# DRAFT TMDL SUMMARY

# *Adams Brook*

## WATERSHED DESCRIPTION

This **TMDL** applies to a 1.2 mile section of Adams Brook, located in the Town of Berwick, Maine. The stream begins just upstream of Blackberry Hill Road and flows southeast through forest. The stream continues across Portland Street (Route 4), and turns east before joining Lover's Brook just upstream of Pond Road. The Adams Brook watershed covers an area of 1.1 square miles. The majority of the watershed is located within the Town of Berwick, however, small portions of the watershed lie within the surrounding Town of South Berwick.

- Runoff from agricultural land located in the areas of Blackberry Hill Road, Portland Street, and Pond Road, are likely the largest sources of **nonpoint source (NPS) pollution** to Adams Brook. Runoff from cultivated lands, active hay lands, and grazing areas can transport nitrogen and phosphorus to the nearest section of the stream.
- The Adams Brook watershed is predominately non-developed (89%). Forested areas (50%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (1.9%) may also help filter nutrients.
- Non-forested areas within the watershed include agricultural (6.6%) and are concentrated in the southern portion of the watershed along Blackberry Hill Road, Portland Street, and Pond Road.
- Developed areas (9.4%) with impervious surfaces in close proximity to the steam may impact water quality.
- Adams Brook is on Maine's 303(d) list of Impaired Streams (Maine DEP, 2012).

### *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:** ME0106000304_625R01

**Town:** Berwick, ME

**County:** York

**Impaired Segment Length:** 1.2 miles

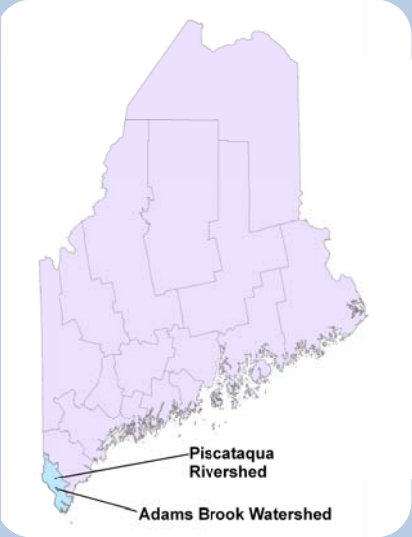
**Classification:** Class B

**Direct Watershed: 1.1** $mi^2$ (684 acres)

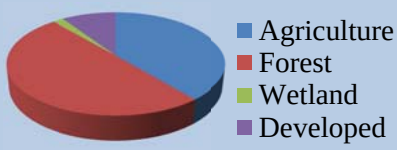
**Impairment Listing Cause:** Benthic macroinvertebrates

