DRAFT TMDL SUMMARY

Merritt Brook

WATERSHED DESCRIPTION

This **TMDL** applies to a 2.8 mile section of Merritt Brook, located in the Town of Presque Isle, Maine. The impaired segment of Merritt Brook begins in the southeastern corner of the watershed in a predominantly agricultural area and flows northwest crossing Conant Road. The stream enters a small pond and continues northwest through agriculture until it crosses Fort Fairfield Road and railroad tracks, then meets the Aroostook River. The Merritt Brook watershed covers an area of 4.04 square miles.

- Runoff from agricultural land located throughout the watershed is likely the largest source of **nonpoint source (NPS) pollution** to Merritt Brook. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Merritt Brook watershed is predominately non-developed (97.9%). Forested areas (23.7%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (10.7%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (63.5%) and are located throughout the watershed.
- Developed areas (2.1%) with impervious surfaces in close proximity to the steam may impact water quality.
- Merritt Brook is on the list of Maine's 303(d) list of Impaired Streams (Maine DEP, 2012).

Definitions

- ***Total Maximum Daily Load (TMDL)*** *represents the total amount of a pollutant that a waterbody can receive and still meet water quality standards.*
- **Nonpoint Source Pollution** *refers to pollution that comes from many diffuse sources across the landscape, and are typically transported by rain or snowmelt runoff.*

Waterbody Facts

Segment ID: ME0101000412_143R02

Town: Presque Isle, ME

County: Aroostook

Impaired Segment Length: 2.8 miles

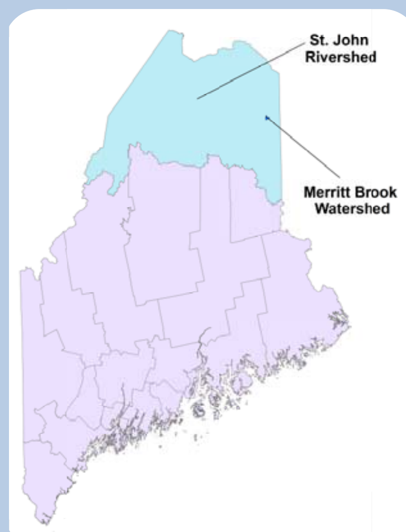
Classification: Class B

Direct Watershed: 4.04 mi^2 (2,586 acres)

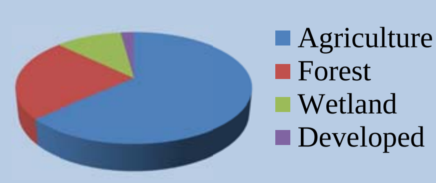
Impairment Listing Cause: Benthic macroinvertebrate and periphyton

