Burnham Brook

WATERSHED DESCRIPTION

This **TMDL** applies to a 3.73 mile section of Burnham Brook, located in the Town of Garland, Maine. Burnham Brook begins in a large forested area in the northern portion of the watershed and flows south through a predominantly forested section, crossing Pillsbury Road near a large farm. The stream then continues through forest, crossing Center Road and Burnham Cemetery Road before entering a largely agricultural area adjacent to Campbell Road. The stream then enters another forested area before crossing Corinth Road and joining Kenduskeag Stream. The Burnham Brook watershed covers an area of 3.68 square miles in Garland, Maine.

- Runoff from agricultural land located in the areas of Center Road and Campbell Road are likely the largest sources of **nonpoint source (NPS) pollution** to Burnham Brook. Runoff from cultivated lands, active hay lands, and livestock grazing areas can transport nitrogen and phosphorus to the nearest section of the stream.
- The Burnham Brook watershed is predominately non-developed (96.8%). Forests (78.1%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (7.3%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (11.4%) and are concentrated in the south central portion of the watershed along Campbell Road.
- Developed areas (3.2%) with impervious surfaces in close proximity to the steam may impact water quality.
- Burnham Brook is on the list of Maine's Impaired Streams (Maine DEP, 2013).

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 is typically transported by rain or snowmelt runoff.*

Waterbody Facts

Segment ID: ME0102000510_224R01

Town: Garland, ME

County: Penobscot

Impaired Segment Length: 3.73 miles

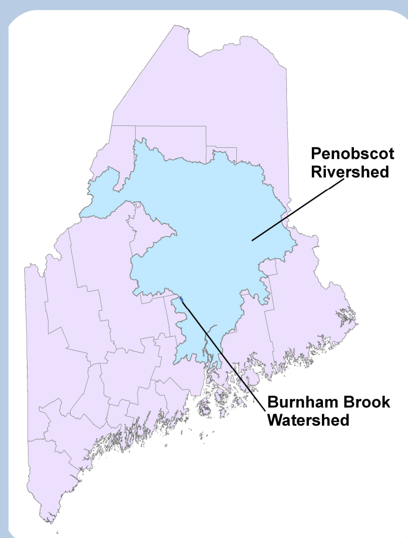
Classification: Class B

Direct Watershed: 3.68 mi^2 (2355 acres)

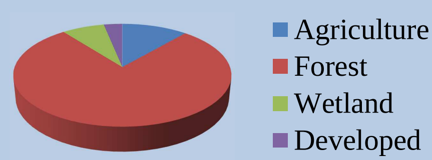
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 11.4%