**Watershed Agricultural Land Use: 39%**

**Major Drainage Basin:** Piscataqua River




**Watershed Land Uses**



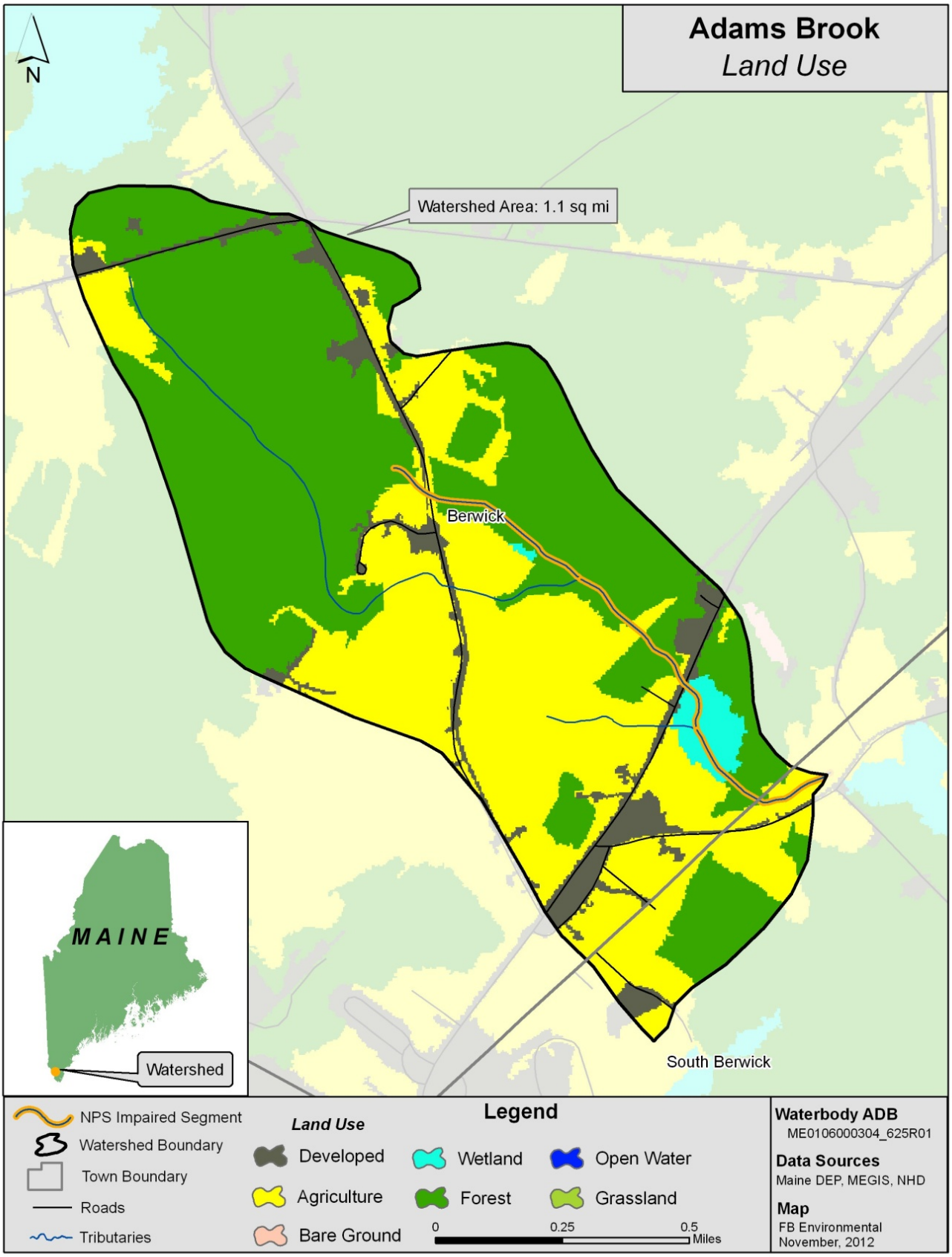



**Figure 1:** Land Use in the Adams Brook Watershed

## WHY IS A TMDL ASSESSMENT NEEDED?

Adams 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.

***Adams Brook** at DEP Sampling Station 267*
*(Photo: FB Environmental)*

Agriculture in Adams Brook makes up 39% of the land area. However, in the southern portion of the watershed, Adams Brook flows through agricultural areas with little or no vegetated buffer for about 0.25 miles (Figure 1). 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

There are three types of numeric data by which Maine DEP measures the ability of a stream to adequately support aquatic life: dissolved oxygen, benthic macroinvertebrates, and periphyton (algae). The aquatic life impairment in Adams Brook is based on benthic macroinvertebrate data collected at station 267 in 1995.

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).

