TMDL Summary

Appendix 6-21

West Brook

Watershed Description

This **TMDL** applies to a 3.22 mile section of West Brook, located in the Towns of Wells and North Berwick, Maine. The impaired segment of West Brook begins just east of the Perry Oliver Road stream crossing and flows west through a large tract of forested. The stream passes close behind the large Pratt and Whitney facility, then joins the Great Works River. The West Brook watershed covers an area of 12.09 square miles. The majority of the watershed is located within the Town of Wells, however, small portions of the watershed lie within the surrounding towns of North Berwick and Sanford.

- Runoff from the Pratt and Whitney facility in the western portion of the watershed is likely the largest sources of **nonpoint source (NPS) pollution** to West Brook.
- The West Brook watershed is predominately non-developed (91.6%). Forested areas (55.8%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (21.4%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly wetlands (21.4%) and are concentrated in the western portion of the watershed.
- Agriculture makes up 8% of the watershed.
- Developed areas (8.43%) with impervious surfaces in close proximity to the steam may impact water quality.
- West Brook is on Maine's 303(d) list of 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: ME0106000304_625R03

Town: Wells, North Berwick, ME

County: York

Impaired Segment Length: 3.22 miles

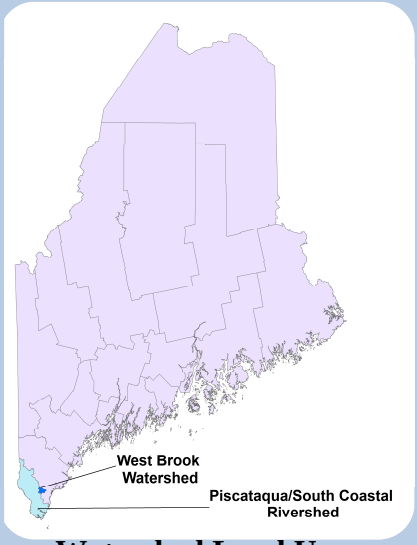
Classification: Class B

Direct Watershed: 12.09 mi^2 (7,739 acres)

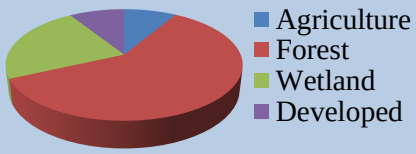
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 8.01%

