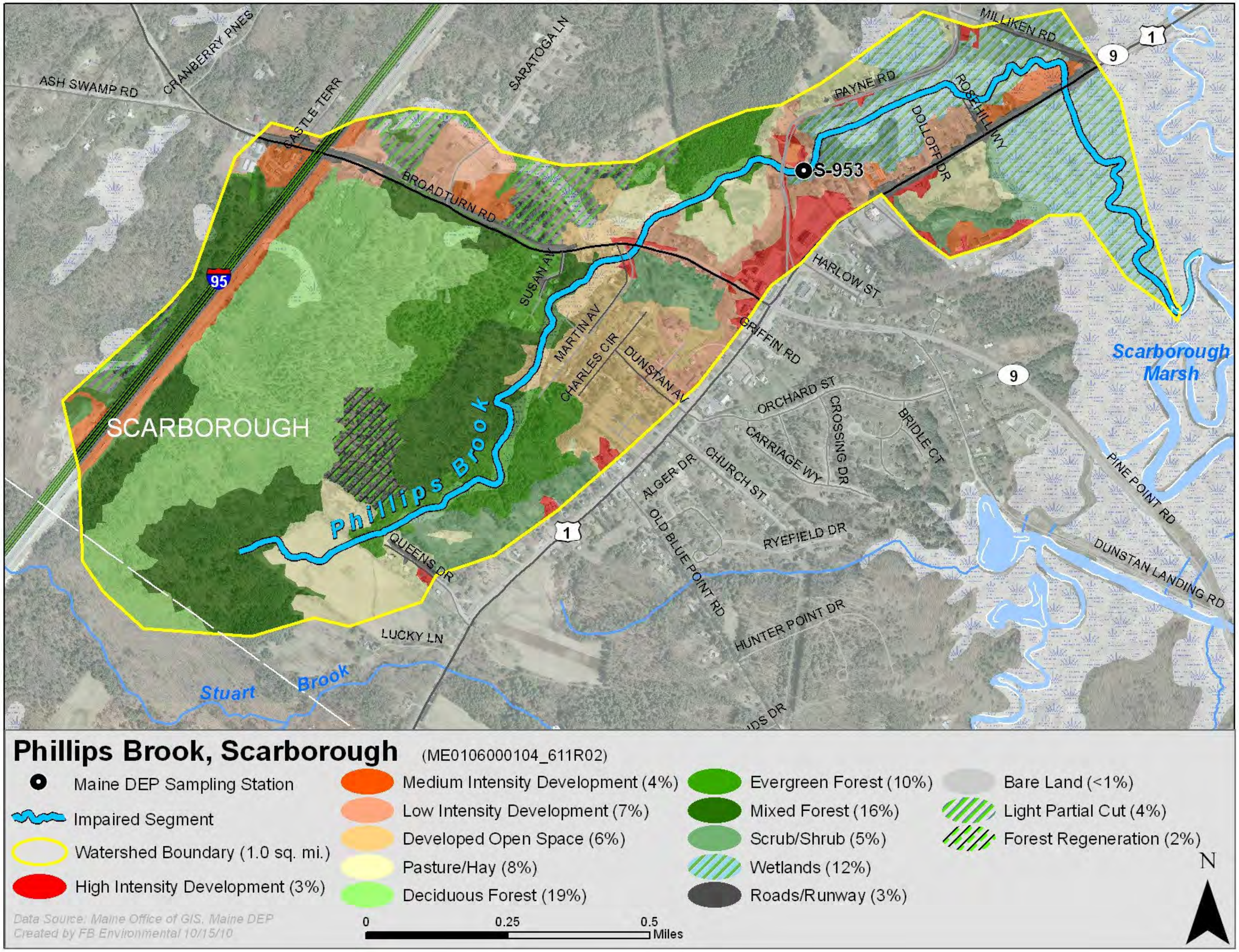

Phillips Brook, Scarborough
(ME0106000104_611R02)
Maine DEP Sampling Station
Impaired Segment
Watershed Boundary (1.0 sq. mi.)
High Intensity Development (3%)
Medium Intensity Development (4%)
Low Intensity Development (7%)
Developed Open Space (6%)
Pasture/Hay (8%)
Deciduous Forest (19%)
Evergreen Forest (10%)
Mixed Forest (16%)
Scrub/Shrub (5%)
Wetlands (12%)
Roads/Runway (3%)
Bare Land (<1%)
Light Partial Cut (4%)
Forest Regeneration (2%)
N
0
0.25
0.5
Miles
Data Source: Maine Office of GIS, Maine DEP
Created by FB Environmental 10/15/10
SCARBOROUGH
Phillips Brook
S-953
Scarborough Marsh
Stuart Brook
ASH SWAMP RD
CRANBERRY PNES
CASTLE TERR
SARATOGA LN
BROADTURN RD
SUSAN AV
MARTIN AV
CHARLES CIR
DUNSTAN AV
QUEENS DR
LUCKY LN
MILLIKEN RD
PAYNE RD
ROSEHILL WY
DOLLOFF DR
HARLOW ST
GRIFFIN RD
ORCHARD ST
CROSSING DR
BRIDLE CT
CARRIAGE WY
CHURCH ST
ALGER DR
OLD BLUE POINT RD
RYEFIELD DR
HUNTER POINT DR
PINE POINT RD
DUNSTAN LANDING RD
95
1
9

