TMDL Summary

Appendix 6-17

Chandler River

Watershed Description

This **TMDL** applies to a 27.19 mile section of the Chandler River, including its eastern branch, located in the Towns of Duram, Pownal and North Yarmouth, Maine. The headwaters of the Chandler River are at the outlet of Runaround Pond in Durham. The river flows south, crossing Runaround Pond Road, then through a wooded area before crossing Poland Range Road, Lawrence Road, Elmwood Road, and Chadsey Road, in an area of mixed forest, agriculture and residential development. The river continues south, crossing Milliken Road, and meets with the East Branch before flowing south to its convergence with the Royal River in Gray. The East Branch originates in a wetland complex in Durham. The river flows south through a predominantly forested area before crossing Quaker Meeting House Road, Brown Road, Poland Range Road, Tuttle Road and Elmwood Road. The river then crosses Hodsdon Road, flows north across Hallowell Road and then south again. Downstream of the West Pownal Road crossing, the East Branch meets the main stem of the Chandler River.

The Chandler River watershed covers an area of 51.89 square miles. The majority of the watershed is located with0in the Town of Pownal, however, smaller portions of the watershed lie within the surrounding towns of Auburn, New Gloucester, Durham, Brunswick, Freeport, Gray, and North Yarmouth.

- Runoff from agricultural land along Tuttle Road is likely the largest source of **nonpoint source (NPS) pollution** to the Chandler River. Runoff from cultivated lands, active hay lands, and pasture can transport nitrogen and phosphorus to the nearest section of the stream.
- The Chandler River watershed is predominately non-developed (95.8%). Forested areas (74.1%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (7%) may also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (14.3%). Developed areas (4.2%) with impervious surfaces may impact water quality.
- The Chandler River including its East Branch 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: ME0106000102_603R02

Town: Duram, Pownal, North Yarmouth, ME

County: Cumberland

Impaired Segment Length: 27.19 miles

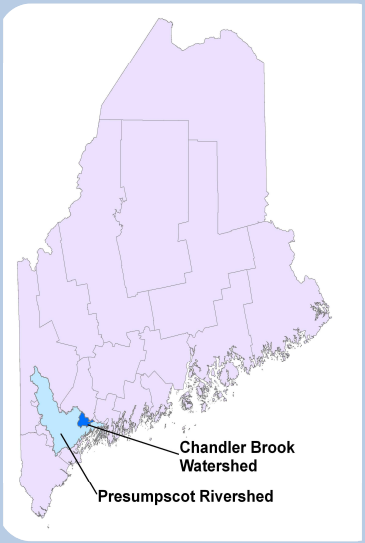
Classification: Class B

Direct Watershed: 51.89 mi^2 (33,210 acres)

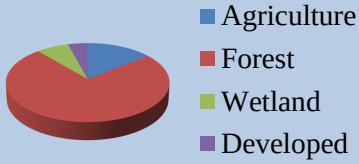
Impairment Listing Cause: Dissolved Oxygen