Major Drainage Basin: Penobscot River



Watershed Land Uses



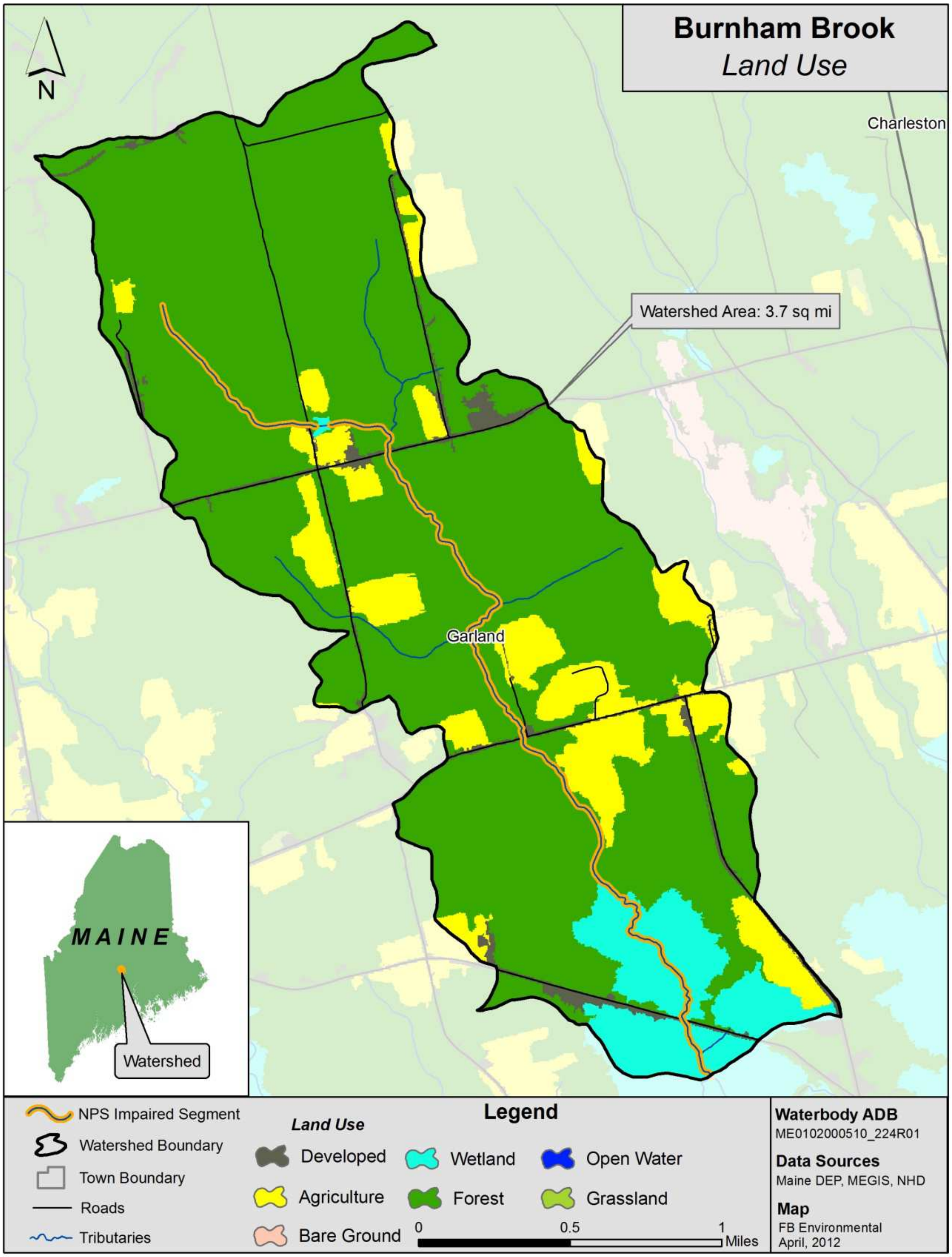


Figure 1: Land Use in the Burnham Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Burnham 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. The goal is for all waterbodies to comply with state water quality standards.

***Burnham Brook** near Station 506 at the Campbell Road crossing. Photo: FB Environmental*

Agriculture in the Burnham Brook watershed makes up 11.4% of the land area, although the impaired segment of the stream does not pass through agricultural land. Burnham Brook land use is shown in Figure 1 above. Agriculture may still be contributing sediment and nutrients to the stream especially along Campbell Road and Center Road where large livestock operations and row crops occur. The close proximity of some agricultural lands to the stream further increases the likelihood that nutrients from disturbed soils, manure, and fertilizer 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). The aquatic life impairment in Burnham Brook is based on historic dissolved oxygen data.

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 and their nutrient and sediment loading estimates and TMDL are presented below in Table 1.

Table 1: 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 Wadeable Streams and 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, Burnham Brook received a score of 166 out of a total 200 for quality of habitat. Higher scores indicate better habitat for fish and other aquatic life. The range of habitat assessment scores for the attainment streams was between 155 and 179, with an average score 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 Burnham Brook watershed, the downstream sample station was located in a forested portion of the stream with a thick riparian buffer, which is typical of the stream, since the majority of Burnham Brook flows through forested areas.

