TMDL SUMMARY — APPENDIX B-5

French Stream

WATERSHED DESCRIPTION

This **TMDL** applies to a 12.75 mile section of French Stream located in the Town of Exeter, Maine. French Stream begins near Chamberlain Meetinghouse Road. The stream flows east through a predominately forested area then crossing Stetson Road into a heavy agricultural area. The stream continues across Avenue Road and Mill Road before converging with Allen Stream at the intersection of Route 43 and Crane Road. It joins Kenduskeag Stream about 1 mi downstream. French Stream watershed covers an area of 38 square miles. The majority of the watershed is located within the Town of Exeter; small portions of the watershed lie within the surrounding towns of Garland, Corinth, Corinna and Dexter.

- French Stream is on Maine's 303(d) list of Impaired Streams as referenced in the 2016 Integrated Report (Maine DEP, 2018).
- The French Stream watershed is predominately non-developed (77.4%). Forested areas (60.6%) within the watershed absorb and filter pollutants helping protect both water quality in the stream and stream channel stability. Wetlands (16.8%) also help filter nutrients.
- Non-forested areas within the watershed are predominantly agricultural (17.7%, 10% is cropland) and concentrated in the center of the watershed along Stetson Road, Fogler Road, and Between the Mills Road.
- Developed areas (1.7%) with impervious surfaces in close proximity to the stream may impact water quality.
- Runoff from agricultural land located in the areas of Stetson Road, Fogler Road, and Between the Mills Road, are likely the largest sources of nonpoint source (NPS) pollution to French Stream. Runoff from cultivated lands, active hay lands, and grazing areas can transport sediment, nitrogen and phosphorus to the stream.

Definitions

- ***Total Maximum Daily Load (TMDL)*** *represents the total amount of a pollutant 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: ME0102000510_224R03

Town: Exeter, ME

County: Penobscot

Impaired Segment Length: 12.75 miles

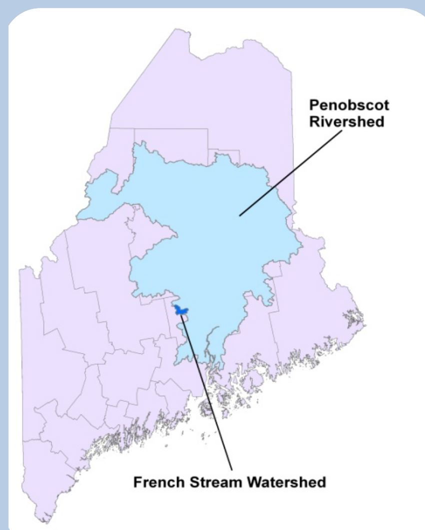
Classification: Class B

Direct Watershed: 38 mi^2 (24,320 acres)

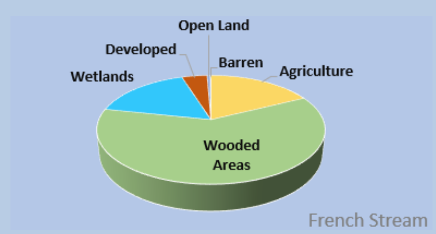
Impairment Listing Cause: Benthic macroinvertebrate and periphyton

