DRAFT TMDL SUMMARY

Pleasant River

WATERSHED DESCRIPTION

This **TMDL** applies to a 11.2 mile section of Pleasant River, located in the towns of Windham and Gray, Maine. The impaired segment of Pleasant River begins at the confluence of Thayer Brook and Upper Pleasant River (attainment) in the northern portion of the watershed just south of Totten Road. Pleasant River flows south crossing Lawrence Road, Gray Road (Route 4), Brand Road, Belanger Avenue, Falmouth Road, William Knight Road, Route 302, Windham Center Road, Pope Road, and River Road before its confluence with the Presumpscot River. The Pleasant River watershed covers an area of 48.92 square miles.

- Runoff from agricultural land located throughout the southern portion of the watershed is likely the largest source of **nonpoint source (NPS) pollution** to Pleasant River. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Pleasant River watershed is predominately non-developed (89.5%). Forested areas (74.4%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (5.3%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (9.5%) and developed (10.5%) and are located throughout the watershed.
- Developed areas (10.5%) with impervious surfaces in close proximity to the steam may impact water quality.
- Pleasant River 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: ME0106000103_607R12

Town: Windham and Gray, ME

County: Cumberland

Impaired Segment Length: 11.2 miles

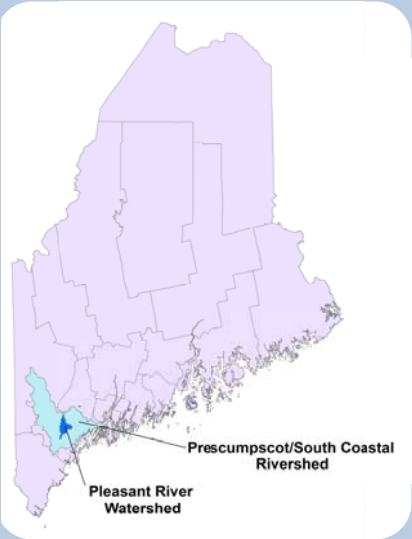
Classification: Class B

Direct Watershed: 48.92 mi^2 (31,309 acres)

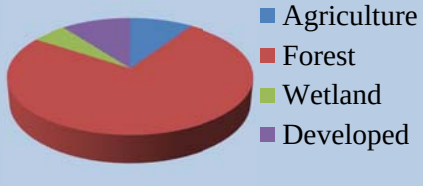
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 9.46%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



