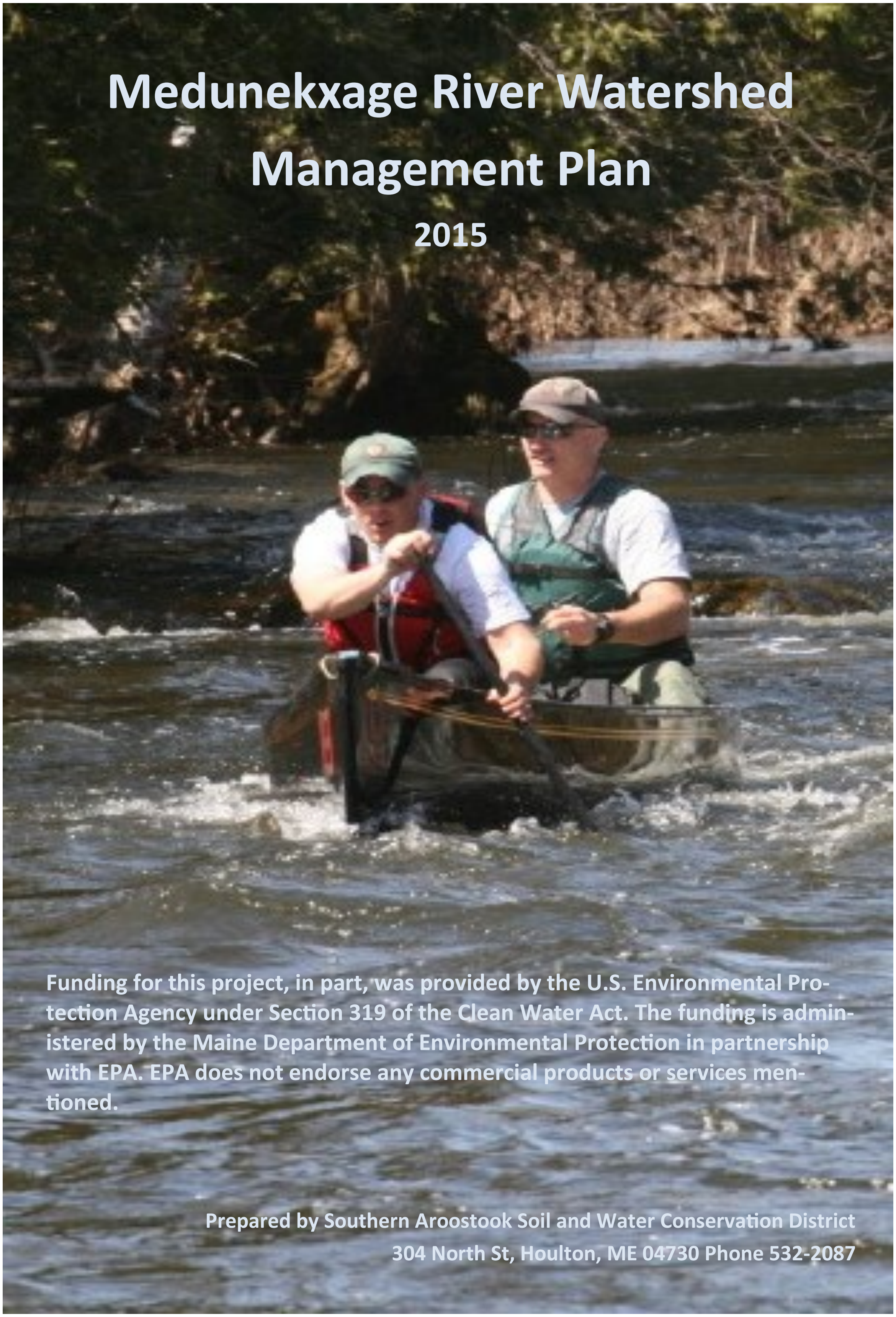

Medunekxage River Watershed Management Plan

2015

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Agricultural producers in the Meduxnekeag Watershed

Southern Aroostook SWCD Board of Supervisors

Meduxnekeag River, Houlton 2014. Photo courtesy of MDEP

Cover photo Meduxnekeag canoe race courtesy of MaCKR.org.

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MEDUXNEKEAG RIVER
Maliseet for "Rocky at its Mouth"

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Covered Bridge Littleton, Maine. Built in 1911. Photo by Kyle Purves

Appendices

1. Introduction

- What is the purpose of a watershed management plan?
- What is the ultimate goal of the plan?
- How is the plan created?
- How were stakeholders involved in the creation of the plan?

1.1 Document Purpose

A watershed is the land area that drains to a river, stream, or other body of water. The purpose of the Watershed Based Plan, herein referred to as the "WBP", is to document the sources of water pollution and present a strategic plan of actions needed to improve water quality. This WBP discusses pollutant sources and potential solutions for the Meduxnekeag River Watershed. There are sections of the Meduxnekeag River that are listed as impaired.

The United States Environmental Protection Agency (EPA) defines impaired waterbodies as any waterbody that does not meet water quality criteria that supports its designated use (EPA, 2008). Impaired waterbodies are then placed on the Section 303(d) list as part of the Clean Water Act. Similarly, under the State of Maine's classification system to establish water quality goals class B waters are classified as:

> *"…be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; agriculture; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation, except as prohibited under Title 12, section 403; navigation; and as habitat for fish and other aquatic life. The habitat must be characterized as unimpaired."*

The Meduxnekeag River and its tributaries are Class B from the outlet of Meduxnekeag "Drews" Lake to the international boundary with a few exceptions. Those segments designated as Class A include the North Branch and its tributaries above Monticello, Moose Brook and its tributaries upstream of Ludlow Road, the South Branch and its tributaries upstream of Oliver Road in Cary, and B Stream and its tributaries upstream of the Burnt Brow Bridge in Hammond.

The dissolved oxygen (DO) content of Class B waters may not be less than 7 ppm or 75% saturation, whichever is higher. *Escherichia coli* bacteria of human and domestic animal origin may not exceed a geometric mean of 64/100ml or an instantaneous level of 236/100ml. The stream should support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community.

The Meduxnekeag River below the outlet of Meduxnekeag Lake and above the outlet of the South Branch of the Meduxnekeag River (9.5 miles) is a Category 3 “rivers and streams with insufficient data or information to determine if designated uses are attained (one or more uses may be impaired).” The listing as a Category 3 comment indicates data submitted by the Houlton Band of Maliseet Indians (HBMI) from 2008 & 2009 showing diurnal DO swings and increased algae. The Meduxnekeag River below the confluence with South Branch is a Category 4-A “rivers and streams with impaired use other than mercury, TMDL completed”. The Integrated Report identifies total phosphorous as the cause. The Meduxnekeag is also listed as a Category 5D for legacy pollutant DDT contamination.

EPA requires the completion of a Watershed Based Plan before obtaining federal funds under Section 319 of the Clean Water Act to implement Best Management Practices (BMPs) in an impaired watershed. A WBP is necessary in outlining the steps needed to achieve pollutant load reductions and address EPA’s 9 mandatory elements for watershed planning.

1.2 Scope of Plan

The WBP identifies and recommends actions needed to improve and ultimately restore the Meduxnekeag River’s water quality in the watershed as a whole. The WBP considers the many influences within the watershed and has developed approaches to minimize future impacts to the river due to human activities. Agriculture and forest land make up the majority of the watershed (11% agriculture and 54% forest) with the remainder characterized as developed, wetland, transportation, and open water. Agricultural landuse dominates in the lower or eastern section of the watershed starting at about Houlton Township to the border crossing into Canada. Forestry dominates the upper or western sections of the watershed. After reviewing available data and reports in Appendix C and recognizing that the nonattainment section of the river is the lower section dominated by agriculture, most of the WBP’s focus is on reducing pollutant loads from agricultural sources.

Since the Meduxnekeag is a large watershed encompassing 426 square miles, the WBP subsampled the larger agricultural watershed by looking at three subwatersheds, Craig, Oliver, and Smith. The data gathered through surveying these three subwatersheds are considered representative of the lower section and were used for planning purposes. The subwatersheds were chosen because of the predominance of agriculture and their potential for good demonstration implementation projects during the WBP’s implementation stage. This was accomplished by surveying the targeted subwatersheds and recording Nonpoint Source Pollution (NPS) sites, BMPs needed, cost estimates and recommended strategies in the resultant watershed survey report, found in Appendix D.

1.3 How was the Plan Created?

The WBP was developed using a collaborative approach, aimed at involving stakeholders in selecting management strategies that may be implemented over time to improve water quality in the watershed. A steering committee, made up of representatives from USDA-Natural Resources Conservation

State of Maine. Maine Revised Statutes: Title 38: Waters and Navigation, Chapter 3: Protection and Improvement of Waters, Subchapter 1: Environmental Protection Board, Article 4-A: Water Classification Program. Retrieved February 11, 2011, from www.mainelegislature.org/legis/statutes/38/title38sec465.html.

Service (NRCS), Southern Aroostook Soil and Water Conservation District (SASWCD), Maine Department of Environmental Protection (MDEP), and Houlton Band of Maliseet Indians (HBMI) met a total of 8 times to guide development of the WBP and adhere to a timeline. Due to the prevalence of agricultural land in the WBP, three focus groups were conducted with individual livestock and potato producers in the Meduxnekeag watershed. The focus groups provided an opportunity to gather historical data, discuss issues particular to row crop and livestock farming, and the real-life and perceived barriers in adopting agricultural practices that benefit water quality. The results of the focus group report can be found in Appendix E.

While the WBP is focusing primarily on agricultural land, forestland does make up a large part of the watershed at 54%. The forestry industry is regulated through the Forest Practices Act which is enforced by the Maine Forest Service (MFS). MFS conducts annual inspections on logging operations and publishes a report with their findings. The annual inspections are part of their BMP program and have been conducted, at random, since 2005.When monitoring staff observe concerns or issues, MFS works closely with the landowner in a non-regulatory manner to seek corrective measures. The primary mission is to prevent problems through education and technical assistance. Formal enforcement action is a last resort, for large, egregious or repeat violations. Since 2005, there have been 16 harvest sites in the Meduxnekeag Watershed that have been inspected. Collected data is analyzed using the MFS's "Best Management Practices Implementation Monitoring Protocol" which assesses the overall effectiveness of the suite of BMPs used rather than monitoring the simple installation of prescribed, individual practices. Of the 16 evaluated sites in the Meduxnekeag, four had stream crossings with one having significant sediment input (120 cubic ft), a result of improper sizing of a structure. Other BMPs were evaluated and four sites have been judged to be inadequate, indicating a higher risk of future sedimentation occurring at these locations.

None of the MFS evaluated sites in the watershed had wetland crossings, a practice that the MFS claims is averted on roughly 90% of harvests statewide. Buffers and filter strips data was collected only in 2005 and 2014. One buffer in the Meduxnekeag Watershed was evaluated in 2005 with harvest retaining 96% canopy cover. (Kanoti, 2014)

Additional information for the WBP was gathered from many different sources, relying heavily on the wealth of existing information and data as listed in the "Secondary Quality Data Assurance Guide" in Appendix C. The available information was analyzed and summarized for this plan. These historical records and data provided valuable information in determining and documenting EPA's 9 mandatory elements for watershed planning.

- What are the features of the landscape?

Suitter Brook, 2014. Photo courtesy of MDEP.

2. Watershed Characteristics

- What are the demographics?
- What effect does hydrology and soil type have on the watershed?
- What are the natural resources?

2.1 Location

As indicated on the map in Figure 1, the Meduxnekeag River Watershed is located in the southeast portion of Aroostook County, traveling 23.1 miles from Meduxnekeag "Drews" Lake to the Canadian border. The watershed includes all or portions of the towns of Hodgdon, Amity, Cary Plantation, Houlton, Linneus, Ludlow, Littleton, Hammond, and Monticello. The northern flowing river drains a watershed area of 426 sq. miles within Maine, including a portion of the North Branch watershed that ultimately joins the mainstem Meduxnekeag in Canada. The total watershed area at the river's confluence with the St. John River in Canada is 516 sq miles. A majority of the watershed is well forested but significant agricultural lands occur on the relatively flat uplands bordering the mainstem and the lower ends of major tributaries. Human development in the watershed is limited, although the river does flow through the town of Houlton, as does the lower end of Pearce Brook, a significant tributary with a history of urban pollution problems such as petroleum leaks, a 1998 oil spill, and listing of a non-National Priorities List Superfund site due to pesticide spills.

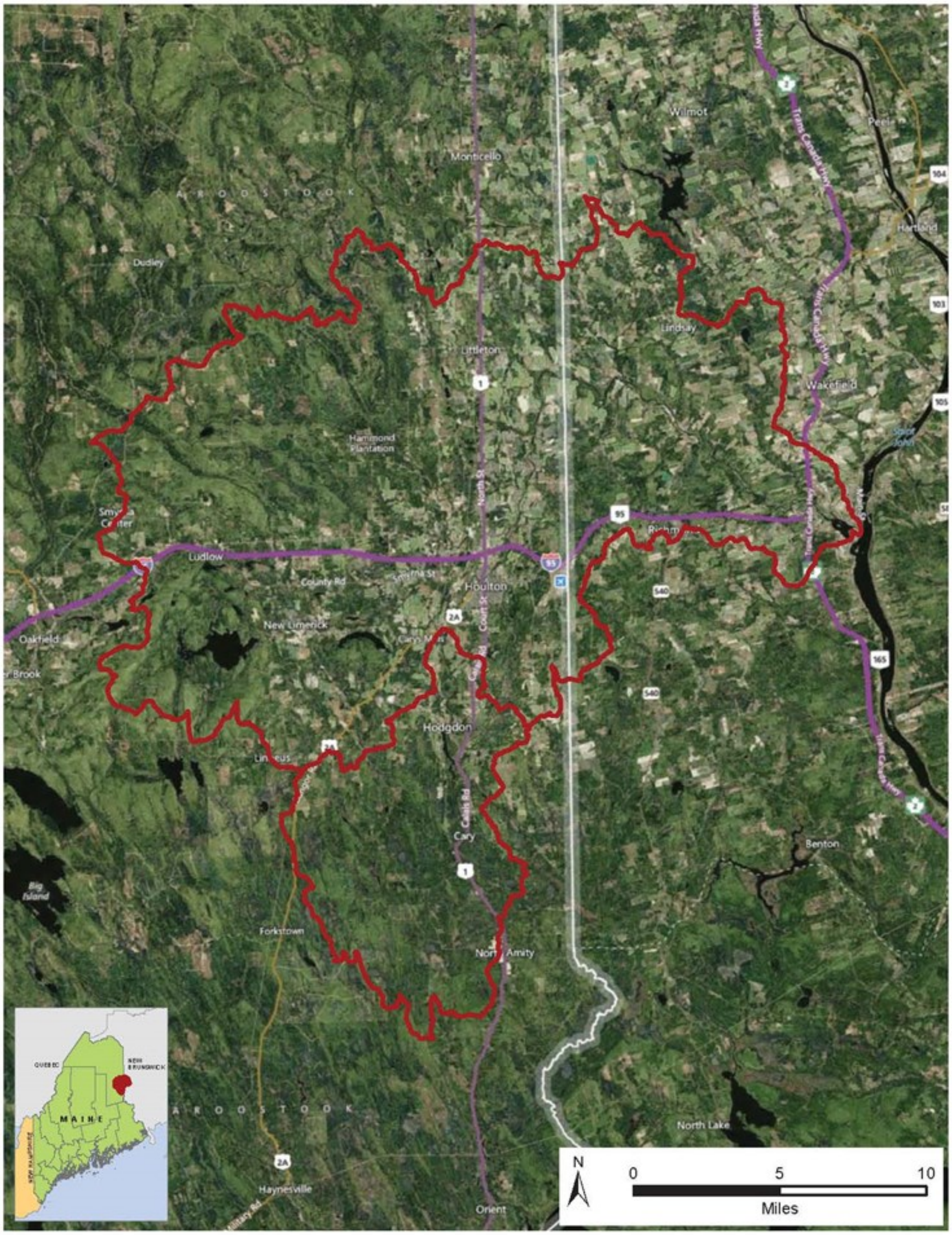
2.2 Climate

The Meduxnekeag River Watershed is located in an area of the northeast with seasonal temperature extremes. Average annual precipitation is 38.63 inches and includes an average snowfall amount between 90 – 100 inches. The warmest month of the year is July with an average maximum temperature of 78.40 degrees Fahrenheit, while the coldest month of the year is January with an average minimum temperature of 0.20 degrees Fahrenheit. Frost-free period is about 120 days, allowing for a growing season of between 100 and 125 days.