Watershed Agricultural Land Use: 14.3%

Major Drainage Basin: Presumpscot River



Watershed Land Uses



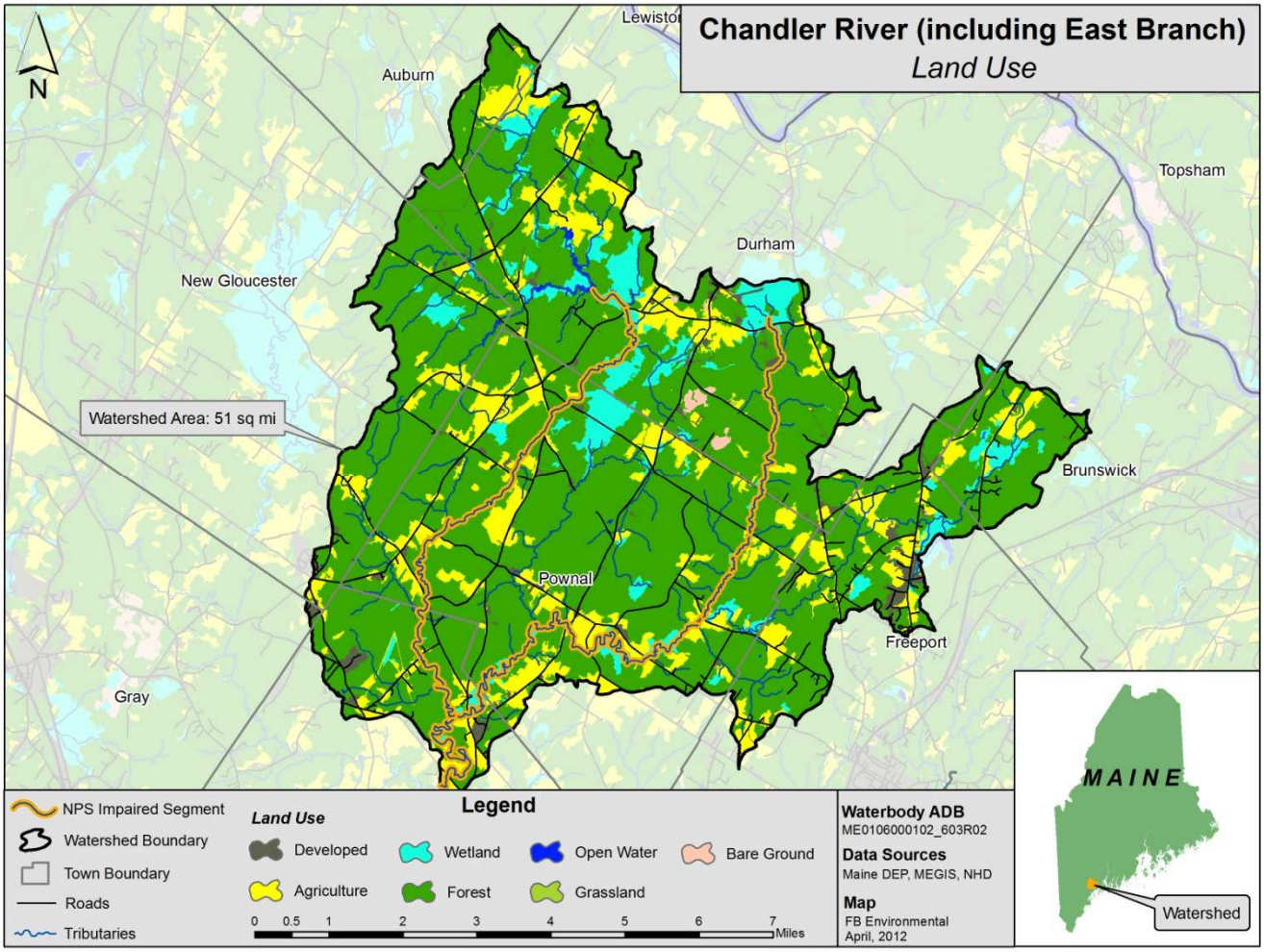


Figure 1: Land Use in the Chandler River Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

The Chandler River including its East Branch, 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.

Chandler River (East Branch) *at Tuttle Road. Photo: FB Environmental*

Agriculture in the Chandler River watershed makes up about 14% of the total land area, more than three times the area of developed land which accounts for about 4% of total land area (Figure 1). Agriculture is therefore likely to be the largest contributor of sediment and nutrient enrichment to the stream. The close proximity of many agricultural lands to the stream further increases

the likelihood that nutrients from disturbed soils, manure, and fertilizers will reach the stream. Along Tuttle Road, in particular, heavy erosion was documented as a result of livestock in 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 Chandler River 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 and physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on Rapid Bioassessment protocols for low gradient streams, the Chandler River received a score of 171 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.

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 Chandler River watershed, the downstream sample station was located in a forested portion of the stream with a thick buffer. Although there is some agriculture within the Chandler River watershed, a majority of the stream flows within forested areas.