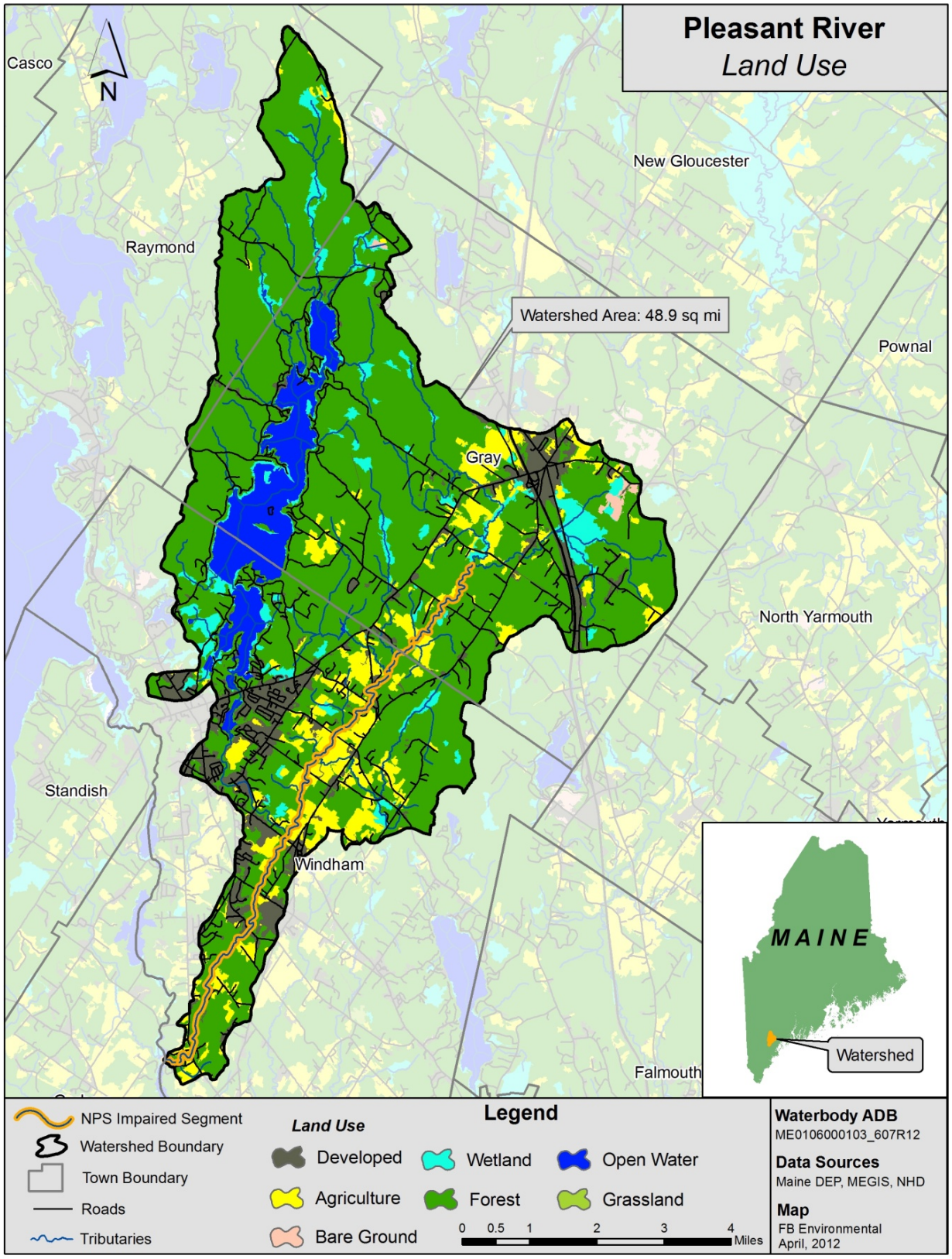


Figure 1: Land Use in the Pleasant River Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

Pleasant River, 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.

Pleasant River *near Pope Road crossing, Station 27. Photo: FB Environmental*

Agricultural land area makes up about 10% of the Pleasant River watershed. This is slightly less than the area of developed land at 11% of the watershed. The Pleasant River watershed is heavily forested as forested lands account for almost 75% of the total area. However, 48% of the impaired stream segment length passes through agricultural land (Figure 1). Agriculture, therefore, is still likely to be the largest contributor of sediment and nutrient enrichment to the stream, especially from Mineral Springs Farm on Lotts Drive where a strong smell of manure was documented, 35 cows observed, and heavily trodden ground on the opposite side of river was observed, indicating a potential cow-crossing. 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). The aquatic life impairment in Pleasant River is based on historic dissolved oxygen data. In addition, periphyton data at station 544 in 1999, station 548 in 2010, and station 549 in 1999 and 2000 suggest a potential impairment, although this is not the current listing cause. Benthic macroinvertebrate data from 2005 and 2010 indicated class B attainment.

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

TMDL ASSESSMENT APPROACH: NUTRIENT MODELING OF IMPAIRED AND ATTAINMENT STREAMS

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

The nutrient loading estimates for the impaired stream were compared to similar estimates for five non-impaired (attainment) streams of similar watershed land uses across the state. The TMDL for the impaired stream was set as the mean nutrient loading estimate of these attainment stream watersheds, and units of mass per unit watershed area per year (kg/ha/year) were used. The difference in loading estimates between the impaired and attainment watersheds represents the percent reduction in nutrient loading required under this TMDL. The attainment streams, nutrient loading estimates, and TMDL are presented below in Table 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 stream. 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, Pleasant River received a score of 190 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.

There are several possible explanations for why the habitat assessment score for this watershed is higher than the score of its reference stream. First, the habitat assessment was 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 Pleasant River watershed, the downstream sample station was located in a forested portion of the stream with a thick buffer, while not all of the stream flows through forested areas within the watershed.

Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for the Pleasant River. These scores show that habitat is not a factor in the impairment of the Pleasant River, it is important to look for other potential sources within the watershed leading to impairment. Consideration should be given to major "hot spots" in the Pleasant River watershed as potential sources of NPS pollution contributing to the water quality impairment.