Table 1 Population Demographics of Meduxnekeag Watershed Communities, 2010

Municipality	2010 Population	Population Aged 0-24	Population Aged 25-64	Population Aged 65+	Median Household Income	Per Capita Income
Hodgdon	1,309	401	688	220	$41,310	$20,087
Houlton	6,123	1,808	3,102	1,213	$35,397	$20,405
Amity	238	64	142	32	$30,625	$19,947
Cary Plant.	218	44	122	52	$23,787	$20,428
Linneus	984	286	578	120	$43,021	$19,674
Ludlow	404	101	227	76	$45,000	$20,345
Littleton	1,068	340	560	168	$37,045	$14,566
Hammond	118	40	62	16	$35,938	$13,709
Monticello	790	203	435	152	$37,981	$18,312

Figure 1. Meduxenekeag Watershed in the US and Canada. (B Stream HUC10—0101000503 & S. Branch HUC10—0101000501)

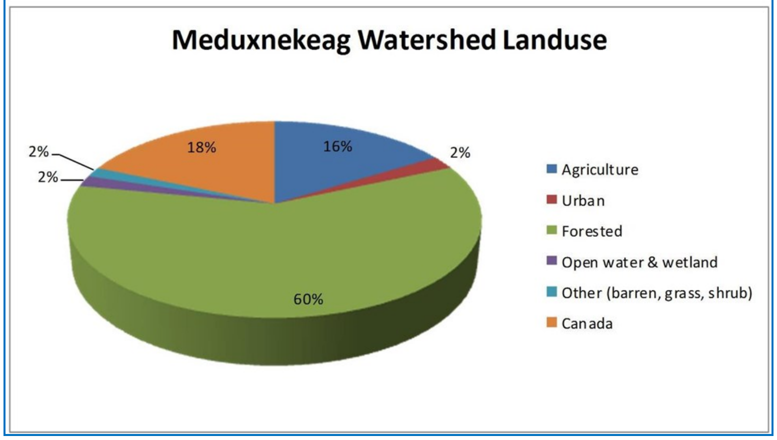


2.3 Population & Demographics

Houlton, incorporated in 1831, is the county seat for Aroostook County, lending it the nickname of "Shiretown". Houlton is also the town with the greatest urban impact to the river and tributaries. Of the three largest towns in the Meduxnekeag Watershed, the levels for individuals living below the poverty line are: Houlton -18.9%; Hodgdon - 13.4%; and Littleton - 19.7%.

2.4 Land Use

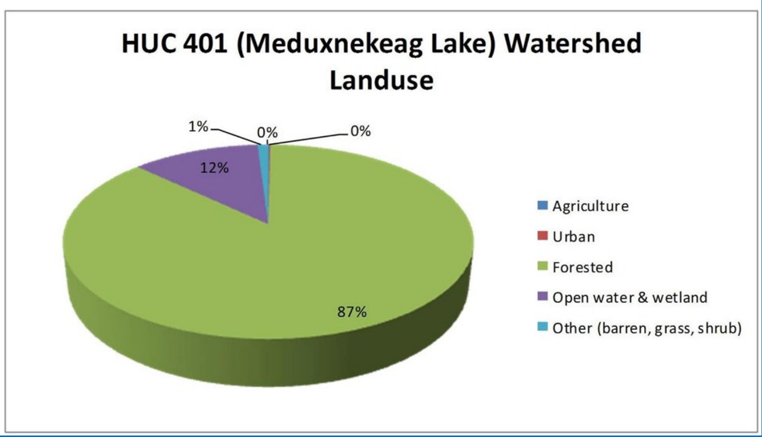
Figure 2.0 – Land uses in the Meduxnekeag Watershed, US & Canada



The Meduxnekeag watershed contains 330,240 acres of farm and forestland with a small, concentrated urban area along the main stem and Pearce Brook, a significant tributary above the confluence with the Meduxnekeag River in Houlton. As identified in the 2010 Pearce Brook Watershed Based Plan, the lower section includes concentrated urban landscape of residential, light industrial and retail stores with significant impervious cover, lack of riparian buffers, and manipulated stream channel morphology near the confluence with the Meduxnekeag River. Pearce Brook has numerous undersized stream crossings significantly impacting stream morphology.

Land use in the watershed affecting water quality is primarily agriculture (16%) (see Meduxnekeag land use map in Appendix B) that includes pasture and hayland for livestock, cropped land for potatoes, grain, and other crops, and fields that are mowed annually but have been taken out of production. The watershed also has abundant wetland features (68,000 ac) and good forest coverage along the main stem providing shade necessary for cool fish habitat. Forested land includes approximately 12.9% wetlands and 60% mixed forest (Figure 2).

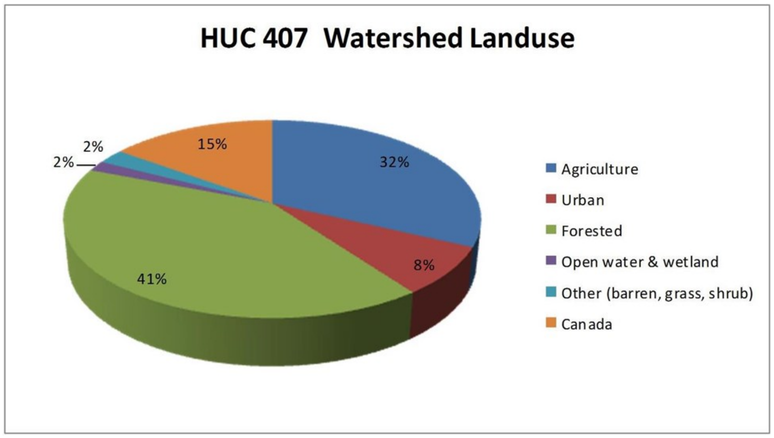
Figure 2.1 HUC 401 (includes Meduxnekeag Lake) watershed land use



According to the Forest Policy and Management Division of the Maine Forest Service, there are 326 landowners in the towns wholly or partly within the watershed that have 66,167 acres of forestland in the Tree Growth program. Three of the towns are in HUC codes that hold several thousand acres of industrial forestland, owned by Irving Woodlands, Prentiss & Carlisle, Huber, and HC Haynes. In addition, Maine Inland Fisheries and Wildlife manage approximately 6,238 acres in the Gordon Manual Wildlife Management Area in the Hodgdon deadwater, adjacent to the South Branch. Other towns, such as Ludlow, have 5,431 acres of forest land in Tree Growth with 37 landowners, suggesting a predominance of small woodlot ownership.

Whiles the Meduxnekeag Watershed as a whole is approximately 16% agriculture and 60% forested, the land use is not evenly distributed throughout the watershed. The western headwater area is dominated by forest land including industrial timberland (87%) and lakes (12%) while the eastern section below Carys Mill has more agriculture (32%) (Figures 2.1 and 2.2).

Figure 2.2 HUC 407 (includes Smith, Craig, Suitter, Pearce Brooks) watershed land use



HBMI is a federally recognized Tribe located in the watershed with over 900 acres of reservation/trust land along the lower section of the Meduxnekeag River. Traditionally, Maliseets are river people who fish, trap, hunt and gather in the waters and floodplains and are therefore concerned with the river's water quality.

2.5 Historic Land Use

The Meduxnekeag Watershed has a long history of logging and agriculture, along with businesses powered in part by dams. These have contributed to past and potential current impacts on the main stem, including its morphology and fish habitat. While most of the dams on the main stem and its tributaries no longer exist, evidence of many smaller dams includes large logs protruding from banks or fine-grained impoundment sediments left behind by the structures (Field, 2010). Today only three dams remain on both Meduxnekeag "Drews" and Nickerson Lakes and Mill Pond on the South Branch in Hodgdon.

Channel straightening on rivers in Maine was a common practice in the 19th and 20th centuries to drive logs downstream beginning with ice-melt in the spring. Indeed, the *Houlton Pioneer Times* ran a "From Our Files" news item from 100 years ago in the October 1, 2014 issue that "Dewey Hersey (Littleton) who has been at work at the Milliken Lumber Co., is at home waiting for rain, the water being so low that lumber cannot be floated to the mill." The 2010 fluvial geomorphology assessment by Dr. John Field indicates that the Meduxnekeag River and its tributaries may have seen limited straightening due to its natural confinement to a narrow valley. Field points out that topographic evidence of straightened tributaries primarily where valley confinement is not present supports this point. Although channel straightening was unable to take place in these narrow valleys, other activities such as removal of wood and boulders probably did occur and would have had similar impacts on the river. Significant changes in channeling have not taken place on the main stem since 1934 although the 1947 removal of the large dam in Houlton proved a striking change on the river. (Field, 2010)

The town of Houlton, where many of the dams and related businesses were, was settled in 1807 and incorporated in 1831. The main stem and its tributary Pearce Brook historically supported several mills. The spring 1895 edition of the *Aroostook Pioneer* notes that a steam-planing mill, woolen mill, and grist mills were located either on Pearce or nearby tributaries. A cheese factory was also located on Pearce Brook serving nearby dairy farms. In the fall of that year, a tannery was built on Pearce for the tanning of moccasins specifically for lumberman's use. These mills contributed to the remains of demolition debris still visible along parts of the stream bank.

2.6 Recreational Use

For many years, the watershed community has placed a high value on the fishing resources in the Meduxnekeag River and its tributaries. For Pearce Brook specifically, the Maine Department of Inland Fisheries and Wildlife (IF&W) biologist Dave Baseley noted that as early as the late '50s or early '60s, Pearce Brook was designated as "fishing restricted to persons 16 years of age and younger" to provide recreational opportunity to school children living in the area. Big Brook in Littleton, another large cold water tributary, is well-known for brook and brown trout fishing. Public concern to maintain a viable wild brook trout fishery resulted in fishing regulation changes in the 1990's. Creel and angler surveys by IF&W after regulations were in place saw an increase in trout densities (Frost, 2002). Due to historic farming practices that used DDT and atmospheric deposition of mercury, there is a fish consumption advisory in place for the Meduxnekeag River.

Chief Brenda Commander picking fiddleheads along the Meduxnekeag River. Photo courtesy of HBMI.

Spring canoeing and kayaking are popular pastimes on the Meduxnekeag River with an annual canoe race to benefit the local Dollars for Scholars program. The Monticello Fish and Game Club is the only fish and game club in the watershed. The facility is located along the North Branch of the Meduxnekeag and is used for many different club and public functions, including canoe races.

2.7 Soils, Geology and Topography

The Meduxnekeag Watershed can be characterized as gently to moderately sloping with some steep banks, primarily in the urban area of Houlton. Surficial material is primarily calcareous till derived from weathered bedrock, with sandier glacial outwashes, kames and eskers. A significant sand and gravel aquifer traverses the watershed, serving as the water supply for the town of Houlton by the Houlton Water Company and some private rural residences. Soil surveys from the United States Department of Agriculture (USDA) show the primary soil classification on agricultural land in the watershed as Mapleton (MhB) and Thorndike (Th), both shallow soils with a "tolerable soil loss value" of 2 tons per acre per year. The three other predominant cropland soils include Caribou, Colton, and Conant with a tolerable soil loss value of 3 tons per acre per year. All of the soils except Colton are classified as prime farmland or farmland of statewide importance (SASWCD, 1993), Bedrock is 12 to 28 inches below the mineral soil surface. These soils do not have a water table, and the rate of water movement through them is moderate. Slopes range from 0% to a high of 45%, but are dominantly 5% to 15% on cropland. Nearly all of the soils are classified as highly erodible or potentially highly erodible. The depth to the seasonally high water table is more than 5 feet and permeability is moderate.

Much of the forested land in the watershed is on poorly or very poorly drained soils, such as Monarda, Burnham, and peat and muck soils, to shallow to bedrock, steep, or stony soils such as Thorndike and Howland. (SASWCD, 1993)

Relief is moderate with hills and ridges rising 200 to 500 feet above the valley floors. Elevations vary from 250 ft at the Canada/USA boundary to 1,120 feet on Bull Ridge in Hammond. (National Geodetic Vertical Datum)

At least 16 manganiferous iron prospects, collectively known as the Southern Manganese District, lie within the watershed. Based on research in the 1950's, at least 50 million short tons of manganiferous iron ore were identified. An abandoned granite quarry is also located on the northeastern side of Meduxnekeag "Drews" Lake. (SASWCD, 1993)

2.8 General Stream Characteristics

A fluvial geomorphology study and culvert assessment, funded with USFWS Tribal Wildlife funds, was undertaken in 2007 and 2008 with a final report submitted to the Houlton Band of Maliseet Indians in 2010. The report aided in prioritizing bank stabilization needs and/or potential habitat restoration areas in the Meduxnekeag River and some of the tributaries. The presence of Meduxnekeag "Drews" Lake in the upper watershed and the many wetlands reduces peak flow in the mainstem. Green Pond, a small body of water which the Meduxnekeag flows through downstream of the Mill Brook confluence, serves in a similar fashion but with less impact than Meduxnekeag Lake. Wetlands along the tributary streams, beaver impoundments, and natural log jams reduce peak flow. (Field, 2010).

The lower portion of the Meduxnekeag River flows mainly through a narrow valley with little to no floodplains. The result is higher flows and at greater depths compared to rivers with a wide floodplain. The fluvial geomorphology study documents several locations in the narrow valleys where the river collides with the steep banks, exposing bedrock with deep pools and glacial deposits that can hold large amounts of sediments. There are 290 miles of tributaries that provide historical and current recreational and environmental services such as fishing, canoeing, trout spawning and nursery habitat.

Three subwatersheds were chosen to be surveyed for the WBP. These include Oliver Brook, originating in Hodgdon and flowing predominately north to its confluence with the Meduxnekeag River in Houlton. Smith Brook originates in New Brunswick, Canada just across the border from Houlton and flows northwest to its confluence in Houlton. Lastly, Craig Brook originates in Littleton and flows southeast to its confluence in Littleton. (Maps of surveyed subwatersheds in Appendices D-F of the Subwatershed Survey Report in Appendix D).

3. Existing Watershed Conditions

- What are the designated and desired uses of our surface waters?
- What standards are used to judge water quality?
- What is the current condition of the Meduxnekeag Watershed?
- What are the impacts of pollutants on the Meduxnekeag Watershed?

3.1 Stream Class & Criteria

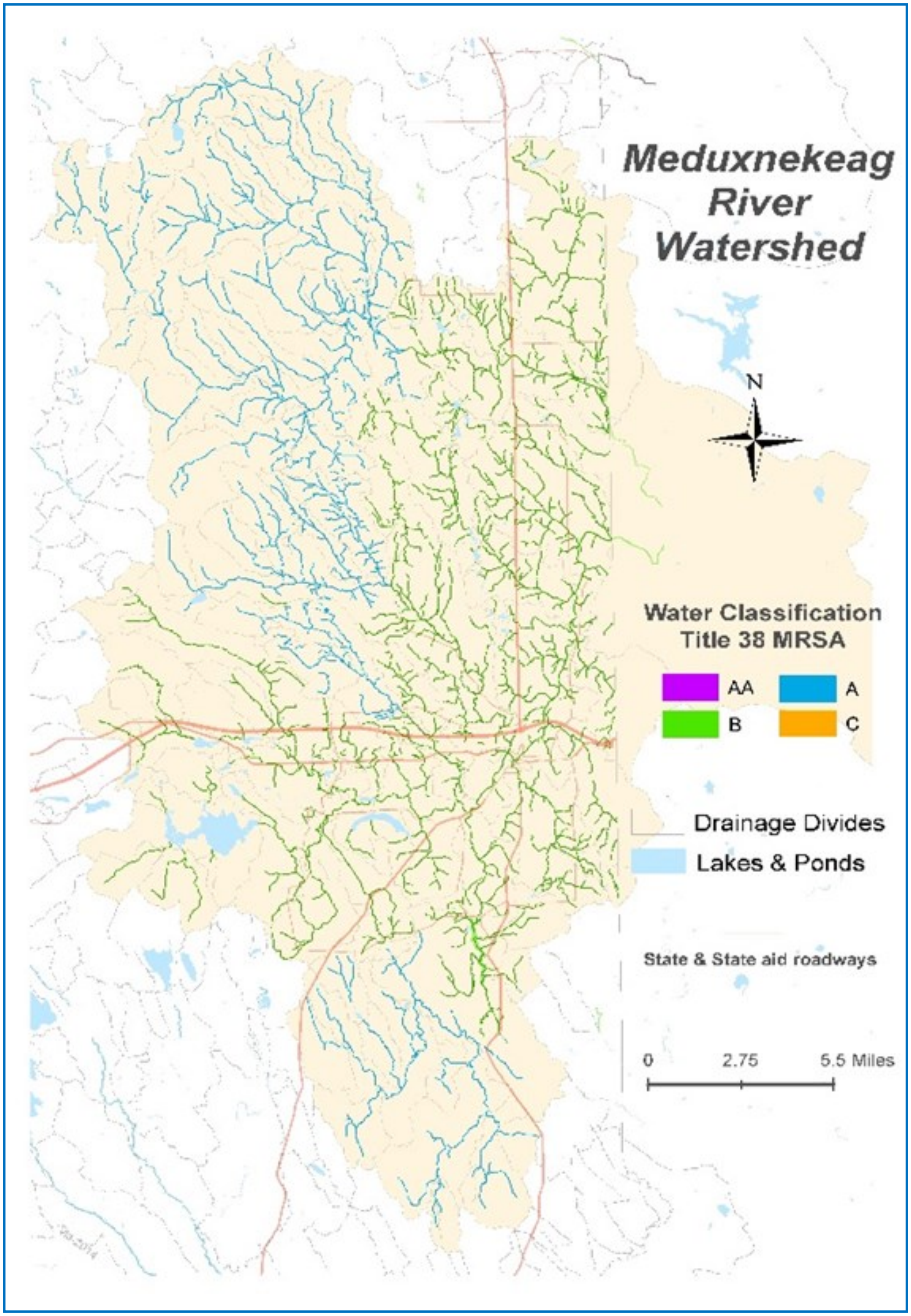
The Maine Legislature (Title 38 MRSA 464-468) has established water quality classification standards for all surface waters in the State of Maine. This system provides water quality goals and criteria and guides management efforts so that individual water bodies can be protected and restored to meet these goals. Although all water bodies must meet fishable and swimmable goals in the Federal Clean Water Act, four classes of freshwater streams and rivers (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.

Sediment laden Smith Brook, 2003.

Class A segments of the Meduxnekeag include the North Branch and its tributaries above Monticello, Moose Brook and its tributaries upstream of Ludlow Road, the South Branch and its tributaries upstream of Oliver Road in Cary, and B Stream and its tributaries upstream of the Burnt Brow Bridge in Hammond (Figure 3).

