Black Brook

WATERSHED DESCRIPTION

This **TMDL** applies to a 6.07 mile section of Black Brook, located in the Town of Windham, Maine. Black Brook begins just upstream of Route 302, flows south through agricultural and forested land, then crosses Windham Center Road. The stream continues through forest, crossing Pope Road and Swett Road adjacent to a large agricultural area. The stream then flows through another forested area, and crosses Webb Road and River Road before entering a more developed section of the watershed. Black Brook meets the Presumpscot River just downstream of Main Street. The Black Brook watershed covers an area of 3.91 square miles.

- Black Brook is on Maine's 303(d) list of Impaired Streams as referenced in the 2016 Integrated Report (Maine DEP, 2018).
- The Black Brook watershed is predominately non-developed (70%). Wooded areas (53%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability.
- Non-forested areas within the watershed are predominantly agricultural (20%) and are concentrated in the central portion of the watershed along Swett Road, Town Farm Road, and Pope Road.
- Developed areas (10%) with impervious surfaces in close proximity to the stream may impact water quality.
- Runoff from agricultural land located in the areas of Swett Road, Town Farm Road, and Pope Road are likely the largest sources of nonpoint source (NPS) pollution to Black Brook. Runoff from active hay lands and grazing areas can transport sediment, nitrogen and phosphorus to the stream.

Definitions

- ***Total Maximum Daily Load (TMDL)*** *represents the total amount of pollutants 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: ME0106000103_607R01

Town: Windham, ME

County: Cumberland

Impaired Segment Length: 6.07 miles

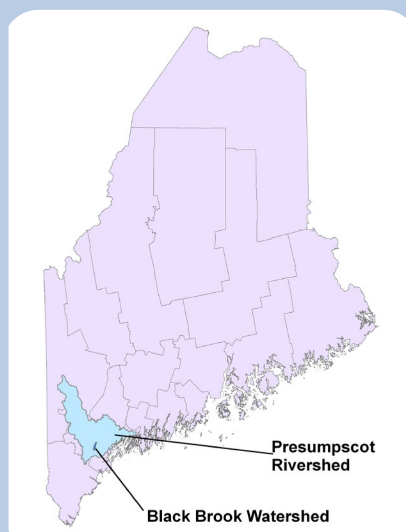
Classification: Class B

Direct Watershed: 3.91 mi^2 (2,502 acres)

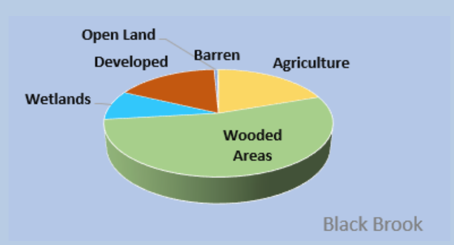
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 20%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



WHY IS A TMDL ASSESSMENT NEEDED?

Black 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 TMDL assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

Black Brook *near Main Street crossing. Photo: FB Environmental*

Agriculture (primarily hay/pastureland) makes up 20% of total land area in the Black Brook watershed. This is twice the developed land area (10%). Ten percent of the impaired stream segment passes through agricultural land (Figure 1). Agriculture is therefore likely to be the largest contributor of sediment and nutrient enrichment to the stream. 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

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). 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 the numeric aquatic life criteria of the class assigned to the stream or river (Davies and Tsomides, 2002). Maine DEP uses an analogous model to aid in the assessment of algal communities but makes aquatic life use determinations based on narrative standards.

The aquatic life impairment in Black Brook is based on historic dissolved oxygen data. Additionally, dissolved oxygen data collected at stations RBK24 in 2007 and RBK05 in 2011 corroborates the impairment.

TMDL ASSESSMENT APPROACH: NUTRIENT AND SEDIMENT 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, an online nutrient loading model, *Model My Watershed* (v. 1.32.0), was used to estimate the sources of pollution based on well-established hydrological equations (Stroud Water Research Center 2017). *Model My Watershed* makes use of the GWLF-enhanced model engine. The model incorporates detailed maps of soil, land use, and slope, daily weather and localized weather data (from the period 2009-2020), and direct observations of agriculture and other land uses within the watershed. *Model My Watershed* is derived from its parent MapShed developed by Evans and Corradini (2012). *Model My Watershed* replaced MapShed in 2017-2018.

The nutrient loading estimates for the impaired stream were compared to similar estimates for a non-impaired (attainment) streams of similar watershed land uses across the state. The TMDL target 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 and their nutrient and sediment loading estimates and TMDL are presented below in Table 1.

Table 1: Numeric Targets for Pollutant Loading Based on Model My Watershed Outputs (2021) for Attainment Streams

Attainment Streams	Town	Total P Load (kg/ha/yr)	Total N Load (kg/ha/yr)	Sediment Load (kg/ha/yr)
Footman Brook	Exeter	0.17	1.73	35.2
Martin Stream	Fairfield	0.13	2.98	57.9
Moose Brook	Houlton	0.18	1.59	48.5
Upper Kenduskeag Stream	Corinth	0.16	1.72	100.5
Upper Pleasant River	Gray	0.16	4.26	86.5
Total Maximum Daily Load		**0.16**	**2.46**	**65.7**

RAPID WATERSHED ASSESSMENT

Habitat Assessment

A habitat assessment survey was conducted in 2012 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 and physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on rapid bioassessment protocols for low gradient streams, Black Brook received a score of 167 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, with an average of 167.