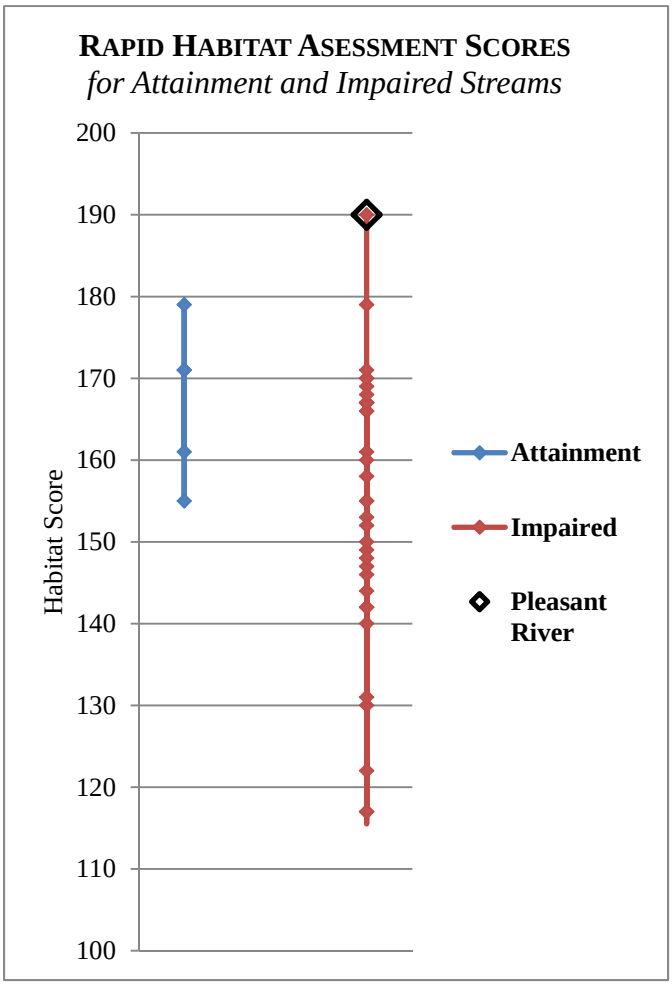


Figure 2: Habitat Assessment Scores by Region

Pollution Source Identification

Pollution source identification assessments were conducted for both Pleasant River (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 the Pleasant River was completed on July 5, 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 Pleasant River Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	Falmouth Road	Road Crossing/ Agriculture	• Agricultural fields with row crops, most likely corn, were observed close to the river near the Falmouth Road crossing. • A mowed lawn also exists with minimal buffer to the stream.
3	William Knight Road	Agriculture	• Agricultural fields with row crops were observed near the William Knight Road crossing with adequate buffer. • However, currently inactive fields adjacent to row crops have a very small buffer from the stream.
4	Old Route 202/Lott's Drive	Agriculture	• Active agricultural fields with a strong smell of manure were documented on Lott's Drive on the grounds of Mineral Springs Farm in Windham. • Approximately 30-35 cows were observed on the farm near the river, and have direct access to the river that runs through a grazing area. • This portion of the Pleasant River does not have a buffer, and from aerial photographs, you can see that cows cross the river. Heavily trodden ground and walking trails are visible. • Row crops were also observed within 20 m of the river.
7	Windham Center Road	Road Crossing	• A heavily eroded road shoulder at the Windham Center Road crossing provided evidence of large volumes of runoff at this site. • Riparian buffer is not adequate here as soil travels down slope toward stream.
9	Pope Road	Road crossing	• Recent road undercutting and erosion was documented at the Pope Road stream crossing. Ditches were vegetated.