Watershed Agricultural Land Use: 17.7%

Major Drainage Basin: Penobscot River



Watershed Land Uses



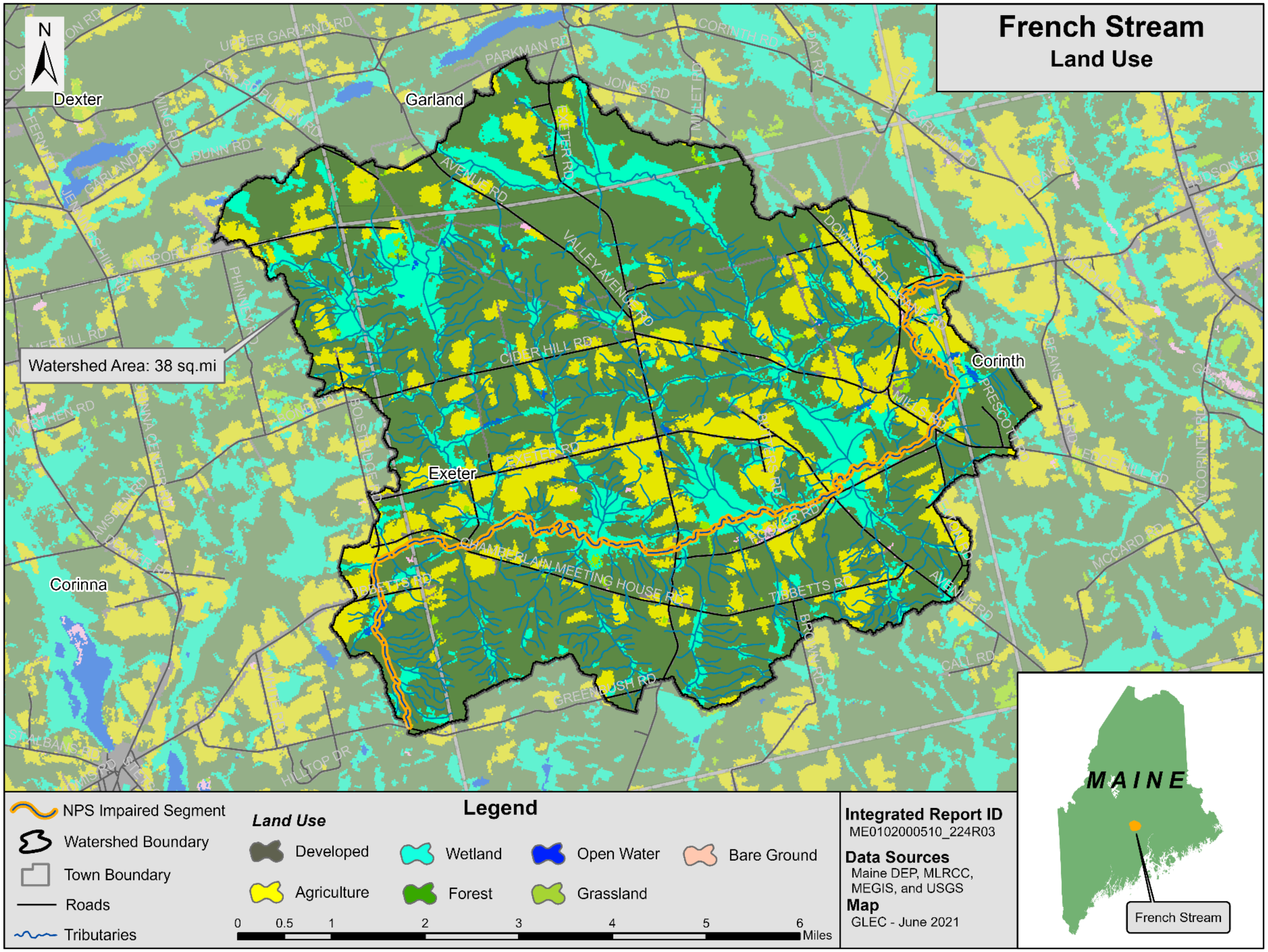


Figure 1: Land Use and Land Cover (from 2016) in the French Stream Watershed

WHY IS A TMDL ASSESSMENT NEEDED?

French Stream, a Class B freshwater stream, has been assessed by Maine DEP as not meeting water quality standards for the designated use of aquatic life, and placed on the 303(d) list of impaired waters under the Clean Water Act. The Clean Water Act requires that all 303(d)-listed waters undergo a Total Maximum Daily Load (TMDL) assessment that describes the impairments and establishes a target to guide the measures needed to restore water quality. The goal is for all waterbodies to comply with state water quality standards.

***French Stream** near Mill Road crossing. Photo: FB Environmental*

Agriculture (cropland, hay and pasture land) in the French Stream watershed makes up about 17.7% of the land area. This is approximately five times the developed land area in the French Stream watershed. 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.

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). 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 the numeric aquatic life criteria of the class assigned to the stream or river (Davies and Tsomides, 2002). Maine DEP uses an analogous model to aid in the assessment of algal communities but makes aquatic life use determinations based on narrative standards.

The aquatic life impairment in French Stream and its tributaries is based on macroinvertebrate and periphyton (algae) data collected from 2001 to 2016. All segments in the watershed have a Class B designation. At station S-505 on French Stream in 2016, periphyton did not meet (attained Class C) whereas macroinvertebrates did meet its Class B designation. At station S-308 on Allen Stream in 2011 and 2016, macroinvertebrates did meet its Class B designation. Allen Stream is the main tributary to French Stream and occupies the northern half of the watershed area. Station S-310 on French Stream was last sampled in 2001 and did meets its Class B designation. In addition to these stream stations, the wetland station W-142 in 2006 showed attainment of class A standards.