## TMDL ASSESSMENT APPROACH: NUTRIENT MODELING OF IMPAIRED AND ATTAINMENT STREAMS

Nonpoint Source Pollution (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 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

Habitat assessment surveys were 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, Adams Brook received a score of 117 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 Adams Brook watershed, the downstream sample station was located in an inactive pasture with minimal trees within a riparian zone dominated by tall grasses with some small trees.

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

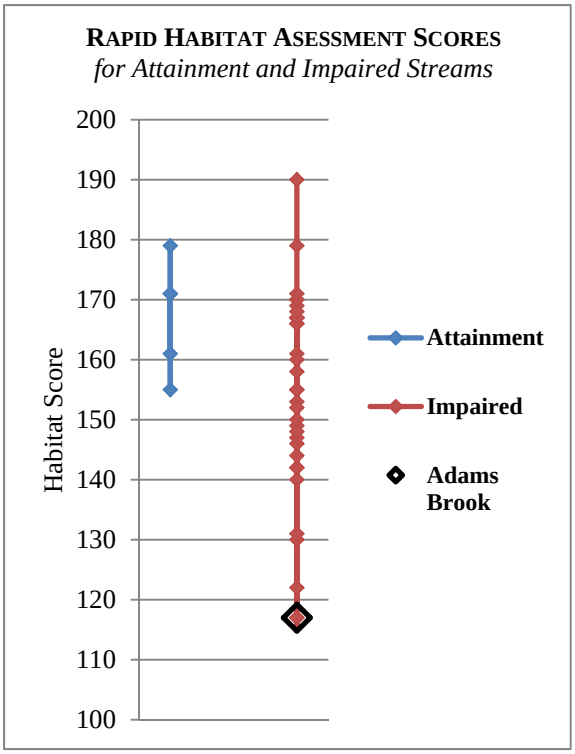



**Figure 2:** Habitat Assessment Scores

**Pollution Source Identification**

Pollution source identification assessments were conducted for both Adams Brook 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 within 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 Adams Brook was completed on July 20, 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, Fig. 3).