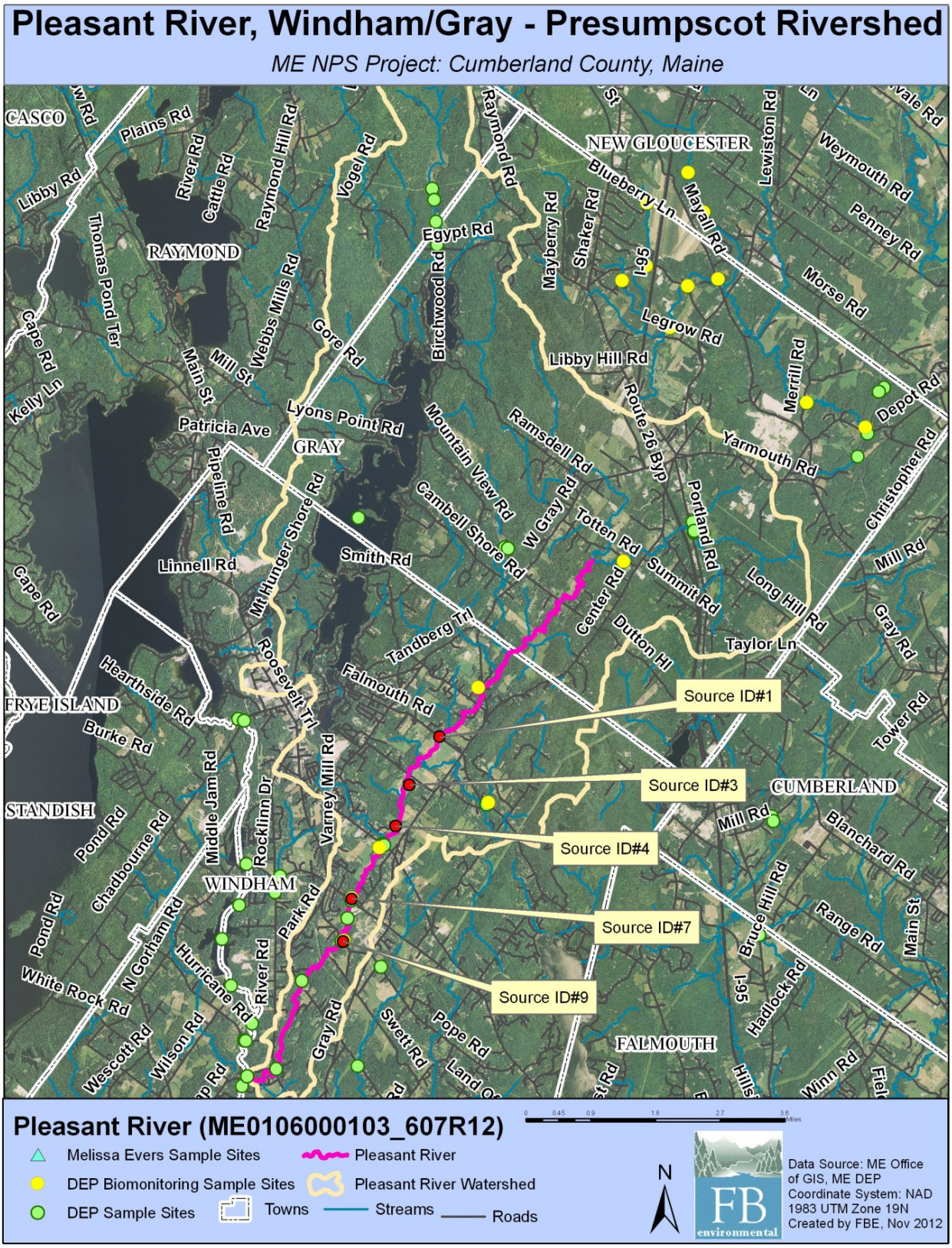


Figure 3: Aerial Photo of Source ID locations in the Pleasant River Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

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

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

Livestock Estimates

Livestock waste contains nutrients which can cause water quality impairment. The nutrient loading model considers numbers and types of animals. Table 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 Pleasant River Watershed

Type	Pleasant River
Dairy Cows	35
Beef Cows	
Broilers	
Layers	
Hogs/Swine	
Sheep	
Horses	
Turkeys	
Other	
Total	**35**

The Pleasant River watershed is predominantly forested, but also has substantial mixed agricultural and developed land uses. Large areas of corn fields and hay were documented throughout the watershed, as well as a dairy farm on Old Route 202 (Lotts Drive). At this property, cows have direct access to the Pleasant River near the road crossing. No buffer exists here, exposed banks are heavily trodden by cows, and paths have formed through the river as a result. Row crops are also present within about 20 meters of the river.

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

Pleasant River
• 98.8 stream miles in watershed (includes ephemeral streams) • 3.2 stream miles in agricultural areas • **16%** of agricultural stream miles have a vegetated buffer

The Pleasant River is an 11.2 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 98.8 miles. Of this total,

3.2 stream miles are located within agricultural areas and 0.5 miles or 16% 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 watersheds ranged from 34% to 92%, with an average of 61%.