TMDL ASSESSMENT APPROACH: NUTRIENT AND SEDIMENT 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, an online nutrient loading model, *Model My Watershed* (v. 1.32.0), was used to estimate the sources of pollution based on well-established hydrological equations (Stroud Water Research Center 2017). *Model My Watershed* makes use of the GWLF-enhanced model engine. The model incorporates detailed maps of soil, land use, and slope, daily weather and localized weather data (from the period 2009-2020), and direct observations of agriculture and other land uses within the watershed. *Model My Watershed* is derived from its parent MapShed developed by Evans and Corradini (2012). *Model My Watershed* replaced MapShed in 2017-2018.

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 Model My Watershed Outputs (2021) for Attainment Streams

Attainment Streams	Town	Total P Load (kg/ha/yr)	Total N Load (kg/ha/yr)	Sediment Load (kg/ha/yr)
Footman Brook	Exeter	0.17	1.73	35.2
Martin Stream	Fairfield	0.13	2.98	57.9
Moose Brook	Houlton	0.18	1.59	48.5
Upper Kenduskeag Stream	Corinth	0.16	1.72	100.5
Upper Pleasant River	Gray	0.16	4.26	86.5
Total Maximum Daily Load		**0.16**	**2.46**	**65.7**

RAPID WATERSHED ASSESSMENT

Habitat Assessment

A habitat assessment survey was conducted (in 2012) 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 and physical characterization and visual assessment of in-stream and riparian habitat quality.

Based on rapid bioassessment protocols for low gradient streams, French Stream received a score of 167 out of a total 200 for quality of habitat. Higher scores indicate better habitat. The range of habitat 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 French Stream watershed, the downstream sample station was located in a forested portion of the stream with a thick buffer, while the majority of the stream and associated tributaries flow in close proximity to agricultural lands.

Figure 2: Habitat Assessment Score for French Stream (2012) Compared to Region

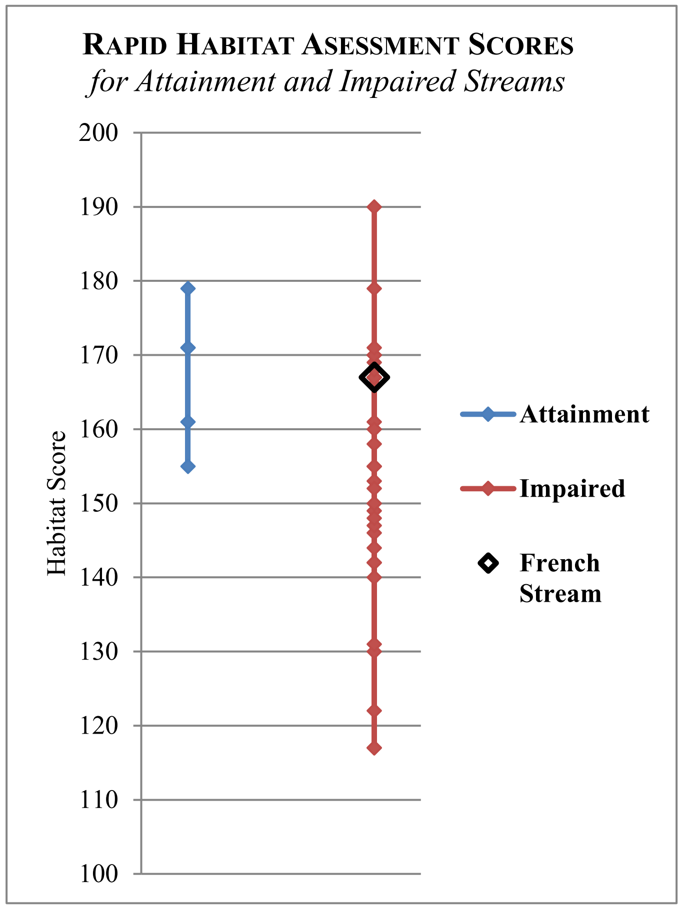


Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for French Stream. Stream habitat for this portion of French Stream is in the upper range of performing well, but it is also important to look for other potential sources within the watershed leading to impairment. Consideration should be given to major "hot spots" in the French Stream watershed as potential sources of NPS pollution contributing to the water quality impairment.