Watershed Agricultural Land Use: 63.5%

Major Drainage Basin: St. John River



Watershed Land Uses



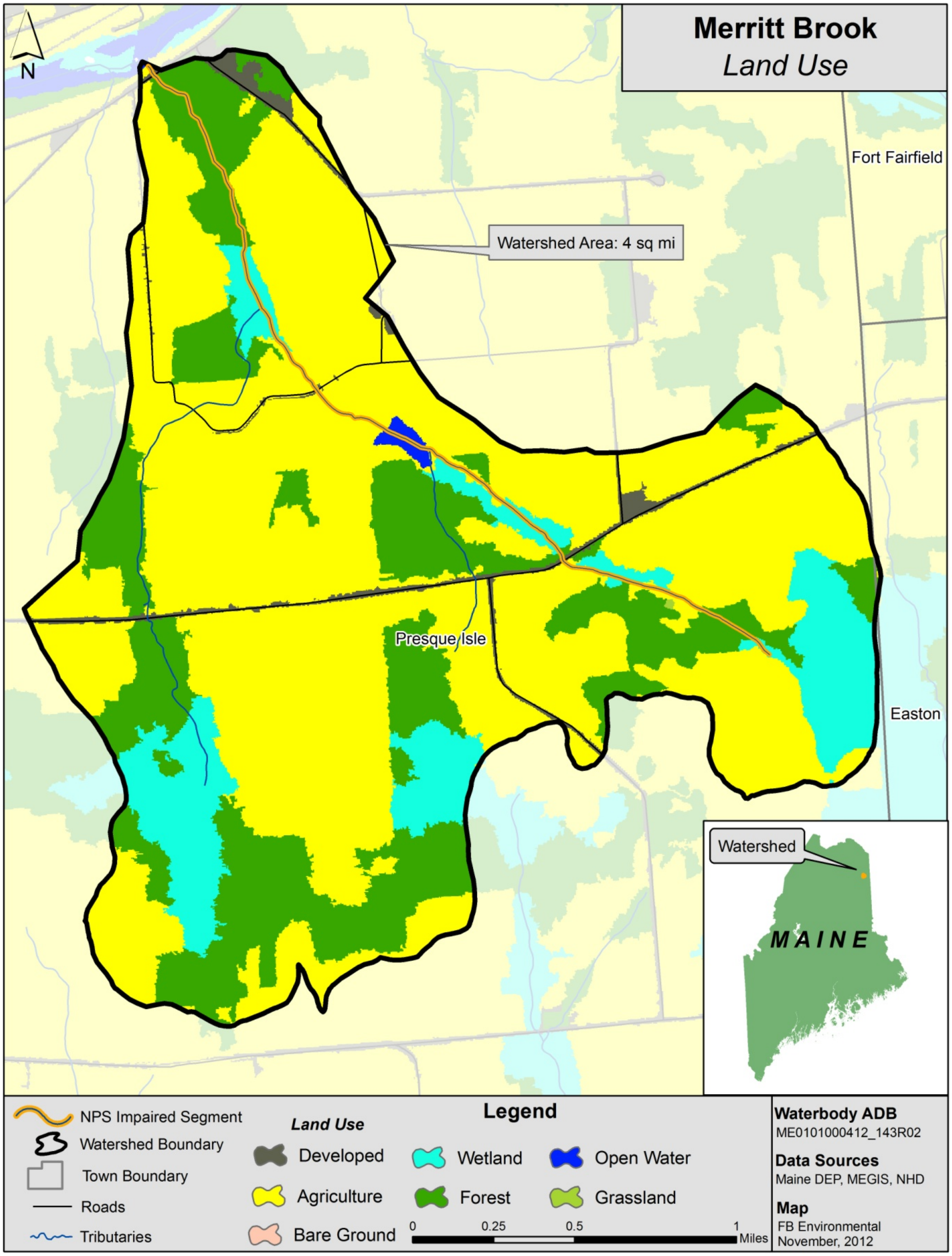


Figure 1: Land Use in the Merritt Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

***Merritt Brook** flowing into the Aroostook River.*
Photo: FB Environmental

Merritt Brook, a Class B freshwater stream, has been assessed by Maine DEP as not meeting water quality standards for the designated use of aquatic life, and placed on the 303(d) list of impaired waters under the Clean Water Act. The Clean Water Act requires that all 303(d)-listed waters undergo a Total Maximum Daily Load (TMDL) assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality.

Agricultural land area in the Merritt Brook watershed makes up 64% of the total watershed area. This is more than thirty times that of developed land which makes up only 2% of total watershed area. 67% of the impaired stream segment length is considered agricultural stream and flows through or within 75 feet of agricultural areas (Figure 1). Agriculture is therefore likely to be the largest contributor of sediment and nutrient enrichment to the stream, especially in the form of field washouts. The close proximity of many agricultural lands to the stream further increases the likelihood that nutrients from disturbed soils, manure, and fertilizers will reach the stream.

WATER QUALITY DATA ANALYSIS

Table 1: Assessment Data for Merritt Brook

Site	Assessment Parameter	Year	Statutory Class	Assessment Result
S-742	Macroinvertebrates	2009	B	NA
S-742	Periphyton	2004	B	NA
S-742	Periphyton	2009	B	NA

Maine DEP uses a variety of data types to measure the ability of a stream to adequately support aquatic life, including; dissolved oxygen, benthic macroinvertebrates, and periphyton (algae). Merritt Brook did not meet the water quality standard for Class B streams for the listing cause benthic macroinvertebrates at Station 742 in 2009 and for periphyton at Station 742 in 2004 and 2009 (Table 1, note that “NA” means non-attainment).

For benthic macroinvertebrates, DEP makes aquatic life use determinations using a statistical model that incorporates 30 variables of data collected from rivers and streams, including the richness and abundance of streambed organisms, to determine the probability of a sample meeting Class A, B, or C conditions. Biologists use the model results and supporting information to determine if samples comply with standards of the class assigned to the stream or river (Davies and Tsomides, 2002). Maine DEP uses an analogous model for periphyton assessment.

TMDL ASSESSMENT APPROACH: NUTRIENT MODELING OF IMPAIRED AND ATTAINMENT STREAMS

NPS pollution is difficult to measure directly, because it comes from many diffuse sources spread across the landscape. For this reason, a nutrient loading model, MapShed, was used to estimate the sources of pollution based on well-established hydrological equations; detailed maps of soil, land use, and slope; many years of daily weather data; and direct observations of agriculture and other land uses within the watershed.

The nutrient loading estimates for the impaired stream were compared to similar estimates for five non-impaired (attainment) streams of similar watershed land uses across the state. The TMDL for the impaired stream was set as the mean nutrient loading estimate of these attainment stream watersheds, and units of mass per unit watershed area per year (kg/ha/year) were used. The difference in loading estimates between the impaired and attainment watersheds represents the percent reduction in nutrient loading required under this TMDL. The attainment streams, nutrient loading estimates, and TMDL are presented below in Table 2.

Table 2: Numeric Targets for Pollutant Loading Based on MapShed Model Outputs for Attainment Streams

Attainment Streams	**Town**	**TP load (kg/ha/yr)**	**TN load (kg/ha/yr)**	**Sediment load (1000 kg/ha/yr)**
Martin Stream	Fairfield	0.14	3.4	0.008
Footman Brook	Exeter	0.33	6.4	0.058
Upper Kenduskeag Stream	Corinth	0.29	5.6	0.047
Upper Pleasant River	Gray	0.22	4.6	0.016
Moose Brook	Houlton	0.25	5.9	0.022
Total Maximum Daily Load		**0.24**	**5.2**	**0.030**

RAPID WATERSHED ASSESSMENT

Habitat Assessment

A Habitat Assessment survey was conducted on both the impaired and attainment streams. The assessment approach is based on the *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (Barbour et al., 1999), which integrates various parameters relating to the structure of physical habitat. The habitat assessments include a general description of the site, physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, Merritt Brook received a score of 130 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range of habitat assessment scores for attainment streams was 155 to 179.

Habitat assessments were conducted on a relatively short sample reach (about 100-200 meters for a typical small stream) near the most downstream Maine DEP sample station in the watershed. For both impaired and attainment streams, the assessment location was usually near a road crossing for ease of access. In the Merritt Brook watershed, the downstream sample station was located in a forested portion of the stream adjacent to the Aroostook River at the Fort Fairfield Road crossing. The buffer here was quite thicker than buffers observed in other areas of the stream.

Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Merritt Brook. Though these scores show that habitat is clearly an issue in the impairment of Merritt Brook, it is important to look for other potential sources within the watershed leading to impairment. Consideration should be given to major "hot spots" in the Merritt Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

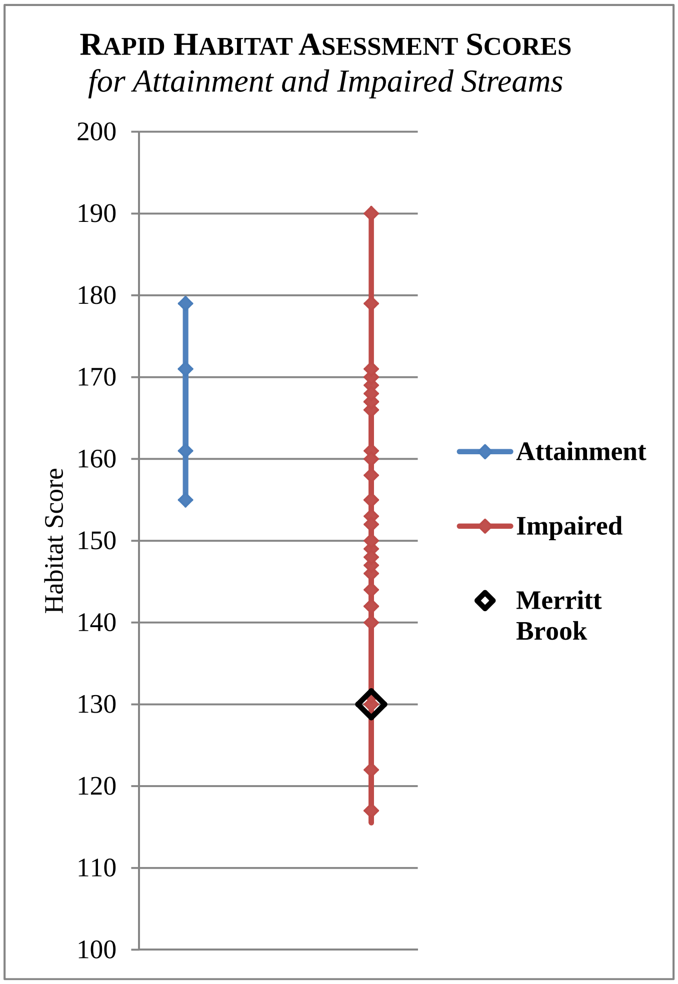


Figure 2: Habitat Assessment Scores

Pollution Source Identification

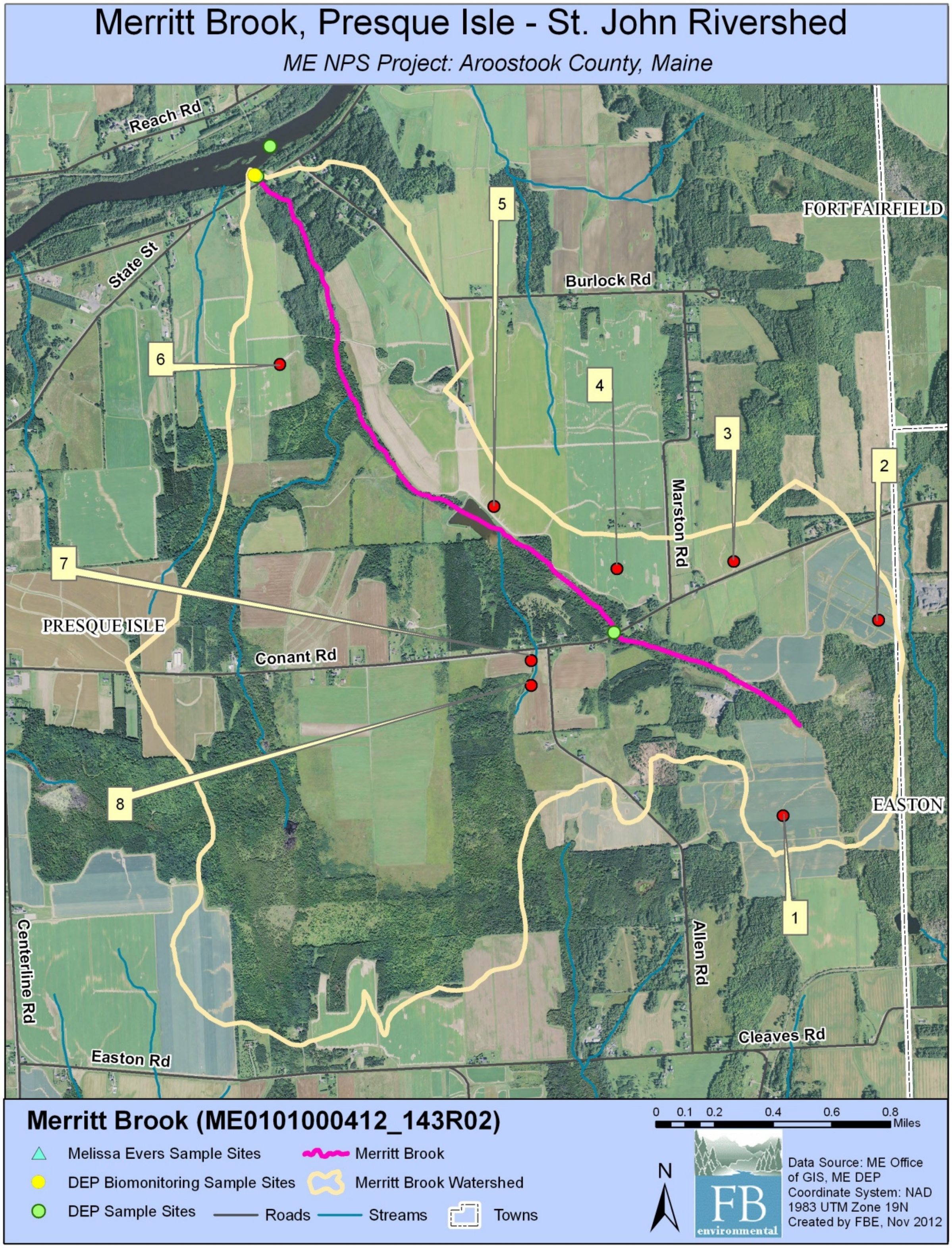
A pollution source identification assessment was conducted for Merritt Brook. The source identification component of this study is based on an abbreviated version of the Center for Watershed Protection's Unified Subwatershed and Site Reconnaissance method (Wright, et al., 2005). The abbreviated method includes both a desktop and field component. The desktop assessment consists of generating and reviewing maps of the watershed boundary, roads, land use and satellite imagery, and then identifying potential NPS pollution locations, such as road crossings, agricultural fields, and large areas of bare soil. When available, multiple sources of satellite imagery were reviewed. Occasionally, the high resolution of the imagery allowed for observations of livestock, row crops, eroding stream banks, sediment laden water, junkyards, and other potential NPS concerns that would affect stream quality. As many potential pollution sources as possible were visited, assessed and documented in the field. Field visits were limited to NPS sites that were visible from roads or a short walk from a roadway. Neighborhoods were assessed for NPS pollution at the whole neighborhood level including streets and storm drains (where applicable). The assessment does not include a scoring component, but does include a detailed summary of findings and a map indicating documented NPS sites throughout the watershed.