There are reaches of the Meduxnekeag River that fail to attain Class B dissolved oxygen standards. The 2012 Integrated Water Quality Monitoring and Assessment Report indicates the cause of nonattainment is total phosphorus. The report also indicated that the Meduxnekeag is impaired as a result of such legacy pollutants as DDT. A Total Maximum Daily Load (TMDL) is the total quantity of a pollutant that a stream can carry and still conform to water quality standards and is used as a measurement in the monitoring, assessment, and remediation of polluted waters. A TMDL study completed by the MDEP in September, 2000 indicated that one of the major factors in non-attainment is nutrient enrichment. In addition, the 1993 Watershed Protection Plan points to significant soil erosion problems from agricultural crop lands and livestock farms. During runoff events, tributary streams and the Meduxnekeag River turn muddy from eroded soil particles. Runoff from snowmelt, spring and fall rains occurs when most croplands are bare, delivering sediment loads to the streams. This runoff also carries “hitchhikers” like nutrients and pesticides. All of these contribute to algae, silt, and macrophytes.

Figure 3 – Map of Stream Class



3.2 Stream Assessments

Numerous assessments have been conducted in the Meduxnekeag Watershed over the past few decades. Table 2 provides a list of relevant assessments that have been completed, including the three subwatershed surveys for this WBP. A complete and detailed list of all informational material gathered and used for this WBP is included in Appendix C in a table entitled "Secondary Data Quality Assurance Guide."

Table 2 – Meduxnekeag Watershed AssessmentsTable 2 – Meduxnekeag Watershed Assessments

Assessment Type	Location	Completed By	Date(s)
Watershed Protection Plan Environmental Assessment	Meduxnekeag River	SASWCD & HBMI	June, 1993
Salmonid Fisheries Management	Special regulation section of main stem	IF&W	1988-1994, 2012
NPS Watershed Survey	South Branch	SASWCD	2002
Water Quality Data Collection	Main stem and tribs	Maine DEP, HBMI	1940's – Present (MDEP) & 1995 – Present (HBMI)
Stream Flow Data Collection	Medux (3), Pearce Brook (1)	USGS	1940 - Present
Fluvial Geomorphology & Culvert Assessment	Medux Watershed (59.8 mi mapped on main stem & tribs)	Dr. John Field	2007 – 2008; Report July, 2010
Rapid Watershed Assessment	Prestile and Medux Watersheds	USDA-NRCS	2006
Subwatershed Survey	Craig, Oliver, Smith	SASWCD & HBMI	April & July, 2013

3.2.1 Assessment of Fisheries and Brook Trout Population

The aquatic life criterion requires that all stream classes support native indigenous fish species, and brook trout are considered indigenous to all flowing Maine streams. The lower Meduxnekeag River supports wild brook and brown trout and has been a popular sport fishery for these fish in the past. Smallmouth bass, a recent invasive fish, was first reported in the mid-1990s. According to fisheries biologist Frank Frost, it is assumed the bass colonized the drainage from the downstream population in the St. John River. The fishery for brown trout is unique and one of the only self-sustaining riverine fisheries for wild fish in Maine. (Frost, 2012)

<u>Lakes</u>: Brook trout are stocked annually in Logan Lake, Houlton; Carry Lake, Littleton; Conroy Lake, Monticello; and Nickerson Lake, New Limerick. Brown trout is stocked in Meduxnekeag "Drews" Lake, New Limerick and Nickerson Lake, New Limerick.

Meduxnekeag "Drews" Lake is the largest lake in the Meduxnekeag Watershed at 1,020 acres and is the headwaters for the Meduxnekeag River. The lake was once stocked annually with salmon, but due to water quality issues such as low dissolved oxygen, the practice was stopped and now relies solely on natural reproduction. Currently, only brown trout is stocked on an annual basis.

Green Pond is a small (29 acres) body of water through which the Meduxnekeag River flows. Even with its small size, the pond provides good habitat for chain pickerel and seasonally good habitat for brook and brown trout. An oxygen deficiency below 15 feet occurs during summer months that eliminates most potential trout habitat. Trout likely utilize Green Pond during cooler months in spring, fall, and winter by movement within the Meduxnekeag River that flows through the eastern end of the pond. (IF&W Lake Surveys)

Nickerson Lake's water quality is excellent for coldwater gamefish and is stocked annually with brook trout and brown trout, providing a sport fishery for these species. Lake trout were introduced to Nickerson Lake in 1959 and subsequently established a self-sustaining population with stocking discontinued in 1994. Chain pickerel and white perch also provide angling opportunity. The presence of smallmouth bass was reported during the late 1990s. (IF&W Lake Surveys)

River and Tributaries: IF&W has monitored sport fishery and fish populations in the watershed through intensive creel and electrofishing surveys. Creel surveys were conducted during 1988-1994 and focused on the special regulation section of the lower Meduxnekeag River that extends from the Route 1 bridge in Houlton to the Canadian border. Electrofishing surveys were conducted at Big Brook, a tributary to the lower main stem during the 1990s, and surveys were also made in 1973, 1977, and 1987 while the study area was under general law fishing regulations. Trout populations in the lower Meduxnekeag River were likely being over-fished prior to 1990. Trout survival, spawning, and recruitment increased after 1990 when special regulations were first implemented. Weather, certain environmental extremes (e.g., drought and mid-winter flooding), and river conditions can affect trout populations and fishing many years later. (Frost, 2002)

An updated river creel survey was completed in 2013 with indications that the river remains a strong fishery and despite the reports of some bass being caught, brook trout fishery remains strong with excellent catch rates (Frost, 2012). The Eastern Brook Trout Joint Venture (EBTJV) is a diverse group of partners, including state fish and wildlife agencies, federal resource agencies, Indian tribes, academic institutions and non-governmental organizations working to conserve Eastern Brook Trout and their habitats. The EBTJV has conducted electrofishing studies but compiled data needs to be summarized.

The tributary Big Brook is known locally for brook trout fishing and Pearce Brook has been specifically designated for fishing for youth 16 and under since the 1960s. Brook trout is also annually stocked in the North Branch of the Meduxnekeag.

The Meduxnekeag is listed as an historic Atlantic Salmon River by NOAA's Marine Fisheries Service, the United States Fish and Wildlife Service, and the Maine Atlantic Salmon Commission. In the November 1935 journal *Monographs on the Natural History of New England* (Vol. 9, Number 1) "The Salmon Family, Part 2 - The Salmons," by William Converse Kendall notes: "Meduxnekeag River -- Authentic records show that during the early part of the century salmon entered this river in abundance, more especially in the vicinity of Houlton, Maine, where they continued plentiful until shut out by dams about 1832. During some years, however, it is reported that a few salmon still find their way into the lower part of the river …. There is no recent available information concerning this river." The HBMI's long-term goal is salmon restoration in the river but continues to be challenged by the Mactaquac dam at Fredericton in New Brunswick, Canada.

3.2.1 Water Quality Assessments

HBMI, a federally recognized tribe since 1980, has had a water quality program since 1995. While it is not clear when the Maine DEP began water quality testing in the Meduxnekeag River, they began testing in Maine's rivers and tributaries in the 1940's.

During the 2012-2014 period of this WBP grant project, MDEP conducted the following water quality sampling in the Meduxnekeag Watershed:

July, 2013 - Algae and water chemistry sampling in Craig, Oliver, and Smith Brooks (targeted sub-watersheds within the Meduxnekeag Watershed)

May, 2014 – Sondes with probes to measure turbidity and conductivity were placed in Smith and Suitter Brooks. Additional sondes in Oliver and Craig Brooks were placed with probes to measure dissolved oxygen, pH, turbidity, and conductivity.

July, 2014 - Algae water chemistry, and macroinvertebrate sampling was completed in Bither, Craig, Henderson, Oliver, Pearce, and Suitter Brooks, and Meduxnekeag 9.1 and below the WWTP.

HBMI sampled water quality during the same period at the following streams:

2012 – Monitored continuous temperature in Smith Brook.

2013 – Monitored continuous temperature in Craig, Oliver, and Smith Brooks. Conducted one total P and one nitrate-nitrite sample on Craig and Smith Brooks. Monitored continuous dissolved oxygen (DO) in Oliver Brook.

2014 – Performed algae survey in Smith Brook. Monitored continuous temperature in the three targeted subwatersheds and continuous DO in Oliver Brook. Conducted one total P and one nitrate-nitrite sample on Craig and Oliver Brooks.

During the summer of 2005, The US Geological Survey (USGS) and HBMI collaborated on establishing a baseline of water quality data to be used in future studies and to determine water quality. As part of the data collection, specific conductance (a measure of the ability of water to conduct an electrical current) was continuously recorded.

Table 4 – Bacterial Contamination

Parameter	N	Results (positive)
Bacteroidales (HF134 and HF 183) *Human Indicator*	22	8
Bacteroidales (CF128 and CF193) *Ruminant Indicator*	22	7

Table 3. Water Sampling Data.

Water Body	Class	Attains Class[5]	Sechi (transparency)	DO	TEMP	Bacteria	ChlA	Algae - periphyton	Macroinver-tebrate	P	N	Conductivity	pH	Alkalinity	Flow	Sediment (Dioxin & PCBs)	Turbidity
Meduxnekeag (Drews) Lake (Linneus)	GPA	Y	MDEP	MDEP VLMP HBMI	MDEP VLMP HBMI		MDEP VLMP			MDEP VLMP		na	na	MDEP VLMP		HBMI	
Drews Lake Wetland (W-117) (Oakfield)	GPA	Y		MDEP	MDEP			MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP			
Timoney Lake (Oakfield)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
Hunter Lake (Linneus)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
Cochrane Lake (New Limerick)	GPA	Y	MDEP VLMP	MDEP VLMP	MDEP VLMP		MDEP VLMP			MDEP VLMP		na	MDEP VLMP	MDEP VLMP		HBMI	
Gould Pond (New Limerick)	GPA	Y	na	na	na					na		na	na	na		HBMI	
Bradbury Lake (New Limerick)	GPA	Y	MDEP VLMP	MDEP VLMP	MDEP VLMP		MDEP VLMP			MDEP VLMP		MDEP VLMP	MDEP VLMP	MDEP VLMP		na	
Bither Brook	B	Y		MDEP	MDEP	na		MDEP[4]	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP		na
Mill Brook	B	Y		HBMI	HBMI	HBMI		na	na	na	na	na	na	na	na		na
Green Pond Wetland (W-118) (New Limerick)	GPA	Y		MDEP	MDEP			MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP			na
Nickerson Lake (New Limerick)	GPA	Y	MDEP VLMP HBMI	MDEP VLMP	MDEP VLMP		MDEP VLMP			MDEP VLMP HBMI		na	MDEP VLMP	MDEP VLMP		HBMI	
Oliver Brook (Houlton)	B	Y		MDEP[1] HBMI	MDEP HBMI	na		MDEP	MDEP	MDEP[2]	MDEP[2]	MDEP	MDEP	MDEP	MDEP		MDEP
Moose Brook (above Ludlow Rd)	A	Y		HBMI	HBMI	na		MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP HBMI		na
Moose Brook (below Ludlow Rd Houlton)	B	Y		HBMI	HBMI	na		MDEP	MDEP	MDEP	MDEP HBMI	MDEP	MDEP	MDEP	MDEP HBMI		na
Meduxnekeag Main Stem below Meduxnekeag Lake & above S. Branch	B	Y		MDEP HBMI	MDEP HBMI	HBMI		MDEP[4]	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	USGS HBMI		na
Hodgon Wetland (W-122)	B	Y		MDEP	MDEP			MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP			
South Branch (above Oliver Rd, Cary)	A	Y		HBMI	HBMI			na	na	HBMI	HBMI	na	na	na	HBMI		na
South Branch (below Oliver Rd, Houlton))	B	Y		MDEP HBMI	MDEP HBMI	HBMI		MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP		na
Meduxnekeag Main Stem below S. Branch [3]	B	N[3]		MDEP HBMI	MDEP HBMI	HBMI		MDEP[4]	MDEP	MDEP HBMI	MDEP HBMI	MDEP	MDEP	MDEP	USGS HBMI		na
Pearce Brook (Houlton)	B	Y		MDEP HBMI	MDEP HBMI	HBMI		MDEP[4]	MDEP	MDEP HBMI	MDEP HBMI	MDEP	MDEP	MDEP	MDEP USGS HBMI		na
B Lake (Hammond)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
B Stream (above Burnt Brow Bridge Hammond)	A	Y		MDEP HBMI	MDEP HBMI	na		na	na	HBMI	HBMI	na	na	na	HBMI		na
B Stream (below Burnt Brow Bridge)	B	Y		MDEP HBMI	MDEP HBMI	HBMI		na	MDEP	HBMI	HBMI	MDEP	MDEP	na	na HBMI		na
Hill Brook (Houlton)	B	Y		MDEP	MDEP	MDEP		MDEP	MDEP	MDEP	MDEP[2]	MDEP	MDEP	MDEP	MDEP		na

Water Body	Class	Attains Class[5]	Sechi (transparency)	DO	TEMP	Bacteria	ChlA	Algae - periphyton	Macroinver-tebrate	P	N	Conductivity	pH	Alkalinity	Flow	Sediment (Dioxin & PCBs)	Turbidity
Suitter Brook (Houlton)	B	Y		MDEP HBMI	MDEP HBMI	na		na	MDEP[4]	na	na	MDEP	MDEP	na	MDEP		na
Henderson Brook (Houlton)	B	Y		MDEP	MDEP	na		MDEP[4]	MDEP[4]	MDEP[2]	MDEP[2]	MDEP	MDEP	MDEP	MDEP		na
Long Lake (Littleton)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
Cary Lake (Littleton)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
Deep Lake (Littleton)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
Pond Parcel on HBMI Lands	B	Y		MDEP	MDEP			MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP			
Big Brook (Littelton)	B	Y		HBMI	HBMI	HBMI		na	na	na	na	na	na	na	na		na
Craig Brook (Littleton)	B	Y		MDEP HBMI	HBMI	na		MDEP[4]	MDEP	MDEP[2] HBMI	MDEP[2] HBMI	MDEP	MDEP	MDEP	MDEP		MDEP
North Branch above Monticello	A	Y		MDEP	MDEP	na		MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP		na
Number 9 Lake (T9 R3)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
North Branch below Monticello	B	Y		na	HBMI	HBMI		na	na	na	na	na	na	na	HBMI		na
Conroy Lake (Monticello)	GPA	Y	MDEP VLMP	MDEP VLMP	MDEP VLMP		MDEP VLMP			MDEP VLMP		na	MDEP VLMP	MDEP VPMP		HBMI	
Jewell Lake (Monticello)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	
N. Branch Wetland (W-113) (Monticello)	B	Y		MDEP	MDEP			MDEP	MDEP	MDEP	MDEP	MDEP	MDEP	MDEP			na
Rideout Lake (Monticello)	GPA	Y	na	na	na		na			na		na	na	na		HBMI	

Table Key

na – data not available

Waterbodies of concern are shaded red.

Grey shaded cells: Parameter not normally collected for water body type (i.e. sechi/transparency only collected for lakes and impoundments.)

MDEP = Maine Department of Environmental Protection, HBMI = Houlton Band of Mailset Indians, VLMP = Volunteer Lakes Monitoring Program, USGS = Untied States Geological Survey.

1. 2014 data indicates DO issue and potential nonattainment.
2. No state standard but measured high value.
3. TMDL completed by MDEP 2002.
4. Data collected but not available at time of report
5. Class attainment based on most recent Integrated Report (2012)

MDEP's biomonitoring data (macroinvertebrate and algae) data for wetlands and streams is available at http://www.maine.gov/dep/water/monitoring/biomonitoring/data.htm
The Meduxnekeag below the confluence with South Branch is listed as impaired for legacy pollutants.

USGS and HBMI 2005 water quality study also included potential sources of nutrient and bacterial contamination in the river. Collections of samples indicated seasonal positive concentration-discharge relations for total phosphorus and total nitrogen. Data collected by HBMI on fecal coliform bacteria indicated that bacterial contamination enters the Meduxnekeag River from multiple paths including tributaries and surface drains and ditches in developed areas in Houlton. Results using Bacteroidales, a more species-specific test than E. coli during both wet and dry weather indicate that both human and ruminant sources of contamination exist.

Two hot spots for human fecal contamination were identified at two stormwater outfalls. Armed with the results, the Houlton Water Company (HWC) was able to identify and correct a cross drain connection. The Houlton Water Company has worked with A. E. Hodsdon Engineers on a GIS project of their storm drain system that will allow the HWC to use precise coordinates in pinpointing manholes and valves for potential cross drain contamination. This project is expected to be completed in 2015 (Clark, 2015). To date none of the waters in the Meduxnekeag are listed as nonattainment as a result of bacteria.

Water chemistry data collected in 2013 and 2014 by the Biological Monitoring Unit of the MDEP indicate nutrient loading of nitrogen and/or phosphorous in each of the subwatersheds Craig, Oliver, and Smith Brooks. Based on algal samples collected in 2013, Oliver attained Class B aquatic life criteria, while Craig and Smith did not. The Biological Monitoring Unit collected both algal and macroinvertebrate samples from the three streams in 2014. Macroinvertebrate results show all sites meet or exceed their aquatic life criteria. Algae results are not yet available. DO measured during the summer of 2014 using a Manta 2 sonde at Craig and Oliver Brooks recorded DO violations of less than 7 mg/l (MDEP, 2014).