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

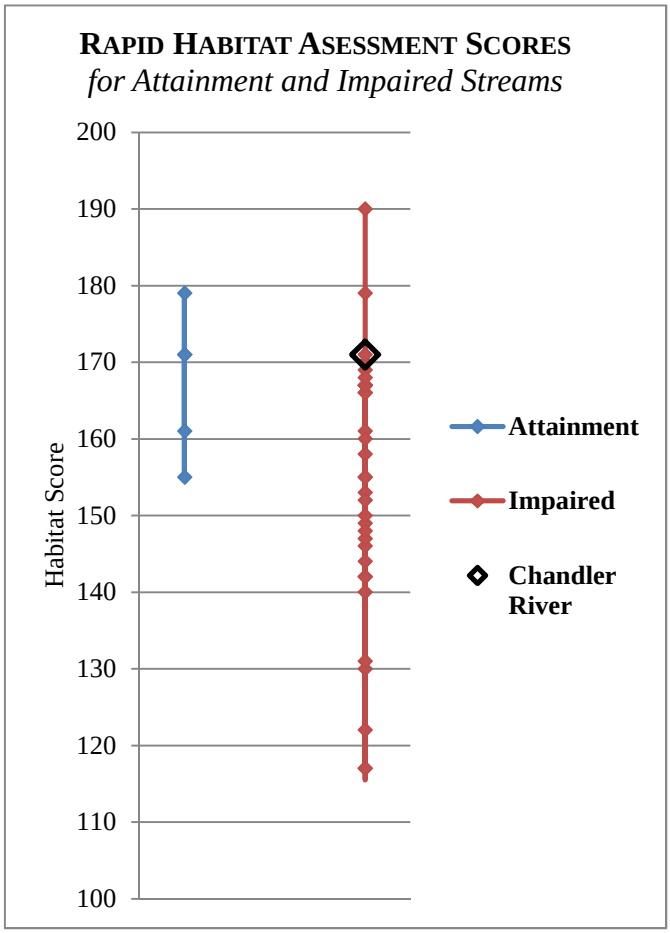


Figure 2: Habitat Assessment Scores

Pollution Source Identification

Pollution source identification assessments were conducted for both Chandler River (impaired) and the attainment streams. The source identification component of this study 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 Chandler River was completed on July 6, 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 1, Figure 3).

Table 2: Pollution Source ID Assessment for the Chandler River Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
9	Lawrence Road	Road Crossing/ Agriculture	• Moderate erosion observed at road crossing. • Residential property near crossing has a small pasture with approximately 5 sheep.
14	Chadsey Road	Road Crossing	• Severe erosion was observed at the Chadsey Road crossing. • The portion of roadway over bridge is paved though all roads leading to bridge are gravel/dirt roadways. • Some sediment is captured by a grassy buffer near the stream and a ditch leading to the crossing. • It is difficult to determine if all sediment is from unpaved roads or construction activity occurring nearby at a power line maintenance staging area.
26 & 27	Tuttle Road	Agriculture /Road Crossing	• Severe sedimentation due to livestock entering river. • No livestock was observed during field visit, however, ample evidence supports observations, e.g. trodden paths with direct access to the river, hoof prints on stream substrates, and large slumping banks contributing to sediment build-up within the river.
39	Elmwood Road (east of Lawrence Road)	Road Crossing	• Moderate road shoulder erosion along Elmwood Road is causing sedimentation at the road crossing. • Unstable areas were marked by DPW sawhorses at some locations. • A steep slope lies between Elmwood Road and Chandler River on the west (downstream) side of the road. • A field enclosed by a livestock fence was observed near the crossing. This field lies within close proximity to the river's edge with a very small vegetated buffer. No livestock was observed during the field visit.