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 Black Brook watershed, the downstream sample station was located at the Webb Road stream crossing and DEP sample station RBK24. Minor erosion was documented at the crossing due to stormwater runoff from Webb Road. The immediate surrounding riparian zone was dominated by shrubs and grasses, but forest was surrounding this area of the reach.

Figure 1: Land Use and Land Cover (from 2011) in the Black Brook Watershed

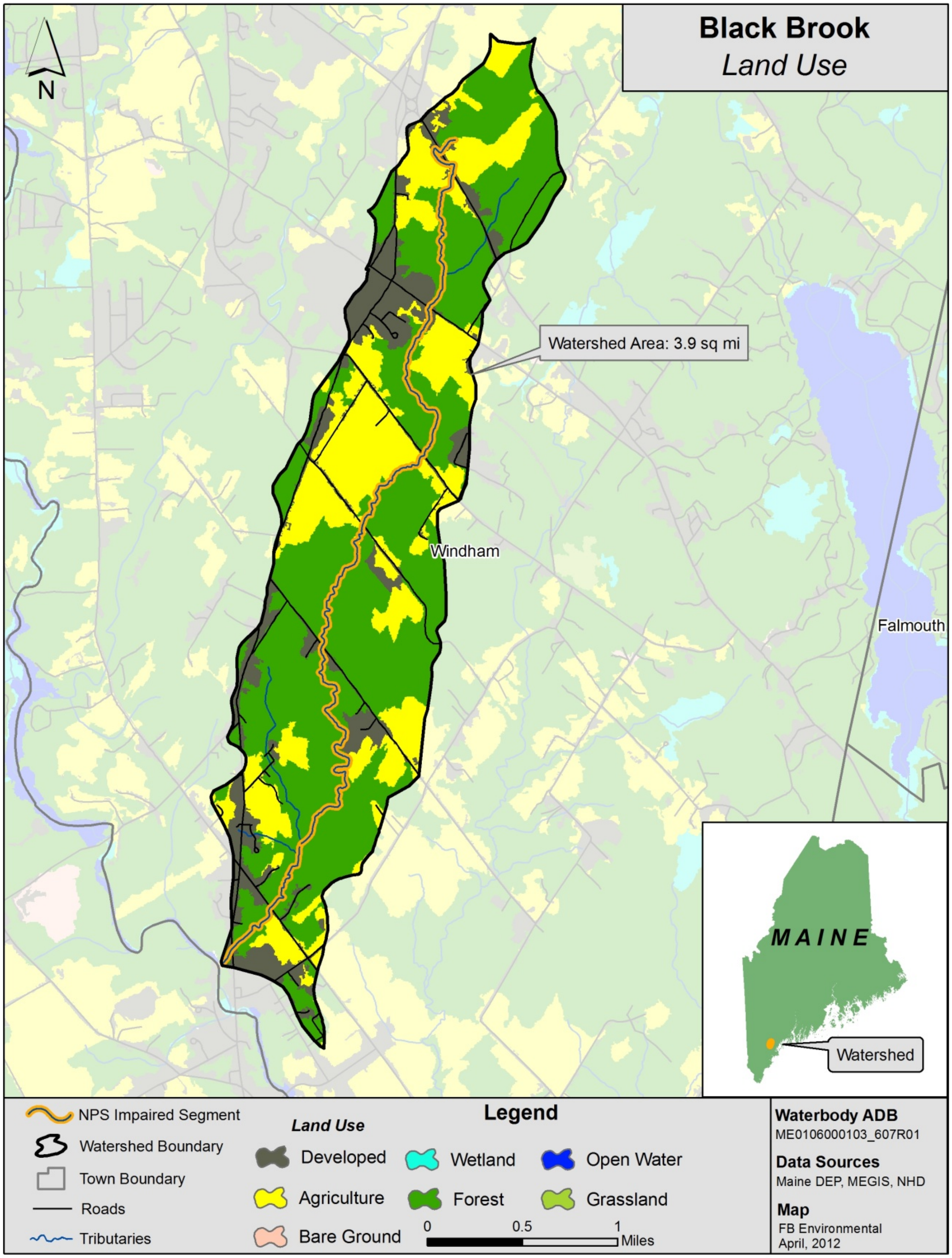


Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Black Brook. The overlapping attainment and impaired stream scores indicate that factors other than habitat should be considered when addressing the impairments in Black Brook. Consideration should be given to major “hot spots” in the Black Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