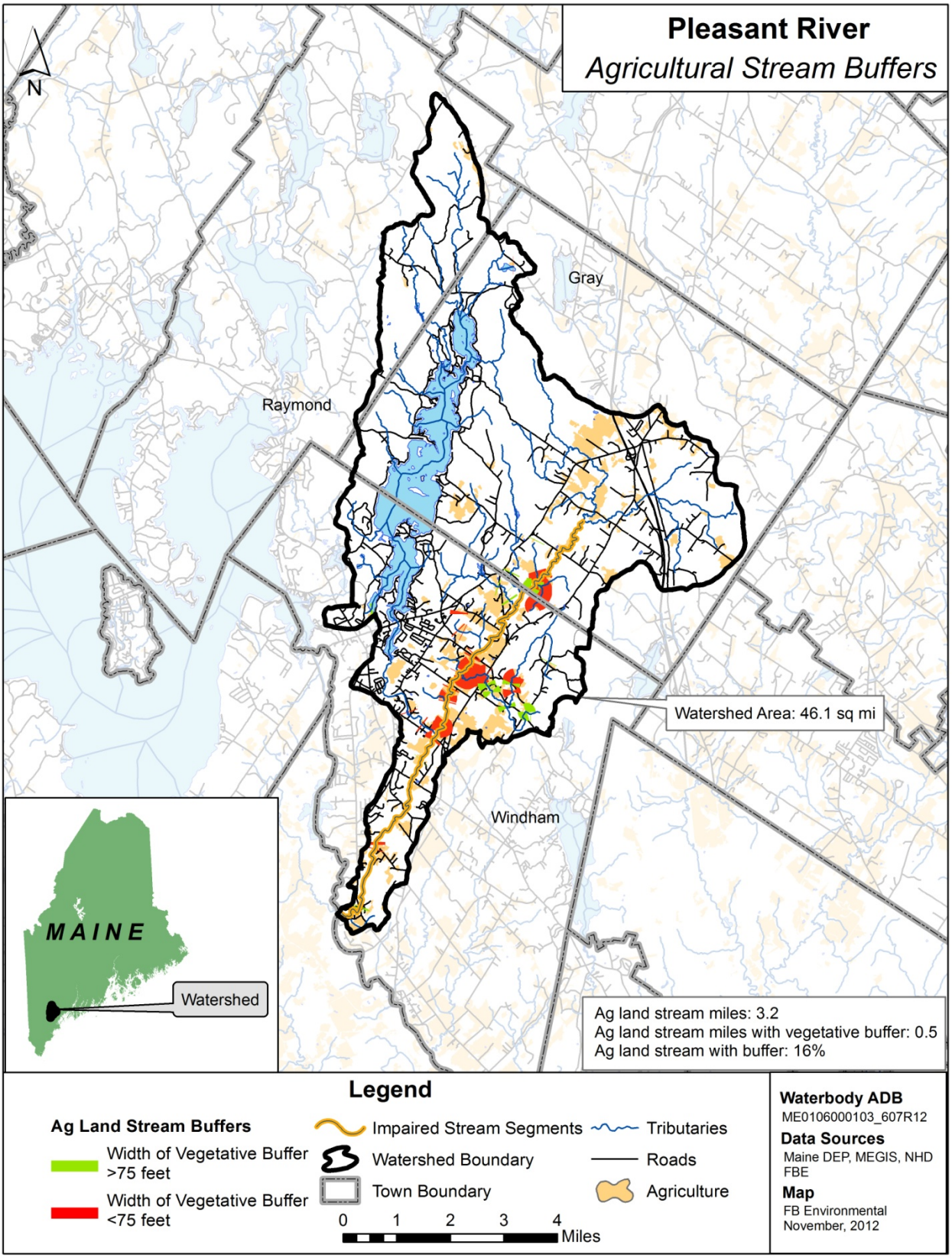


Figure 4: Buffered Agricultural Stream Miles in the Pleasant River watershed

Best Management Practices (BMPs)

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

- *Cover Crops:* Cover crops are the use 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. Little Sebago Lake is located in the northwestern portion of the Pleasant River watershed. It is estimated that 25% of the Pleasant River watershed drains into ponds or wetlands, primarily Little Sebago Lake in the northwestern portion of the watershed. 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 the Pleasant River indicate reductions of nutrients and sediment are needed to improve water quality. Below, loading for sediment, nitrogen and phosphorus are discussed individually.

Sediment

Sediment loading in the Pleasant River watershed is mainly derived from cropland and hay/pasture which, combined, account for 62% of the total load. Forested lands also contribute a significant portion of the load at 20%, respectively. Development also contributes 19% of the total sediment load in the Pleasant River (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 Pleasant River* (below) for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Load by Source

Pleasant River	Sediment (1000kg/year)	Sediment (%)
Source Load		
Hay/Pasture	76.79	21%
Crop land	152.55	41%
Forest	73.42	20%
Wetland	1.22	0%
Disturbed Land	0	0%
Sandy Areas	0	0%
Low Density Mixed	24.89	7%
Medium Density Mixed	0	0%
High Density Mixed	43.75	12%
Low Density Residential	1.04	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**373.66**	**100%**
Pathway Load		
Stream Banks	411.88	-
Subsurface / Groundwater	0	-
Total Watershed Mass Load:	**785.54**	