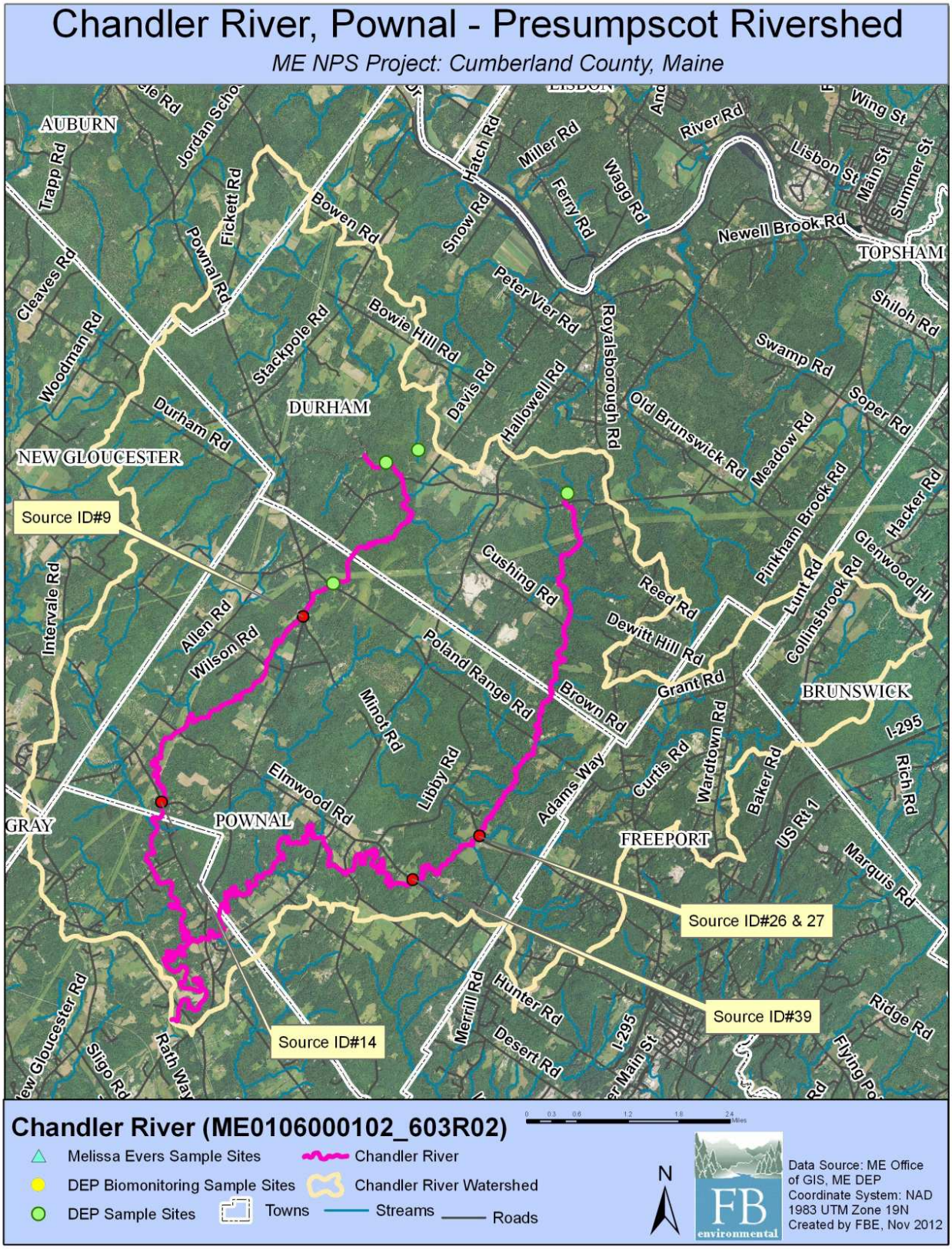


Figure 3: Aerial Photo of Source ID Locations in the Chandler River Watershed

NUTRIENT LOADING – MAPSHED ANALYSIS

The MapShed model was used to estimate stream loading of sediment, total nitrogen and total phosphorus in the Chandler 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 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 Chandler River Watershed

Type	Chandler River
Dairy Cows	30
Beef Cows	
Broilers	
Layers	
Hogs/Swine	20
Sheep	5
Horses	18
Turkeys	
Other	
Total	**73**

There are agricultural areas throughout the Chandler River watershed. Several NPS pollution sites were documented in the field including livestock. A cow farm located on Tuttle Road adjacent to the Tuttle Road stream crossing is a hotspot of pollution entering the Chandler River. At this location stream banks are significantly slumping and eroded due to livestock accessing the stream. The river flows through unfenced pasture, hoof prints and manure were observed in the river and on the banks. Significant sedimentation was observed downstream of the crossing. A strong manure smell was also present.

A pig breeding farm is located on Knoll Hill Farm on Hallowell Road. No livestock were observed, but 20 pigs were estimated based on multiple signs reading “pigs and piglets for sale.” Eighteen horses were observed throughout the watershed on two properties on West Pownal Road and Grant Road. Five sheep were also observed grazing along Lawrence Road.

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

Chandler River
• 82.8 stream miles in watershed (includes ephemeral streams)
• 1.74 stream miles in agricultural areas
• 98% of agricultural stream miles have a vegetated buffer

The Chandler River including its East Branch is a 27.2 mile-long impaired segment as listed by Maine DEP. As modeled, the total stream miles (including tributaries) within the watershed was calculated as 82.8 miles. Of this total, 1.74 stream miles are located within agricultural areas; of this length, 1.71 miles (98%) 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%.