Major Drainage Basin: Piscataqua River



Watershed Land Uses



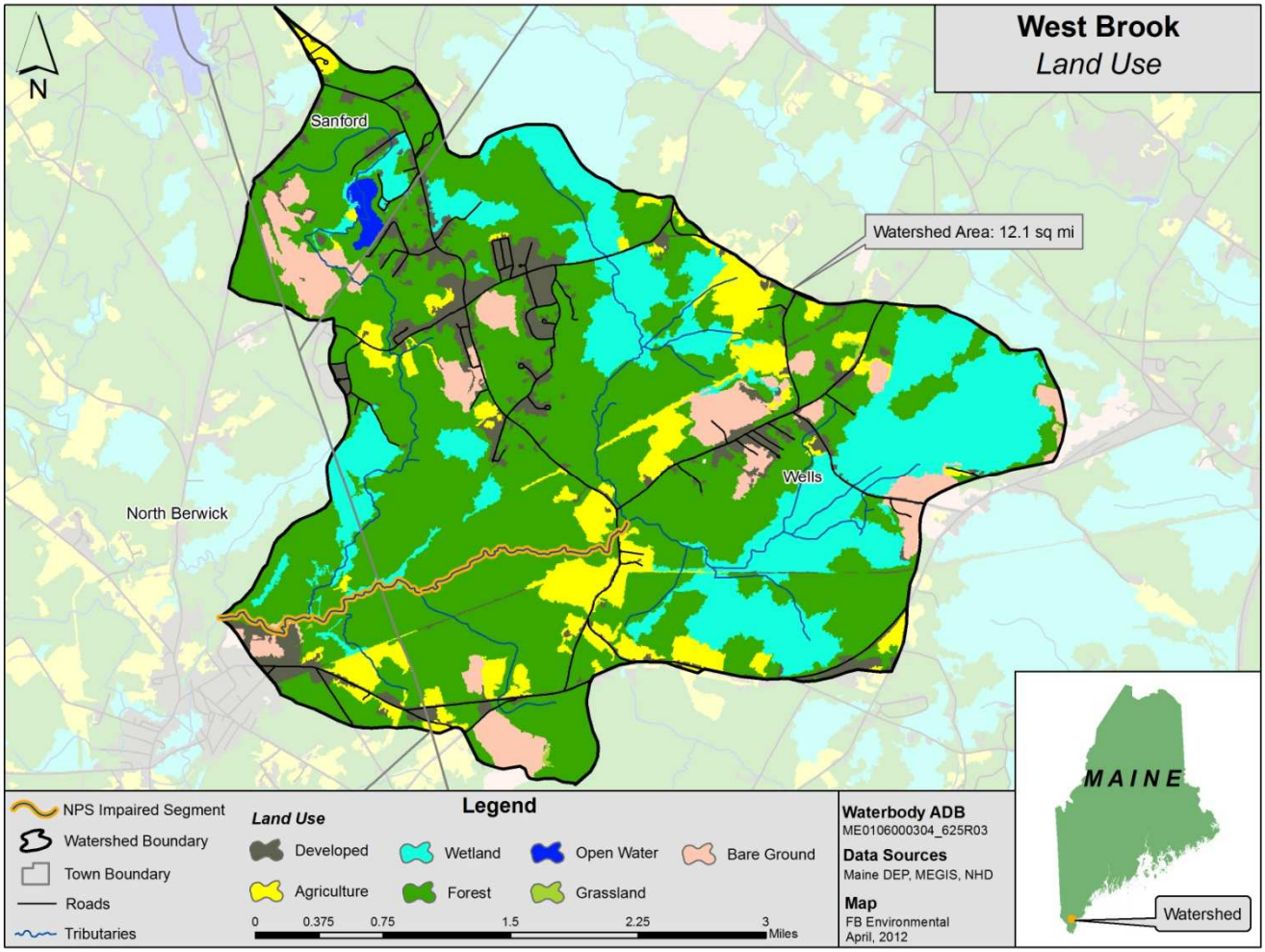


Figure 1: Land Use in the West Brook Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

West 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.

West Brook *at the Great Works Estate Road crossing. Photo: FB Environmental*

Wetland area (21.4%) in the West Brook watershed is more than double the area of both developed land (8.4%) and agricultural land (8%) (Figure 1). Therefore, wetlands may be causing West Brook to have naturally low dissolved oxygen concentrations. However, several agricultural sites located on Bradgon Road and Bald Hill Road were noted as potential nonpoint source pollution hotspots.

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 West 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, West Brook received a score of 167 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range in habitat assessment scores for attainment streams was 155 to 179.

The habitat assessments were conducted on a relatively short sample reach (about 100-200 meters for a typical small stream), and was located near the most downstream Maine DEP sample station. For both impaired and attainment streams, the assessment location was usually near a road crossing for ease of access. In the West Brook watershed, the downstream sample station was located off a dirt road behind the Pratt and Whitney Facility off of Route 9 (Wells Road). The sample reach was located within a forested portion of the watershed and had a thick wooded buffer (mainly coniferous).