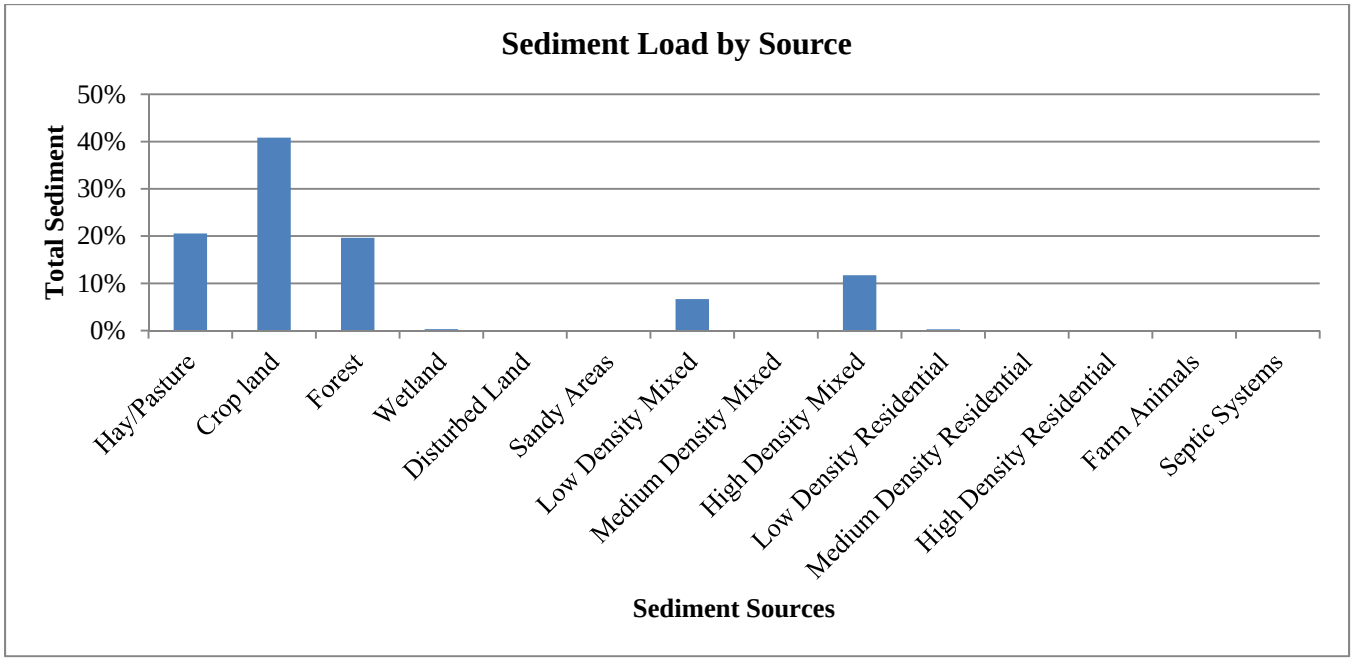


Figure 5: Total Sediment Loads by Source in the Pleasant River Watershed

Total Nitrogen

Nitrogen loading is attributed to agriculture, with combined agricultural sources making up 33% of the sediment load in the Pleasant River. Forested lands also contribute a significant portion of the load at 26%, respectively. Development and septic systems each contribute 19% and 17% of the total load. Table 6 and Figure 6 (below) shows estimated total nitrogen load in terms of mass and percent of total by source, in the Pleasant River. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for Pleasant River* (below) for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Pleasant River	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	1989.1	13%
Crop land	2358.5	16%
Forest	3864.9	26%
Wetland	591.1	4%
Disturbed Land	0	0%
Sandy Areas	0.0	0%
Low Density Mixed	796.9	5%
Medium Density Mixed	0	0%
High Density Mixed	2082.7	14%
Low Density Residential	33.4	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	668.1	4%
Septic Systems	2499.8	17%
Source Load Total:	**14884.4**	**100%**
Pathway Load		
Stream Banks	310.4	-
Subsurface / Groundwater	55274.7	-
Total Watershed Mass Load:	**70469.5**	