**Table 2:** Pollution Source ID Assessment for the Adams Brook Watershed

| Potential Source | | | Notes |
|---|---|---|---|
| **ID#** | **Location** | **Type** | |
| **1** | Blackberry Hill Road | Agriculture | • Estimated 25 dairy cows observed.<br>• Blackberry Hill Farm. |
| **4** | Blackberry Hill Road (just north of RR tracks) | Agriculture | • Active corn crops and hayfields.<br>• About dairy 60 cows observed grazing. |
| **7** | Blackberry Hill Road | Road Crossing/ Agriculture | • Active row crops on surrounding properties.<br>• Bare soil.<br>• Nearby electric fence indicates livestock on adjacent property. |
| **12** | Portland Street | Agriculture | • Active hayfields.<br>• 2 horses observed grazing.<br>• Tributary is drainage from agricultural fields in Location #4, and flows through active hay fields in location #12. Ephemeral. |
| **15** | Pond Road | Agriculture | • 2 horses observed grazing.<br>• Active row crops. |
| **16** | Pond Road | Sampling Location | • Location of sample reach.<br>• Inactive fields surrounding.<br>• DEP Sample Station 267. |

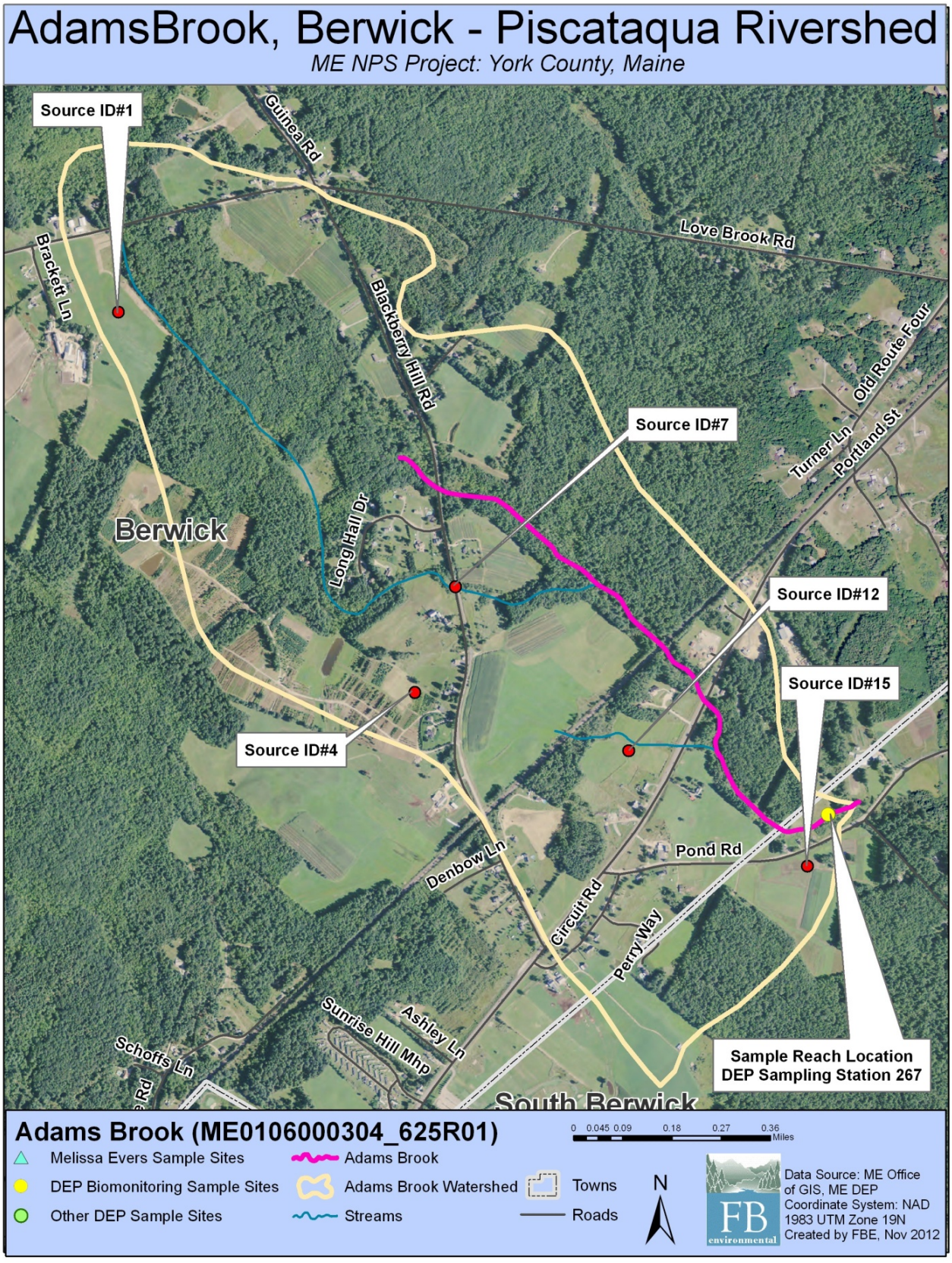



**Figure 3:** Aerial Photo of Source ID Locations in the Adams Brook Watershed

## NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total phosphorus and total nitrogen in Adams Brook (impaired) plus five attainment watersheds 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 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 buffers, 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 Adams Brook watershed contains substantial mixed agricultural land uses. Areas of active corn and hayfields were commonly observed, and two dairy farms were documented on Blackberry Hill Road. An estimated total of 85 cows are located on these properties. Four horses were also observed during the watershed survey.

**Table 3:** Livestock Estimates in the Adams Brook Watershed

| Type | Adams Brook |
|---|---|
| Dairy Cows | 85 |
| Beef Cows | |
| Broilers | |
| Layers | |
| Hogs/Swine | |
| Sheep | |
| Horses | 4 |
| Turkeys | |
| Other | |
| **Total** | **89** |

### *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

| **Adams Brook** |
|---|
| • 2.05 stream miles in watershed (includes ephemeral streams) |
| • 0.82 stream miles in agricultural areas |
| • **70%** of agricultural stream miles have a vegetated buffer |

Adams Brook is a 1.2 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 2.05 miles. Of this total, 0.82 stream miles are located within agricultural areas and 0.57 miles or 70% of the stream shows 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 watershed ranged from 34% to 92% with an average of 61%.