The watershed source assessment for Merritt Brook was completed on July 10, 2012. In-field observations of erosion, lack of vegetated stream buffer, extensive impervious surfaces, high-density neighborhoods and agricultural activities were documented throughout the watershed (Table 3, Figure 3).

Table 3: Pollution Source ID Assessment for the Merritt Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	19N5818645168778	Agriculture	• Washouts in broccoli fields visible in photo layer (2011) south of Conant Road. Note – These fields are in grain in 2012 and washouts are no longer visible. However, though these washouts are visible in the aerial photos, they are not considered gullies in agricultural terms. In USDA terms, it isn't a gully unless you can't drive your tractor through it.
2	19N5823885169850	Agriculture	• Many washouts in broccoli field south of Conant Road. Not sure how much sediment/runoff travel to the stream. This field is not immediately adjacent to Merritt Brook. Erosion problems are not visible in 2012 as the fields are in grain – strip cropped alternating grain & potatoes.
3	19N5815955170171	Agriculture	• Washout in grain field north of Conant Road. Erosion problems are not visible in 2012 as fields are in grain. Fields are strip cropped with alternating grain and potato crops.
4	19N5809545170130	Agriculture	• Washout in potato field north of Conant Road, and west of Marston Road. No public access to this site.
5	19N5802795170472	Agriculture	• Washout in grain field adjacent to pond. No public access to this site.
6	19N5791085171251	Agriculture	• Possible bare waterway. Past aerial photos also show this. 1996 aerial photos show that it may be grass lined and not bare as in 2011. No public access to this site.
7	19N5804855169628	Agriculture	• Lack of buffer.
8	19N5816405169491	Agriculture	• Private Road – quarry access. Road to Quarry is impounding water. Could not see outlet. It appears to be a sediment trap.

Figure 3: Aerial Photo of Source ID locations in the Rocky Brook Watershed



NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Merritt Brook (impaired), plus five attainment watersheds throughout the state.. The model estimated nutrient loads over a 15-year period (1990-2004), which was determined by the available weather data provided within MapShed. This extended period captures a wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time.

Many quality assured and regionally calibrated input parameters are provided with MapShed. Additional input parameters were manually entered into the model based on desktop research and field observations, as described in the section on Habitat Assessment and Pollution Source Identification. These manually adjusted parameters included estimates of livestock animal units, agricultural stream miles with intact vegetative buffer, Best Management Practices (BMPs), and estimated wetland retention and/or drainage areas.

Livestock Estimates

Livestock waste contains nutrients which can cause water quality impairment. The nutrient loading model considers numbers and types of animals. Table 4 (right) provides estimates of livestock (numbers of animals) in the watershed, based on direct observations made in the watershed, plus other publicly available data.

Table 4: Livestock Estimates in the Merritt Brook Watershed

Type	Merritt Brook
Dairy Cows	
Beef Cows	
Broilers	
Layers	
Hogs/Swine	
Sheep	
Horses	1
Turkeys	
Other	
Total	**1**

The Merritt Brook watershed land use is predominantly agricultural, consisting of row crops of broccoli with grain rotation. One horse was observed within the watershed.

Vegetated Stream Buffer in Agricultural Areas

Vegetated stream buffers are areas of trees, shrubs, and/or grasses adjacent to streams, lakes, ponds or wetlands which provide nutrient loading attenuation (Evans & Corradini, 2012). MapShed considers natural vegetated stream buffers within agricultural areas as providing nutrient load attenuation. The width of buffer strips is not defined within the MapShed manual, and was considered to be 75 feet for this analysis. GIS analysis of recent aerial photos along with field reconnaissance observations were used to estimate the number of agricultural stream miles with and without vegetative buffers, and these estimates were directly entered into the model.