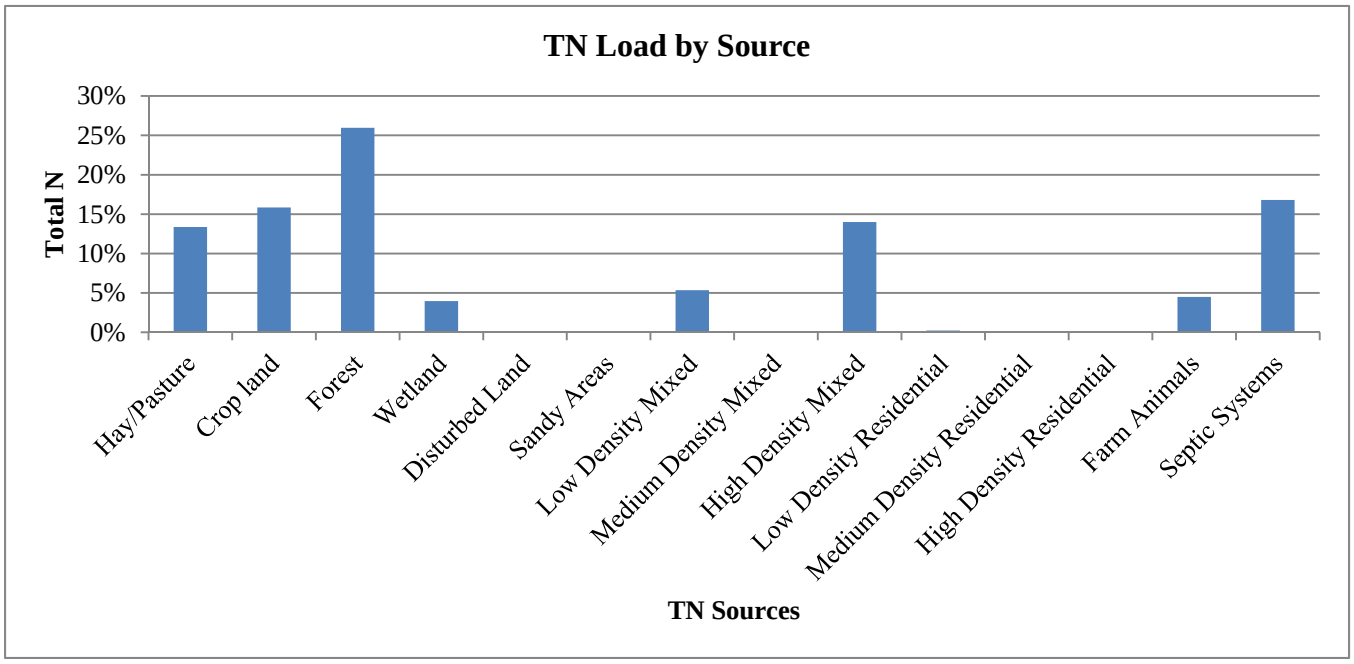


Figure 6: Total Nitrogen Loads by Source in the Pleasant River Watershed

Total Phosphorus

Phosphorus loading within the watershed is attributed primarily to hay and pasture (37%), with combined agricultural sources contributing over 60% of the total load. Development also contributes a significant portion of the load at 18%. 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 Pleasant River* (below) for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Pleasant River	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	596.3	37%
Crop land	248.0	15%
Forest	234.1	14%
Wetland	30.4	2%
Disturbed Land	0	0%
Sandy Areas	0	0%
Low Density Mixed	86.9	5%
Medium Density Mixed	0	0%
High Density Mixed	209.1	13%
Low Density Residential	3.6	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	146.4	9%
Septic Systems	65.4	4%
Source Load Total:	**1620.2**	**100%**
Pathway Load		
Stream Banks	79.8	-
Subsurface / Groundwater	1574.6	-
Total Watershed Mass Load:	**3274.6**	