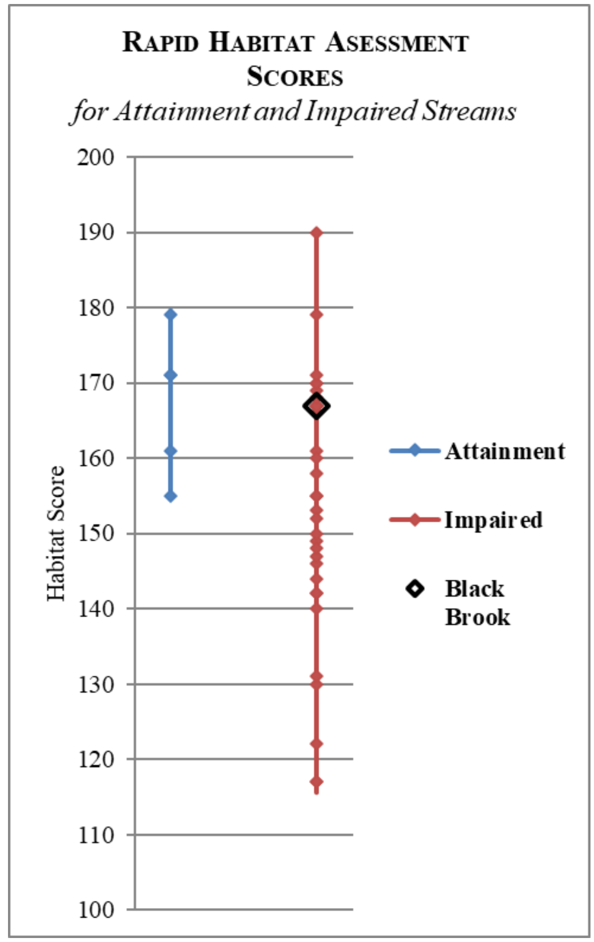


Figure 2: Habitat Assessment Score for Black Brook (2012) Compared to Region

Pollution Source Identification

Pollution source identification assessments were conducted for both Black Brook (impaired) and the attainment streams. The source identification work 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 could 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 Black Brook was completed in July 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 2, Figure 3).

Table 2: Potential Pollution Source ID Assessment (2012) for the Black Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
4	Barnes Road	Residential	• Tributary flows through mowed lawn with no buffer.
6	Webb Road	Road Crossing	• Minor erosion at bridge. • Sample Reach Location; DEP station RBK24. • Immediate riparian zone composed of grasses & shrubs.
7	Off Webb Road	Agriculture	• Christmas tree farm and active hayfields.
9	Swett Road	Road Crossing	• Immediate riparian zone composed of predominantly of grasses.
10	Swett Road	Agriculture	• Active hayfields. • Swett Road is an unpaved dirt road.
11	Between Pope Road & Swett Road	Agriculture	• Active hayfields. • Black Brook follows forest perimeter and is bordered to the west by hayfields with minimal buffer.
12	Pope Road	Road Crossing/ Agriculture	• Hayfields near crossing.
16	North of Windham Center Road	Recreation	• Sign reads *Black Brook Preserve*. • Evidence of ATV trails. • Small bridge over Black Brook. • Field seems inactive.
20	Roosevelt Trail	Impervious Surfaces/	• An auto repair shop is located at the headwaters of Black Brook. • Impervious parking and working areas.
24	Roosevelt Trail	Forestry	• Logging business located on the south side of Roosevelt Trail. • Tree/log piles visible. • Activity in immediate area is unknown.