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

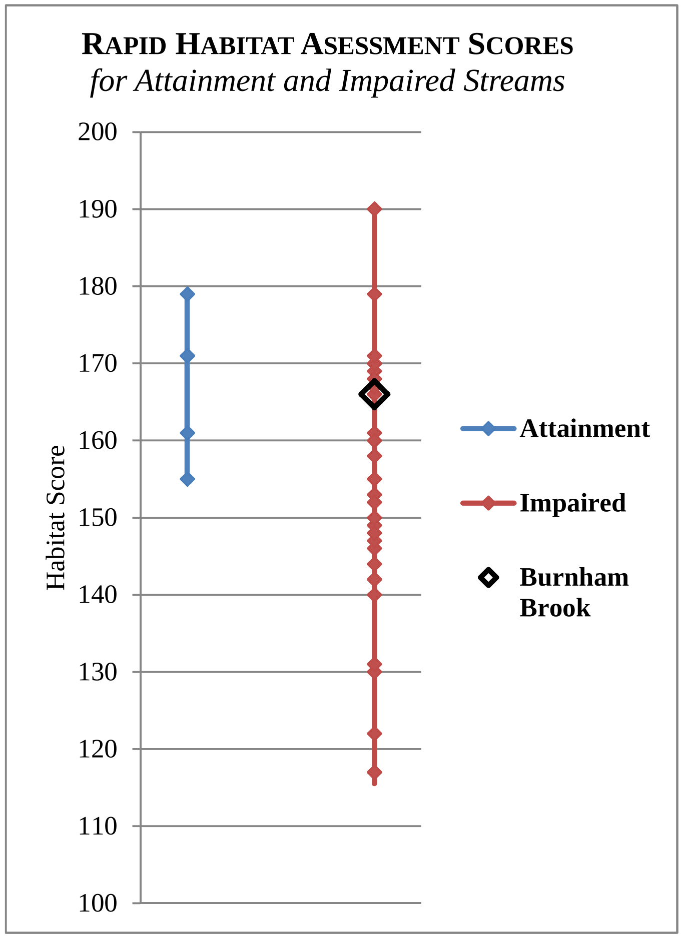


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both Burnham 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 Burnham Brook was completed on July 16, 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: Pollution Source ID Assessment for the Burnham Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
3	Center Road	Agriculture	• Estimated 100 dairy cows. • A large impoundment of Burnham Brook, observed on aerial imagery, is located to the north of farm buildings and is not visible from Center Road. This impoundment may be a major source of pollution to Burnham Brook.
3b	Hanson Road	Agriculture	• Active hay fields west of Hanson Road. Corn field to the north.
6 & 7	Burnham Cemetery Road	Road Crossings	• Burnham Cemetery Road is a posted and private road. • Aerial photographs reveal two road crossings on this road. Two large agricultural areas are located to the east along with a potential forestry area near a small tributary to Burnham Brook. • Erosion problems and nutrient sources in these areas are unknown.
9	Campbell Road	Agriculture	• 10 beef cows observed grazing. • Southern most portion of fields on this property come quite close to Burnham Brook with a very minimal buffer. This is not visible from roadways, but possible source of NPS pollution.
9b	Campbell Road	Agriculture	• Large active hay fields.
10	Campbell Road	Road Crossing	• Sample reach location. Large sediment deposit at downstream side of culvert.
14	Campbell Road	Agriculture	• Active hay and corn fields.
16	Corinth Road & Skillins Road	Agriculture	• Active hay field. • About 10 horses observed grazing.