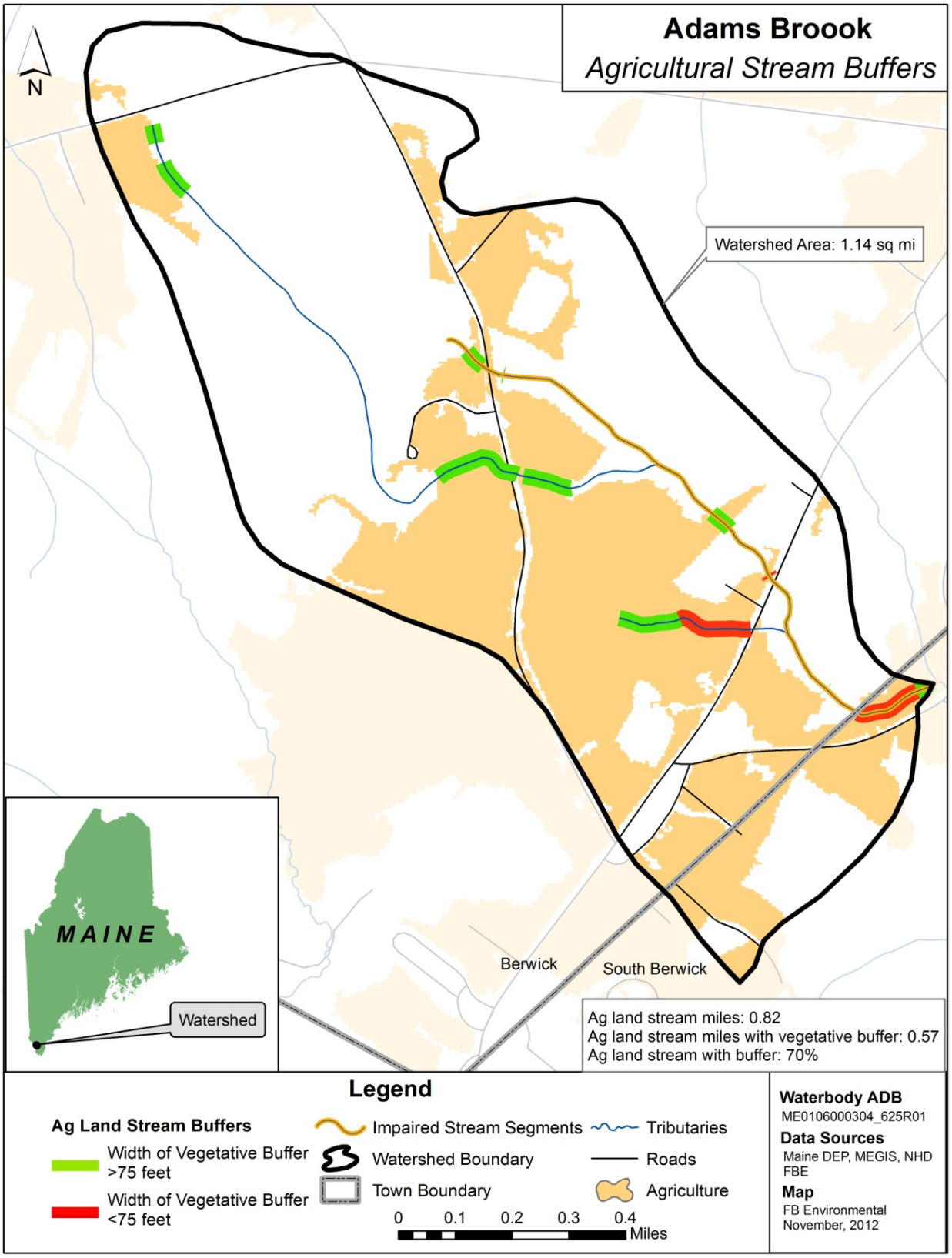



**Figure 4:** Buffered Agricultural Stream miles in the Adams Brook Watershed

### *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 stream watersheds. More localized data on agricultural practices would improve this component of the model.

- *Cover Crops:* Cover crops are annual or perennial crops used to protect soil from erosion during time periods between harvesting and planting of the primary crop. The percent of agricultural acres with cover crops used in the model is estimated to be 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 Adams Brook watershed has a large wetland south of Portland Street that is estimated to drain 20% of the watershed land area. The percentage 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 monthly 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 Adams 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*

High density mixed development contributes 15% of the sediment load to Adams Brook. Hay/pasture accounts for about 47% with cropland accounting for 32% of sources. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Adams Brook* (below) for loading estimates that have been normalized by watershed area.

**Table 5:** Total Sediment Load by Source

| **Adams Brook** | **Sediment (1000kg/year)** | **Sediment (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 5.45 | 47% |
| *Crop land* | 3.69 | 32% |
| *Forest* | 0.42 | 4% |
| *Wetland* | 0.01 | 0% |
| *Disturbed Land* | 0.14 | 1% |
| *Low Density Mixed* | 0.23 | 2% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 1.74 | 15% |
| *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:*** | **11.68** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 1.02 | - |
| *Groundwater* | 0 | - |
| | | |
| ***Total Watershed Mass Load:*** | **12.70** | |