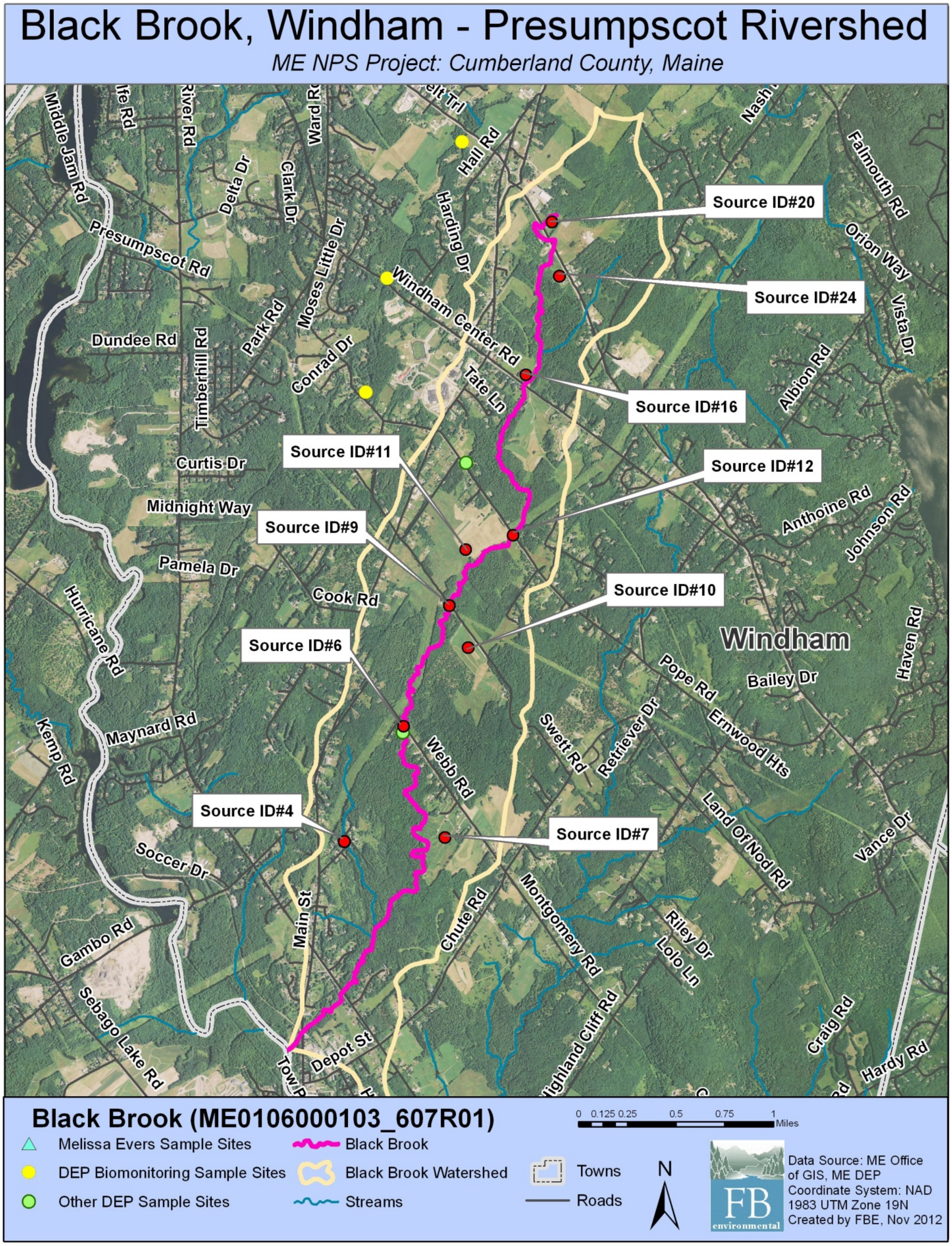


Figure 3: Aerial Photo of Potential Source ID Locations (identified in 2012) in Black Brook Watershed

NUTRIENT AND SEDIMENT LOADING – *MODEL MY WATERSHED* ANALYSIS

The *Model My Watershed* model was used to estimate stream loading of total phosphorus, total nitrogen, and sediment in Black Brook watershed. The model estimated nutrient loads over a 12-year period (2009-2020), which was determined by local (Portland Jetport USW00014764) weather data inserted into *Model My Watershed*. This extended period captures a recent but wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time. Loads for the attainment watersheds (five total; Table 1) were computed using the same model with the same recent inputs (i.e., regional weather, 2016 land use and land cover, 2016 wetland extent, and BMPs similar to the impaired watersheds).

Many quality assured and regionally calibrated input parameters are provided with *Model My Watershed*. However, several updates to some of the default parameters were made in this TMDL effort, and namely more recent land use/cover using **MRLC-NLCD 2016** [1], more recent and local weather (precipitation and temperature) data (as described above), and more regional estimates of Best Management Practices (BMPs; see ensuing discussion). Because land use/cover is more recent, the estimated filtration fraction of wetland and open water and the amount of stream buffer in agricultural land should be more accurate. It is also worth noting that improved classification algorithms were employed by MLRC in the NCLD 2016 and these new algorithms were used in the revisions of all previous NLCD versions (including the first version in 2001).

Livestock Estimates

Livestock waste contains nutrients which can cause water quality impairment. The nutrient loading model considers numbers and types of animals. Table 3 (right) provides livestock (numbers of animals) in the watershed based on the USDA National Agricultural Statistics Service (NASS) estimation for 2012. Some of these totals were modified by direct observations made in the watershed in the 2012 survey. To generate watershed-based livestock counts, NASS county-based livestock totals are converted to a per unit area (based on the total area of the county). The unit area amount is then multiplied by the total watershed area to derive a watershed total count (as seen in Table 3).

Table 3: Livestock Count in Black Brook Watershed

Type	Black Brook
Dairy Cows	3
Beef Cows	3
Broilers	4
Layers	18
Hogs/Swine	4
Sheep	12
Horses	6
Turkeys	1
Other	--
Total	**51**

[1] MRLC-NLCD 2016 : Multi-Resolution Land Characteristics – National Land Cover Dataset (version 2016) provided by the MRLC Consortium (Jin et al. 2019).

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 and Corradini, 2012). *Model My Watershed* considers natural vegetated stream buffers within agricultural land areas as providing nutrient load attenuation. A width of approximately 98 feet (30 m) on one side of a stream is required to be considered a streamside buffer per the *Model My Watershed* technical manual (Stroud Water Research Center 2017). Analysis of recent aerial photos was used to estimate the number of agricultural land stream miles with and without vegetative buffers, and these estimates were directly entered into the model.

Table 4: Summary of Vegetated Buffers in Agricultural Areas (2012)

Black Brook
• Agricultural Land Stream Length = 0.83 mi • Agricultural Land Stream Length with Buffer = 0.7 mi (or 84% of total agricultural land stream length) • Percentage of total stream length flowing through non-buffered agricultural land = 1.9%

Black Brook is a 6.07 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 6.8 miles. Of this total, 0.83 stream miles are located within agricultural areas and 0.7 miles or 84% of that area *appear* to have a 98 foot or greater vegetated buffer (Table 4, Figure 4). From a watershed perspective, this equates to 0.13 miles or 1.9% of the total stream length running through agricultural land with less than a 98 foot buffer. By contrast, for attainment stream watersheds the percentage of total stream miles running through agricultural land without a 75 foot vegetated buffer ranged from 0% to 3.9% with an average of 1.3%. Note, a minimum vegetated buffer width of *75 feet* was used in an earlier (2012) effort to produce Figure 4 shown here. Differences in stream length estimates using a 98-foot or 75-foot buffer were practically insignificant.

Home Septic System Loads

Loads for "normally functioning" septic systems are calculated in *Model My Watershed* using an estimate of the average number of persons per acre in "Low-Density Mixed" areas. In these areas, it is assumed that the populations therein are served by septic systems rather than centralized sewage systems. All homes in such areas are assumed to be connected to "normally functioning" systems rather than those that experience "surface breakouts" (surface failures), "short-circuiting" to underlying groundwater (subsurface failures), or have direct conduits to nearby water bodies. Non-functioning systems would be modeled with a higher load contribution to the waterbody.