Table 5: Summary of Vegetated Buffers in Agricultural Areas

Merritt Brook
• 4.8 stream miles in watershed (includes ephemeral streams) • 1.9 stream miles in agricultural areas • **68%** of agricultural stream miles have a vegetated buffer

Merritt Brook is listed by Maine DEP as a 2.8 mile-long impaired segment. However, as modeled, the total stream miles (including tributaries) within the watershed was calculated by MapShed to be 4.8 miles. Of this total, 1.9 stream miles are located directly adjacent to agricultural land, and 1.3 miles (68%) of those have a 75 foot vegetative buffer (Table 5, Fig. 4). By contrast, agricultural stream miles (as modeled) with a 75 foot vegetated buffer in the attainment stream watersheds ranged from 34% to 92%, with an average of 61%.

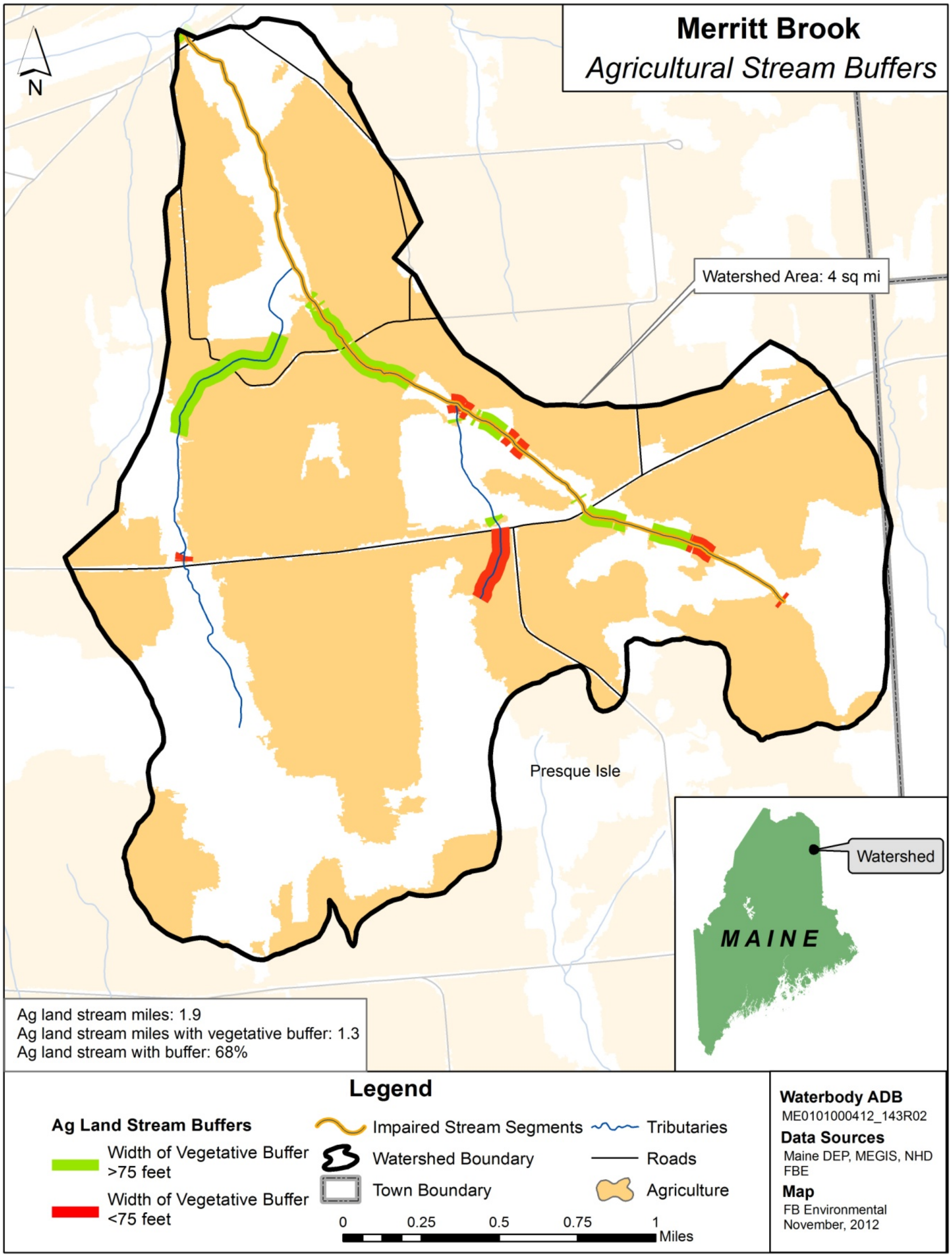


Figure 4: Agricultural Stream Buffer in the Merritt Stream Watershed

Best Management Practices (BMPs)

For this modeling effort, four commonly used BMPs were entered based on literature values. These estimates were applied equally to impaired and attainment stream watersheds. More localized data on agricultural practices would improve this component of the model.