Table 5 – USGS gage stations in the Meduxnekeag Watershed

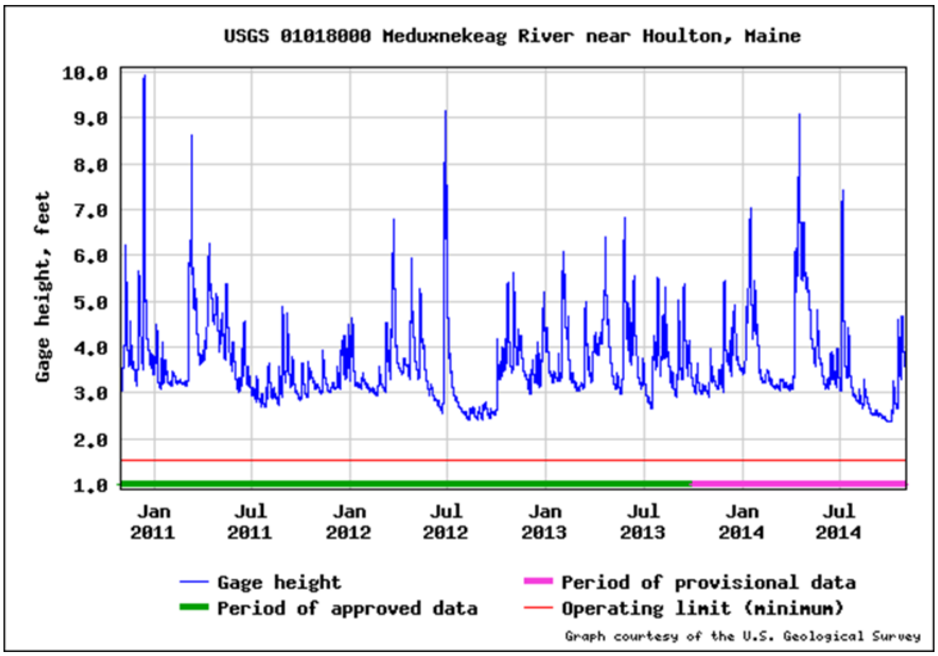
Gage site	GPS coordinates (NAD83)	Datum gage	Established	Drainage area	Parameters
01017960 (below Tate & Lyle)	46°06'18", 67° 52'53”	355 feet	2003 - present	88 sq miles	Gage height, Discharge
01018000 (Historic gage site. Below confluence with S. Branch)	46°06'18", 67° 52'00"	333.92 feet	194-1982 2003-present	175 sq miles	Gage height, Discharge
01018035 (Lowery Bridge)	46°10'52", Longitude 67° 48'14"	290 feet	2003-present	257 sq miles	Gage height, Discharge, Water temperature
01018009 (Pearce Brook)	46°06'55", 67° 50'25"	355 feet	2008 - present	7.99 sq miles	Gage height, Discharge

3.2.3 Stream Flow Assessments

USGS maintains four gage stations in the Meduxnekeag Watershed with the cooperation of Tate & Lyle and HBMI. Data for the sites is available on USGS's web site at http://waterdata.usgs.gov/me/nwis/sw

A typical annual hydrograph (Figure 4) of flow at "historical" stream gage 01018000 is dominated by high spring runoff (late March to middle May) with relatively low flows during most of the rest of the year except during summer storm events. Autumn rains can cause secondary peaks in October and November.

Figure 4 – USGS Streamflow Data 2010 - 2014



3.2.4 Fluvial Geomorphology and Culvert Assessment

Fluvial geomorphology is a science devoted to understanding rivers, both in their natural setting as well as how they respond to human-induced changes in a watershed. Dr. John Field conducted a fluvial geomorphology and culvert assessment in the Meduxnekeag River Watershed during 2007 and 2008 with a completed report submitted to HBMI July, 2010. According to Field's report, "The geomorphology assessment identified watershed conditions and human activities influencing river morphology – the shape, sinuosity, and slope of the channel." One of the report's three conceptual restoration designs was implemented in July, 2014 between the Lowery Bridge in Houlton and Covered Bridge in Littleton. The 2014 project involved placement of instream structures such as boulders and log jams to increase stream complexity as shown in Figure 5.

The objectives of the culvert assessment included characterization of culvert impacts and identification of mitigation design measures to improve accessibility and increased fish access to desirable habitat. No culverts are present on the mainstem of the Meduxnekeag River but dozens are on tributaries in the watershed. HBMI partnered with the Organization for Watershed Living and Trout Unlimited to conduct a preliminary study of stream crossing on some of the larger tributaries in 2006 and 2007. The survey resulted in a priority list of ten culverts that were potentially impacting aquatic organism passage and habitat. Prioritized culverts were selected for assessment as part of John Field's fluvial geomorphology study.

Figure 5. Habitat Improvement Project. Boulders are placed in the Meduxnekeag River to create a more natural aquatic habit for fish. Photo credit: USFWS . https://usfwsnortheast.wordpress.com/2014/09/05/wabanaki-days-in-maine/

The Nature Conservancy (TNC), in partnership with over 25 non-government organizations, state, federal, and industry groups, are participants of the Maine Stream Connectivity Work Group. Culvert assessments and stream crossing surveys conducted over the past several years by volunteers provided survey data for the development of an online habitat viewer. Partnering with Maine Office of GIS**, the "Stream Habitat Viewer"** provides a "tool for visualizing the locations of certain habitats of restoration and conservation interest and a way to identify known dams and public road crossings that could interfere with the productivity of those habitats." (Maine Stream Habitat Viewer) Viewers are able to build a query based on geographic interest or by towns and search various habitat layers and barriers/stream crossings. For example, a query for the town of Hodgdon shows the two surveyed stream crossings on Oliver Brook Table 6.

In 2014, the group partnered with Soil and Water Conservation Districts in Maine, providing District staff Habitat Viewer training and stipends to conduct outreach to local municipalities. The goal of the outreach was to provide a tool for towns to use for planning purposes and prioritizing municipal road projects. SASWCD attended training but did not participate in the 2014 outreach to municipalities.

The Nature Conservancy is also currently working on the "Moose Brook Culvert Replacement Project" at Morningstar Road in Houlton. Field work and surveys have been conducted and preliminary stream bed design drafted (Jordan, 2014). Partnerships with field work include HBMI, John Field, and NRCS. A US Fish and Wildlife Tribal grant has been awarded to HBMI to help fund the project. TNC chose this culvert as their priority because of the high quality trout habitat upstream. TNC approached HBMI as a project partner since Moose Brook was included on the top ten list per John Field's Habitat Assessment. Project implementation is tentatively scheduled for 2016, after final design and securement of additional funding. (Venno, written commun. 2015).

Table 6 – Maine Stream Habitat Viewer Data Example (partial list of information presented from query)

Site ID	Basic Structure Type	Barrier Class	Date Surveyed	Road Name	Specific Structure Type	Blocked	Structure Length (ft)
30067	Multiple	Potential	7/23/12	Bangor Rd	Pipe Arch	No	55.77
30071	Culvert	Barrier	7/20/12	Winship Rd	Round Culvert	No	46.75

3.2.5 Watershed Surveys and Implementation Projects

The last watershed plan of the Meduxnekeag Watershed was conducted by the SASWCD and HBMI in 1993. The resulting document described a plan for water quality improvement and watershed protection using accelerated planning assistance, installation of conservation practices, and initiation of management practices.

Table 7 – Grant-funded Surveys and Implementation Projects

Waterbody	Watershed Survey	Special Implementation Projects
Meduxnekeag River	South Branch, 2002 NRCS Rapid Watershed Assessment, 2007	95-08 Meduxnekeag Phase 1 $87,809.00 (CWA 319) 97-08 Meduxnekeag Phase II $109,341.00 (CWA 319) 99R-32 Meduxnekeag Restoration Phase I $174,505.00 (CWA 319)
Meduxnekeag "Drews" Lake	2004	2005R-23 Meduxnekeag (Drews) Lake Shoreline Erosion Control Project $50,000 (CWA 319 + state)
Nickerson Lake	2009	2010RR-04 Nickerson Lake Phase I $64,789.00 (CWA 319) 2013RR-04 Nickerson Lake Phase II $58,362.00
Pearce Brook	2006	2010 Pearce Brook Watershed Based Plan (CWA 319) 2014 NRCS Emergency Watershed Protection $30,000
Craig Brook	2013	2012RT-19 Meduxnekeag River Watershed-based Plan $13,748.00 (CWA 319)
Oliver Brook	2013	2012RT-19 Meduxnekeag River Watershed-based Plan $13,748.00 (CWA 319) 2011 NRCS Water Quality Initiative $724,311.00
Smith Brook	2013	2012RT-19 Meduxnekeag River Watershed-based Plan $13,748.00 (CWA 319)

A watershed survey of the South Branch of the Meduxnekeag River was conducted in 2002 by the SASWCD. NPS pollution sites were recorded using GPS software as surveys canoed the stream. Follow-up surveys were conducted on foot to verify identified sources. The survey focused on the lower 5 miles of the river due to the predominance of agricultural and active timber production. The survey identified a lack of conservation practices including vegetative buffers, grass waterways, and soil cover. Since then, various NRCS cost-sharing initiatives have helped put many of these practices on the ground, as well as specific grant-funded projects.

Watershed surveys have also been completed in the subwatersheds of Meduxnekeag "Drews" Lake and Nickerson Lake, resulting in three implementation grants funded through the EPA's Clean Water Act 319 program. The most recent project, Nickerson Lake Phase II will be completed July, 2015. The implementation projects primarily involved driveway and shoreline BMPs.

A manure management study was completed in 2004 documenting the need and potential for collaboration to improve soil health between livestock and cropland owners. Other cost-share grants that have assisted with agricultural practices implementation are HBMI's EPA-funded Winter Cover Grant (2003-2008), administered by the SASWCD and focused on cost-sharing with farmers within the Meduxnekeag Watershed to plant a winter cover crop after potatoes or grain, or mulching bare fields with a bale processor. The success of this particular project (34 farmers) resulted in the widespread adoption of a mulching practice through NRCS's Environmental Quality Incentives Program (EQIP).

As part of the Meduxnekeag Watershed Based Plan, three watershed surveys were conducted in 2013 in the Craig, Oliver, and Smith Brook subwatersheds. The completed watershed survey report is included in this plan as Appendix D.

Meduxnekeag River sample site 9.1 (above Carry's Mill and below Oliver Brook confluence.), 2014. Photo courtesy of MDEP

4. Identifying Pollutants, Sources and Causes (Element One)

- What are the impairments in the watershed?
- What are the sources (causes) of the major pollutants in the watershed?
- What are the potential solutions to improve water quality?

As indicated, given the large size of the Meduxnekeag Watershed and its predominance of agriculture in the lower reaches of the watershed, a slightly different approach was taken to identify pollutant sources, calculate pollutant loads, and recommend solutions. The strategy included looking at three targeted subwatersheds to better understand the Meduxnekeag Watershed's most intense land use activity and explore various "change in practice" efforts to address agricultural impacts.

NRCS District Conservationist assisted MDEP, SASWCD and HBMI in determining what subwatersheds to survey. Watershed characteristics included percentage of wetland and forestland, number of agriculture producers in the subwatershed, availability of water quality monitoring data, and a list of pros and cons based on any known pollutant issues, type of farming, etc. The potential list of targeted watersheds was narrowed to three: Craig Brook in Littleton, Oliver Brook in Hodgdon/Linneus, and Smith Brook in Houlton. One of the goals of the subwatershed approach is to identify which BMPs agricultural landowners are willing to adopt and if they will be enough to improve water quality prior to promoting the BMPs watershed-wide. Suggestion of BMPs will take into account on-the-ground surveys and information gleaned from focus group discussions with agricultural producers.

4.1 Nonpoint Source Pollution (NPS) Sources

NPS is essentially the pollutants that are washed off the land into local streams, lakes, rivers and groundwater during storm events and spring melting. Common NPS pollutants include pathogens like bacteria from failing septic systems, illicit discharges or livestock, nutrients from fertilizer and manure, soil from construction sites, forestry operations, crop agricultural activities, transportation, petroleum products from spilled or leaked gas and oil, and pesticides.

<u>Pollutants of concern in the Meduxnekeag Watershed:</u>

<u>Sediments:</u> In excess, sediment degrades aquatic habitat by filling in pools, embedding gravel substrate and contributing nutrients. Many cold water fish species lay their eggs in well-oxygenated gravel beds and the fry often seek cover and hang out in the interstitial spaces. High sediment loads to streams can fill these spaces eliminating important habitat. Suspended and embedded sediments also impact aquatic organisms directly. Visual feeders like brook trout find it difficult to locate food in cloudy water. The suspended sediments also act like sandpaper along delicate gills on fish and aquatic insects.

Nutrients: There are two nutrients of concern – phosphorus and nitrogen. Phosphorus is the limiting nutrient and the nutrient of most concern in fresh water systems. Sources of phosphorus include eroded soils, fertilizers, animal waste, and failing septic systems. These nutrients accumulate in the stream and contribute excess algae growth. In lakes the result is algal blooms and reduction of water clarity (the lake looks green). If algal blooms become a regular and/or occur over an extended period the lake can become eutrophic with anoxic waters which can kill fish. In flowing systems (streams and rivers) excess phosphorus will increase attached algae production resulting in algae mats covering aquatic habitat (rocks, logs, bottom). During the day algae photosynthesis drives oxygen levels into the supersaturate zone and at night respiration can drive oxygen levels critically low.

MDEP's Integrated Report identifies nutrients as the pollutant driving the nonattainment in the lower section of the Meduxnekeag River. MDEP and HBMI's water chemistry data from 2013 and 2014 stream monitoring indicate nutrient loading of nitrogen and/or phosphorus in all three targeted subwatersheds. Strategies to identify and complete projects that mitigate nutrient delivery to the streams will be discussed as part of the action plan in Section 8 (Element Six) with the highest priority projects tied directly to repetitive problems at surveyed sites.

Phosphorous (P) is the second most applied nutrient and has the ability to bind with positive ions in the soil, limiting its leachability. However, if the soil is completely saturated with nutrients, then P has nothing to bind to and is washed through the soil into groundwater. Chemical reactions that reduce P availability occur in all ranges of soil pH but can be very pronounced in alkaline soils with pH > 7.3 and in acidic soils with pH < 5.5. Maintaining soil pH between 6 and 7 will generally result in the most efficient use of phosphate. Potatoes grow best in less alkaline soil of 5.5 pH. The following graph in Figure 6 shows P availability based on soil pH:

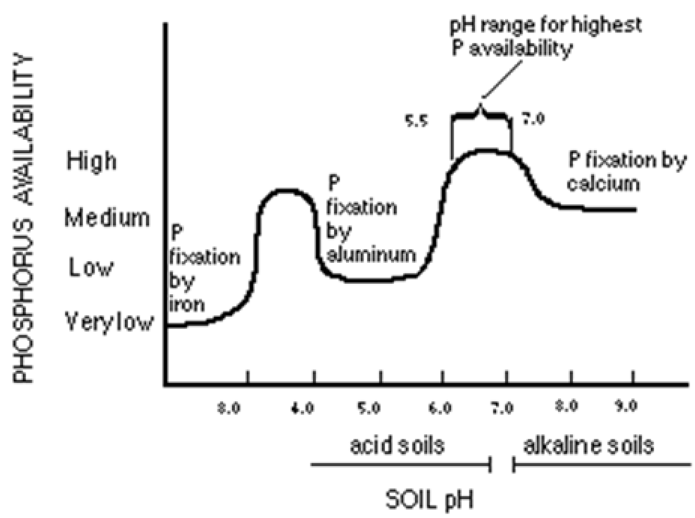
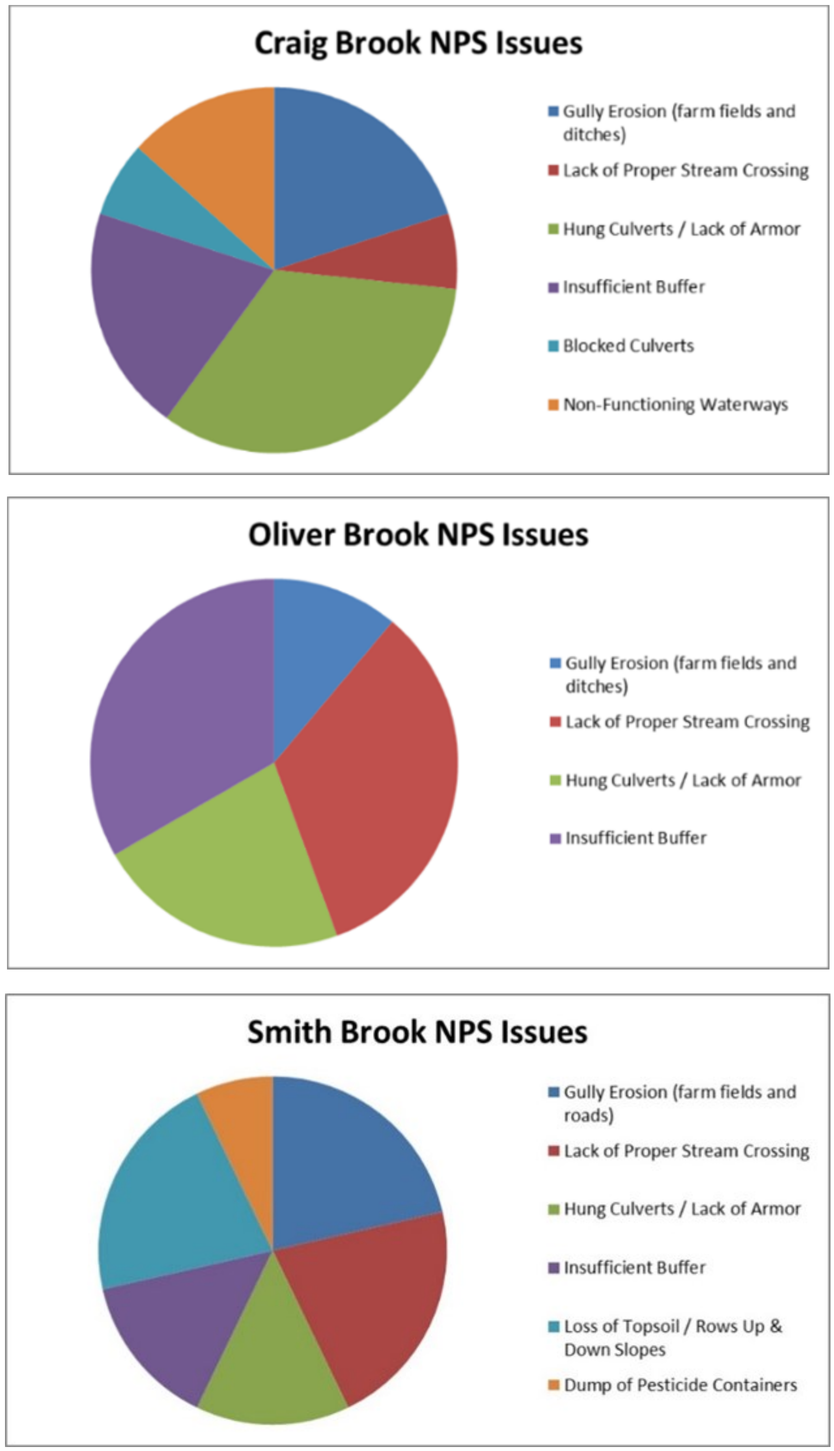


Figure 6 - Phosphorus Availability. http://www.extension.umn.edu/agriculture/nutrient-management/phosphorus/the-nature-of-phosphorus/index.html#predicting

Nitrogen is normally not a nutrient of concern in fresh water systems. However, when present in exceedingly high concentrations, which have been recorded in this watershed, it can and will have an impact on aquatic plants. Nitrogen is a very mobile nutrient easily carried by water on the surface or in the groundwater. The sources of nitrogen are the same as for phosphorus but fertilizers and animal waste tend to be the bigger drivers.