Pollution Source Identification

Pollution source identification assessments were conducted in 2012 for both French Stream (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 French Stream was completed in July 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: Potential Pollution Source ID Assessment (2012) for the French Stream Watershed

Potential Source			Notes
ID#	**Location**	**Type**	
1	Crane Road	Ag	• Large active cropland in close proximity to stream; corn and hay. • Stream flows adjacent to fields to the west and north of farm property located just south of Crane Road/Rte. 43 intersection. • Adequate forested buffer along most of stream length.
2	Exeter Road	Ag	• Very large agricultural fields located north and south of Exeter Road. • Large scale irrigation systems were observed in use during assessment. • Corn and potato fields observed.
3	Mill Road	Ag, Road crossing	• No erosion was observed at road crossing. • Adequate buffer exists between stream and surrounding agricultural fields. • Farm pond located on adjacent property displaying signs of eutrophication.
8	Avenue Road & Fogler Road	Ag, Road crossing	• Farm observed adjacent to stream with 5 horses and a stable observed in close proximity. • Corn and hay fields surrounding.
9	Fogler Road	Ag	• Large dairy farm located on the north side of Fogler Road. • Grazing areas, cropland, and hay land surrounding on both sides of road. • Large manure piles observed; very strong manure odor in this area.
11	Stetson Road	Ag	• Large corn and potato fields. • Irrigation systems in use during visit. • Tributaries run through fields and associated hay lands.
13	Stetson Road	Ag, Road crossing	• No major erosion observed at road crossing. • Agricultural fields surround crossing area to the north and south of French Stream. • Large fields of potatoes and corn to the north. • Industrialized irrigation systems were observed in use.
15	Chamberlain Meetinghouse Road	Ag	• 10 cows observed; more may be present.
17	Exeter Road	Ag	• Large corn and potato fields north and south of Exeter Road. • Tributaries run through fields and associated hay lands.
19	Exeter Road & Avenue Road	Ag	• Large agricultural fields surrounding Exeter Road, Avenue Road and Valley Avenue Road. • Tributaries run through fields.