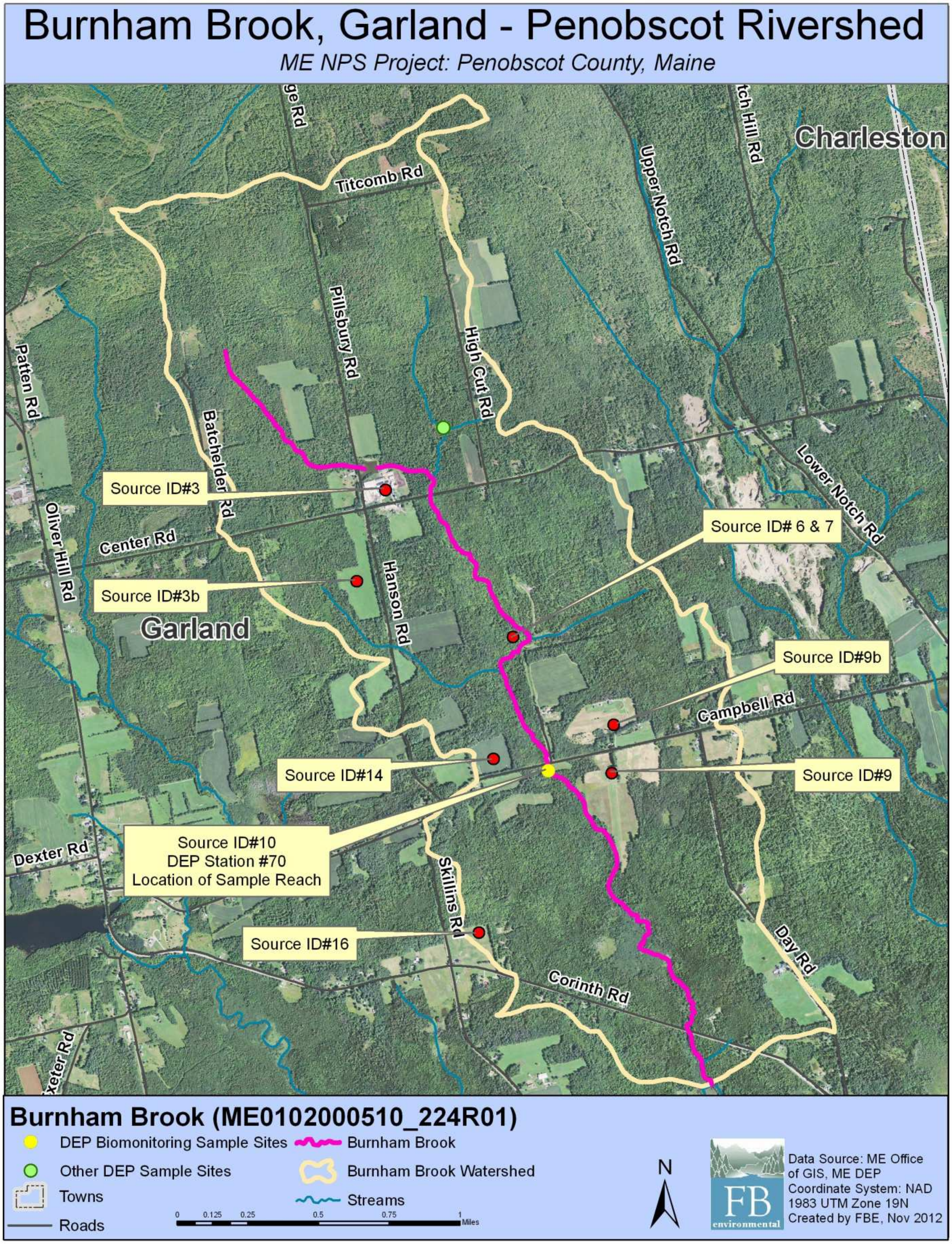


Figure 3: Aerial Photo of Source ID Locations in the Burnham Brook Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in Burnham Brook (impaired), plus five attainment watersheds located throughout the state. The model estimated daily nutrient loads over a 15-year period (1990-2004), which was determined by the available weather data provided within MapShed. This extended time 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 sections 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 3 (right) provides estimates of livestock (numbers of animals) in the watershed, based on direct observations made in the watershed, plus other publicly available data.

The Burnham Brook watershed is predominately forested with small areas of agriculture concentrated along major roadways including Center Road and Campbell Road. Hay is the dominant agricultural use, with small areas of row crops (corn). A farm is located on Center Road includes a large facility and several large manure piles visible from the roadway. It is estimated that 100 or more cows are located on the property, and a slight manure smell was documented during field surveys. A large impoundment of Burnham Brook is located north of the farm facilities, but not visible from Center Road.