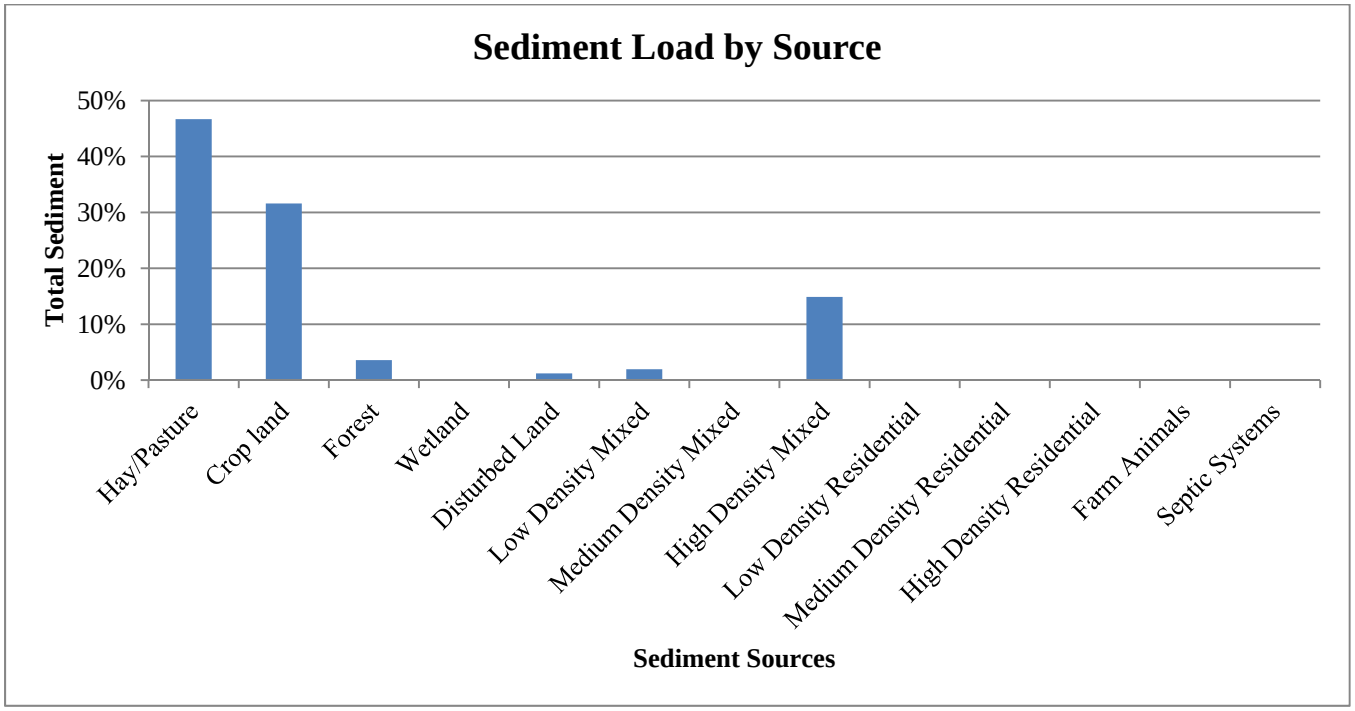



**Figure 5:** Total Sediment Loads by Source in the Adams Brook Watershed

### *Total Nitrogen*

Table 6 and Figure 6 (below) show the estimated total nitrogen load in terms of mass and percent of total, and by source, in Adams Brook. Farm animals account for 66% of the nitrogen load to the brook, followed by hay/pasture and cropland at 13% and 4%, respectively, suggesting that agriculture makes up the largest overall category of sources in the Adams Brook watershed. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Adams Brook* below for loading estimates that have been normalized by watershed area.

**Table 6:** Total Nitrogen Loads by Source

| **Adams Brook** | **Total N (kg/year)** | **Total N (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 142.1 | 13% |
| *Crop land* | 47.0 | 4% |
| *Forest* | 55.9 | 5% |
| *Wetland* | 3.9 | 0% |
| *Disturbed Land* | 1.1 | 0% |
| *Low Density Mixed* | 6.7 | 1% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 73.0 | 6% |
| *Low Density Residential* | 0 | 0% |
| *Medium Density Residential* | 0 | 0% |
| *High Density Residential* | 0 | 0% |
| *Farm Animals* | 746.3 | 66% |
| *Septic Systems* | 59.8 | 5% |
| ***Source Load Total:*** | **1135.8** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 1.0 | - |
| *Subsurface / Groundwater* | 2542.5 | - |
| | | |
| ***Total Watershed Mass Load:*** | **3679.3** | |