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

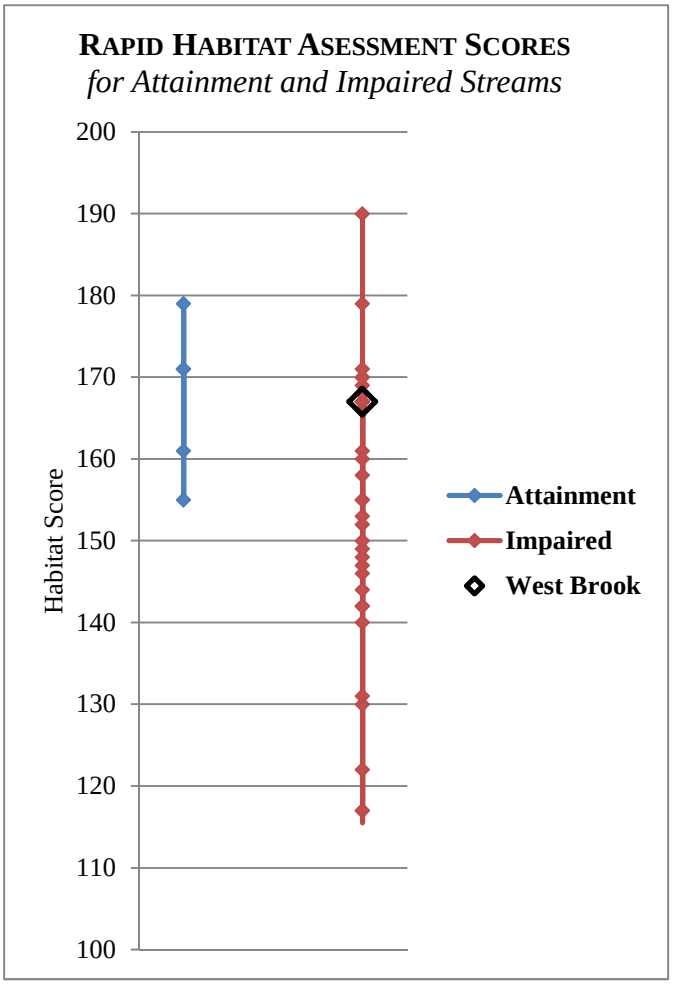


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both West Brook (impaired) 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 West Brook was completed on July 26, 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 West Brook Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
3	Behind Pratt & Whitney Plant	Stream Aerators	• Aerators were placed in West Brook as a result of a ME DEP requirement to address low oxygen levels potentially caused by the impoundment of the stream in this location.
15	Quarry Road	Agriculture	• 3 cows were observed grazing in a pasture.
15b	Quarry Road	Road Crossing	• A stream culvert replacement and paving on Quarry Road. • Exposed soils.
17	Quarry Road	Gravel Pit	• Southern Maine Nursery gravel pit is located in the center of the watershed.
19	Bald Hill Road	Agriculture	• Happy Acres Farm. • Pastures and fallow fields observed.
20	Bragdon Road	Quarry	• Active quarry. • Tributaries to West Brook nearby, but buffered.
22	Bald Hill Road	Agriculture	• 15 chickens were observed at a residential site on Bald Hill Road.
23	Bragdon Road	Agriculture	• Active hay fields.
24	Bragdon Road	Agriculture	• Horse stables. • At least 8 horses observed.
25	Bragdon Road	Agriculture	• Christmas tree farm. • Livestock fencing observed though no animals visible.
26	North Berwick Road	Commercial	• A sign for “Hawkeye Maintenance” was observed on North Berwick Road in the lower portion of the watershed. This site was not visible from the roadway. • Aerial photos indicate a medium sized facility and utility equipment maintenance yard. Earth moving is taking place behind the paved site.
28	Lake Drive	Residential	• A yard with no buffer to Little Pond; 4 golden retrievers observed in the yard. Potential dog breeder.