Table 3: Livestock Estimates in Burnham Brook Watershed

Type	Burnham Brook
Dairy Cows	100
Beef Cows	10
Broilers	
Layers	
Hogs/Swine	
Sheep	
Horses	10
Turkeys	
Other	
Total	**120**

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. Geographic Information System (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 4: Summary of Vegetated Buffers in Agricultural Areas

Burnham Brook
• 6.1 stream miles in watershed (includes ephemeral streams) • 0 stream miles in agricultural areas

Burnham Brook is listed by Maine DEP as a 3.73 mile-long impaired segment. However, as modeled, the total stream miles (including tributaries) within the watershed was calculated by MapShed to be 6.1

miles. Of this total, zero stream miles are located directly adjacent to agricultural land (Table 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%.

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 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 cropland 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 Burnham Brook watershed is 7.3% wetland. A forested/scrub shrub wetland surrounds the most downstream portion of the brook north and south of Corinth Road. It is estimated that this wetland drains 10% of land area within the watershed (not accounting for water drained directly by Burnham 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 Burnham Brook indicate that reductions of sediment and nutrients are needed to improve water quality. Below, loading estimates for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the Burnham Brook watershed is primarily from crop land, which contributes 78% of the total sediment load (Table 5, Fig. 4). Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Burnham Brook* below for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Loads by Source

Burnham Brook	**Sediment (1000kg/year)**	**Sediment (%)**
Source Load		
Hay/Pasture	1.05	3%
Crop land	26.17	78%
Forest	3.11	9%
Wetland	0.05	0%
Disturbed Land	0	0%
Low Density Mixed	0.03	0%
Medium Density Mixed	0	0%
High Density Mixed	3.32	10%
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:	**33.7**	**100%**
Pathway Load		
Stream Banks	2.13	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**35.9**	