Best Management Practices (BMPs)

Best management practices (BMPs) are typically instituted to reduce the loading of sediment and nutrients from upland (i.e., non-point) sources. Ideally, information on BMPs for a specific watershed from local and regional sources would improve this component of the water quality model. Maine DEP sought information on BMP use in early 2021 from local, regional, and state agricultural agencies for rural BMPs and from nearby municipalities for urban BMPs. Very little to no information was returned in the solicitation. Hence, estimates for typical New England watersheds were derived from information available from Vermont. An upper limit of BMP use was garnered from watersheds entering the Chesapeake Bay where BMP use is intensive.

Four agricultural BMPs were used in this modeling effort and in the following manner:

- *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 cropland area in a cover crop BMP deployed was estimated at 25% and selected as the low end of the range (25 to 30 percent) expected for cropland in New England. This value was assigned to the five attainment watersheds.
- *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. This BMP was estimated to occur in 25% of cropland. This value was assigned to the five attainment watersheds.
- *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. Both interview sources suggest this practice is minimal to non-existent for New England watersheds. Hence, no BMP of this type was used in this modeling effort. This value was assigned to the five attainment watersheds.
- *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. Both interview sources were not aware of this practice being active and is likely minimal for New England watersheds. Hence, no BMP of this type was used in this modeling effort for both impaired and attaining watersheds.

Note that other agricultural and development BMPs likely exist in the watershed but their location and type were not available in a watershed-wide format that is necessary to include in the model. Agricultural BMPs recommended by Maine DEP to reduce sediment and nutrient loads include vegetated buffers, covered manure storage facilities, and stream exclusion fencing. BMPs for developed areas recommended by the Maine DEP include vegetated buffers, stormwater BMPs, and minimization of impervious cover.

Pollutant Load Attenuation by Lakes, Ponds and Wetlands

Depositional environments such as lakes, ponds, and wetlands can attenuate watershed sediment and nutrient loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a lake, pond, or wetland. The Black Brook watershed is 8.9% wetland and open water, per the 2016 NLCD land use/cover. There are a few wetlands that surround tributaries throughout the watershed. It is estimated that 17.9% of land area within the watershed drains to wetlands and open water. The percent of watershed draining to a wetland in the attainment watersheds, based on the 2021 analysis, ranged from 26 to 58 percent, with an average of 40%.