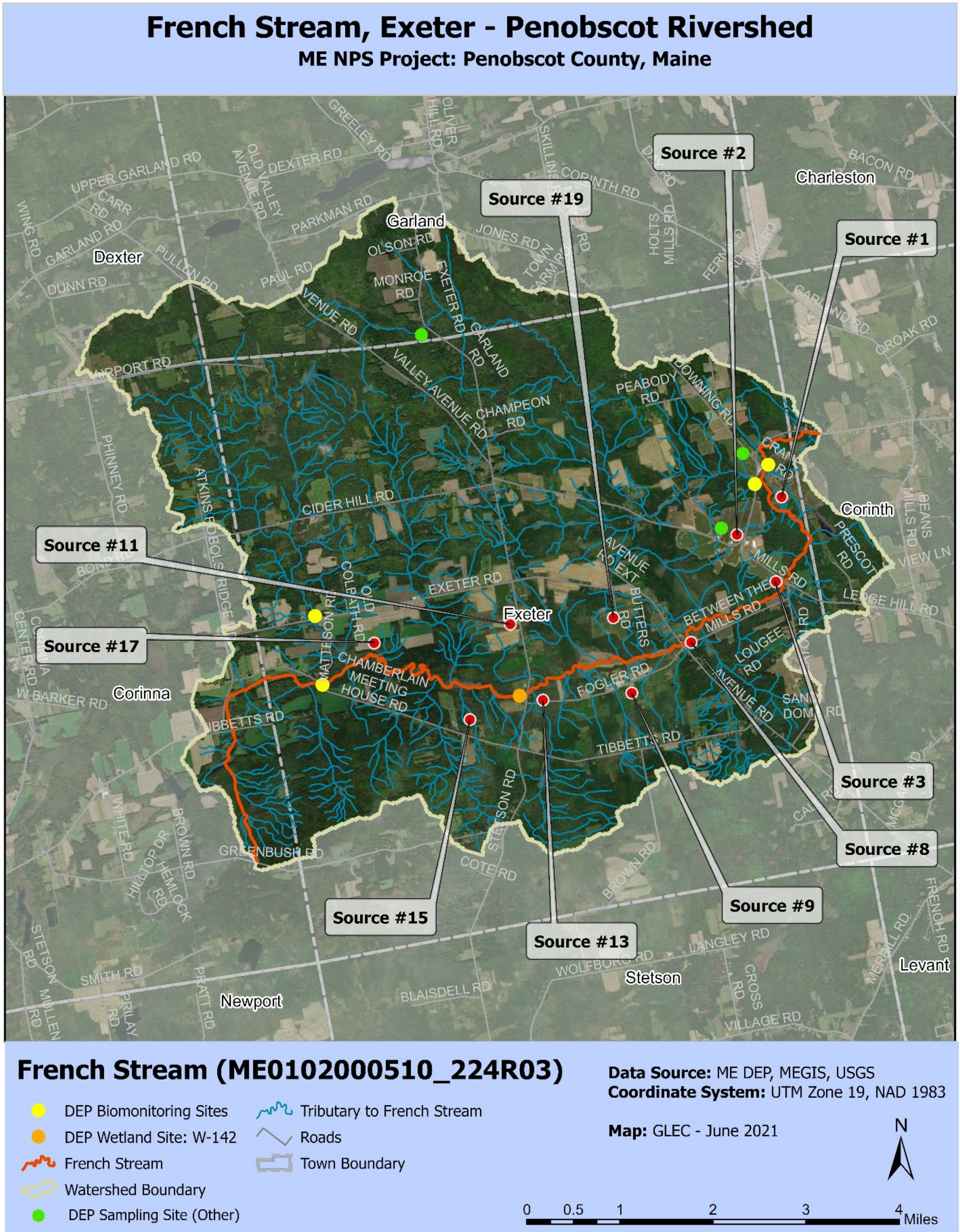


Figure 3: Aerial Photo of Potential Source Locations (identified in 2012) in the French Stream Watershed

NUTRIENT AND SEDIMENT LOADING – *MODEL MY WATERSHED* ANALYSIS

The *Model My Watershed* model was used to estimate stream loading of total phosphorus, total nitrogen, and sediment in French Stream watershed. The model estimated nutrient loads over a 12-year period (2009-2020), which was determined by local (Bangor International Airport USW00014606) weather data inserted into *Model My Watershed*. This extended period captures a recent but wide range of hydrologic conditions to account for variations in nutrient and sediment loading over time. Loads for the attainment watersheds (five total; Table 1) were computed using the same model with the same recent inputs (i.e., regional weather, 2016 land use and land cover, 2016 wetland extent, and BMPs similar to the impaired watersheds).

Many quality assured and regionally calibrated input parameters are provided with *Model My Watershed*. However, several updates to some of the default parameters were made in this TMDL effort, and namely more recent land use/cover using **MRLC-NLCD 2016** [1], more recent and local weather (precipitation and temperature) data (as described above), and more regional estimates of Best Management Practices (BMPs; see ensuing discussion). Because land use/cover is more recent, the estimated filtration fraction of wetland and open water and the amount of stream buffer in agricultural land should be more accurate. It is also worth noting that improved classification algorithms were employed by MLRC in the NCLD 2016 and these new algorithms were used in the revisions of all previous NLCD versions (including the first version in 2001).

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 livestock (numbers of animals) in the watershed based on the USDA National Agricultural Statistics Service (NASS) estimation for 2012. Some of these totals were modified by direct observations made in the watershed in the 2012 survey. To generate watershed-based livestock counts, NASS county-based livestock totals are converted to a per unit area (based on the total area of the county). The unit area amount is then multiplied by the total watershed area to derive a watershed total count (as seen in Table 3).

Table 3: Livestock Count in the French Stream Watershed

Type	French Stream
Dairy Cows	2,000
Beef Cows	6
Broilers	230
Layers	--
Hogs/Swine	7
Sheep	26
Horses	11
Turkeys	1
Other	--
Total	**2,281**

Based on the 2012 field survey, French Stream watershed is predominantly forested, but also contains substantial mixed agriculture. Large areas of potato and corn fields were documented throughout the watershed, as well as a large dairy farm on Fogler Road. This dairy farm has approximately 2,000 cows, according to the website of its subsidiary (accessed July 2021). The dairy farm's subsidiary has an anaerobic digestion system used for turning manure and other organic matter into energy, recycled animal bedding, and liquid fertilizer. In addition to this farm, another ten cows were observed on Chamberlain Meetinghouse Road in Exeter, and five horses were noted at a farm at the corner of Avenue Road and Fogler Road.

[1] MRLC-NLCD 2016 : Multi-Resolution Land Characteristics – National Land Cover Dataset (version 2016) provided by the MRLC Consortium (Jin et al. 2019).

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 and Corradini, 2012). *Model My Watershed* considers natural vegetated stream buffers within agricultural land areas as providing nutrient load attenuation. A width of approximately 98 feet (30 m) on one side of a stream is required to be considered a streamside buffer per the *Model My Watershed* technical manual (Stroud Water Research Center 2017). Analysis of recent aerial photos was used to estimate the number of agricultural land 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

French Stream
• Agricultural Land Stream Length = 2,006 ft • Agricultural Land Stream Length with Buffer = 201 ft (or 10% of total agricultural land stream length) • Percentage of total stream length flowing through non-buffered agricultural land = 0.6%

French stream is a 12.75 mile-long impaired segment. The total stream miles (including tributaries) modeled within the watershed is 33.5 miles. Of this total, 0.38 stream miles (2,006 ft) were located within agricultural areas (hay/pasture and cropland), and 201 ft (10%) of those stream miles showed a 98 foot or greater vegetated buffer (Table 4 and Figure 4). From a watershed perspective, this equates to 1,805 ft or 0.6% of the total stream length running through agricultural land with less than a 98 foot buffer. By contrast, for attainment stream watersheds, the percentage of total stream miles running through agricultural land without a 75 foot vegetated buffer ranged from 0% to 3.9% with an average of 1.3%. Differences in stream length estimates using a 98-foot or 75-foot buffer were practically insignificant.