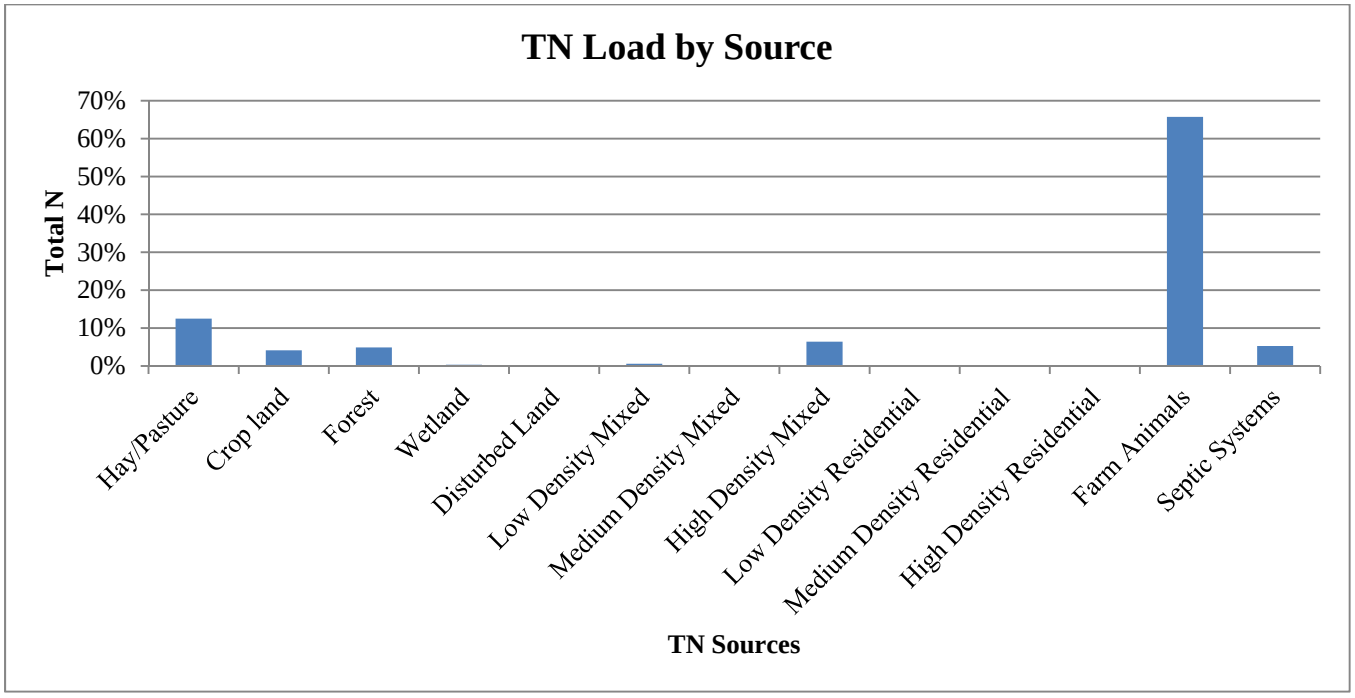



**Figure 6:** Total Nitrogen Loads by Source in the Adams Brook Watershed

### *Total Phosphorus*

Phosphorus loads are presented in Table 7 and Figure 7. In the Adams Brook watershed, Farm animals account for 63% of the total phosphorus load to the brook, and hay and pasture contribute another 27% of the phosphorus load. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Adams Brook* (below) for loading estimates that have been normalized by watershed area.

**Table 7:** Total Phosphorus Loads by Source

| **Adams Brook** | **Total P (kg/year)** | **Total P (%)** |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 58.1 | 27% |
| *Crop land* | 7.6 | 3% |
| *Forest* | 3.2 | 1% |
| *Wetland* | 0.2 | 0% |
| *Disturbed Land* | 0.5 | 0% |
| *Low Density Mixed* | 0.7 | 0% |
| *Medium Density Mixed* | 0 | 0% |
| *High Density Mixed* | 7.5 | 3% |
| *Low Density Residential* | 0 | 0% |
| *Medium Density Residential* | 0 | 0% |
| *High Density Residential* | 0 | 0% |
| *Farm Animals* | 138.1 | 63% |
| *Septic Systems* | 1.6 | 1% |
| ***Source Load Total:*** | **217.6** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Banks* | 0 | - |
| *Subsurface / Groundwater* | 38.7 | - |
| | | |
| ***Total Watershed Mass Load:*** | **256.3** | |