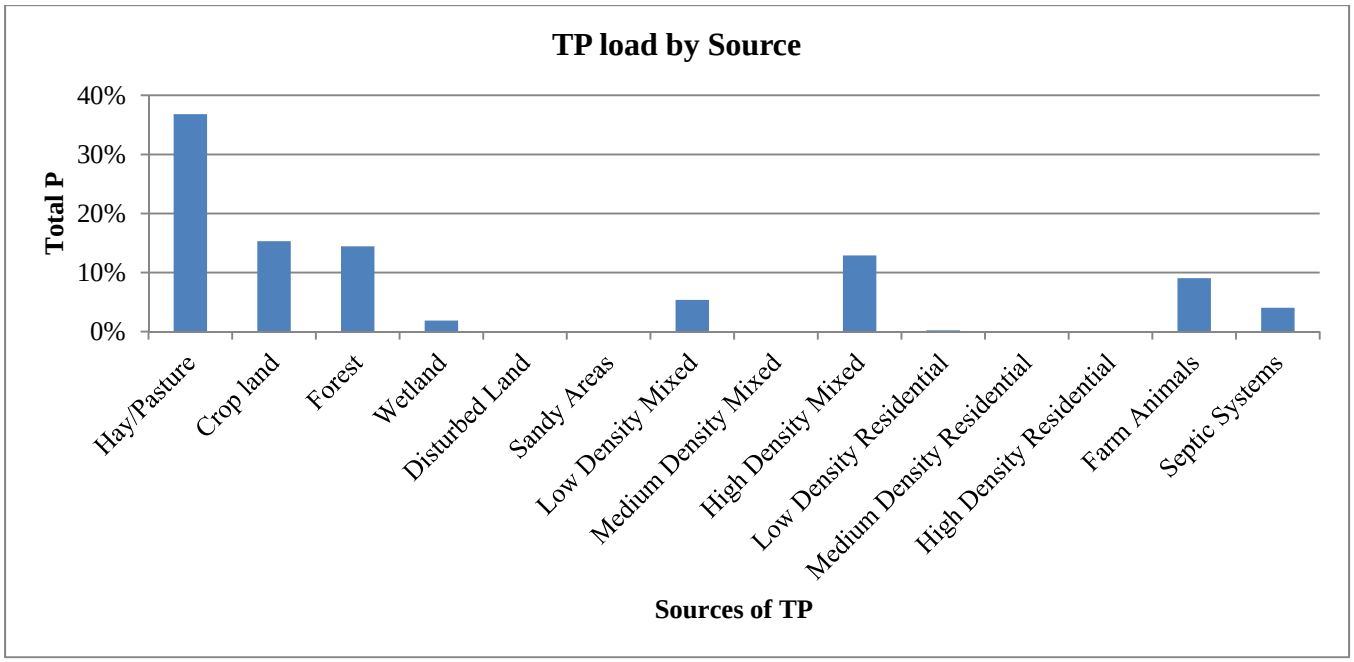


Figure 7: Total Phosphorus Loads by Source in the Pleasant River Watershed

TMDL: TARGET NUTRIENT LEVELS FOR THE PLEASANT RIVER

The existing loads for nutrients and sediments in the impaired segment of the Pleasant River are listed in Table 8, along with the TMDL 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 nutrient and sediment loads in the Pleasant River 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 the Pleasant River Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads Pleasant River**	**Total Maximum Daily Load**	**TMDL % REDUCTIONS Pleasant River**
Sediment Load *(1000 kg/ha/year)*	**0.066**	**0.030**	**55%**
Nitrogen Load *(kg/ha/year)*	**5.92**	**5.2**	**12%**
Phosphorus Load *(kg/ha/year)*	**0.28**	**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 the Pleasant River. 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 Pleasant River watershed because Cumberland County has increasing population trends, with a 3.9% increase between 2000 and 2008 (USM MSAC, 2009). The growth in agricultural lands is also increasing, with a 6% increase in the total number of farms in Cumberland County between 2002 and 2007. However, a decrease of 5% was seen in the land (acres) in farms between 2002 and 2008, and a 10% decrease occurred in the average farm size in this time period as well (USDA, 2007a). Future activities and BMPs that achieve TMDL reductions are addressed below.

Next Steps

The use of agricultural and developed area BMP's can reduce sources of polluted runoff in the Pleasant River. It is recommended that municipal officials, landowners, and conservation stakeholders in Windham and Gray 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 the Pleasant River
- Address existing nonpoint source problems in the Pleasant River watershed by instituting BMPs where necessary; and
- Prevent future degradation of the Pleasant River through the development and/or strengthening of local Nutrient Management Ordinance.

Table 9: Modeling Results Calculations for Derived Numeric Targets and Reduction Loads for Pleasant River

Pleasant River				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	903	76.8	1989.1	596.3
Crop land	211	153.0	2358.5	248.0
Forest	8855	73.4	3864.9	234.1
Wetland	641	1.2	591.1	30.4
Disturbed Land	0	0.0	0.0	0.0
Low Density Mixed	836	24.9	796.9	86.9
High Density Mixed	419	43.8	2082.7	209.1
Low Density Residential	35	1.0	33.4	3.6
Other Sources				
Farm Animals			668.1	146.4
Septic Systems			2499.8	65.4
Pathway Loads				
Stream Banks		411.9	310.4	79.8
Groundwater			55274.7	1574.6
Total Annual Load		786 x 1000 kg	70469 kg	3275 kg
Total Area	11901 ha			
Total Maximum Daily Load		**0.066 1000kg/ha/year**	**5.92 kg/ha/year**	**0.28 kg/ha/year**

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