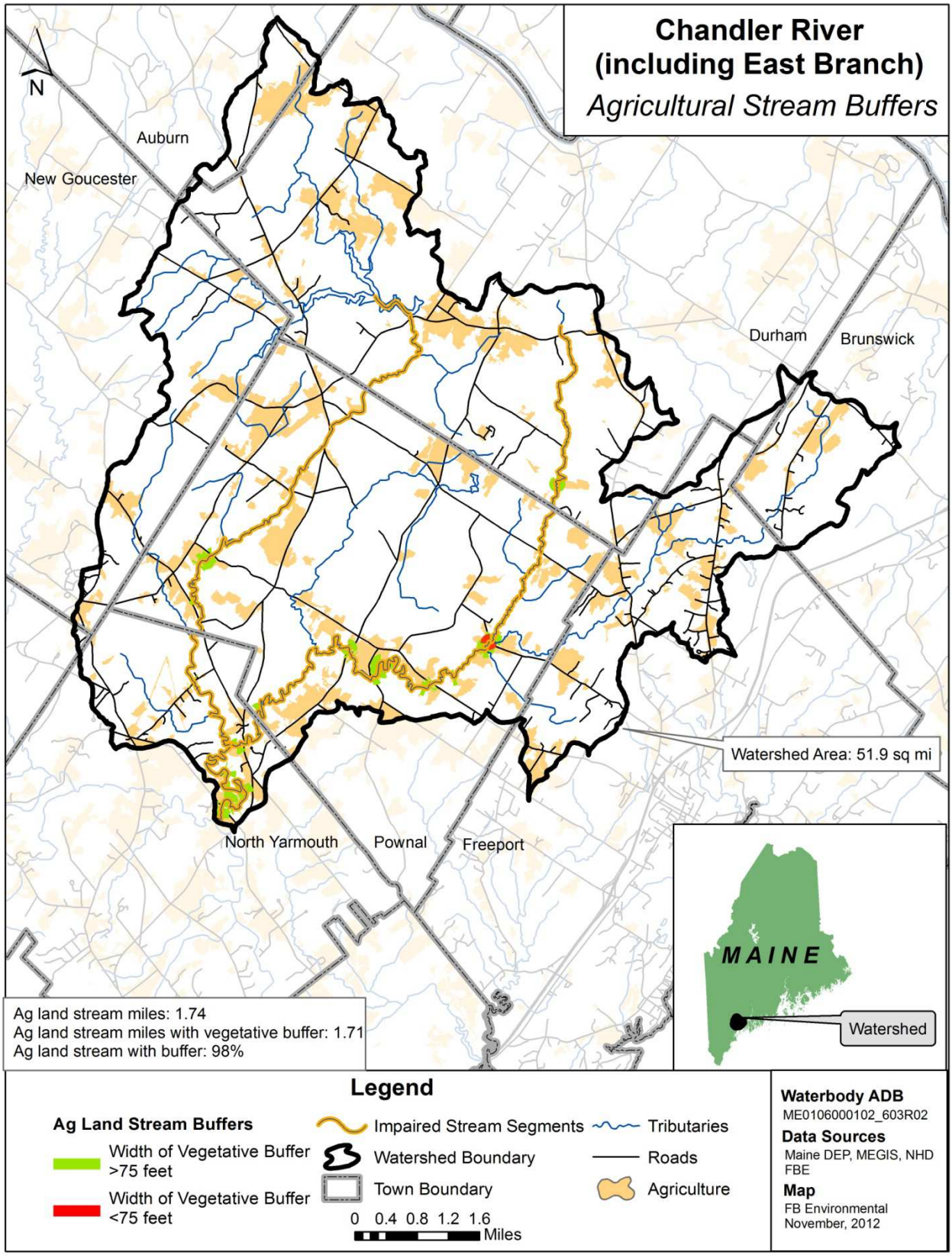


Figure 4: Buffered Agricultural Stream Miles in the Chandler River Watershed

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. The Chandler River watershed is 7% wetland, and overall 5% of the watershed drains to wetlands. 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 Chandler River indicate that significant 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 Chandler River watershed is mainly derived from hay/pasture which contributes 37% of the total load. Forested lands are also a main source of sediment accounting for 35% of the total sediment load. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for the Chandler River* (below) for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Loads by Source

Chandler River	**Sediment (1000kg/year)**	**Sediment (%)**
Source Load		
Hay/Pasture	145.32	37%
Crop land	53.93	14%
Forest	135.30	35%
Wetland	3.08	1%
Disturbed Land	4.32	1%
Low Density Mixed	9.46	2%
Medium Density Mixed	0	0%
High Density Mixed	39.38	10%
Low Density Residential	1.25	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	0	0%
Septic Systems	0	0%
Source Load Total:	**392.04**	**100%**
Pathway Load		
Stream Banks	331.13	-
Subsurface / Groundwater	0.00	-
Total Watershed Mass Load:	**723.17**	