Home Septic System Loads

Loads for "normally functioning" septic systems are calculated in *Model My Watershed* using an estimate of the average number of persons per acre in "Low-Density Mixed" areas. In these areas, it is assumed that the populations therein are served by septic systems rather than centralized sewage systems. All homes in such areas are assumed to be connected to "normally functioning" systems rather than those that experience "surface breakouts" (surface failures), "short-circuiting" to underlying groundwater (subsurface failures), or have direct conduits to nearby water bodies. Non-functioning systems would be modeled with a higher load contribution to the waterbody.

Best Management Practices (BMPs)

Best management practices (BMPs) are typically instituted to reduce the loading of sediment and nutrients from upland (i.e., non-point) sources. Ideally, information on BMPs for a specific watershed from local and regional sources would improve this component of the water quality model. Maine DEP sought information on BMP use in early 2021 from local, regional, and state agricultural agencies for rural BMPs and from nearby municipalities for urban BMPs. Very little to no information was returned in the solicitation. Hence, estimates for typical New England watersheds were derived from information available from Vermont. An upper limit of BMP use was garnered from watersheds entering the Chesapeake Bay where BMP use is intensive.

Four agricultural BMPs were used in this modeling effort and in the following manner:

- *Cover Crops:* Cover crops are the use annual or perennial crops to protect soil from erosion during time periods between harvesting and planting of the primary crop. The percent of cropland area in a cover crop BMP deployed was estimated at 25% and selected as the low end of the range (25 to 30 percent) expected for cropland in New England. These same values were assigned to the five attainment watersheds.
- *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. This BMP was estimated to occur in 25% of cropland. These same values were assigned to the five attainment watersheds.
- *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. Both interview sources suggest this practice is minimal to non-existent for New England watersheds. Hence, no BMP of this type was used in this modeling effort. These same values were assigned to the five attainment watersheds.
- *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. Both interview sources were not aware of this practice being active and is likely minimal for New England watersheds. Hence, no BMP of this type was used in this modeling effort for both impaired and attaining watersheds.

Note that other agricultural and development BMPs likely exist in the watershed but their location and type were not available in a watershed-wide format that is necessary to include in the model. Agricultural BMPs recommended by Maine DEP to reduce sediment and nutrient loads include vegetated buffers, covered manure storage facilities, and stream exclusion fencing. BMPs for developed areas recommended by the Maine DEP include vegetated buffers, stormwater BMPs, and minimization of impervious cover.

Pollutant Load Attenuation by Lakes, Ponds and Wetlands

Depositional environments such as lakes, ponds, and wetlands can attenuate watershed sediment and nutrient loading. This information is entered into the nutrient loading model by a simple percentage of watershed area draining to a lake, pond, or wetland. The French Stream watershed is 16.9% wetland and open water. Multiple wetlands and open water surround tributaries throughout the watershed. It is estimated that 55% of land area within the watershed drains to wetlands and open water. The percent of watershed draining to a wetland in the attainment watersheds, based on the 2021 analysis, ranged from 26 to 58 percent, with an average of 40%.

NUTRIENT AND SEDIMENT MODELING RESULTS

Selected results from the watershed loading model are presented below. 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 French Stream indicate significant reduction of phosphorus, a moderate reduction of nitrogen, and a smaller reduction in sediment are needed to improve water quality. Below, loading for nitrogen, phosphorus and sediment are discussed individually.

There are two categories of loads – sources and pathways. Sources are determined by land use/cover and the overland flow they generate, livestock counts by animal type, and home sewage treatment systems in developed areas. Pathways represent additional loads derived from subsurface flow and streambank erosion. Subsurface loads are calculated using dissolved N and P coefficients for shallow groundwater and are mainly derived from atmospheric inputs. Sediment and nutrient loads produced by eroding streambanks are estimated using an approach developed by Evans et al. (2003). This pathway is comprised of loads originating from five sources, and listed in order of decreasing importance: amount of developed land area, soil erodibility (K-factor), density of livestock, runoff curve number, and topographic slope. For any given model run, the amount of developed land in the watershed is responsible for just over 72% of the total streambank load, whereas soil erodibility and animal density are responsible for 21% and 7% of the total streambank load, respectively.