Legacy Pollutants: The two historic pollutant issues in the Meduxnekeag are DDT and a chemical/petroleum area. DDT (dichloro-diphenyl-trichloroethane) was developed as an insecticide in the 1940's and was widely used during World War II to combat insect-borne diseases. DDT's effectiveness, persistence, and low cost made it popular for agricultural and commercial uses. More than a billion pounds were used in the U.S. over a 30-year period. Although EPA banned nearly all domestic uses of DDT in 1972 as a result of public outcry about its impact on wildlife and people, DDT builds up in sediment in rivers, lakes, and coastal areas, then accumulate in fish. The Meduxnekeag River, like many waterbodies with an agricultural watershed, is listed as impaired for the legacy pollutants of DDT.

Figure 7 – NPS Sources



Pathogens (bacteria): Bacteria such a E. coli and fecal coliform are often indicators of human or animal waste. When these pathogens are ingested they can cause an infection that can lead to severe bloody diarrhea and abdominal cramps; sometimes the infection causes non-bloody diarrhea.

Sources of Pollutants:

Agriculture: Most of the agriculture in the Meduxnekeag Watershed can be found from Hodgdon to the Canadian border. While row crop agriculture dominates, there are a number of small and large livestock operations of beef and dairy. The major NPS sources identified in the 2013 subwatershed surveys (Figure 7) were:

Soil erosion in potato field, 2013. Photo courtesy of MDEP

The once prevalent small farms of crop and livestock integration have given way to larger farms growing crops or raising livestock. Potato still reigns as the major commodity grown with oats or barley typically grown as a rotation crop. Rotation crops grown on a smaller scale include forage corn or soybeans. Within the watershed, there are fourteen potato farms growing an average of 300 - 400 acres of potatoes on roughly 14,200 acres as indicated on the land use map in Appendix B. Few producers sell direct to market, as most contract with McCain Foods or Frito Lay or grow for seed. Competition from western potato growing states has fueled the recent trend of irrigation, discussed in detail in section 4.2

Currently, there are six dairy farm operations within the watershed's boundaries, with two selling to the independent Houlton Farms Dairy processing plant. The larger dairy farms (milking 140 or more cows) operate with free-stall open barn systems where only dry cows are

Table 8 – Type and Size of Livestock Farms

Type	Approx. Animal Numbers	No. of Farms w/ ≤ 50	No. of Farms w/ ≥ 50
Beef	~1,045	12	4
Dairy	~470	3	3*
Horse	~125	3 (riding stables only)	1
Sheep/Goat	~140	7	1
Poultry	~700	Numerous backyard poultry	1
Deer	1,000		1

**One dairy farm's cattle is housed outside of the watershed, however, manure is spread on farmer's land in the watershed and is thus included in the number above. Additionally, future plans include moving the herd to a location within the Meduxnekeag Watershed.*

on pasture for several weeks a year. Recently, three smaller dairy farms have begun production. Two of those farms have plans of transitioning to organic and supplying Organic Valley, a co-operative looking to expand the number of their milk producers in the County.

In addition to a few of the larger beef operations, there are several smaller farms with less than 50 beef cattle. There is at least one sheep farm located near the main stem. Education of raising animals is promoted to the young through Cooperative Extension's 4-H groups in the County with students raising beef, swine, goats and sheep. Students actively show their animals at various local fairs. Table 8 indicates type and approximate size of livestock farms in the watershed as determined by Angela Wotton, SASWCD and Helena Swiatek, NRCS.

Forestry: Forest land makes up approximately 67% of the Meduxnekeag Watershed with wetlands an additional 13%. Areas of the watershed include industrial landowners owning vast tracts of forest land. For example, 95% of the land in the town of Hammond in the B Stream subwatershed is owned by Irving Woodlands, a large international industrial timber company. In other townships there are numerous small woodlot owners. Most farms include wooded areas too wet or steep to farm. These woodlots are used for firewood, maple syrup production, to supply wood to portable sawmill businesses, or wildlife habitat. Education for small woodlot owners in the watershed and beyond is limited as most outreach in Southern Aroostook is geared towards crop production. The SASWCD partners with MFS District Forester to provide at least one educational class per year for small woodlot owners as part of the annual "Winter Ag School."

One of the most common forms of harvesting in the Maine north woods is called one-cut shelterwood or "overstory removal." These cuttings resemble clearcuttings except that most of the new age class is already growing at the site prior to tree removal. This type of removal is best suited to the poplar/fir stands but has it challenges. This cut leads to an increase in soil moisture, which combined with mechanical harvesting (exposed soil from skidders and processors), can increase muddy runoff. Another issue is that trees left for seed production are often selected based on their lack of timber quality, reducing the quality genetics in the stand overtime (Swiatek, written commun., 2015).

The Maine Forest Service works with the forestry community to develop and refine BMPs to protect water quality during forest harvests. Forestry BMPs are voluntary only with no prescriptive regulation. Random statewide monitoring of BMPs on timber harvesting operations began in 2005 with over 500 sites monitored to date, 16 of these in the Meduxnekeag Watershed. Of the 16 sites, four were stream crossings with one crossing that did not follow BMPs and resulted in sediment input (120 cu/ft). MFS works closely with the harvesting operation on remediation when such sites are found, believing that works in everyone's interest better than regulatory BMPs. MFS concentrates BMP monitoring on waterbody crossings and approaches as these pose the greatest risk to water quality. The potential for water quality impact is greatest during large rain events and spring thaw.

In 2014, the *"Forestry Rules of Maine – A Practical Guide for Foresters, Loggers and Woodlot Owners"* was released through MFS. The forestry rules were produced as a collaborative effort with various partners. The guide is divided into sections by topic covering state laws and rules for timber harvesting, information specific sections for foresters, loggers and landowners, and reference to state agencies. This guide is downloadable at (http://www.maine.gov/tools/whatsnew/attach.php?id=623259&an=1).

Groundwater: When not managed properly, land-applied nutrients in the form of chemical fertilizers and animal manures have the potential to leach into the groundwater and be delivered to the stream. In soil, N becomes highly leachable, especially during times of excess rainfall and in fields with well-drained soils. Saturation point is highly variable and loss of N will always depend on weather. N management tools include in-season nitrate testing or computer modeling systems like Adapt-N, but all are at least somewhat compromised by the weather (Bruce Hoskins, Cooperative Ext Soil Lab, written commun. 2015). Studies completed in the 1980's in Aroostook County in agricultural watersheds found a number of wells with high nitrogen levels.

Groundwater discharge from aquifers to surface waters can account for as much as 50 percent of average annual streamflow. (Culbertson, et al, 2012) There are a number of large mapped sand and gravel aquifers in the Meduxnekeag Watershed. One of these serves as the drinking water source for the Houlton community (Cary's Mill). To better understand and provide information about possible contaminated groundwater discharges to the river, thermal infrared (TIR) remote sensing technology was used in 2003 and 2004 to identify thermal anomalies in a 25-mile reach of the main stem and tributaries, a collaborative project between USGS and HBMI. Aerially imaged thermal anomalies identified as potentially significant discharges were followed with individual site readings on-the-ground. In all, 31 thermal anomalies were detected between the two flights. One outcome from the project included the removal of a pipe at a natural freshwater spring frequently used by the public after documenting high nitrate levels. Other anomalies that need following up include discharge sites on Meduxnekeag and Nickerson Lakes, along with an agricultural-related site on the main stem.

Septic systems can also be a source of groundwater nitrogen. Due to the low density of development in the watershed compared to the significant amount of agricultural fields and the volume of fertilizers applied, reducing nutrient levels from fertilizer use should be the priority.

4.2 Other Water Quality Impact Sources

There are a number of other documented watershed activities that impact the Meduxnekeag River system. These include urban stormwater runoff, water withdrawal for irrigation, public and private roads, stream crossings (fish passage/habitat connectivity), and historical contamination (DDT, brown field sites, mercury). Mercury is also a current pollution source from aerial deposition.

Urban Stormwater: The only urban area in the watershed is Houlton. Houlton has a number of small named and unnamed tributaries and one larger tributary running through it, Pearce Brook. The 2010 Pearce Brook Watershed Based Plan provides information on the town of Houlton's municipal stormwater system. The plan also identifies a number of stream crossing projects including Green Street bridge replacement. Impervious surface issues from parking lots, roofs, gutters, and roads contribute to the flashiness of Pearce Brook and exacerbate the undersized stream crossings.

Bailey Brook is a small stream originating on Hillview Avenue and running under the downtown section of Houlton outletting via a stormdrain near the Meduxnekeag bridge. The stream runs through yards, exposing it to the potential for nutrient (fertilizer) and bacterial (pet waste) contamination. The Town of Houlton's 1891 historical records mention a $500 expenditure for the brook and describes it as "…enclosed in a sewer composed of timber, plank and cedar sleepers for a distance of nearly 800 feet, from Lawlis' stable to a point two-thirds of the distance from Court to Kendall Street. We strongly recommend another appropriation for continuance of the work."

In addition, urban streams are at risk from "every day" urban impacts of gas and oil drips, litter, and pet waste that are likely to make their way to nearby storm drains.

Historical Contamination: Near the confluence with the Meduxnekeag River in Houlton, the tributary Pearce Brook runs through an area historically known as "gasoline alley" so-named because of the 30 underground gas tanks that once existed within 1,000 feet of Pearce Brook. While many of the tanks were removed in the early 1980's and 90's, it is unknown if all have been removed. Gasoline odors in the area in the 1990's prompted an environmental site assessment by MDEP that was completed in 2006. In 2005, MDEP collected pore water samples along Pearce Brook in order to identify current and/or historical petroleum discharges through groundwater to surface water. In 2007, MDEP began an extensive contaminated soil clean-up in and around the area. A pesticide processing site once located on Pearce Brook was declared a non-National Priorities List (NPL) Superfund site in April, 1989. The same site was also identified with a petroleum discharge by MDEP in May, 2002. Some of the subsequent report's recommendations have been implemented such as revamping a specific site's Agricultural Spill Tank (AST) overfill containment set-up but other

Pearce Brook urban debris, 2014. Photo courtesy of MDEP.

recommendations still need to be implemented. These include removal of contaminated soil and groundwater on the former processing site. (SASWCD, 2010)

The most recent work on Pearce Brook occurred in 2014 with funding through NRCS's Emergency Watershed Protection (EWP) program. Working with the Town of Houlton public works department, the stream bank at Bangor and Sugarloaf Streets was stabilized after determining that bank slumping was endangering an existing building and exposing contaminated soil.

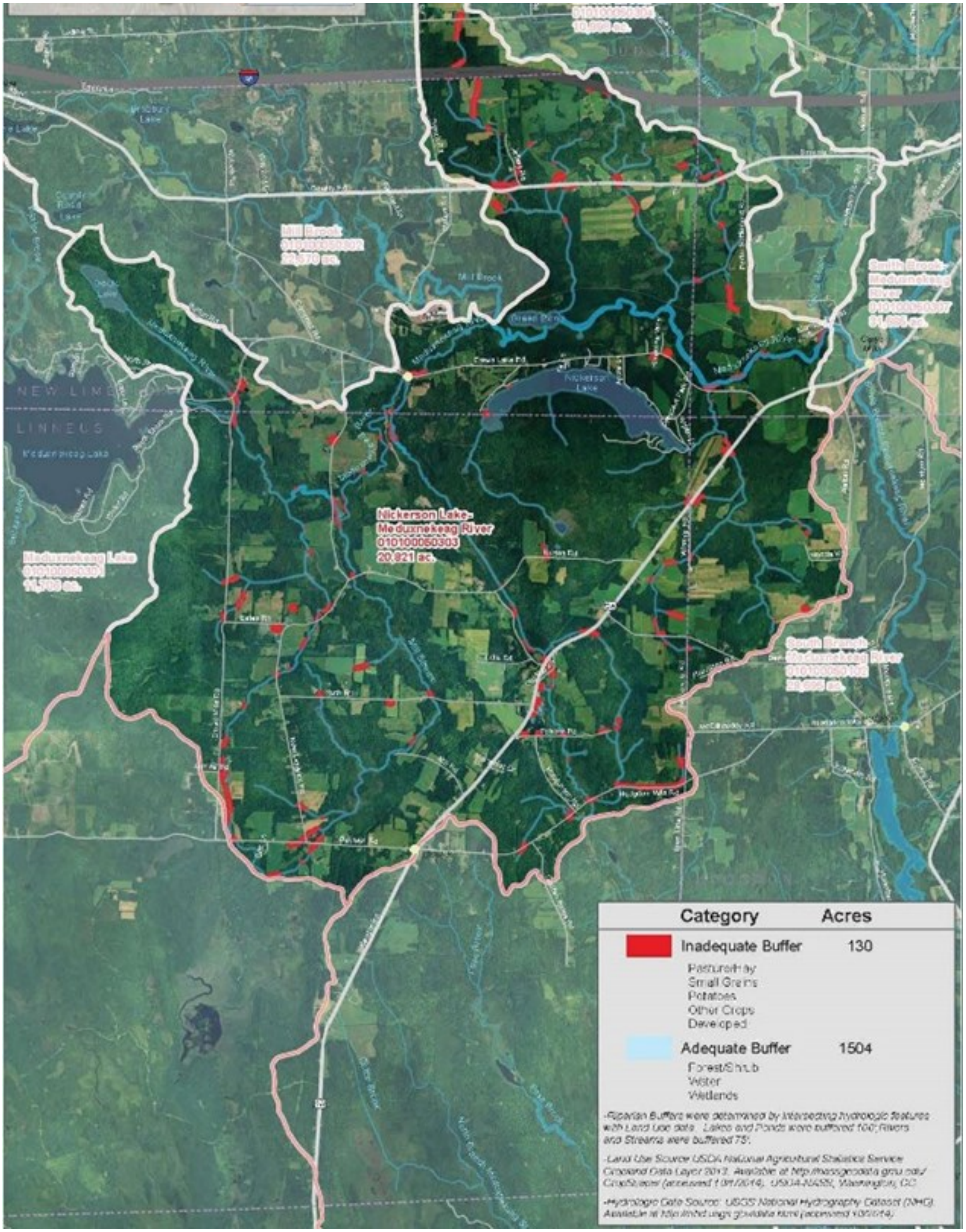
Irrigation: Direct withdrawal of water from Maine's surface waters was supposed to decrease with the passage of MDEP's Sustainable Water Use Rulemaking in 2007. The rule stipulates that existing agricultural producers (as defined) have 5 years from the effective date of the rule to attain the applicable in-stream flow and water level requirements in chapter 587. Producers currently irrigating are subjected to these low flow rules.

To assist farmers in complying with the Flow Rule, NRCS's EQIP and Agricultural Management Assistance (AMA) programs beginning in 2010 established dedicated funds for irrigation projects. Since traveling irrigation guns tend to over apply and are inefficient, the programs have funded installing more efficient central pivot irrigation systems for five potato producers and alternative water sources like irrigation ponds (one pond). Four other known ponds were dug for irrigation without NRCS cost-share funds.