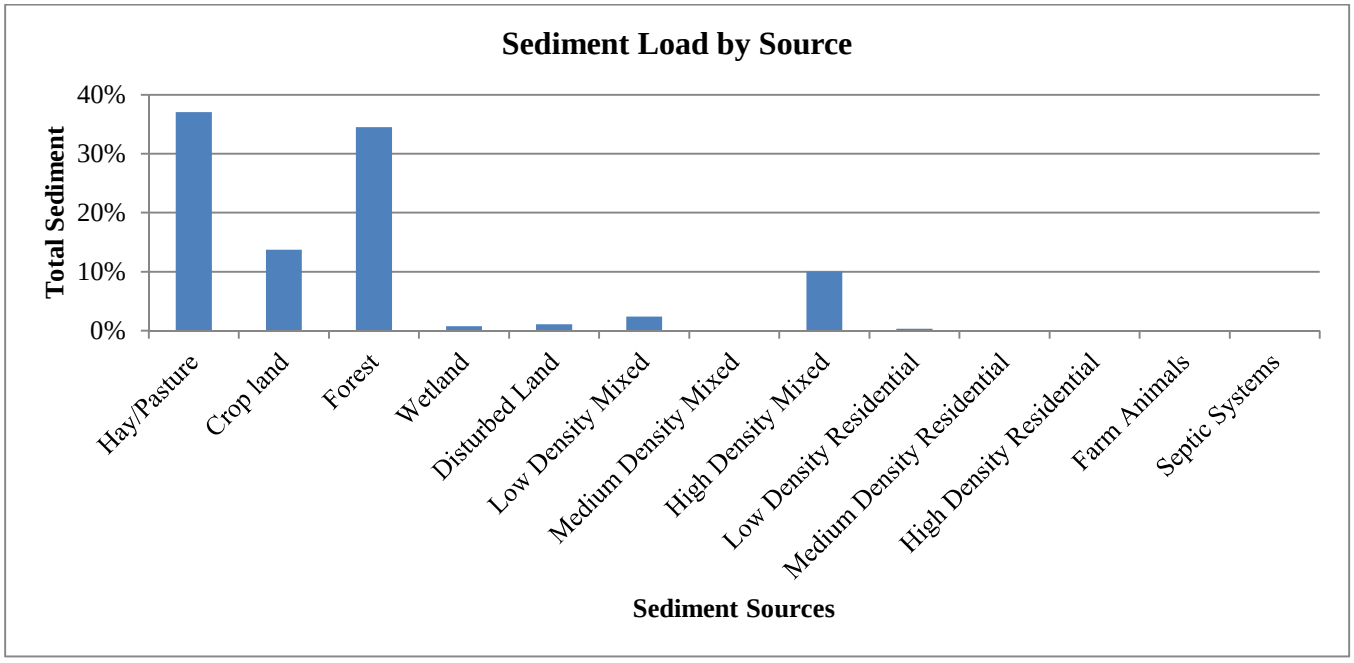


Figure 5: Total Sediment Loads by Source in the Chandler River Watershed

Total Nitrogen

Nitrogen loading in the Chandler River watershed is mainly attributed to forested lands which account for 41% of the total load. Hay/pasture and septic systems also contribute a significant percent of the load with 19% and 13%, respectively. Table 6 and Figure 6 (below) show the estimated total nitrogen load in terms of mass and percent of total by source in the Chandler River. Total loads by mass cannot be directly compared between watersheds due to differences in watershed area. See section *TMDL: Target Nutrient Levels for the Chandler River* (below) for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Loads by Source

Chandler River	**Total N (kg/year)**	**Total N (%)**
Source Load		
Hay/Pasture	2895.4	19%
Crop land	1024.6	7%
Forest	6419.5	41%
Wetland	883.5	6%
Disturbed Land	18.3	0%
Low Density Mixed	251.1	2%
Medium Density Mixed	0	0%
High Density Mixed	1584.2	10%
Low Density Residential	33.2	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	503.9	3%
Septic Systems	2010.7	13%
Source Load Total:	**15624.5**	**100%**
Pathway Load		
Stream Banks	177.9	-
Subsurface / Groundwater	62525.8	-
Total Watershed Mass Load:	**78328.2**	