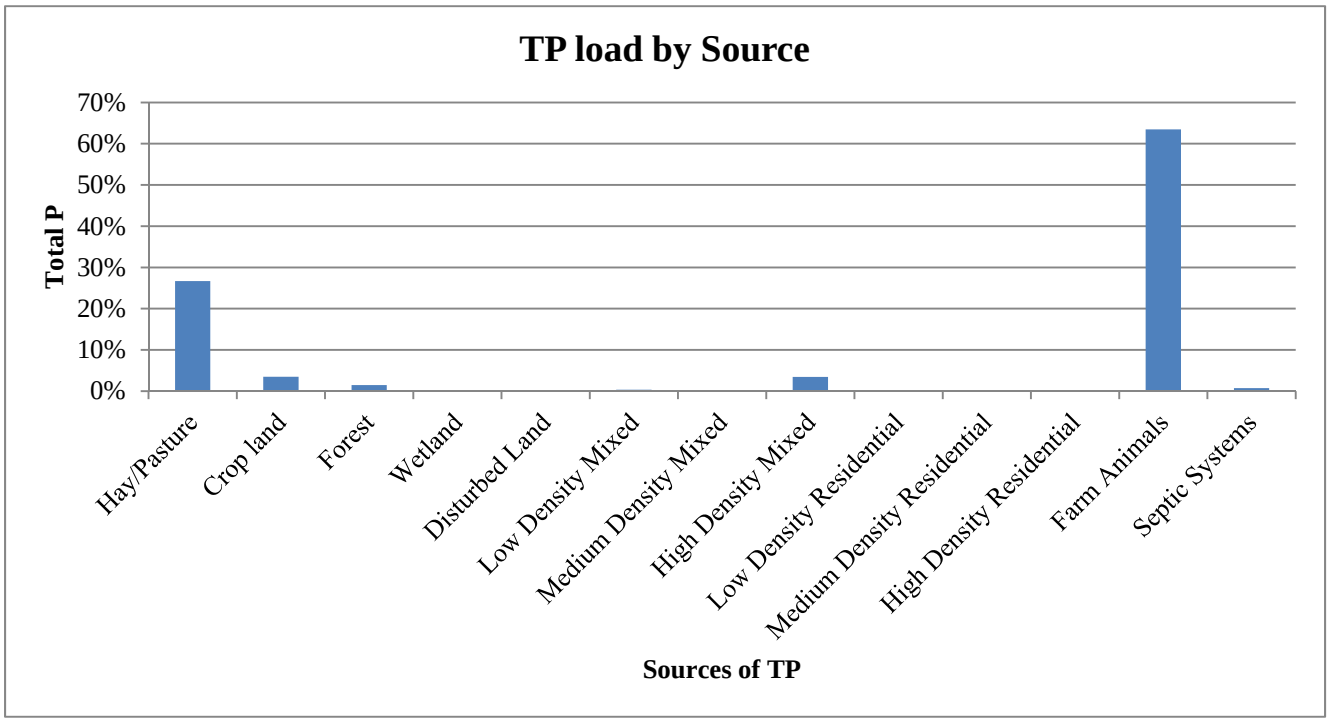



**Figure 7:** Total Phosphorus Loads by Source in the Adams Brook Watershed

## TMDL: TARGET NUTRIENT LEVELS FOR ADAMS BROOK

The existing nutrient and sediment loads for the impaired segment of Adams Brook are listed in Table 8 (below), along with the TMDL numeric target which was calculated as 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 nutrient and sediment loads in Adams 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 Adams Brook Pollutant Loading

| **TMDL POLLUTANT LOADS** Annual Loads per Unit Area | **Estimated Loads Adams Brook** | **Total Maximum Daily Load** | **TMDL % REDUCTIONS Adams Brook** |
|---|---|---|---|
| ***Sediment Load*** *(1000 kg/ha/year)* | **0.043** | **0.030** | **30%** |
| ***Nitrogen Load*** *(kg/ha/year)* | **12.47** | **5.2** | **58%** |
| ***Phosphorus Load*** *(kg/ha/year)* | **0.87** | **0.24** | **72%** |

### Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities has the potential to increase runoff and associated pollutant loads to Adams Brook. To ensure that the TMDL targets are attained, future agriculture or development activities will need to meet the TMDL targets. Future growth from population increases is a moderate threat in the Adams 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 are 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 BMP's can reduce sources of polluted runoff in Adams Brook. It is recommended that municipal officials, landowners, and conservation stakeholders in 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 Adams Brook;
- Address existing nonpoint source problems in the Adams Brook watershed by instituting BMPs where necessary; and
- Prevent future degradation of Adams Brook through the development and/or strengthening of local Nutrient Management Ordinance.

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

| **Adams Brook** | | | | |
|---|---|---|---|---|
| | **Area ha** | **Sediment 1000kg/yr** | **TN kg/yr** | **TP kg/yr** |
| **Land Uses** | | | | |
| *Hay/Pasture* | 105 | 5.45 | 142.11 | 58.07 |
| *Crop land* | 7 | 3.69 | 47.02 | 7.58 |
| *Forest* | 146 | 0.42 | 55.9 | 3.21 |
| *Wetland* | 5 | 0.01 | 3.85 | 0.21 |
| *Disturbed Land* | 9 | 0.14 | 1.09 | 0.51 |
| *Low Density Mixed* | 8 | 0.23 | 6.7 | 0.74 |
| *High Density Mixed* | 15 | 1.74 | 72.99 | 7.53 |
| **Other Sources** | | | | |
| *Farm Animals* | | | 746.34 | 138.11 |
| *Septic Systems* | | | 59.8 | 1.63 |
| **Pathway Loads** | | | | |
| *Groundwater* | | | 2542.49 | 38.73 |
| *Stream Banks* | | 1.02 | 0.99 | |
| Total Annual Load | | 12.7 x 1000 kg | 3679.3 kg | 256.3 kg |
| Total Area | 295 ha | | | |
| **Load per Unit Area** | | **0.043 1000kg/ha/year** | **12.47 kg/ha/year** | **0.87 kg/ha/year** |

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