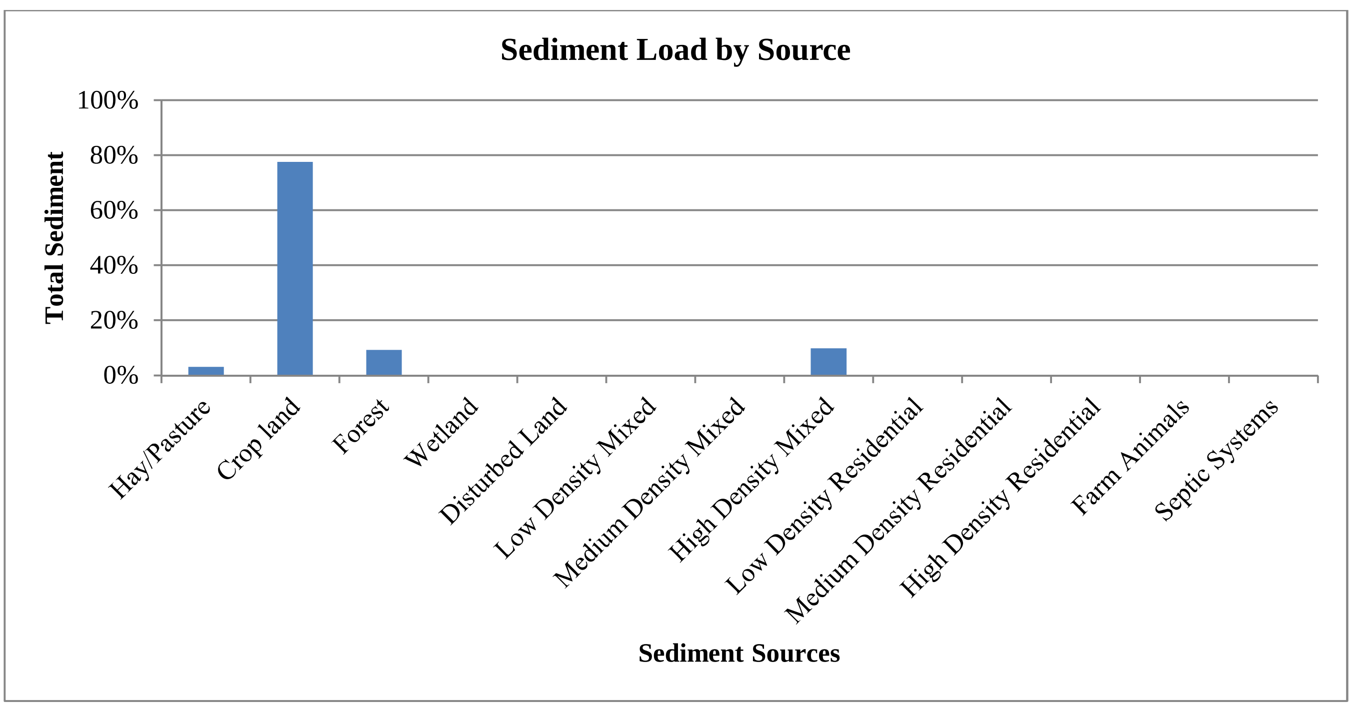


Figure 4: Total Sediment Loads by Source in the Burnham Brook Watershed

Total Nitrogen

Nitrogen loading in the Burnham Brook watershed is mainly attributed to farm animals and crop land which contribute 44% and 29% of the total nitrogen load, respectively. Table 6 and figure 5 (below) present estimated total nitrogen load in terms of mass and percent of total, and by source, in Burnham Brook. Forested land within the watershed also accounts for 14% of nitrogen loading to the brook. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Burnham Brook* (below) for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Burnham Brook	**Total N (kg/year)**	**Total N (%)**
Source Load		
Hay/Pasture	67.46	3%
Crop land	738.74	29%
Forest	365.82	14%
Wetland	67.77	3%
Disturbed Land	0	0%
Low Density Mixed	0.85	0%
Medium Density Mixed	0	0%
High Density Mixed	139.04	5%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	1121.43	44%
Septic Systems	34.62	1%
Source Load Total:	**2535.7**	**100%**
Pathway Load		
Stream Banks	0.99	-
Subsurface / Groundwater	3085.7	-
Total Watershed Mass Load:	**5622.4**	