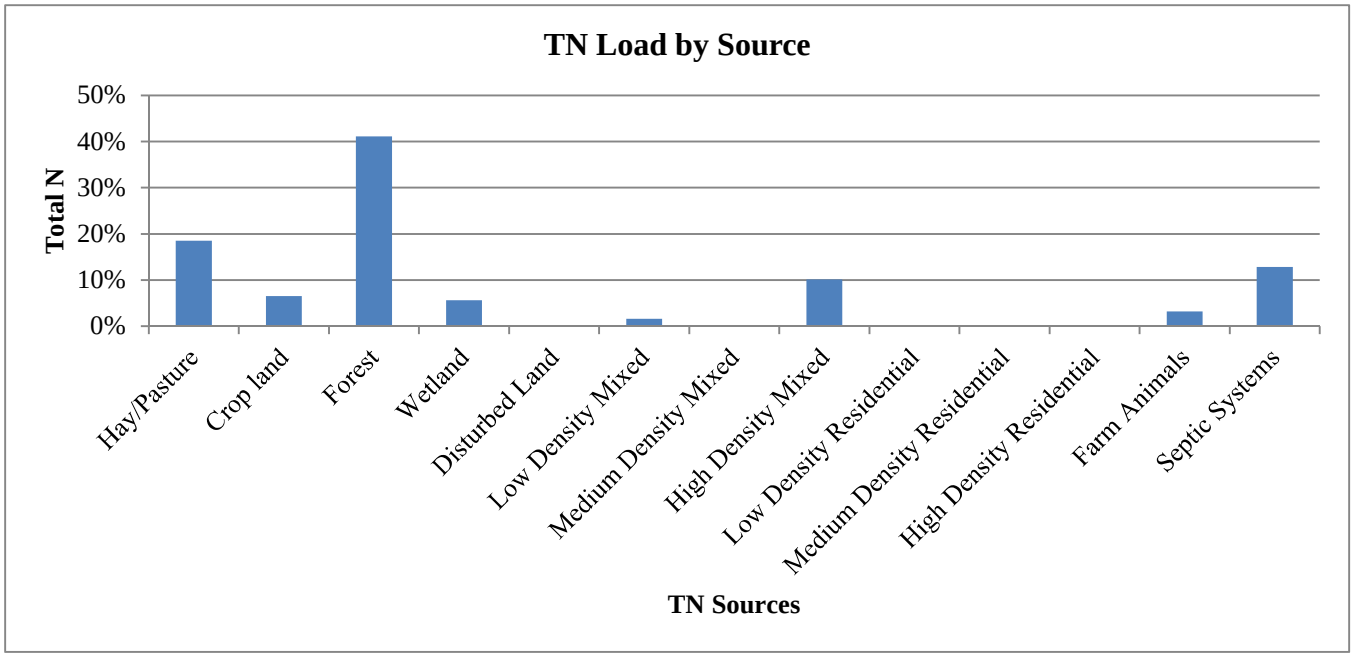


Figure 6: Total Nitrogen Loads by Source in the Chandler River Watershed

Total Phosphorus

Phosphorus loading in the Chandler River watershed is attributed primarily to hay/pasture lands (51%). 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 the Chandler River* (below) for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Loads by Source

Chandler River	**Total P (kg/year)**	**Total P (%)**
Source Load		
Hay/Pasture	1101.8	51%
Crop land	135.6	6%
Forest	424.2	19%
Wetland	48.1	2%
Disturbed Land	8.0	0%
Low Density Mixed	28.3	1%
Medium Density Mixed	0	0%
High Density Mixed	164.9	8%
Low Density Residential	3.7	0%
Medium Density Residential	0	0%
High Density Residential	0	0%
Farm Animals	99.1	5%
Septic Systems	165.6	8%
Source Load Total:	**2179.1**	**100%**
Pathway Load		
Stream Banks	65.0	-
Subsurface / Groundwater	1631.2	-
Total Watershed Mass Load:	**3875.4**	