- *Cover Crops:* Cover crops are the use annual or perennial crops to protect soil from erosion during time periods between harvesting and planting of the primary crop. The percent of agricultural acres cover crops used within the model is estimated at 4%. This figure is based on information from the 2007 USDA Census stating that 4.1% of crop land acres is left idle or used for cover crops or soil improvement activity, and not pastured or grazed (USDA, 2007b).
- *Conservation Tillage:* Conservation tillage is any kind of system that leaves at least 30% of the soil surface covered with crop residue after planting. This reduces soil erosion and runoff and is one of the most commonly used BMPs. This BMP was assumed to occur in 42% of agricultural land. This figure is based on a number given by the Conservation Tillage Information Center's 2008 Crop Residue Management Survey stating that 41.5% of U.S. acres are currently in conservation tillage (CTIC, 2000).
- *Strip Cropping / Contour Farming:* This BMP involves tilling, planting and harvesting perpendicular to the gradient of a hill or slope using high levels of plant residue to reduce soil erosion from runoff. This BMP was assumed to occur in 38% of agricultural lands, based on a study done at the University of Maryland (Lichtenberg, 1996).
- *Grazing Land Management:* This BMP consists of ensuring adequate vegetation cover on grazed lands to prevent soil erosion from overgrazing or other forms of over-use. This usually employs a rotational grazing system where hays or legumes are planted for feed and livestock is rotated through several fenced pastures. In this TMDL, a figure of 75% of hay and pasture land is assumed to utilize grazing land management. This figure is based on a study by Farm Environmental Management Systems of farming operations in Canada (Rothwell, 2005).

Pollutant Load Attenuation by Lakes, Ponds and Wetlands

Depositional environments such as ponds and wetlands can attenuate watershed sediment loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a pond or a wetland. The Merritt Brook watershed is 11% wetlands. A large wetland complex is located at the headwaters of Merritt Brook to the south, and another smaller wetland can be found at the headwaters of the main tributary to Merritt Brook. Multiple small wetlands also surround the main stem. These wetlands combined are estimated to about 10% of the watershed land area (not accounting for water drained directly by Merritt Brook). Percent of watershed draining to a wetland in the attainment watersheds ranged from 15% to 60%, with an average of 35%.

NUTRIENT MODELING RESULTS

The MapShed model simulates surface runoff using daily weather inputs of rainfall and temperature. Erosion and sediment yields are estimated using monthly erosion calculations and land use/soil composition values for each source area. Below, selected results from the watershed loading model are presented. The TMDL itself is expressed in units of kilograms per hectare per year. The additional results shown below assist in better understanding the likely sources of pollution. The model results for

Merritt Brook indicate significant reductions of nutrients and sediment are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in Merritt Brook is primarily attributed to crop land which accounts for 97% of the total sediment load (Table 6, Figure 5). Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Merritt Brook* below for loading estimates that have been normalized by watershed area.

Table 6: Total Sediment Load by Source

Merritt Brook	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	0.55	1%
Crop land	101.75	97%
Forest	0.63	1%
Wetland	0.09	0%
Disturbed Land	0.01	0%
Low Density Mixed	0.05	0%
Medium Density Mixed	0	0%
High Density Mixed	2.19	2%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**105.27**	**100%**
Pathway Load		
Stream Banks	1.89	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**107.16**	

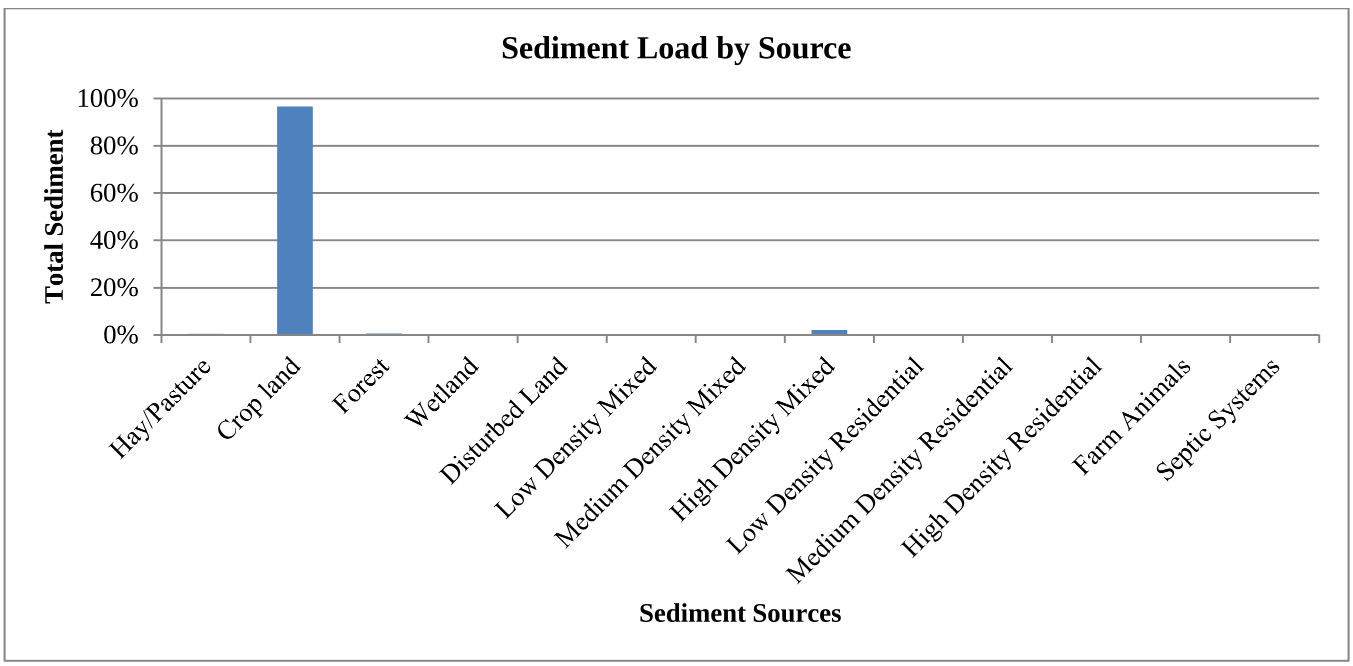


Figure 5: Total Sediment Loads by Source in the Merritt Brook Watershed

Total Nitrogen

Most nitrogen loading in the Merritt Brook watershed is attributed to crop land (Table 7 and Figure 6). Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Merritt Brook* below for loading estimates that have been normalized by watershed area.