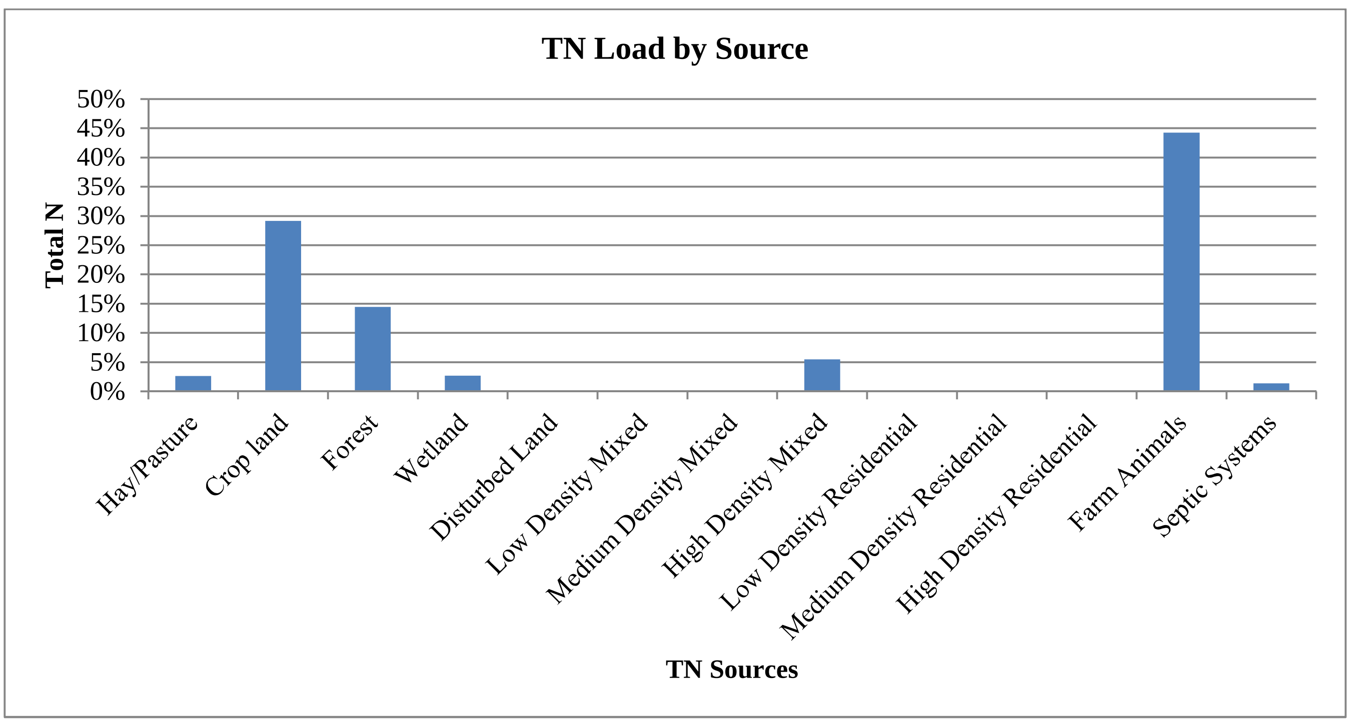


Figure 5: Total Nitrogen Loads by Source in the Burnham Brook Watershed

Total Phosphorus

Phosphorus loading in the Burnham Brook watershed is attributed primarily to farm animals which contribute 61% of the total phosphorus load. Crop land is also a large contributor of phosphorus as it accounts for 22% of the total load (Table 7 and Figure 6). Agricultural sources combined represent about 90% of the modeled TP load. 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 Burnham Brook* below for loading estimates normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Burnham Brook	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	25.01	7%
Crop land	80.65	22%
Forest	20.97	6%
Wetland	3.54	1%
Disturbed Land	0	0%
Low Density Mixed	0.09	0%
Medium Density Mixed	0	0%
High Density Mixed	14.34	4%
Low Density Residential	0	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	221.5	61%
Septic Systems	0	0%
Source Load Total:	**366.1**	**100%**
Pathway Load		
Stream Banks	98.23	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**464.3**	