There are no records detailing how many producers were or are irrigating, making it difficult to assess impact of irrigation on the watershed. The need or perceived need in irrigation traces to competition with other potato growing states where there is heavily subsidized irrigation. The market is driving Maine growers to produce consistent yield and sized crops regardless of weather patterns each year. The national market competition has pushed the trend to irrigation for a quick yield response rather than the more lengthy process of build-up of organic soil matter through longer rotations and planting of green manures. In a potato systems research project led by Dr. Wayne Honeycutt, then research soil scientist and leader at USDA-Agricultural Research Service (ARS), potato yields increased with soil improving practices. As presented in his January, 2014 webinar "An Experimental Case Study for Soil Health" through the NRCS East National Technology Support Center, Dr. Honeycutt shared his three-year research results. Begun in 2004, four different potato systems were implemented all under both rainfed and irrigated management. Potato yields increased and surpassed irrigated fields in just three years with the soil improving system, along with soil aggregate, bulk density, and bacterial population improvements. http://www.conservationwebinars.net/webinars/an-experimental-case-study-for-soil-health

Emerging technology allows producers to see rainfall patterns across a field, helpful in determining yield data but also potentially helpful in reducing irrigation use. Unmanned aerial vehicles (UAV) began undergoing research in 2013 for use in irrigation efficiency, using thermal infrared detection.

Figure 8, Nickerson Lake subwatershed



A project in place since 1991 has been the Soil Climate Analysis Network (SCAN). SCAN is an established soil-climate network, led by NRCS, which retrieves data from remote sites in 40 states. One of the related uses of SCAN data is to predict regional shifts in irrigation water requirements that may affect ground-water levels. Maine is not currently part of the network and has no real-time soil and climate information to draw from in helping to predict long-term sustainability of cropping systems and watershed health.

Bither Brook, 2014. Example of hanging culvert impeding fish passage and impacting aquatic connectivity. Photo courtesy MDEP.

Unprotected Riparian Areas: The riparian area is the land adjacent to a river or stream which includes the stream bank and extends 75-100 feet back. For stream health, riparian areas should be heavily vegetated with sheet flow from adjacent uplands. These vegetated areas are known as riparian buffers. Using the 75 foot buffer width (as per Maine's Shoreland Zoning Rules), an analysis of all subwatersheds and vegetative cover were mapped (see Appendix B). The example of surveyed Oliver Brook in the Nickerson Lake subwatershed in Figure 8 indicates that 130 acres are lacking adequate forest cover in the buffer area. Riparian areas with adequate cover consist of a network of tree roots along the shoreline that stabilize the stream banks and hold the soil in place. The above ground network of trunks, branches, leaves and needles alters the way in which precipitation reaches the ground, greatly reducing the erosional impact. The canopy of leaves and needles also provide shade to keep water temperatures cool, especially important for native brook trout.

Missing Fish Habitat and Connectivity Issues: According to work completed by John Field and Maine IF&W, there are missing structural stream habitat characteristics in the Meduxnekeag. For example, there is a lack of pools and woody debris. In 2014 a project between the Lowery and Covered Bridges started the in-stream restoration efforts. Embedded tree trunks and root balls and boulders were strategically placed in the stream channel to increase habitat diversity. In addition to studying stream habitat characteristics, John Field looked at stream crossing for habitat connectivity. There were ten culverts surveyed and all were found to be undersized and constricting the channel. The recommended solution was bottomless arch culverts spanning channel widths. Ongoing channel adjustments at the culverts demonstrate the need for replacement but other mitigation measures can be taken to improve impaired habitat in the short term. These shorter term efforts are described in Field's Assessment. HBMI's next-step for in-stream restoration focuses on a section of the North Branch of the Meduxnekeag River in Monticello. Obtaining funding for this project is a current goal of the environmental staff at the tribe.

As mentioned in section 3.2.4, The Nature Conservancy (TNC) and its partners completed a stream crossing survey and an online tool "Stream Habitat Viewer." The site identifies 166 surveyed road-stream crossings in the Meduxnekeag Watershed, of which 28 are determined to be in poor condition, affecting fish passage. This survey data can be used to prioritize culvert replacements based on factors such as numbers of river miles and habitat blocked by culverts.

4.3 Point Sources

There are two licensed wastewater treatment dischargers in the Meduxnekeag watershed. Tate & Lyle Mfg. Company is a commercial starch processing facility located above the confluence of South Branch of the Meduxnekeag River and its main stem in Houlton. Their MEPDES permit (MEPDES #ME0002216) contains stream dissolved oxygen (DO) and flow discharge restrictions, as well as nutrient, total phosphorous (TP) discharge limits. Seasonal DO limits to allow discharge to the Meduxnekeag River are in effect when DO levels are above 7 ppm at Cary's Mill Bridge and 7.3 ppm at the point directly above the Houlton Water Company's POTW discharge site. The seasonal effluent TP monthly average concentration and mass limitations are also in effect. During low stream flow conditions (<15 cubic ft per second, cfs), discharge to the river is prohibited by Tate & Lyle. Recent history shows that although Tate and Lyle have had to stop discharging to the river due to DO and river flow restrictions, it is far more likely to occur due to low flow than low DO conditions. Tate and Lyle's effluent data is monitored by MDEP compliance staff on a monthly basis.

Houlton Water Company owns the second licensed wastewater discharge, a municipal wastewater treatment facility for the Town of Houlton. The facility is licensed to discharge an average monthly treated effluent flow 1.5 mgd and serves approximately 6,500 residential and commercial entities. Their MEPDES permit (MEPDES #0101290) also contains nutrient and TP discharge limits in effect seasonally. Houlton's effluent data is continually monitored also and Houlton periodically monitors ambient river water quality under a Department approved monitoring plan.

In addition to the 'pipe' point source discharges mentioned above, there are various Industrial Stormwater permit holders in the watershed. These can be characterized as needing a "general permit" for best management practices and discharge monitoring of stormwater associated with their respective sites. These sites are associated with certain specifically identified industrial activities list that have an identified discharge conveyance or concentrated flow point and have an activity that would have exposure to stormwater. These general stormwater discharges are scattered throughout the Meduxnekeag River Watershed; their activities and monitoring of discharges are periodically inspected by the MDEP personnel.

5.0 Linking Pollutant Sources to Water Quality (Element Two)

- What does water quality data tell us about the watershed?
- What is the estimation of pollutant loads in the watershed?

5.1 Water Quality and Pollutants

Linking pollutants to water quality in a large watershed with numerous waterbodies and landuses such as the Meduxnekeag River is complicated. There are numerous lakes, wetlands, small and large tributaries and the mainstem. Organizing the discussion around water body type and geographic location allows for discussion to focus on the major pollution sources: (1) The lakes found predominantely in the upper watershed area; (2) tributaries and mainstem in the western section of the watershed above Cary's Mill; (3) South Branch; (4) tributaries below Cary's Mill and the mainstem; and (5) North Branch.

<u>The Lakes:</u>

There are two large lakes (Meduxnekeag and Nickerson) in the watershed and numerous smaller lakes and ponds. Both Meduxnekeag and Nickerson Lakes have a lake volunteer monitor and meet GPA water quality standards. MDEP rates Meduxnekeag Lake to have "average" water quality based on Secchi Disk Transparency (SDT), Total Phosphorus (TP) and Chlorophyll-a (chl-a). There is moderate dissolved oxygen (DO) depletion in the deep areas of the lake. MDEP rates Nickerson Lake water quality as "above average" based on SDT, TP and chl-a. However, Meduxnekeag and Nickerson Lakes along with a few of the smaller lakes have significant shorefront development with the associated poor road construction challenges. Without careful thoughtful use of shoreland zoning and second tier development standards these lakes could see water quality decline.

Lake Status: Meets water quality criteria.

Recommendation: Protect water quality from degrading through use of shoreland zoning, LakeSmart like programs, and proper road maintenance.

<u>Tributaries and Mainstem above Cary's Mill:</u>

The stream gradient above Cary's Mill is about half of what it is below Houlton (John Field per. communication) due to geology. The upper watershed (western area) is a granite formation while below Cary's Mill there are eroded limestone formations (John Hopeck per. communication). There are numerous wetlands associated with the area above Cary's Mill. MEDEP has water quality monitoring data on three tributaries and three mainstem locations (Bither, Oliver, Moose, river mile 9.1, above and below Tate & Lyle). All meet or exceed Class B biological aquatic criteria. However, during the summer of 2014 Oliver Brook had numerous DO readings below 7 mg/l. Nutrient data collected on Oliver Brook by both HBMI and MDEP indicated nutrient enrichment. Oliver is the one tributary with a significant agricultural acreage. It is believed that the increased nutrients, large diurnal DO swings and low DO are strongly influenced by agriculture, a dominatant land use in the watershed.

Sample site 9.1 is on the mainstem located just below the Oliver Brook confluence and below Green Pond with a large wetland complex in and along the mainstem. Site 9.1 currently meets Class B macroinvertebrate water quality criteria; algae data is not yet available. HBMI's DO data routinely records DO values below the 7 mg/l water classification threshold.

Water Quality Status: Most tributaries and the mainstem in this reach meet or exceed water quality criteria. However, water quality monitoring of Oliver Brook recorded elevated nutrient levels, DO violations, and large DO swings. Monitoring at river mile 9.1 indicates some stressors present but it is unclear if the stressors are natural or anthropogenically induced and what the stressor(s) is.

Recommendation: Work to reduce nutrient and sediment loading from agriculture. Continue to collect data to determine natural or anthropogenically induced stressors at 9.1.

South Branch:

The South Branch of the Meduxnekeag originates in the forested area of Cary Planation. In the town of Hodgdon it is impounded as part of the Lt. Gordon Manuel Wildlife Management area creating a large wetland that meets Class A water criteria. Below the impoundment agricultural land use activities increase. MDEP has two sample sites along South Branch and both indicate that South Branch attains Class B water quality criteria.

Water Quality Status: Most current data indicates attainment.

Recommendation: Consider periphyton (algae) sampling to confirm attainment of all biological aquatic criteria especially in the lower watershed.

Tributaries below Cary's Mill and the Mainstem to the border:

The stream gradient increases in the Cary's Mill area due to a change in geology (limestone formation). Faster water running through riffles is more oxygenated. In addition, there are large sand and gravel aquifers running along South Branch and in the upper watersheds of Moose, B Stream and Big Brook. These large aquifers discharge cold well-oxygenated water to the tributaries whose confluence is in the lower section of the mainstem. The increased gradient along with the discharge of cold well oxygenated water influences the assimilation capacity providing some buffering capacity within the system (John Hopeck per. communication). However, algae and nutrient data demonstrate nutrient loading issues and aquatic life impairment in tributaries sampled (Craig, Henderson, Hill, Smith)

Craig Brook, 2014. Photo courtesy of MDEP.

and the mainstem (near Lower Bridge). The dominant land use in the tributaries is agriculture and thus the likely source of the nutrients.

Water withdrawal for agricultural irrigation purposes is occurring in this section of the watershed. There is currently no available data regarding the number of acres irrigated, the volume of water used, timing or duration, nor the sources of the water which makes it challenging to evaluate the impact or potential impact on the aquatic community. If there is impact, it will likely occur first in the small tributaries by possibly dewatering sections of the stream bottom desiccating aquatic organisms or lowering water levels enough to reduce fish movement.

The mainstem passes through the Houlton urban area where there are numerous stormwater outfalls; a few of which have had high bacteria indicating possible illicit connections to the stormwater collection system.

This section of the river also has two licensed point source dischargers (Tate & Lyle and Houlton Water Company). Both of these facilities have licensed nutrient restrictions. Tate & Lyle's discharge also has river flow and DO restrictions.

In the lower Pearce Brook watershed there are historic chemical and petroleum storage sites. While there is currently no measured water quality criteria impact from these sites, the stream banks are unnaturally steep and unstable. The resulting bank sloughing and instability has occasionally exposed contaminants. MDEP has conducted pore water sampling along Pearce Brook's urbanized lower reach and documented petroleum compounds. A number of soil contamination removal projects have been completed yet there is more still to be done.

Water Quality Status: Impairment in monitored tributaries and the mainstem from nutrients. Sources: most likely agricultural runoff with additions from urban stormwater. Petroleum product contamination concerns in Pearce Brook's lower reach.

Recommendation: Work with agricultural community to reduce nutrient and soil runoff to both surface and groundwater. Work with the agricultural community to ensure water withdrawals don't impact aquatic life. Continue to work with Houlton Public Works to identify and eliminate illicit connections. Continue to work with the town of Houlton, Pearce Brook land owners, and MDEP Brown Fields program to prevent historic contaminates from reaching Pearce Brook.

<u>North Branch:</u>

There is very little water quality data available for the North Branch of the Meduxnekeag. Available data indicates that it and an associated wetland meets water quality criteria.

Water Quality Status: Current data indicates water quality criteria are met.

Recommendation: Consider periphyton, nutrient and DO sampling in the lower watershed (off Hare or Bell Road) to confirm attainment.

Watershed Wide:

Salmonids like brook trout require cold, well-oxygenated water for survival along with other key habitat components (cobble, riffles, pools). This habitat and good water quality can be found throughout the watershed's waterbodies. However, the habitat isn't always accessible due to connectivity issues from road crossings that can create barriers to fish passage. Since brook trout will try to avoid poor habitat and water quality especially in times of stress, they need access to higher value habitat and water quality, and they need to be able to move throughout the drainage system. A partnership of government and NGOs has surveyed and identified numerous stream crossing obstacles.

Water Quality Status: Numerous fish passage barriers have been identified for public stream crossings.

Recommendation: Work with private landowners to identify fish passage barriers. Work with public and private sectors to remove fish passage barriers.

5.2 Pollutant Loads

As a result of the size of the watershed, landuse and land ownership occurring over large tracks of land, and the similarities in types of NPS pollution sites the pollutant load discussion is focused on one subwatershed as a model or example for the impaired reach. Smith Brook was surveyed in 2013 with results summarized in "Subwatershed Survey Summary Report, January 2015" in Appendix D. For the eleven surveyed sites the Region 5 "Michigan Method" Model was used. For annual erosion and sediment loss, the Revised Universal Soil Loss Equation (RUSLE) was used to predict based on soil type. The figures are loading estimates that assist in planning estimates rather than exact predictions of loads entering the watershed.

With implementation of the recommended BMPs the pollutant load to Smith Brook could be reduced by a third. Additional management activities such as reduced fertilizer application could further reduce the pollutant load.

Best management practices for nitrogen fertilizer application rates are developing with promising new practices like "variable rate applications" using GPS. These systems are able to target rates based on what each field or portion of fields need, alleviating over-application. Also, with the recent NRCS focus on soil health, more research is being done within the USDA on nitrogen already available in the soil and how much of that can be used for new crops. As of 2013, a few labs now perform soil tests that provide results on soil microbial biomass, nitrogen and phosphorus mineralization potential, all representing nutrients that are likely to be plant relevant. Nitrogen fertilizer rate is one of the most important N management variables, both economically and environmentally.

White tailed deer.

Table 9. Pollutant Loads – Smith Brook Surveyed Sites 2013

	Before BMPs			After BMPs			
BMPs	**Soil t/yr**	**P lbs/yr**	**N lbs/yr**	**Soil t/yr**	**P lbs/yr**	**N lbs/yr**	**Est. Cost**
Cover crop; culvert	17.64	17.64	35.28	3.1	3.1	6.2	$50/ac $1,500-$3,000
New culvert	16.0	16.0	32.0	4.0	4.0	8.0	$1,500-$3,000
Contour/strip cropping; grass waterway	41.5	41.5	83.0	12.5	12.5	25.0	$13/ac $600 - $800
Cover crop; cul-	22.0	22.0	44.0	8.8	8.8	17.6	$50/ac
Contour/strip cropping; permanent vegetation on headlands	14.9 gully 26 sheet/rill	14.9 26	29.8 52.0	≤.1 13	≤.1 13	≤.2 26.0	$13/ac $50/ac
Stabilize rd shoulder erosion	0.6	0.6	1.2	≤.1	≤.1	≤.2	
Stabilize culvert	-	-	-	-	-	-	$150-$250
New, larger cul-	8.0	8.0	16.0	4.0	4.0	8.0	$2,000-$3,000
Contour/strip cropping; permanent vegetation on headlands	3.8 gully 15 sheet/rill	3.8 15	7.6 30.0	≤.1 6.0	≤.1 6.0	≤.2 12.0	$13/ac $50/ac
Totals	165.44	165.44	330.88	51.7	51.7	103.4	

MDEP biomonitoring of Smith Brook, 2014. Photo courtsey of MDEP.

6.0 Description of Management Measures & Technical and Financial Assistance (Elements Three & Four)

- What BMPs need to be implemented to reduce pollution load reductions?
- What are the critical areas for management measures?
- What are the resources to plan and funding needs to implement BMPs?

6.1 Agriculture

Agriculture (hay/pasture/cropland) accounts for 16% of land in the Meduxnekeag Watershed with most farmland located primarily along the relatively flat uplands bordering the main stem and the lower ends of major tributaries.

Many farms in the watershed utilize a 1:1 rotation with potato/small grains. Experimental use of cover crops and /or winter cover has been encouraged through an EPA-funded 2003-2008 "Winter Cover Project" that provided cost-share. Farmers could either plant a fall cover or mulch post-harvested fields. These practices were adopted by some farmers but numbers remain low, especially when financial assistance wasn't available through NRCS. Most farms experience an average soil loss of 1.7 tons, which is below the tolerable soil loss of 2 tons for the predominant soil type of Mapleton shaly silt loam. However, since any soil loss into a water body is intolerable, this soil needs to remain in the field. The soil conditioning index (SCI) which measures organic matter is -0.1. This number shows a trend of organic matter depletion in these soils which will increase the potential of soil erosion, reduce yields over time and require more irrigation. Bare soil pre- and post-harvest allows erosion (most show visible signs of sheet and rill erosion after a heavy rain) and provides poor wildlife food and cover.