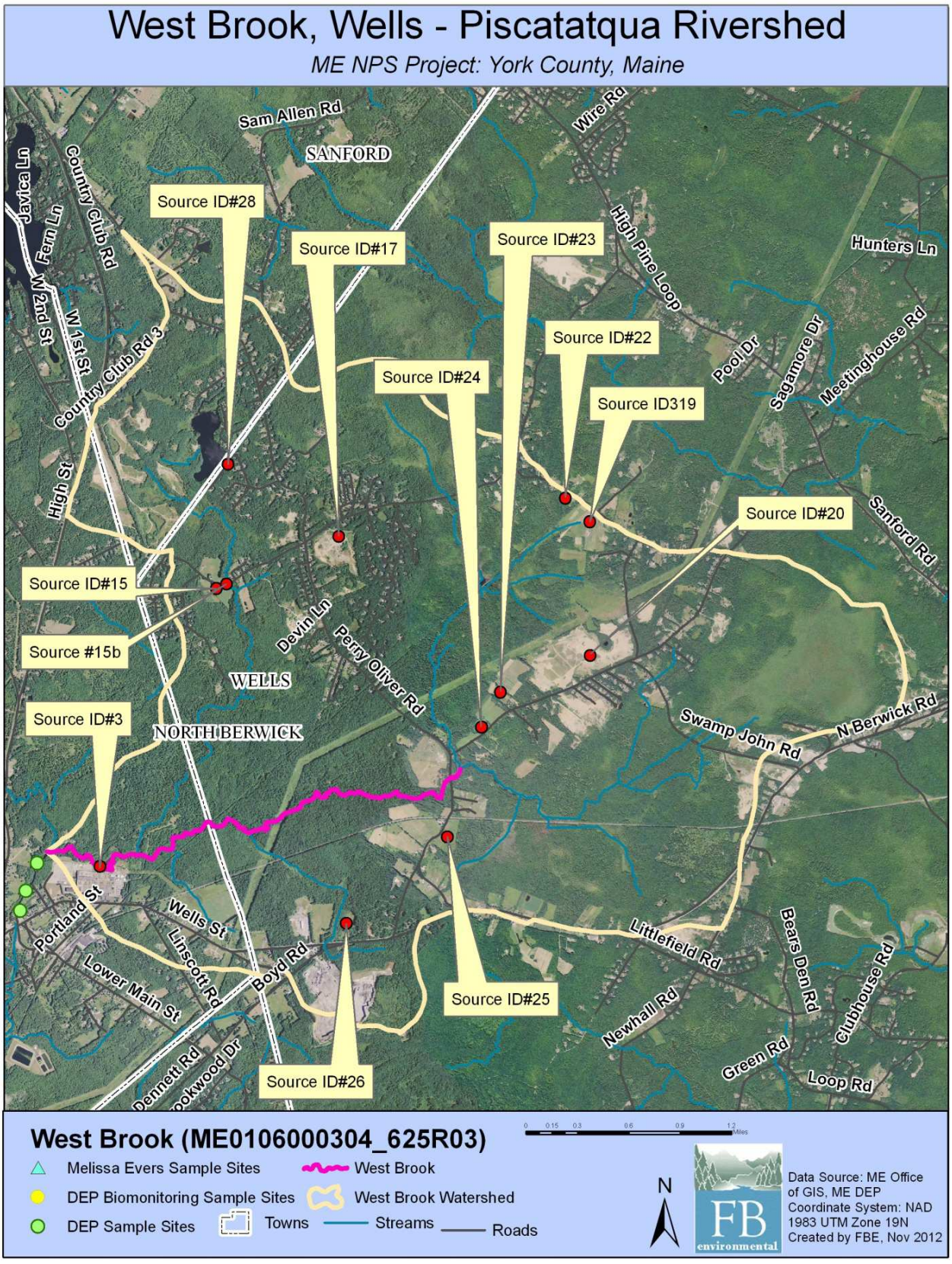


Figure 3: Aerial Photo of Source ID Locations in the West Brook Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in West 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 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.

Table 3: Livestock Estimates in the West Brook Watershed

Type	West Brook
Dairy Cows	3
Beef Cows	
Broilers	
Layers	15
Hogs/Swine	
Sheep	
Horses	8
Turkeys	
Other	4 (dogs)
Total	**30**

The West Brook watershed is predominantly forested, with some developed land and agriculture throughout the watershed. Few livestock were observed, and most were in a small-scale “hobby farm” setting. Three cows at pasture were observed at a farm on Quarry Road. This pasture was in close proximity to a tributary to West Brook. Fifteen chickens were observed on a residential property outside a small coop on Bald Hill Road. Eight horses and a stable were observed on Bragdon Road. Four dogs were observed at what appeared to be a dog breeding operation on a shorefront property on Little Pond. While dogs are usually not counted as livestock, the breeding facility and proximity to the shoreline accounted for their inclusion here.

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

West Brook
• 13.6 stream miles in watershed (includes ephemeral streams)
• 0.7 stream miles in agricultural areas
• 43% of agricultural stream miles have a vegetated buffer

West Brook is a 3.2 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 13.6 miles. Of this total, 0.7 stream miles are located within agricultural areas; of this length, 0.3 miles (43%) show a 75-foot or greater vegetated buffer (Table 4, 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%.