Figure 2: *Map of Phillips Brook watershed land cover.*

References

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Appendix J: **Phillips Brook Action Plan Table & Timeline**

Site ID	Action	Priority	Cost Estimate	DOT/MTA	DEP	Town of Scarborough	Landowners	Other	DEP/EPA Grant	Other Grants	Municipal	Landowner	Volunteer
				Responsible Party									
Phase I: 2019-2020 | Estimated Cost = $854K													
SC-1	Culvert failure evident causing scour and stream channel blockage - Replace with properly-sized structure meeting Aquatic Organism Passage (AOP) standards; stabilize stream banks with log and/or boulder cross vane structures	High	$200K			x	x			x		x	
SC-5	Undersized culverts causing scour and erosion, flooding - Replace with properly-sized structure meeting AOP standards; stabilize stream with log and/or boulder cross vane structures	High	$225K	x		x			x	x			
IS-1	Incised stream channel, log jam, and bank failures - Reconnect floodplain using log and/or boulder cross vane structures; dredge aggraded materials; construct riffles with suitable native materials	Low	$40K			x	x			x		x	
IS-6	Floodplain fill affecting flow and causing bank erosion - Work with Scarborough Public Works to identify acceptable modifications to the layout of the property to allow fill to be pulled out of the floodplain; employ bankfull bench structure at slopes; stabilize banks in place with boulders, woody debris, or similar	High	$300K			x	x			x		x	
SR-4	Possible flow regime changes - Reach was not part of the study. A reach assessment is recommended to understand the potential cause of flow regime changes	Low/Study/ MTA	$20K	x		x	x			x		x	
Education & Outreach	YardScaping Outreach Campaign and Winter Operations Training	High	$5k			x				x	x		
Ordinance / Development Standards / Policy	Seek Development Review Authority / Capacity	High	N/A			x							
Phase 2: 2021-2022 | Estimated Cost = $205K													
SC-3	Undersized culvert causing sour and bank erosion - Replace with properly-sized structure meeting AOP standards; stabilize banks in place with boulders and/or woody debris	Medium	$50K				x					x	
SR-1	Stormwater runoff from Route 1 causing severe erosion - Camera work needed to locate discharge point; restore and stabilize outfall with rip rap and plunge pool as needed	Medium / DOT	$100K	x		x	x			x		x	
IS-2	Invasive species control needed - Slopes adjacent to culvert may need to be re-worked to establish native vegetation; alternatively, slopes can be covered with a non-woven geotextile and riprap for stabilization without vegetative cover	High	$20K			x	x			x		x	
IS-3	Bank failures - Stabilize banks with log and/or boulder cross vane structures	Low	$30K			x	x			x		x	
Education & Outreach	YardScaping Outreach Campaign and Winter Operations Training	High	$5k			x				x	x		
Ordinance / Development Standards / Policy	Expand Stream Protection Zones	High	N/A			x							
Phase 3: 2023-2024 | Estimated Cost = $190-295K													
SC-4	Undersized culverts causing scour and erosion - Replace with properly-sized structure meeting AOP standards; stabilize stream banks with log and/or boulder cross vane structures	High	$200K	x	x				x				
SR-3	Possible flow regime changes - Reach was not part of the study. A reach assessment is recommended to understand the potential cause of flow regime changes	High	$20K	x	x	x			x		x		
Ordinance / Development Standards / Policy	Allow credits/exchange to developers to increase flexibility	High	N/A		x								
Phase 4: 2025-2026 | Estimated Cost = $250K													
SC-6	Undersized culvert causing bank failures - Stabilize slopes; replace with properly sized structure meeting AOP standards; stabilize banks in place with boulders and/or woody debris	High	$100K				x					x	
IS-7	Bank failures and incised bed - Reconnect floodplain using log and/or boulder cross vane structures	Medium	$30K			x	x					x	
IS-8	Scour and stream channel blockage - Work with release rates from detention ponds; instream structures like log/boulder cross vanes and energy dissipation to accommodate higher velocities during detention pond runoff release	Medium	$40K			x	x					x	
SR-2	Stormwater pond retrofits at Dunstan Crossing property are underway and will address flow rate and velocity	High	$75K			x	x			x		x	
Education & Outreach	YardScaping Outreach Campaign and Winter Operations Training	High	$5k			x				x	x		
Ordinance / Development Standards / Policy	Incentives for conservation and protection of natural landscape (land, water, flora, fauna, etc.)	High	N/A			x							
Phase 5: 2027-2028 | Estimated Cost = $250													
SC-2	Undersized culvert causing flooding and bank instability - Explore public/private partnership to replace with properly-sized structure meeting AOP standards.	Low	$100K				x					x	
IS-4	Accumulated sediments in stream channel - Consider removal/modification of dam to allow enhanced stream connectivity; evaluate for historical significance; conduct comprehensive feasibility study including hydrological analysis; follow with stream bank restoration and dredging of aggraded materials	Low/Study	$150K				x					x	
Ordinance / Development Standards / Policy	Tax Increment Financing (TIF)	High	N/A				x						

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