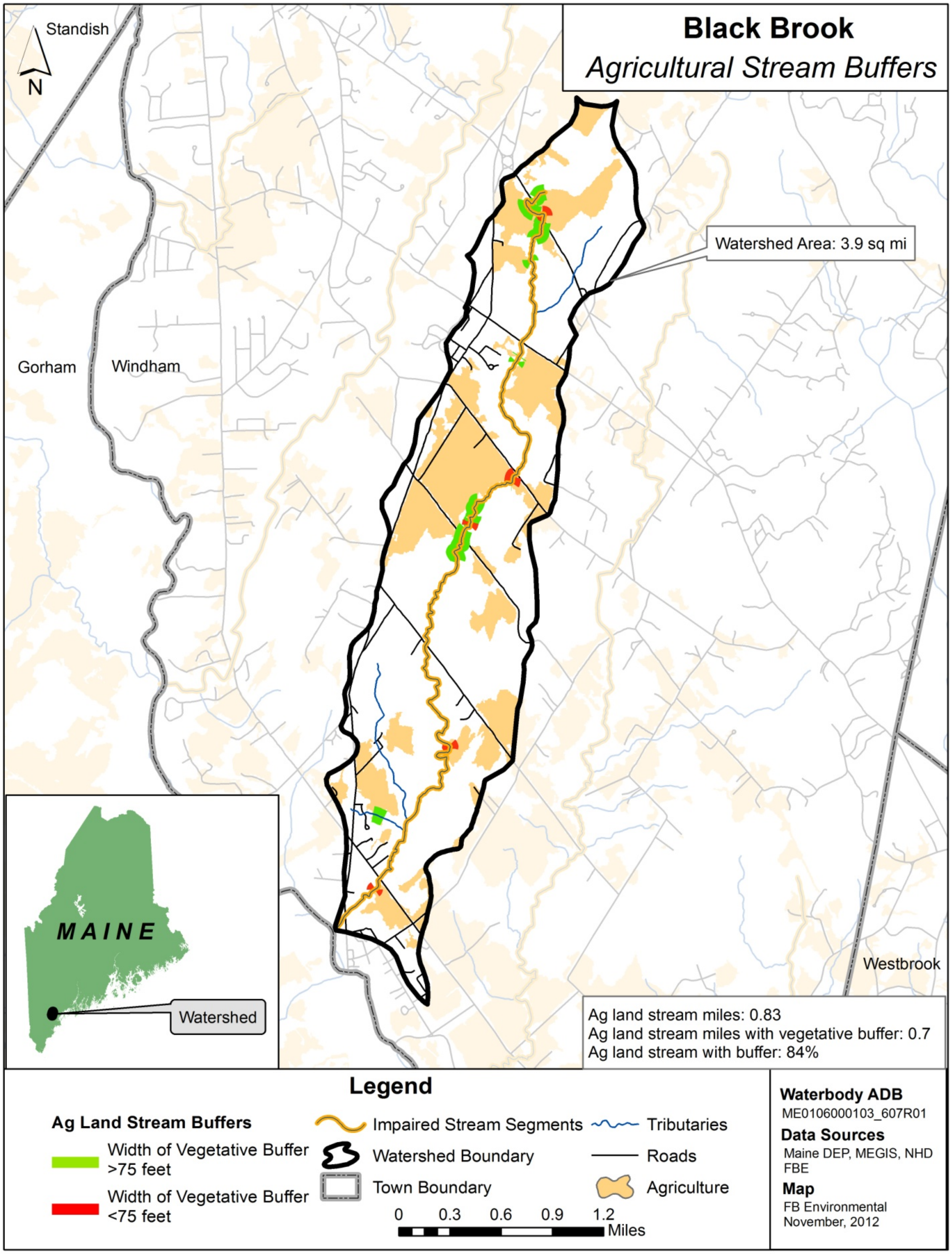


Figure 4: Agricultural Stream Buffers (from 2012) in the Black Brook Watershed

NUTRIENT AND SEDIMENT MODELING RESULTS

Selected results from the watershed loading model are presented here. 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 Black Brook watershed indicate significant reductions of phosphorus and sediment and a moderately small reduction of nitrogen are needed to improve water quality. Below, loading for nitrogen, phosphorus and sediment are discussed individually.

There are two categories of loads – sources and pathways. Sources are determined by land use/cover and the overland flow they generate, livestock counts by animal type, and home sewage treatment systems in developed areas. Pathways represent additional loads derived from subsurface flow and streambank erosion. Subsurface loads are calculated using dissolved N and P coefficients for shallow groundwater and are mainly derived from atmospheric inputs. Sediment and nutrient loads produced by eroding streambanks are estimated using an approach developed by Evans et al. (2003). This pathway is comprised of loads originating from five sources, and listed in order of decreasing importance: amount of developed land area, soil erodibility (K-factor), density of livestock, runoff curve number, and topographic slope. For any given model run, the amount of developed land in the watershed is responsible for just over 72% of the total streambank load, whereas soil erodibility and animal density are responsible for 21% and 7% of the total streambank load, respectively.

Sediment

Sediment loading in the Black Brook watershed is mainly derived from stream bank erosion which contributes almost 60% of the total watershed sediment load. Hay/pasture land makes up 81% of the source load (Table 5 and Figure 5). Residential areas contribute 15.7% of the source load.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Black Brook* below for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Load by Source

Black Brook	Sediment (1000 kg/year)	Sediment (%)
Source Load		
Hay/Pasture	64.4	80.6%
Cropland	0.8	1.0%
Wooded Areas	1.5	1.8%
Wetlands	0.2	0.3%
Open Land	0.4	0.5%
Barren Areas	0	0
Low-Density Mixed	3.8	4.7%
Medium-Density Mixed	4.4	5.5%
High-Density Mixed	0.9	1.1%
Low-Density Open Space	3.5	4.4%
Farm Animals	0	0
Septic Systems	0	0
Source Load Total:	**79.9**	**100%**
Pathway Load		
Stream Bank Erosion	117.9	-
Subsurface Flow	0	-
Total Watershed Mass Load:	**198**	