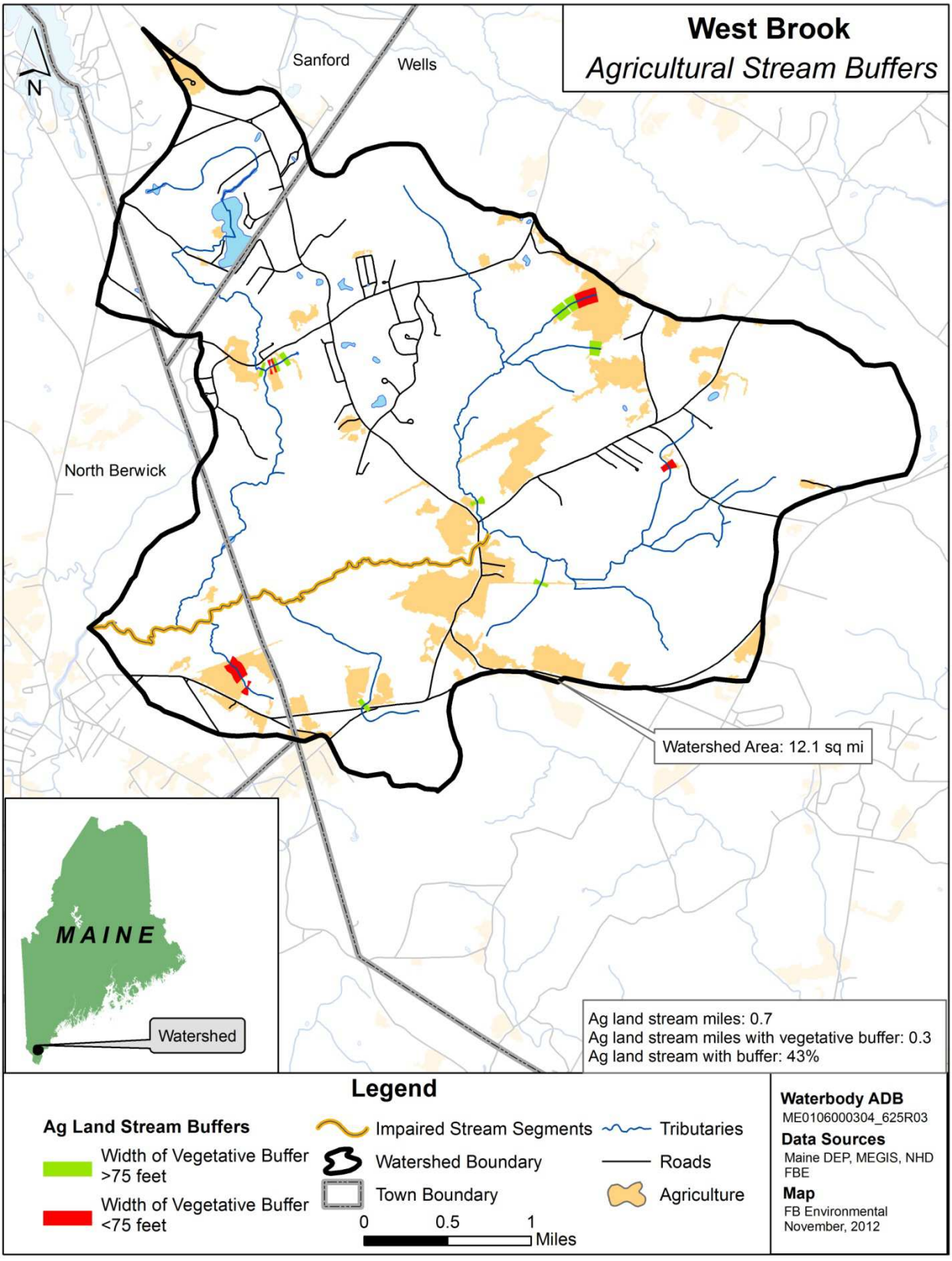


Figure 4: Buffered Agricultural Stream Miles in the West Brook Watershed

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 streams watersheds. More localized data on agricultural practices would improve this component of the model.

- *Cover Crops:* Cover crops are the use of 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. Large wetland areas located in the eastern and northeastern portion of the West Brook watershed drain a majority of the land within those areas of the watershed. It is estimated that these wetland complexes drain about 30% of the watershed land area. 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 West Brook indicate that reductions of sediment and nutrients are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the West Brook watershed is mainly derived from agricultural sources. Crop land and hay/pasture account for almost 60% of the total sediment load. Development is a secondary source and makes up 28% of the total load to West Brook (Table 5, Figure 5). Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for West Brook* (below) for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Loads by Source

West Brook	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	7.79	9%
Crop land	41.48	50%
Forest	8.91	11%
Wetland	1.01	1%
Disturbed Land	0.17	0%
Low Density Mixed	5.30	6%
Medium Density Mixed	0	0%
High Density Mixed	11.37	14%
Low Density Residential	6.59	8%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**82.62**	**100%**
Pathway Load		
Stream Banks	30.37	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**112.99**	