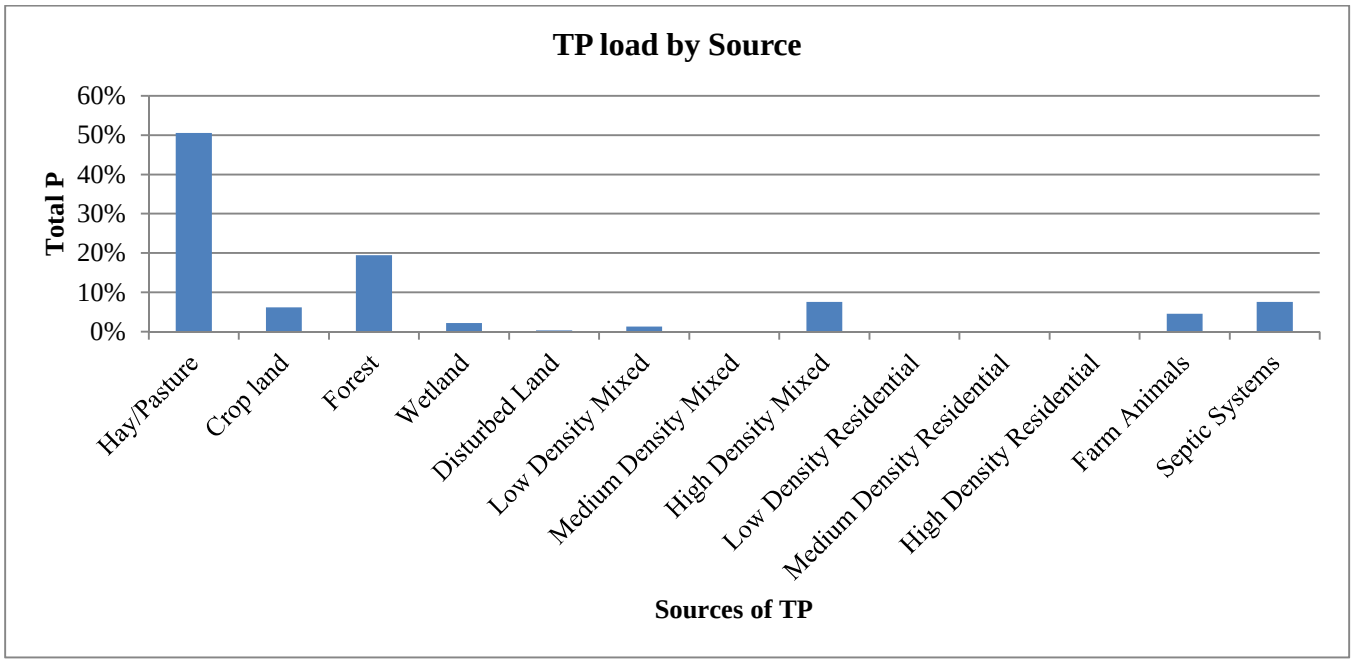


Figure 7: Total Phosphorus Loads by Source in the Chandler River Watershed

TMDL: TARGET NUTRIENT LEVELS FOR THE CHANDLER RIVER

The existing sediment and nutrient loads for the impaired segment of the Chandler River 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 the Chandler 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 Chandler River Pollutant Loading

TMDL POLLUTANT LOADS Annual Loads per Unit Area	**Estimated Loads for Chandler River**	**Total Maximum Daily Load Numeric Target**	**TMDL % REDUCTIONS Chandler River**
Sediment Load *(1000 kg/ha/year)*	**0.054**	**0.030**	**45%**
Nitrogen Load *(kg/ha/year)*	**5.88**	**5.2**	**12%**
Phosphorus Load *(kg/ha/year)*	**0.29**	**0.24**	**16%**

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 Chandler River. 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 Chandler 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 BMPs can reduce sources of polluted runoff in the Chandler River. It is recommended that municipal officials, landowners, and conservation stakeholders in Duram, Pownal and North Yarmouth 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 Chandler River;
- Address existing nonpoint source problems in the Chandler River watershed by instituting BMPs where necessary; and
- Prevent future degradation of the Chandler River 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 the Chandler River

Chandler River				
	Area ha	**Sediment 1000kg/yr**	**TN kg/yr**	**TP kg/yr**
Land Uses				
Hay/Pasture	1765	145.3	2895.4	1101.8
Crop land	147	53.9	1024.6	135.6
Forest	9805	135.3	6419.5	424.2
Wetland	933	3.1	883.5	48.1
Disturbed Land	73	4.3	18.3	8.0
Low Density Mixed	257	9.5	251.1	28.3
High Density Mixed	311	39.4	1584.2	164.9
Low Density Residential	34	1.3	33.2	3.7
Other Sources				
Farm Animals			503.9	99.1
Septic Systems			2010.7	165.6
Pathway Loads				
Stream Banks		331.1	177.9	65.0
Groundwater			62525.8	1631.2
Total Annual Load		723 x 1000 kg	78328 kg	3875 kg
Total Area	13326 ha			
Total Maximum Daily Load		**0.054 1000kg/ha/year**	**5.88 kg/ha/year**	**0.29 kg/ha/year**

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