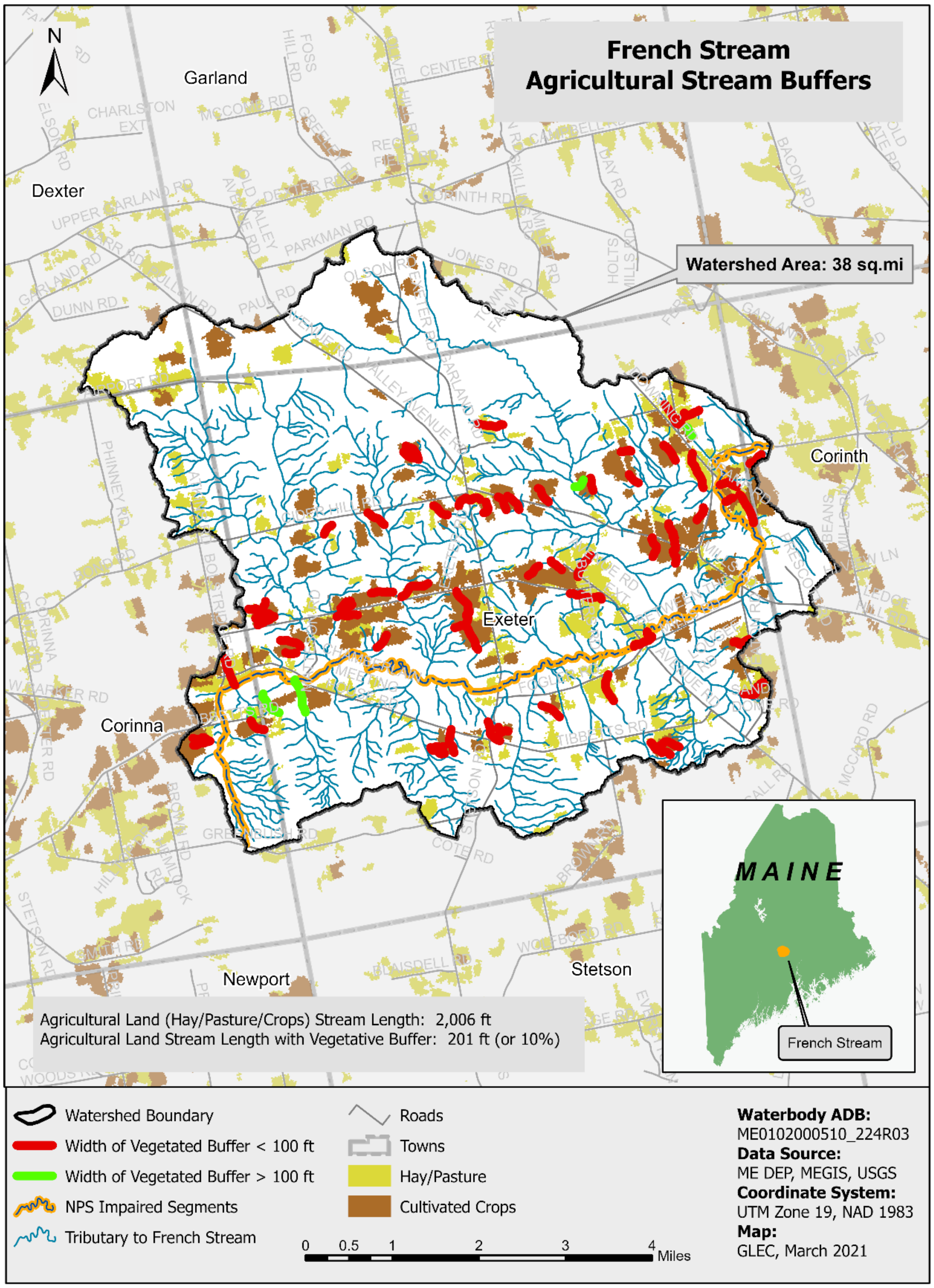


Figure 4: Agricultural Stream Buffers (from 2021) in the French Stream Watershed

Sediment

Sediment loading in the French Stream watershed is mainly derived from cropland which makes up almost 92% of the total sediment load from sources (Table 5 and Figure 5). Hay/pasture and low-density open space comprise about 2% each. Of the entire watershed sediment load, stream bank erosion contributes 61.5%.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section TMDL: Target Nutrient Levels for French Stream below for loading estimates that have been normalized by watershed area.