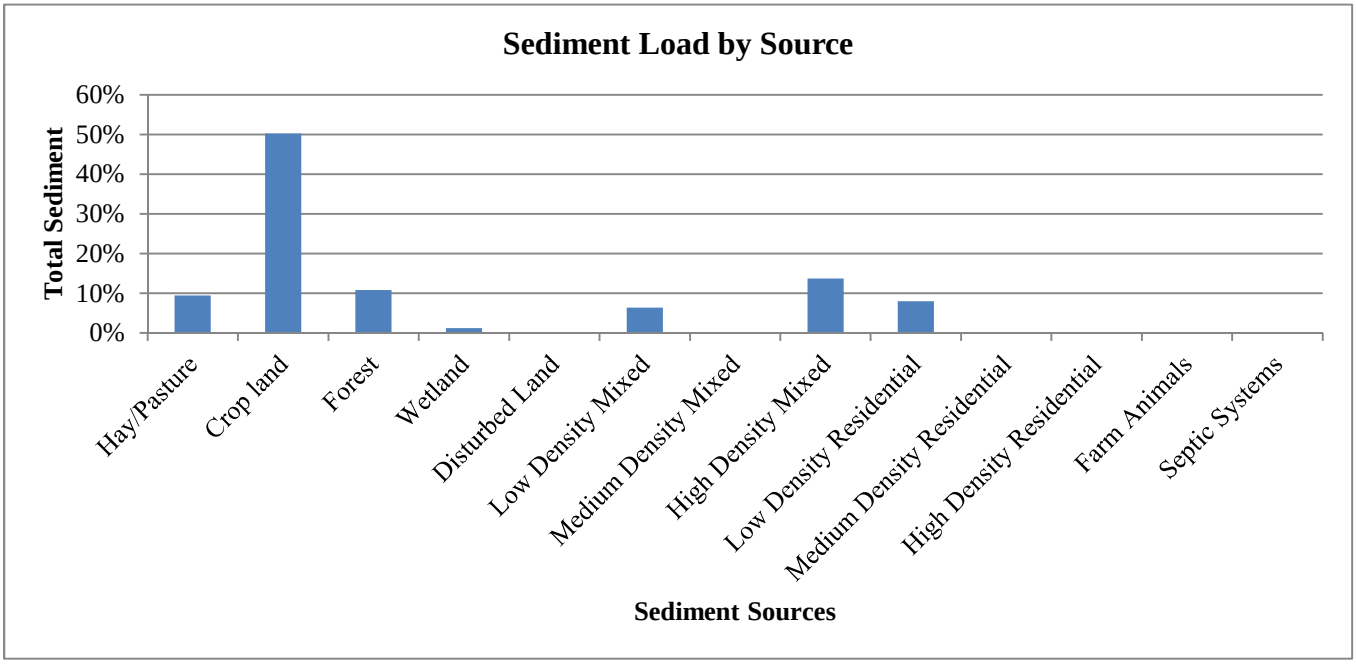


Figure 5: Total Sediment Loads by Source in the West Brook Watershed

Total Nitrogen

Nitrogen loading is attributed to agricultural sources, which make up 28% of the total load. Development is a secondary source and accounts for 22% of the nitrogen load to West Brook. Forest and wetland also contribute significant portions of the nitrogen load, each accounting for 18% of the load. Table 6 and Figure 6 (below) show the estimated total nitrogen load in terms of mass and percent of total, and by source in West Brook. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for West Brook* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

West Brook	**Total N (kg/year)**	**Total N (%)**
Source Load		
Hay/Pasture	401.7	10%
Crop land	732.9	17%
Forest	738.6	18%
Wetland	764.0	18%
Disturbed Land	1.6	0%
Low Density Mixed	157.5	4%
Medium Density Mixed	0	0%
High Density Mixed	568.4	13%
Low Density Residential	195.9	5%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	59.6	1%
Septic Systems	598.8	14%
Source Load Total:	**4219.0**	**100%**
Pathway Load		
Stream Banks	25.1	-
Subsurface / Groundwater	14614.3	-
Total Watershed Mass Load:	**18858.4**	