As part of this plan, focus groups of potato and livestock farmers were convened in March, 2014. The focus groups' goal was to provide a first step in determining knowledge, awareness, attitudes, and opinions from the farmers within the watershed to help shape suggested management measures. Additionally, a paper survey was developed and submitted to participants in a class as part of the SASWCD's "Winter Ag School" with findings included in the final focus group report. The final report can be found as Appendix E. Two focus groups with potato farmers and one group of livestock farmers met with discussion led by two facilitators. In preparation for the meetings, phone interviews were conducted with natural resource professionals and focus group questions developed by the steering committee and facilitators. The results of this research are being used to identify which BMPs are most likely to be adopted, barriers to adoption, and which BMPs are unlikely to be adopted regardless of effort.

<u>Agricultural – Cropland</u>

Focus group participants were aware and concerned about soil erosion, but many seemed to accept some soil loss as a part of farming. On the other hand, when the facilitator tested eight different visual messages to determine what the farmers responded to, the message with a photo of a bare field with erosion and the caption “Is your soil bleeding?” was the preferred message. The visual spoke to them emotionally and, most importantly, they felt it was something they could fix. The second most popular message was “Keep your soil, keep your farm.”

The general mantra for addressing soil erosion is first, try not to let soil move to begin with. If it moves, try to capture as close to the site as possible. With increasing distance there is increasing volume of water and soil that increases the cost and maintenance of the practices. This is why leaving crop residue, or using cover crops and/or mulch, are a first line of defense.

Mulching and planting of a fall cover has also been adopted over the last few years, mostly with assistance through EQIP. While potato crops are tillage intensive with seasonal periods of bare soil, there are practices that can be implemented to shorten the time of bare, vulnerable land. An important BMP in preventing soil erosion is the adoption of fall-planted cover crops. According to Iowa State University Extension and Outreach, raindrops in a normal rainfall range in size from 1 to 7 millimeters in diameter and hit the ground going as fast as 20 miles per hour. The impact of millions of raindrops hitting the bare soil surface can be incredible, dislodging soil particles and splashing them 3 to 5 feet away. Focus group perception that a cover crop needed to be at least six-inches tall to be effective is a misconception that can be overturned with demonstration of on-the-ground application of different quick-germinating and hardy covers such as rye, even after a late potato harvest. Any growth is preferable to bare soil and even an inch can help break up the velocity of rainfall. The correlation between the farmers in the potato focus group who felt that they simply did not have time to grow a fall cover after the harvest of late russet potatoes may just be that they feel that the cover does not have time to establish sufficient growth. Education and outreach with on-the-ground demonstrations, such as through the SASWCD’s 2014-2017 Conservation Innovation Grant (CIG) project, can help show the advantage of cover, no matter the plant height.

Options for steeper slope areas, especially those fields once in USDA’s Conservation Reserve Program (CRP) but taken out after contract expirations in 2012 and 2014, include permanent vegetation, strip cropping, and planting on the contour, all of which can reduce the speed of water runoff and slow soil erosion. Contour and strip cropping were both common practices in the 1970’s in Southern Aroostook when equipment and farms were smaller. As both farms and equipment became larger, it became more difficult to turn large equipment in small fields or strips, while it became easier to manage fields and farms that were planted to the same crop. Contour strips generally range from 90 to 120 feet in width, based on the land slope and cropping system used. Traditionally, strip cropping was defined as alternating strips of row crop with strips of either small grain or hay. For strips to be effective, hay, small grain or heavy residue must be alternated with a row crop. Contour and strip cropping may be used together to further help reduce potential for gully erosion. As was evidenced in runoff on a farm field planted to potatoes up and down the slope in the Smith Brook subwatershed survey, it would be beneficial to employ at least contour or strip cropping on steeper sloped fields to reduce runoff and erosion. The rise in use of GPS systems and adoption of “precision planting” could potentially help with adoption of these once-common practices.

More oversight of nutrient use and soil health provide alternatives to trying to capture nutrients in basins or buffers. One relatively new approach, after decades of relying on chemicals and petroleum-based inputs, is to re-build soil health with the basic understanding that healthy soil equals healthy plants. This premise opens up a range of BMPs including multi-species cover crops where grasses, legumes, flowers, and cereals are planted together in a six to ten variety mix, mimicking the diversity of nature, coined "biomimicry" within soil health circles. Adoption of such an approach within a 1:1 potato rotation could replace the small grain planting. Economics of payoff in potato yield and quality based on a healthy soil would help farmers with their contract requirements and ease pressure from competition with western states who are able to produce more on much less money. USDA research and producer real-life application indicates that soils can be re-built after a 3-5 year time when fields are farmed with the diversity that nature requires to provide a living ecosystem. In 2014 SASWCD was awarded a three-year NRCS state Conservation Innovation Grant titled "Building Soil Health with Innovative Potato Cropping Systems." The project will work with three potato farmers to develop multi-species mixes for Southern Aroostook and incorporate such mixes within their rotation. Farmers will also interplant at least two companion plants with the potatoes, helping to fix nitrogen, attract beneficial insects and provide diversity. One of the goals is to choose a plant that will reseed in the fall during harvest disturbance, thus providing some naturally-germinating fall cover to the fields. One of the participating farmers has recently acquired a small beef herd and will plant a multi-species mix suited to grazing. Livestock integration has been the missing link in agriculture in the Meduxnekeag Watershed for many years and if managed wisely, can be an important soil building resource.

Winter cover, 2014 in Oliver Brook watershed. Part of NWQI project. Photo courtesy of MDEP.

Table 10.2 - Ag BMPs

BMP Type	Technical Resource(s)	Cost of Implementation
Multi-species Cover Crop	SASWCD, NRCS, Cooperative Ext.	\$50/ac @ 43 lbs/ac
Biochar	NRCS, Cooperative Ext, HBMI, SASWCD	\$1,500/ac @ 5 ton/ac
Compaction Tillage Radish Deep Tillage	NRCS, Cooperative Ext.	\$65/ac tillage radish @ 8-15 lbs/ac \$34/ac

Table 10.0 - Ag BMPs

BMP Type	Technical Resource(s)	Cost of Implementation
Winter Cover Mulching Fall Cover	NRCS, Cooperative Ext.	 $173/ac mulch $65/ac cover
Strip cropping	NRCS, Cooperative Ext, MOFGA	$13/ac
Contour planting	NRCS, Cooperative Ext.	$13/ac

Grass waterway, 2013. Photo courtesy of MDEP.

The second line of defense is to make sure moving sediment-laden runoff doesn't scour a channel and increase the amount of soil movement. In this situation, grass or rock-lined waterways are used. The main goal of grass and rock-lined waterways is to provide a stable water course for stormwater runoff but they also often act as sediment traps for the larger sediment particles. Basins, the third and final line of defense are actual traps for sediments and nutrients. When properly sized they allow for smaller particles to settle out. Like all structural practices, waterways and basins require maintenance. Several of the focus group's farmers recognized the need for maintenance and remarked how a waterway constructed twenty years ago was no longer working and needed to be rebuilt. NRCS's EQIP provides cost-share funding for both of these practices, as well as FSA's CRP program for continuous waterways.

There are also management BMPs that can help reduce soil and nutrient loading to local waterbodies. Using a three year rotation has many benefits including increasing organic matter which reduces erodability and the number of months there is bare ground. NRCS and Cooperative Extension have been promoting the benefits of a three-year rotation for years but widespread adoption has been resisted due to "lack of available land" and yield requirements for potato contract growers.

Table 10.1 - Ag BMPs

BMP Type	Technical Resource(s)	Cost of Implementation
Waterways Grass-lined Rock-lined	NRCS	(Avg 30' x 400') .20/sq ft grass $48/cy rock
Nutrient/Sediment Basins	NRCS	$48/cf rock / $65-$500 cf grass (based on
Three-year crop rotation	NRCS, Cooperative Ext	Need true economics

An additional innovative soil health building tool is the use of biochar. Biochar is a form of charcoal created by pyrolysis of biomass. HBMI was recently awarded a grant through Elmina B. Sewall Foundation to study the benefits of biochar as an agricultural soil amendment on potato fields. The positives of biochar could include carbon sequestration, reduced fertilizer rates, improved crop nutrient and water availability, soil pH balance, and reduced nutrient leaching. The field experiment, conducted in partnership with NRCS, SASWCD, Cooperative Extension and a local potato farmer in Houlton, will take place during the growing seasons of 2015 and 2016. This grant project will provide another opportunity for farmer education and retain the momentum of soil health outreach.

Soil health BMPs have the ability to increase the water-holding capacity of soils, reduce erosion, and chemical and petroleum-based inputs. Field days and informal "farmer coffee" workshops will further educate and provide information to other farmers wanting to adopt such innovative practices.

Potato contracts with McCain Foods in 2014 resulted in a twenty percent reduction of potatoes planted County-wide and less money per hundredweight. In theory, with more land available, farmers will now have more options, including a three year crop rotation and trying new mixes for building soil. NRCS EQIP has already started promoting these practices by working with four farmers in the Meduxnekeag Watershed in 2014 with planting tillage radish (grown for its long tap root and ability to help break up hardpan), a small grain, and clover together in a mix. Market and corporate forces are dictating on-farm changes and these BMPs can act as tools to help end 'farming as usual' while rebuilding watershed soils and keeping soil in the fields. Healthier soils lead to healthier, more nutritious plants, providing potential for new "natural" markets.

The costs associated with implementing the various individual BMPs were drawn from NRCS's regional average costs. These costs are for implementation only and do not reflect annual upkeep and maintenance.

Agriculture – Livestock

The Nutrient Management Program was established by the Maine legislature in 1998, initiated and developed by the Maine Department of Agriculture, Soil and Water Conservation Districts, and interested farmers. A nutrient management plan (NMP) is a document that describes how nutrients are stored, managed and utilized on the farm. The state requires an NMP for farms confining and feeding 50 or more animal units (1,000 lbs), storage or utilization of more than 100 tons of manure or compost not generated on that farm or any other byproduct that has a source of crop nutrient or soil amendment. NRCS requires a Comprehensive Nutrient Management Plan (CNMP) from those producers participating in EQIP funding programs for livestock-related practices or BMP implementations such as waste storages or heavy use areas.

The establishment of Pineland Natural Meats feedlot in 2005 in central Aroostook County has led to several farms raising livestock under contract with Pineland with one beef operation backgrounding cattle for the company. Backgrounding cattle is an intermediate stage that begins after weaning and ends upon placement in a feedlot. Background feeding relies more heavily on forage (e.g., pasture, hay) in combination with grains to increase a calf's weight by several hundred pounds and to build up immunity to diseases before it enters a feedlot. Recently, Meyer's Natural Meats opened up another opportunity for smaller farms to sell their meat products within Maine through a program known as Local Harvest. Both Pineland Farms and Meyer's promote their products as "natural" beef and do not allow antibiotics or hormones. Most of the beef farms in the watershed have cow/calf operations where the animals are on grass until weaned and sale of calves in fall or winter to primarily feedlots.

The March 2014 focus group meeting with livestock producers found that one of the biggest complaints associated with NRCS cost-share funding of heavy use and manure storage areas was the inability to fund roofing, a practice funded in other states. With annual precipitation close to 39 inches/year it makes sense to prevent clean rain water from contacting manure, becoming contaminated, and increasing disposal handling volumes. SASWCD needs to work with the appropriate decision makers to allow the roofing practice. Unlike the potato producers who have a strong lobby presence through Maine Potato Board, the livestock producers do not have a strong organized voice. Livestock producers tend to see themselves as individuals and not part of an industry. They distrust government agencies only approaching them for cost-share programs and rarely seek technical assistance. It should be noted that there currently is no livestock technical expertise in the County through Cooperative Extension or Maine Department of Agriculture, Conservation and Forestry (DACF). It also doesn't help that livestock producers feel 'picked on' and worried that they could be fined or regulated further by the DACF.

There are currently no known livestock farms in the watershed implementing a continuous or intensive grazing rotation. SASWCD has tried to promote such practices in the past through workshops but farmers have yet to adopt the practice. NRCS also offers EQIP practices for pasture management and establishment of grazing plans. Looking at intensive rotations, including those with multi-mix forage plantings, and emerging practices such as "mob grazing" have yet to be adopted into NRCS standards. SASWCD will explore the barriers preventing farmers from adopting these practices.

Beef producers commonly feed cull potatoes to their cattle as supplemental feed. Without proper siting or storage of cull potato piles, as the potatoes break down their leachate can run off into local waterbodies. In addition, cull potatoes fed in abundance to cattle poses a manure management issue since the manure becomes more liquid.

Table 10.3. Ag Nutrient Management BMPs

Conservation Practice (Livestock)	Current BMPs funded thru NRCS	Future BMPs planned / waiting to be funded thru NRCS	Estimated Cost
Waste Storage Structures (no.)	16	2	$249,500
Heavy Use Area (no.)	18	2	$75,100
Filter Area (ac)	1.0	0.6	$14,000
Prescribed Grazing (ac)	28.2	93.9	$2,500
Riparian Buffers (ac)	9.5	0.5	$500

Table 11 describes the current and future conditions of livestock BMPs needing to be implemented (future condition = what is planned within NRCS – not a reflection of all that may be needed) of agricultural land in the Meduxnekeag Watershed as determined through applicants enrolled in NRCS EQIP. Livestock producers rely on EQIP to provide cost share for waste storage structures that are otherwise prohibitively expensive.

An often overlooked segment of livestock owners include the small hobby and horse farms. These owners often fall through the cracks not coming in contact with NRCS for technical assistance nor qualifying for many NRCS programs. They often have limited acreage and farm equipment. The result is poor manure handling practices and pasture management. On small streams the impact of a few horses or cattle with poor manure handling or pasture management can have a significant effect on water quality. The Craig Brook watershed survey identified at least one horse farm in need of BMPs. A concerted effort needs to be made to reach the small hobby and horse farms, to introduce BMPs and look for ways to address problem areas.

To facilitate better pasture management, the SASWCD purchased a Tye Pasture Pleaser no-till seeder in 2013. The no-till seeder allows livestock farmers to reseed their pasture without exposing the soil. Previously, the district shared a county-wide no-till seeder, limiting its use in Southern Aroostook due to seasonal timing, availability, and transport. Two dairy farmers in the watershed have converted all of their forage cropping to no-till systems.

6.2 Forestry

Because forestry can account for as much as 87% of a subwatershed and 60% of the whole watershed, it is important that wood harvesting activities follow BMPs. The Maine Forest Service's BMP inspection program identified stream crossing problems in the watershed.

Table 11 Forestry BMPs

BMP Type	Technical Resource(s)	Cost of Implementation
Portable skidder bridges	MFS, Private	No cost
Culvert	MFS, NRCS, Private	$1,500 - $3,000
Low water crossings	MFS, NRCS	$12/sq ft

6.3 Historical Sources

Addressing pollutants from historic land use activities that include petroleum and pesticides often involved contaminated soil removal and disposal after first identifying the contamination boundary. This type of activity requires technical expertise and can be quite expensive. Until the boundaries of the contamination are delineated and the specific contaminants identified it is difficult to estimate the cost of cleanup.

6.4 Unprotected Riparian Areas

Restoring riparian areas can involve as little effort as not mowing and letting it grow to planting trees and shrubs. When riparian areas at the shoreline are unstable rip rap may be necessary to hold the bank in place while woody vegetation above the unstable site is established. To ensure the maximum effectiveness of a riparian buffer the up-slope area should be shaped such that there is sheet flow (no concentrated flow) through the buffer.

Oliver Brook, 2014. Unstable riparian area due to lawn, bank is 'slipping' into stream. Photo courtesy of MDEP.

Table 12 Riparian Buffer BMPs

BMP Type	Technical Resource (s)	Cost of Implementation
Riparian buffer planting	MFS, Towns, NRCS, Private	$1,000/ac
Rip rap	MFS, NRCS, Private	$85-$95/linear ft

6.5 Fish Habitat

There are 28 identified public stream crossings in the watershed with impaired fish passage. The solutions involved include realigning culverts, installing properly sized culverts, and using arch culverts and bridges. Specific information for the 28 sites can be found at http://mapserver.maine.gov/streamviewer/index.html. In addition to the identified public stream crossings there are an unknown number of crossings on private land (forest and agriculture) that should be surveyed.

Table 13 Fish Habitat BMPs

BMP Type	Technical Resource(s)	Cost of Implementation
Replace undersized culverts with open-bottom arch culverts	MFS, NRCS, Private, MDOT, ME Audubon	$955 - $1,472/lf for 12'w x 6'h
Culvert maintenance	Towns, Private, MDOT, ME Audubon	$500/yr
GRS-IBS Bridge* or Timber Deck bridge (typically on forest roads)	MFS, NRCS, Private, ME Audubon	$25 - $33/sq ft $140 - $160/sq ft

**Geosynthetic Reinforced Soil Integrated Bridge System*

6.6 Critical Areas

This plan has identified the eastern section of the Meduxnekeag Watershed (generally Oliver Brook subwatershed to the Maine border) as the area needing critical focus. It is in this area that there is the most intense landuse (agriculture and urban development) and historic contaminants. It is also in this area that the impaired waterbodies are located.

6.7 Technical and Financial Assistance – Current and Future Strategies

Technical Assistance

Agriculture: Technical assistance (TA) from various state and federal agencies has been reduced over the last few decades. Historically, NRCS provided the lions share of technical assistance to farmers but beginning with the 2002 Farm Bill, the agency turned their focus on cost-share funding. The result is limited technical assistance funding, fewer NRCS staff and fewer staff hours spent 'kicking the dirt' with the farmers and encouraging conservation practices.