Table 7: Total Nitrogen Loads by Source

Merritt Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	22.2	1%
Crop land	2599.4	89%
Forest	47.8	2%
Wetland	58.4	2%
Disturbed Land	0.2	0%
Low Density Mixed	1.5	0%
Medium Density Mixed	0	0%
High Density Mixed	91.7	3%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	3.8	0%
Septic Systems	94.4	3%
Source Load Total:	**2919.3**	**100%**
Pathway Load		
Stream Banks	1.0	-
Subsurface / Groundwater	10688.8	-
Total Watershed Mass Load:	**13609.1**	

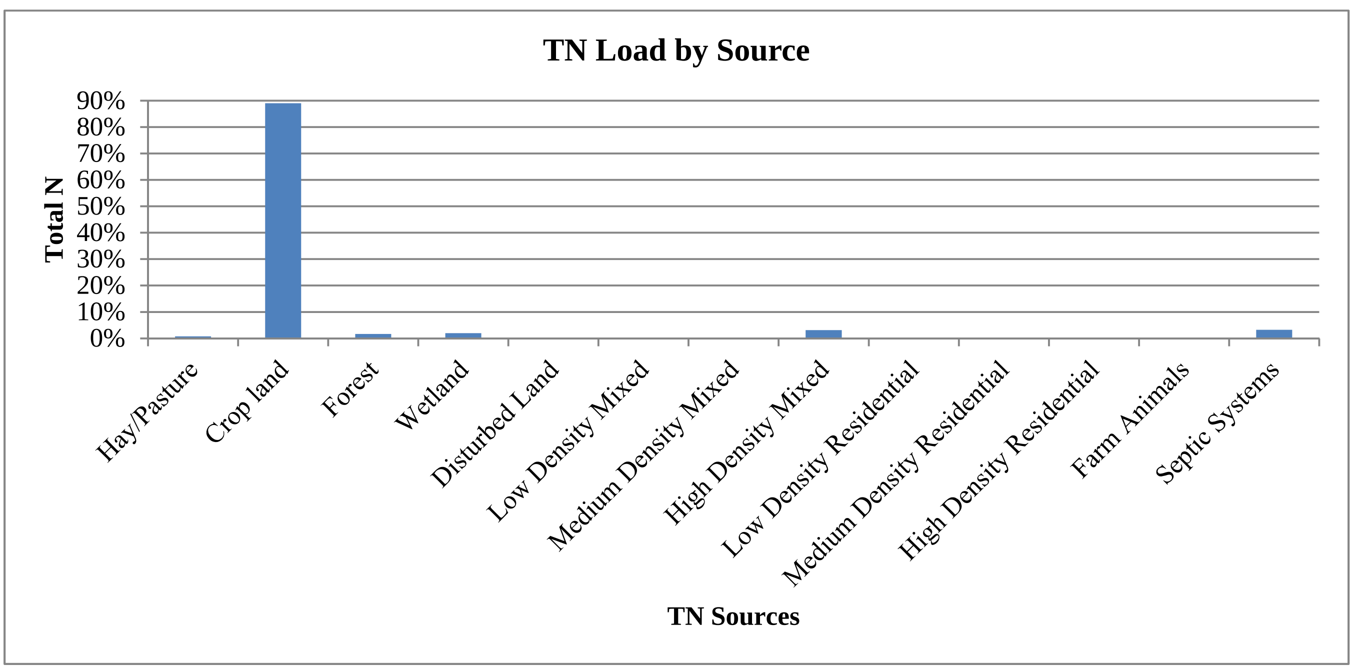


Figure 6: Total Nitrogen Loads by Source in the Merritt Brook Watershed

Total Phosphorus

Phosphorus loading within the Merritt Brook is primarily attributed to crop land. Phosphorus loads are presented in Table 8 and Figure 7. Note that total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Merritt Brook* below for loading estimates that have been normalized by watershed area.

Table 8: Total Phosphorus Loads by Source

Merritt Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	10.6	3%
Crop land	393.5	93%
Forest	3.1	1%
Wetland	3.1	1%
Disturbed Land	0.1	0%
Low Density Mixed	0.2	0%
Medium Density Mixed	0	0%
High Density Mixed	9.5	2%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	1.0	0%
Septic Systems	0	0%
Source Load Total:	**420.9**	**100%**
Pathway Load		
Stream Banks	1.0	-
Subsurface / Groundwater	141.0	-
Total Watershed Mass Load:	**562.8**	