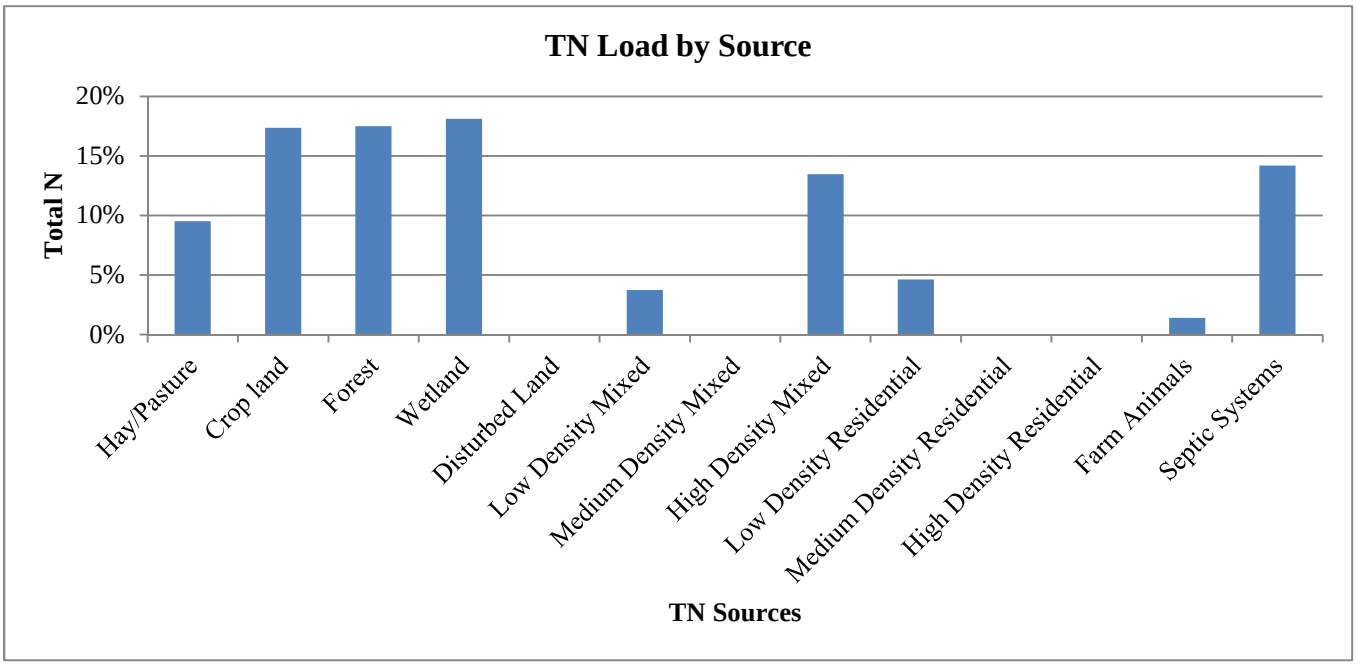


Figure 6: Total Nitrogen Loads by Source in the West Brook Watershed

Total Phosphorus

Phosphorus loading in the West Brook watershed is attributed primarily to crop land and hay/pasture, with combined agricultural sources making up 56% of the total load. Development is a secondary source and accounts for 22% of the phosphorus load. Phosphorus loads are presented in Table 7 and Figure 7. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for West Brook* (below) for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

West Brook	**Total P (kg/year)**	**Total P (%)**
Source Load		
Hay/Pasture	134.2	31%
Crop land	86.3	20%
Forest	42.9	10%
Wetland	38.8	9%
Disturbed Land	0.7	0%
Low Density Mixed	16.6	4%
Medium Density Mixed	0	0%
High Density Mixed	56.5	13%
Low Density Residential	20.7	5%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	19.9	5%
Septic Systems	19.2	4%
Source Load Total:	**435.7**	**100%**
Pathway Load		
Stream Banks	7.3	-
Subsurface / Groundwater	408.9	-
Total Watershed Mass Load:	**851.9**	