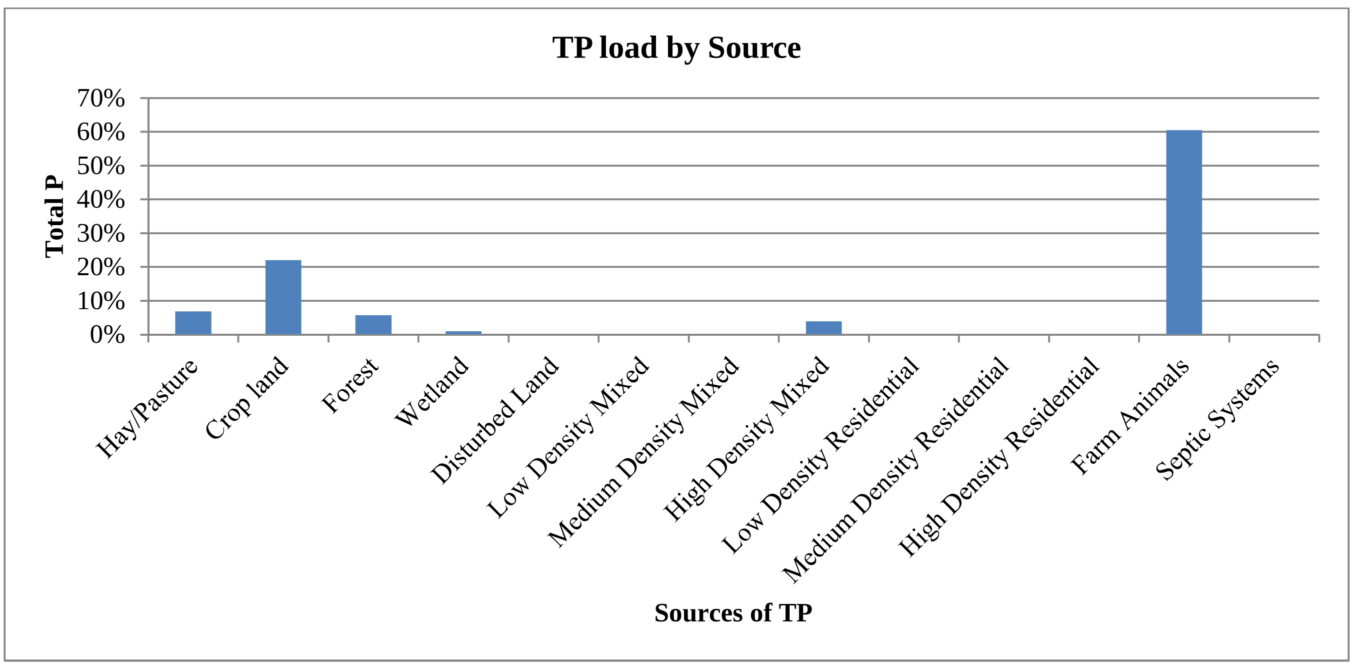


Figure 6: Total Phosphorus Loads by Source in the Burnham Brook Watershed

TMDL: TARGET NUTRIENT LEVELS FOR BURNHAM BROOK

The existing sediment and nutrient loads for the impaired segment of Burnham Brook are listed in Table 8, along with the TMDL numeric target which was calculated from the average loading estimates of five attainment watersheds throughout the state. Table 9 presents a more detailed view of the modeling results and calculations used in Table 8 to define TMDL reductions, and compares the existing sediment and nutrient loads in Burnham 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 8: TMDL Targets Compared to Burnham Brook Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Watershed Area	**Estimated Loads Burnham Brook**	**Total Maximum Daily Load Numeric Target**	**TMDL % REDUCTIONS Burnham Brook**
Sediment Load *(1000 kg/ha/year)*	**0.037**	**0.030**	**18%**
Nitrogen Load *(kg/ha/year)*	**5.77**	**5.19**	**10%**
Phosphorus Load *(kg/ha/year)*	**0.48**	**0.24**	**49%**

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 Burnham Brook. To ensure that the TMDL targets are attained, future agriculture or development activities in the watershed will need to meet the TMDL targets. Future growth from population increases is a moderate threat in the Burnham Brook watershed, due to an increasing population trend in Penobscot County of 2.6% between 2000 and 2008 (USM MSAC, 2009). The growth in agricultural lands is also increasing, with a 23% increase in the total number of farms in Penobscot County between 2002 and 2007, and a 7% increase in the land (acres) in farms between 2002 and 2007. However, a 13% decrease occurred in the average farm size in this time period (USDA, 2007a). Future activities and BMPs that achieve TMDL reductions are addressed below.

Next Steps

The use of agricultural and developed area BMPs can reduce sources of polluted runoff in Burnham Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Garland 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 Burnham Brook;
- Address <u>existing</u> nonpoint source problems in the Burnham Brook watershed by instituting BMPs where necessary; and
- Prevent <u>future</u> degradation of Burnham Brook through the development and/or strengthening of a local Nutrient Management Ordinance.

Table 9: Modeling Results Calculations for Derived Numeric Targets and Reduction Loads for Burnham Brook

Burnham Brook				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	42	1.1	67.5	25.0
Cropland	73	26.2	738.7	80.7
Forest	755	3.1	365.8	21.0
Wetland	74	0.1	67.8	3.5
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	1	0.0	0.9	0.1
High Density Mixed	30	3.3	139.0	14.3
Other Sources				
Farm Animals			1121.4	221.5
Septic Systems			34.6	0.0
Pathway Loads				
Stream Banks		21.1	0.1	0.0
Groundwater			3087.7	98.3
Total Annual Load		36 x 1000 kg	5622 kg	464 kg
Total Area	975 ha			
Total Maximum Daily Load		**0.037 1000kg/ha/year**	**5.77 kg/ha/year**	**0.48 kg/ha/year**

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