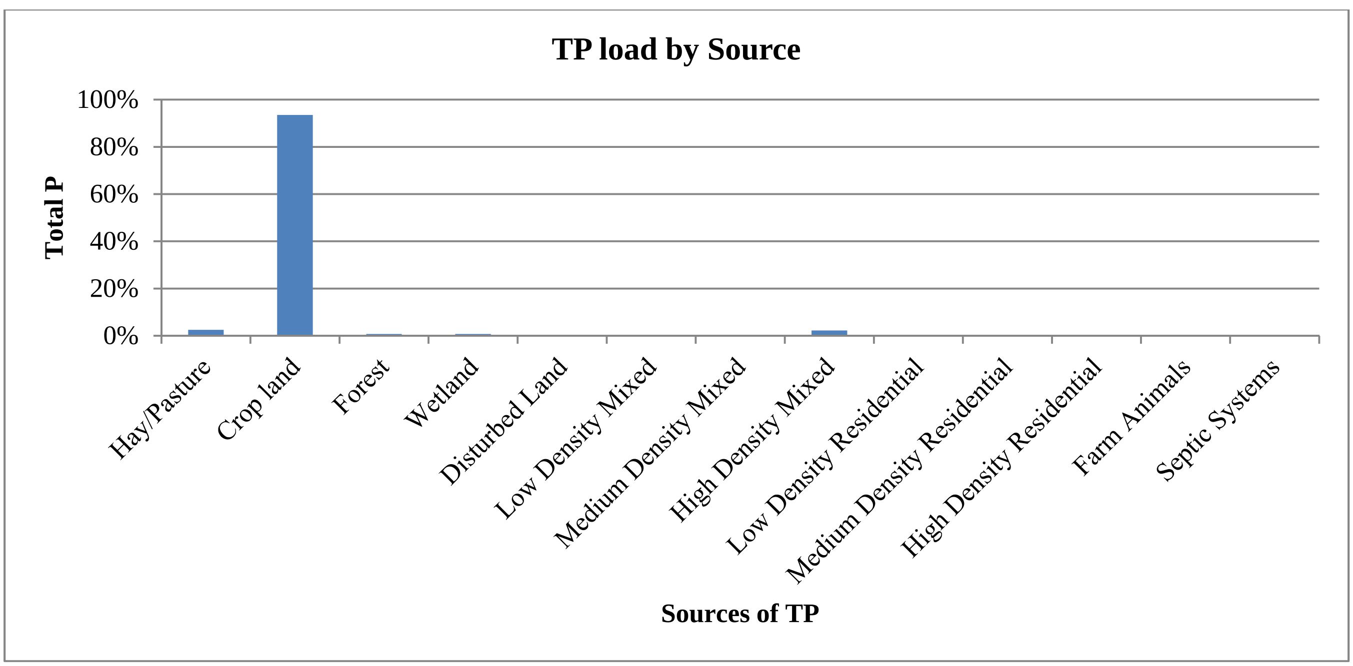


Figure 7: Total Phosphorus Loads by Source in the Merritt Brook Watershed

TMDL: TARGET NUTRIENT LEVELS FOR MERRITT BROOK

The existing loads for sediments and nutrients in the impaired segment of Merritt Brook are listed in Table 9, along with the TMDL which was calculated from the average loading estimates of five attainment watersheds throughout the state. Table 10 presents a more detailed view of the modeling results and calculations used in Table 9 to define TMDL reductions, and compares the existing sediment and nutrient loads in Merritt Brook to TMDL endpoints derived from the attainment waterbodies. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads.

Table 9: TMDL Targets Compared to Merritt Brook Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads for Merritt Brook**	**Total Maximum Daily Load**	**TMDL % REDUCTIONS Merritt Brook**
Sediment Load *(1000 kg/ha/year)*	0.100	0.030	**70%**
Nitrogen Load *(kg/ha/year)*	12.75	5.2	**59%**
Phosphorus Load *(kg/ha/year)*	0.53	0.24	**54%**

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities have the potential to increase runoff and associated pollutant loads to the Merritt Brook. To ensure that the TMDL targets are attained, future agriculture or development activities within the watershed will need to meet the TMDL targets. However, future growth from population increases is not a threat in the Merritt Brook watershed due to Aroostook County showing a 3.1% decreasing population trend of between 2000 and 2008 (USM USM MSAC, 2009). Though decreasing population trends, the growth in agricultural lands is increasing, with a 15% increase in the total number of farms in Aroostook County between 2002 and 2007. This may bring a moderate threat to water quality within the watershed. However, a decrease of 4% was seen in the land (acres) in farms between 2002 and 2007, and a 17% decrease occurred in the average farm size in this time period as well (USDA, 2007a). Future activities and BMPs that achieve TMDL reductions are addressed below.

Next Steps

The use of agricultural and developed area BMP's can reduce sources of polluted runoff in Merritt Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Presque Isle work together to develop a watershed management plan to:

- Encourage greater citizen involvement through the development of a watershed coalition to ensure the long term protection of Merritt Brook;
- Address <u>existing</u> nonpoint source problems in the Merritt Brook watershed by instituting BMPs where necessary; and
- Prevent <u>future</u> degradation of Merritt Brook through the development and/or strengthening of local Nutrient Management Ordinance.

Table 10: Modeling Results Calculations for Derived Numeric Targets and Reduction Loads for Merritt Stream

Merritt Stream				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	32	0.6	22.2	10.6
Crop land	645	101.8	2599.4	393.5
Forest	251	0.6	47.8	3.1
Wetland	114	0.1	58.4	3.1
Disturbed Land	2	0.0	0.2	0.1
Low Density Mixed	2	0.1	1.5	0.2
High Density Mixed	21	2.2	91.7	9.5
Other Sources				
Farm Animals			3.8	0.9
Septic Systems			94.4	0.0
Pathway Loads				
Stream Banks		1.9	1.0	1.0
Groundwater			10688.8	141.1
Total Annual Load		107 x 1000 kg	13609 kg	563 kg
Total Area	1067 ha			
Total Maximum Daily Load		**0.100 1000kg/ha/year**	**12.75 kg/ha/year**	**0.53 kg/ha/year**

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