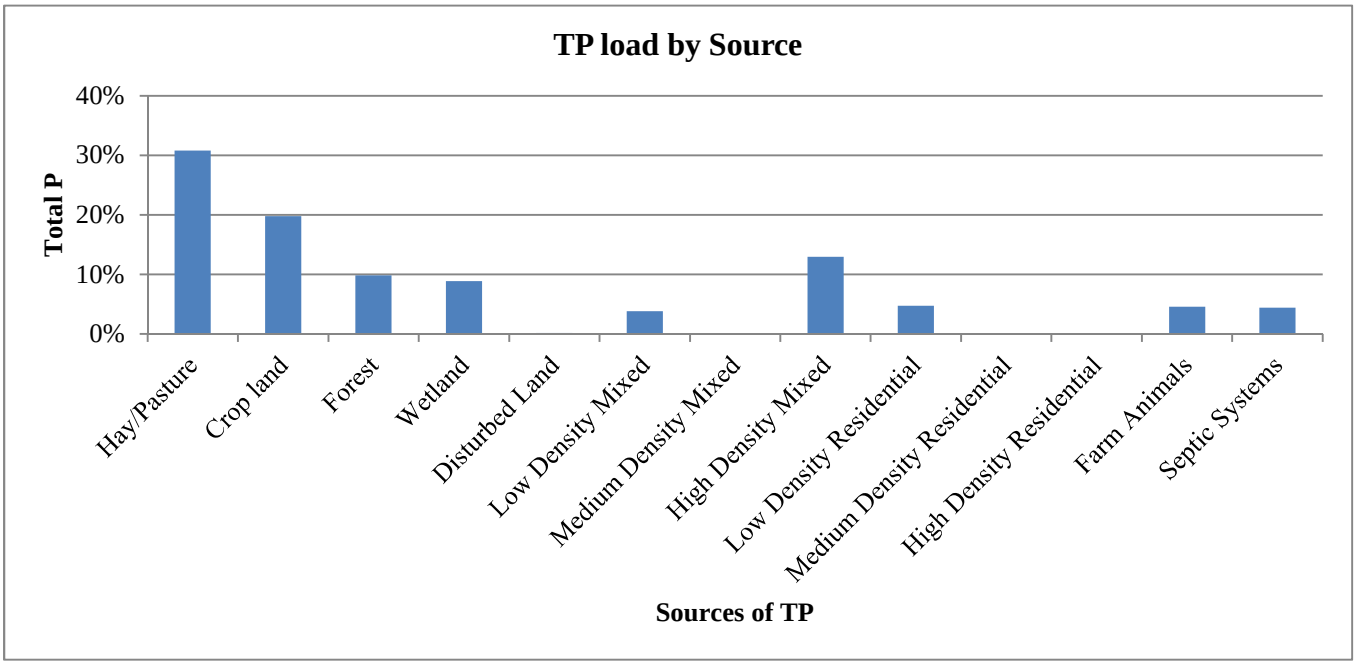


Figure 7: Total Phosphorus Loads by Source in the West Brook Watershed

TMDL: TARGET NUTRIENT LEVELS FOR WEST BROOK

The existing sediment and nutrient loads for the impaired segment of West 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 West 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 West Brook Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads West Brook**	**Total Maximum Daily Load Numeric Target**	**TMDL % REDUCTIONS West Brook**
Sediment Load *(1000 kg/ha/year)*	**0.036**	**0.030**	**17%**
Nitrogen Load *(kg/ha/year)*	**6.05**	**5.2**	**14%**
Phosphorus Load *(kg/ha/year)*	**0.27**	**0.24**	**11%**

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 West 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 West Brook watershed because of increasing population trends in York County, with an 8% increase between 2000 and 2008. York county is the fastest growing county in the state (USM MSAC, 2009). The growth in agricultural lands is also increasing, with a 4% increase in the total number of farms in York County between 2002 and 2007, and a 4% increase in the land (acres) in farms between 2002 and 2007 (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 West Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in Wells and North Berwick 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 West Brook;
- Address existing nonpoint source problems in the West Brook watershed by instituting BMPs where necessary; and
- Prevent future degradation of West Brook through the development and/or strengthening of local a Nutrient Management Ordinance.

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

West Brook				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	190	7.8	401.7	134.2
Crop land	62	41.5	733.0	86.3
Forest	1732	8.9	738.6	42.9
Wetland	667	1.0	764.0	38.8
Disturbed Land	9	0.2	1.6	0.7
Low Density Mixed	156	5.3	157.5	16.6
High Density Mixed	107	11.4	568.4	56.5
Low Density Residential	194	6.6	195.9	20.7
Other Sources				
Farm Animals			59.6	19.9
Septic Systems			598.8	19.2
Pathway Loads				
Stream Banks		30.4	25.1	7.3
Groundwater			14614.3	408.9
Total Annual Load		113 x 1000 kg	18858 kg	852 kg
Total Area	3117 ha			
Total Maximum Daily Load		**0.036 1000kg/ha/year**	**6.05 kg/ha/year**	**0.27 kg/ha/year**

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