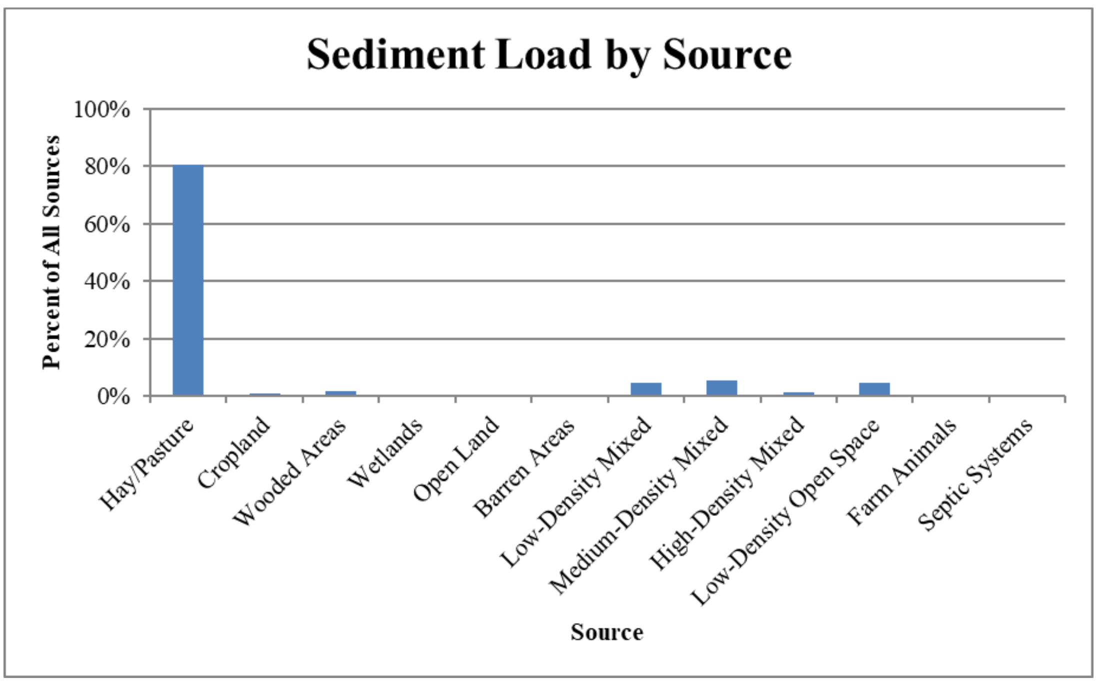


Figure 5: Total Sediment Load by Source in the Black Brook Watershed

Total Nitrogen

Table 6 and Figure 6 (below) show the estimated total nitrogen load, in terms of mass and percent of total by source, in the Black Brook watershed. Hay and pasture lands are the largest source of nitrogen loading to Black Brook, contributing about 43% of the source load of total N. Residential areas combined contribute 24.4% of the source load. Lastly, both septic systems and farm animals each contribute about 5% of the source load.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Black Brook* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Load by Source

Black Brook	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	588	43.1%
Cropland	12	0.9%
Wooded Areas	200	14.7%
Wetlands	78	5.7%
Open Land	13	1.0%
Barren Areas	0	0
Low-Density Mixed	111	8.1%
Medium-Density Mixed	98	7.2%
High-Density Mixed	19	1.4%
Low-Density Open Space	105	7.7%
Farm Animals	68	5.0%
Septic Systems	73	5.3%
Source Load Total:	**1,364**	**100%**
Pathway Load		
Stream Bank Erosion	112	-
Subsurface Flow	1,178	-
Total Watershed Mass Load:	**2,654**	

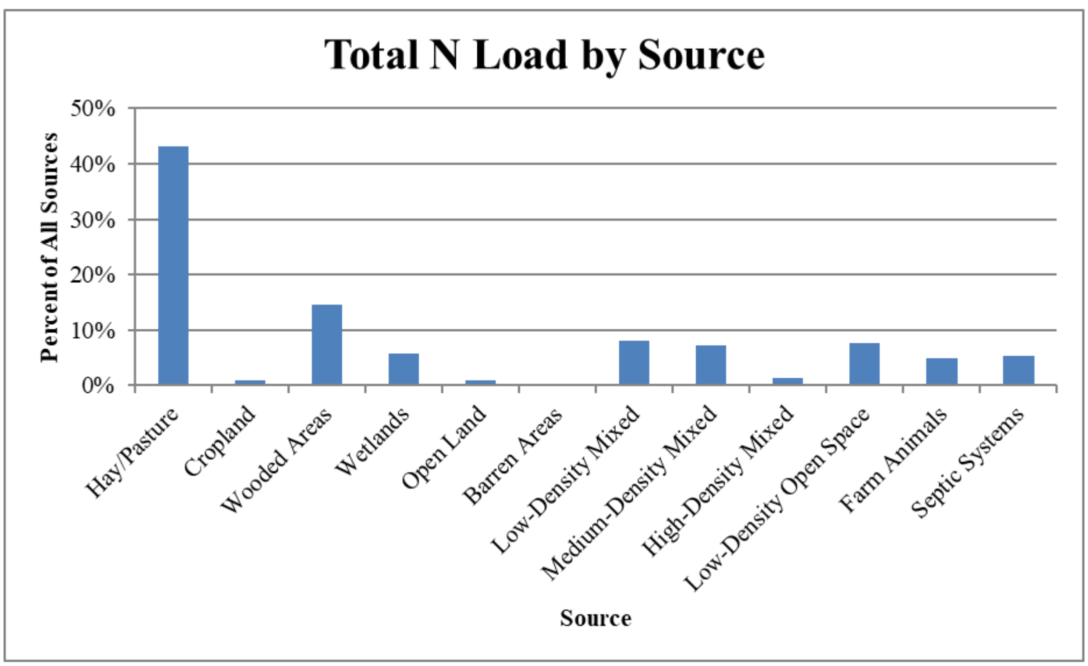


Figure 6: Total Nitrogen Load by Source in the Black Brook Watershed

Total Phosphorus

Table 7 and Figure 7 (below) show the estimated total phosphorus load in terms of mass and percent of total by source, in the Black Brook watershed. Hay and pasture lands are the largest source of phosphorus loading to Black Brook contributing over 68% of the source load. Residential areas combined contribute 16% of the source load. Farm animals contribute about 8% of the source load of total P. Stream bank erosion contributes 8.6% of the total watershed load.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Black Brook* below for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Load by Source

Black Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	145.6	68.3%
Cropland	1.5	0.7%
Wooded Areas	11.0	5.2%
Wetlands	4.1	1.9%
Open Land	0.5	0.2%
Barren Areas	0	0
Low-Density Mixed	11.6	5.4%
Medium-Density Mixed	9.7	4.5%
High-Density Mixed	1.9	0.9%
Low-Density Open Space	10.9	5.1%
Farm Animals	16.4	7.7%
Septic Systems	0	0
Source Load Total:	**213.2**	**100%**
Pathway Load		
Stream Bank Erosion	23.0	-
Subsurface Flow	29.9	-
Total Watershed Mass Load:	**266**	