One attempt to address the reduction in TA staff was the creation of the collaborative "Beginning Farmer Resource Network." While a grand idea the collaborative is limited on its ability to provide on-site TA. It mainly provides online resources and links to additional information. Attempts at providing information and TA in large group settings such as field days and "Winter Ag School" can provide some opportunity for technical transfer but it is not the same as one-on-one instruction literally in the very field that needs BMPs.

Farm mentorings are happening through Maine Organic Farmers and Gardeners Association (MOFGA) through their very successful journeyperson apprenticeship and placement of farm interns on established organic farms. A similar effort could be tried with other farming practices by establishing a peer-to-peer technical assistance program pairing a farmer experienced with a practice with a farmer who isn't.

Cooperative Extension has also reduced staff, on-farm visits, and technical assistance due to funding cuts. The future of the Houlton Cooperative Extension office remains unclear. The office was listed for potential closing in 2014 but was later removed. Funding within the University of Maine Cooperative Extension remains challenged. SASWCD is able to provide limited technical assistance to farmers but currently does not have the necessary additional funding to hire a technical person to alleviate NRCS's lack of dedicated funds.

Maine DEP through Clean Water Act §319 can provide technical assistance funding in design and implementation of BMPs/conservation practices http://www.maine.gov/dep/water/grants/319.html.

Forestry: Historically NRCS has offered two programs to assist landowners in forest management practices. Currently, forestry programs are funded through EQIP and primarily provide funding to help with development of forest management plans. Funding for these programs has been inconsistent but when available can be used for non-industrial woodlot management. There are a limited number of private consulting foresters in the area who provide technical assistance. To locate a licensed forester visit http://www.pfr.maine.gov/almsonline/almsquery/SearchIndividual.aspx . The Maine Forest Service and Small Woodlot Owners Association of Maine (SWOAM) both offer field-days and workshops.

Urban issues: There are two main NPS pollutant concerns, illicit connections/discharges and impervious cover. Technical assistance for illicit detection and illumination is available through Maine DEP. Addressing stormwater runoff issues from impervious cover is available from Maine NEMO http://www.mainenemo.org/ .

Historic pollutant sources: The historic pollutants of concern are associated with a brownfields area in the Pearce Brook watershed. Technical assistance is available through Maine DEP's Division of Remediation.

Fish Habitat: The Nature Conservancy and its partners have worked to train SASWCD staff with the Stream Habitat Viewer tool to provide technical assistance to municipalities in helping to prioritize road crossing projects. TNC also provided funds in 2014 for outreach to municipalities in Maine. HBMI's priority for fish habitat allows them to provide limited t/a within the watershed through education and outreach. Maine IF&W can also work with landowners in this regard.

Financial Assistance

Agriculture: Current assistance with on-farm implementation management comes mainly from cost-share assistance through NRCS's EQIP, Conservation Stewardship Program (CSP), or through specially-funded initiatives such as the recent National Water Quality Initiative (NWQI). The NWQI, beginning in 2012 in the Nickerson Lake subwatershed, was extended FY 15 to incorporate HUC code 010100050307 which includes Smith and Craig Brooks and the nonattainment section of the mainstem. MDEP's water quality data in these subwatersheds has indicated excess nutrients are a concern. It is hoped that pre-implementation water quality data will provide a baseline against which to show water quality improvements post-NWQI.

Other existing strategies include the afore-mentioned SASWCD CIG grant project that will serve as a foundation for potential adoption of multi-species plant mixes to help improve soil health. Such monitoring and demonstrated benefits could help secure project specific funding through grant sources such as EPA's Clean Water Act §319 funds.

Forestry: NRCS EQIP funding for forestry has been reduced and cost-share is provided mainly for writing forest management plans and implementing practices such as crop tree release or thinning. Project Canopy, a cooperative partnership between MFS and GrowSmart Maine, provides grant funding to municipalities and organizations for planting and maintenance.

Maine DEP through CWA §319 program offers implementation grants to address NPS pollution problems from a variety of sources including forestry http://www.maine.gov/dep/water/grants/319.html.

Urban issues: Funding assistance for urban issues can come from several sources. NRCS's Emergency Watershed Protection (EWP) program responds to emergencies created by natural disasters. EWP can help public and private landowners with such watershed impairments as jeopardized water control structures, debris-clogged stream channels or, like the 2014 Pearce Brook project, bank stabilization.

The Maine Office of Community Development (OCD) is a division within the Department of Economic & Community Development (DECD). The primary focus of OCD is the administration of the HUD funded Community Development Block Grant Program (CDBG) which includes regional technical assistance and training. In 1982 the State of Maine began administering the CDBG Program to assist units of local government in various community projects in areas ranging from infrastructure, housing, downtown revitalization to public facilities and economic development. http://www.maine.gov/decd/meocd/cdbg/index.shtml. Community Development Block Grants are a source of financial assistance that can help communities with wastewater, water, other infrastructure projects and limited planning.

Maine DEP handles a State Revolving Fund (SRF) that municipalities and water & sewer districts can access to help pay for infrastructure projects http://www.maine.gov/dep/water/grants/srfparag.html .

Historic pollutant sources: A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant (MDEP). Brownfields grants continue to serve as the foundation of EPA's Brownfields Program. These grants support revitalization efforts by funding environmental assessment, cleanup, and job training activities. Brownfields Assessment Grants provide funding for brownfield inventories, planning, environmental assessments, and community outreach. Brownfields Revolving Loan Fund Grants provide funding to capitalize loans that are used to clean up brownfields http://www.epa.gov/brownfields/basic_info.html. A site in the subwatershed of Pearce Book was declared a non-National Priorities List (NPL) Superfund site in April, 1989. (SASWCD, 2010)

For emergency oil spills, MDEP has the Petroleum Clean-up program http://www.maine.gov/dep/spills/petroleum/. MDEP's CWA §319 also provides funding to address urban NPS issues http://www.maine.gov/dep/water/grants/319.html.

Fish Habitat: Sourcing funding for fish passage and road crossings is limited. The 2014 passage of a $10 million water bond secured $5.4 million for culvert upgrades for stream crossings. NRCS has a state-wide Aquatic Fish Passage program that cost-shares on culvert replacements as well. For shovel-ready projects, Maine Audubon's Stream-Smart program has provided municipal employees, contractors and landowners with tools such as the online Stream Habitat Viewer to prioritize the replacement of old culverts with 'streamsmart' road crossings that reconnect wildlife.

Meduxnekeag River below sample site 9.1, 2014. Photo curtesy of MDEP.

7.0 Outreach and Education (Element Five)

- How to encourage adoption and continued participation of NPS abatement measures?
- What/Who will be used to engage landowners?

Objectives of the WBP are focused on protecting and improving water quality for the benefit of fish, birds, and other wildlife, as well as local residents, landowners, and visitors. The Meduxnekeag River Watershed has a wealth of natural resources that the public needs to appreciate and value. Enhancing public understanding of this plan and encouraging community participation in promoting stewardship of the watershed's water resources is an important educational goal to maintaining a healthy watershed ecosystem.

The following are ways to continue outreach and education within the watershed to all stakeholders:

- Conduct workshops to train municipal officials about stream crossings and utilizing tools such as Maine Stream Habitat Viewer to help towns prioritize stream crossing work.
- Sponsor or host MDEP's Nonpoint Source Training Center's erosion control workshops for town personnel and local contractors.
- Open discussion with Maine Farmland Trust and landowners (including HBMI) along tributaries and river for contiguous buffer easements.
- Provide technical assistance and funding resources to farmers and landowners for BMPs through SASWCD, NRCS, and Cooperative Extension.
- Promote use of multi-species planting and fall cover crops through on-the-ground field day demonstrations, farmer "coffee" talks, and SASWCD's annual "Winter Ag School."
- Promote implementation of soil health practices by selling multi-species seed mixes or provide reliable sources.
- Provide economic calculations to determine cost of "putting soil back on the ground versus cover cropping."
- Encourage groups like Small Woodlot Owners of Maine to host workshops in Southern Aroostook.
- Expand partnership with Maine Forest Service on workshops and community outreach events.
- Increase availability of technical assistance for landowners.
- Utilize monthly "Conservation Corner" column in weekly local paper to highlight farmers, forestry, or organization(s) implementing BMPs or other projects such as the 2014 in-stream restoration or agricultural field work through CIG.
- Secure speaker presentation funding to bring soil health crop and livestock producers to Southern Aroostook for special workshops

8.0 Implementation Schedule (Element Six)

- What is the proposed implementation schedule of restoration measures?

8.1 Plan Oversight

This WBP will be carried out by various agencies and organizations including, but not limited to, HBMI, NRCS, SASWCD, MDEP, and Cooperative Extension. Participation by local municipalities is also an integral part of the success of the plan. Agencies and organizations may work collaboratively on projects or independently, and notify any stakeholder groups of practice implementations. Some of the BMPs described in the plan are contingent on funding; either through cost-share programs or grant-funded projects.

Placement of logs and boulders in the Meduxnekeag River

8.2 Action Plan

Action items (Table 14) are included within six major categories: Education and Outreach, Water Quality Monitoring and Habitat Improvement, Agricultural BMPs, Forestry BMPs, Riparian Buffers, Roadway BMPs, Historical Sources Clean-up and Urban Stormwater. This action plan was developed using several sources including focus group meetings, paper survey, subwatershed surveys, and steering committee meetings.

Table 14. Action Plan

9.0 Measurable Milestones (Element Seven)

Establishing indicators to measure progress provides short term input on how successful the plan has been in meeting the established goals and objectives for the watershed. It provides for periodic updates to the plan, maintains and sustains the action items, and makes the plan relevant on an ongoing basis. In addition to water quality monitoring, the following environmental, social, and programmatic indicators will be used to measure the progress of the Meduxnekeag River WBP:

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

- Improvement in macroinvertebrate community
- Number of acres or linear feet of improved riparian habitat
- In-stream habitat restoration project (2014) determined to be stable and functioning
- Cropland in permanent or late season cover

Biomonitoring Meduxnekeag River 2014.

Social Indicators measure changes in social or cultural practices and behavior changes that lead to implementation of management measures and water quality improvement.

- Number of requests for information from towns and landowners
- Number of landowners who participate in Meduxnekeag River events
- Number of volunteers for stream walks or spring cleanup days
- Participation by school groups and local recreational groups
- Participation in “Winter Ag School,” field days, and other workshops
- Number of landowners voluntarily implementing BMPs

Programmatic Indicators are indirect measures of watershed protection and restoration activities. Rather than indicating that water quality reductions are being met, these programmatic indicators will indicate actions intended to improve water quality.

- Number of farmers implementing recommended BMPs
- Number of BMPs installed
- Amount of funding secured for plan implementation
- Number of surveyed roadways and crossings 'fixed'
- Number of new acres of cropland with agricultural BMPs
- Reduction in field gullies post-storm events
- Adoption of additional BMPs in NRCS EQIP
- Funding and new grants received

HBMI Water Resource staff sampling the Meduxnekeag River. Photo courtesy of HBMI.

10.0 Criteria to Determine Achievement of Load Reductions (Element Eight)

For the majority of major BMPs implemented, especially as part of the National Water Quality Initiative (NWQI), pollutant load reduction estimates will be made using methods approved and recommended by EPA and NRCS. In addition, future CWA 319 grant funding through this plan will require annual pollutant load calculations.

Meduxnekeag canoe race. Photo from MaCKR.org

11.0 Monitoring Plan (Element Nine)

Water sampling will be done by MDEP in the Craig, Smith and Oliver Brook subwatersheds as part of NRCS's NWQI. Biological monitoring in the summer of 2014 will help establish baseline water quality for the streams. Agricultural BMP implementation will take place over a number of years. Add to this the crop rotation schedule and the variability in weather it will be a number of years before there is an expected measurable water quality improvement. Therefore there is an expected long-term and ongoing sampling needed to determine the WBP's effectiveness.

MDEP has committed to biological monitoring, water chemistry and DO/temp at a minimum every 5 years.

HBMI has a water quality monitoring program for the Meduxnekeag and some of the tributaries. They will continue to collect data at their established mainstem locations and other locations as funding and time permits.

11.1 Evaluation Plan

SASWCD will host an annual check-in to review the WBP implementation efforts with the steering committee. Review will include past year's progress and plan potential new focus projects for the future. Annual progress can be documented by the indicators in Element Eight to evaluate the effectiveness of the plan and to implement changes if needed to meet goals set forth.

Bridge over the Meduxnekeag, Houlton Maine. Photo courtesy of http://onemansmaine.blogspot.com/

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Appendix A: Glossary of Terms

Best Management Practices (BMPs): Techniques to reduce nonpoint source pollution impacts from construction, agriculture, timber harvesting, and stormwater.

Biochar: Name for charcoal stored in the soil as a means of removing carbon dioxide from the atmosphere.and used for particular purposes, such as a soil amendment. Like most charcoal, biochar is created by pyrolysis of biomass, generally wood chips.

Buffers (Riparian Zone): Land bordering a river, stream or wetland for the protection of water quality, wildlife, and/or recreation.

Conductivity: Specific conductance is the ability of water to conduct an electrical current at 25^{o}C.

Confluence: A flowing together of two or more streams, rivers, or the like.

Cover Crop: A crop or crops planted primarily to manage soil erosion, soil fertility, soil quality, water, weeds, pests, diseases, biodiversity and wildlife in an agroecosystem.

Dissolved Oxygen (DO): Oxygen dissolved in the water is essential for all plants and animals living in the water. DO is the measurement of the amount of oxygen in the water that is available to these plants and animals. The amount of DO is used as an indicator of water quality and the level of life that the water can support.

Erosion: Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical and chemical forces. Human activities can greatly speed this process.

Eskers: A long ridge of gravel and other sediment, typically having a winding course, deposited by meltwater from a retreating glacier or ice sheet.

Fluvial Geomorphology: The study of stream and river morphology.

Geosynthetic Reinforced Soil Integrated Bridge: An innovative and cost-effective technology that uses alternating layers of compacted granular fill material and geotextile reinforcement fabric sheets to support bridges and create smooth and even approach.

Heavy Use Area: A stable surface with suitable materials and any needed structures to protect areas heavily impacted by livestock, vehicles or development.

Kames: A steep-sided mound of sand and gravel deposited by a melting ice sheet.

Macroinvertebrate: Organisms without backbones, visible to the eye without use of microscope.

Macrophytes: Aquatic plants that grow in or near water and are either emergent, submergent, or floating.

Mob Grazing: Short-duration, high-intensity grazing of many cattle on a small area of pasture, moved several times a day to new forage

Nitrogen: An element that is the most abundant in Earth's atmosphere, but also found in a majority of organic matter, living and non-living. It is a limiting nutrient of plant and algae growth in aquatic environments and can cause unnatural plant growth, along with phosphorus. Nitrogen is released to the environment through decaying matter.

Nonpoint Source Pollution (NPS): Runoff that has picked up contaminants or nutrients from the landscape (or air), as it flows over the surface of the land to a body of water.

Nutrient Management: Controlling the timing, amount, application method, source and placement of plant nutrients through the use of fertilizers. By controlling application variables, a landowner can limit the amount of non-point source enriched runoff.

pH: pH is a measure of how acidic/basic water is. The range goes from 0 - 14, with 7 being neutral. pH of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically.

Phosphorus: An element found throughout the environment; it is a nutrient essential to all living organisms. Phosphorus binds to soil particles, is found in fertilizers, sewage, and motor oil, and is found in high concentrations in stormwater runoff. The amount of phosphorus present in a stream determines the stream's production of algae. A very small change in phosphorus levels can dramatically increase algae growth.

Point Source Pollution: Readily identifiable inputs where waste is discharged to the receiving waters from a pipe or drain. Most industrial wastes are discharged to rivers and the sea in this way. With few exceptions, most point source waste discharges, are controlled by EPA.

Prescribed Grazing: Managing pastureland or cover cropped fields with grazing and/or browsing animals.

Runoff: Water that drains or flows across the surface of the land.

Sediment: Mineral and organic soil material that is transported in suspension by wind or flowing water, from its origin in another location.

Sediment/Nutrient Basin: A constructed low lying area with sloped sides built to capture eroded or disturbed soil and nutrients that is washed off during rain storms, and protect the water quality of a nearby stream, river, lake, or bay.

Shoreland: The area of land from the water line stretching inland. The definition of this distance may vary by town zoning and state definitions.

Sonde: An instrument probe that automatically transmits information about its surroundings underground, under water, in the atmosphere, etc

Stream Morphology: Used to describe the shapes of river and stream channels and how they change over time. The morphology of a river channel is a function of a number of processes and environmental conditions.

Strip Cropping/Contour Farming: Strip cropping refers to the system of placing crops in strips or bands in a field. Contour farming refers to the practice of conducting tillage, planting, and harvesting operations perpendicular to the gradient of a hill or slope in order to reduce erosion.

Subwatershed: Topographic perimeter of the catchment area of a stream tributary.

TMDL: A Total Maximum Daily Load is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Tributaries: Streams or rivers that flow to a large body of water.

Watershed: The geographic region within which water drains into a particular river, stream, or body of water. A watershed includes hills, lowlands, and the body of water into which the land drains. Watershed boundaries are defined by the ridges of land separating watersheds.

Waterway: A ditched channel that is lined with vegetation or rock to carry water at a slower pace to a stable outlet.

Hay field.

Appendix B: Watershed Maps

Appendix C: Secondary Data Quality Assurance Guide

Appendix D: Subwatershed Survey Report

Appendix D: Subwatershed Survey Report

Appendix E & F: Focus Group Report With Paper Survey

Appendix G: Focus Watershed Survey Implementation Plan