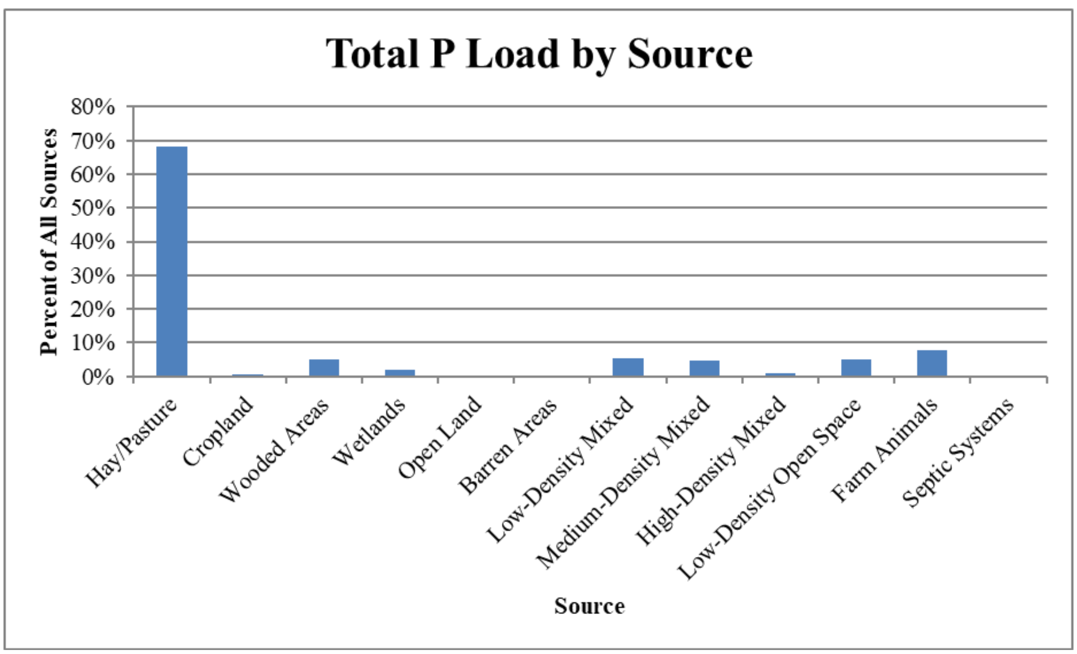


Figure 7: Total Phosphorus Load by Source in the Black Brook Watershed

TMDL: TARGET NUTRIENT AND SEDIMENT LEVELS FOR BLACK BROOK

The existing loads for nutrients and sediments in the impaired segment of Black Brook are listed in Table 8, along with the TMDL (the allowable load) which was calculated from the average loading estimates of five attainment watersheds throughout the state. Table 8 also shows required reductions (as a percent) for each of sediment, total N, and total P pollutants. Table 9 presents a more detailed view of the modeling results and calculations used to compute the existing loads in Table 8. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads.

Table 8: Black Brook Pollutant Loading Compared to TMDL Targets

Black Brook			
Pollutant Load	**Existing Load**	**TMDL**	**Reduction Required**
Total Annual Load per Unit Area		Attainment Streams	
Sediment (kg/ha/yr)	195.9	65.72	66.5%
Total N (kg/ha/yr)	2.63	2.46	6.5%
Total P (kg/ha/yr)	0.26	0.16	39.4%

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities in the watershed have the potential to increase runoff and associated pollutant loads to Black Brook. To ensure that the TMDL targets are attained, future agricultural and development activities will need to meet the TMDL targets. Between 2012 to 2017 in Cumberland County, the growth in agricultural lands was decreasing, with a 7% decrease in the total number of farms and a 20.2% decrease in total farm area. Average farm size has also declined significantly (13.8%) during this time period. These values are extracted from the most recent (2017) Census of Agriculture (USDA 2017). Human population in Cumberland County increased by 4.8% from 2000 to 2019 (US Census 2020). 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 the Black Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Windham work together to develop and implement the watershed management plan currently under development to:

- Address existing nonpoint source problems in the Black Brook watershed by instituting BMPs where necessary;
- Run a "Hot-Spot Analysis" in *Model My Watershed* to determine sub-watershed locations of higher existing contributions of sediment and nutrients to the outlet of Black Brook watershed; then focus BMP mitigation in these hot-spot sub-areas of the watershed;

- Encourage greater citizen involvement through the development of a watershed coalition to ensure the long term protection of Black Brook; and

- Prevent future degradation of Black Brook through the development and/or strengthening of a local Nutrient Management Ordinance.

Table 9: Annual Loads by Land Use, Other Sources, and Pathways for Black Brook Based on Modeling

Black Brook				
	Area (ha)	**Sediment** (1000 kg/yr)	**Total N** (kg/yr)	**Total P** (kg/yr)
Land Uses				
Hay/Pasture	198	64.4	588	145.6
Cropland	1	0.8	12	1.5
Wooded Areas	540	1.5	200	11.0
Wetlands	90	0.2	78	4.1
Open Land	6	0.4	13	0.5
Barren Areas	2	0.000	0	0.0
Low-Density Mixed	77	3.8	111	11.6
Medium-Density Mixed	21	4.4	98	9.7
High-Density Mixed	4	0.9	19	1.9
Low-Density Open Space	72	3.5	105	10.9
Total Area	1,010			
Other Sources				
Farm Animals		0.0	68	16.4
Septic Systems		0.0	73	0.0
Pathway Load				
Stream Bank Erosion		117.9	112	23.0
Subsurface Flow		0.0	1,178	29.9
Total Annual Load		198	2,654	266
Total Annual Load per Unit Area		0.20	2.63	0.26
		1000 kg/ha/yr	kg/ha/yr	kg/ha/yr

References

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