Table 5: Total Sediment Load by Source

French Stream	Sediment (1000 kg/year)	Sediment (%)
Source Load		
Hay/Pasture	7.1	2.3%
Cropland	278.3	91.9%
Wooded Areas	2.2	0.7%
Wetlands	0.7	0.2%
Open Land	0.6	0.2%
Barren Areas	0.003	0.001%
Low-Density Mixed	3.7	1.2%
Medium-Density Mixed	3.1	1.0%
High-Density Mixed	0.6	0.2%
Low-Density Open Space	6.5	2.1%
Farm Animals	0	0
Septic Systems	0	0
Source Load Total:	**302.8**	**100%**
Pathway Load		
Stream Bank Erosion	483.0	-
Subsurface Flow	0	-
Total Watershed Mass Load:	**786**	

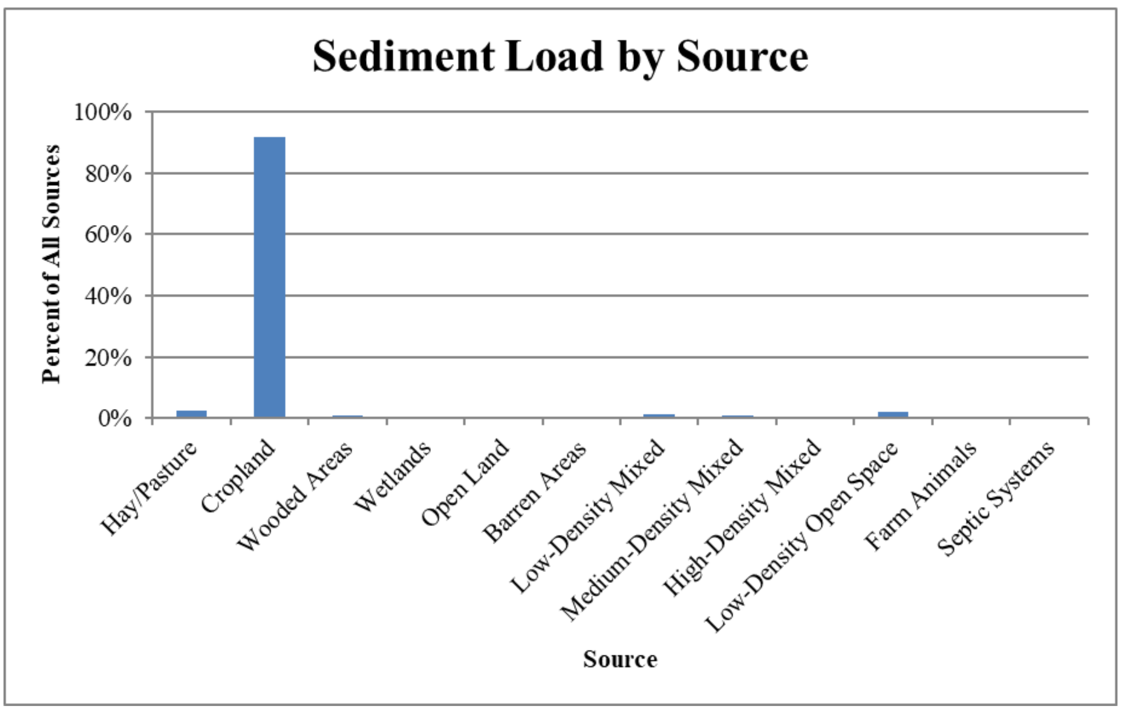


Figure 5: Total Sediment Load by Source in the French Stream Watershed

Total Nitrogen

Nitrogen loading is attributed primarily to farm animals (67.5%) and cropland (19.9%) (Table 6 and Figure 6). Combined agricultural sources account for almost 91% of the total nitrogen load to French Stream. This load calculation incorporated the exceptional waste management of the large dairy farm.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient Levels for French Stream* below for loading estimates that have been normalized by watershed area.

Table 6: Total Nitrogen Load by Source

French Stream	Total N (kg/year)	Total N (%)
Source Load		
Hay/Pasture	942	3.3%
Cropland	5,645	19.9%
Wooded Areas	1,085	3.8%
Wetlands	852	3.0%
Open Land	70	0.2%
Barren Areas	9	0.0%
Low-Density Mixed	156	0.5%
Medium-Density Mixed	103	0.4%
High-Density Mixed	20	0.1%
Low-Density Open Space	274	1.0%
Farm Animals	19,156	67.5%
Septic Systems	82	0.3%
Source Load Total:	**28,394**	**100%**
Pathway Load		
Stream Bank Erosion	875	-
Subsurface Flow	9,168	-
Total Watershed Mass Load:	**38,436**	

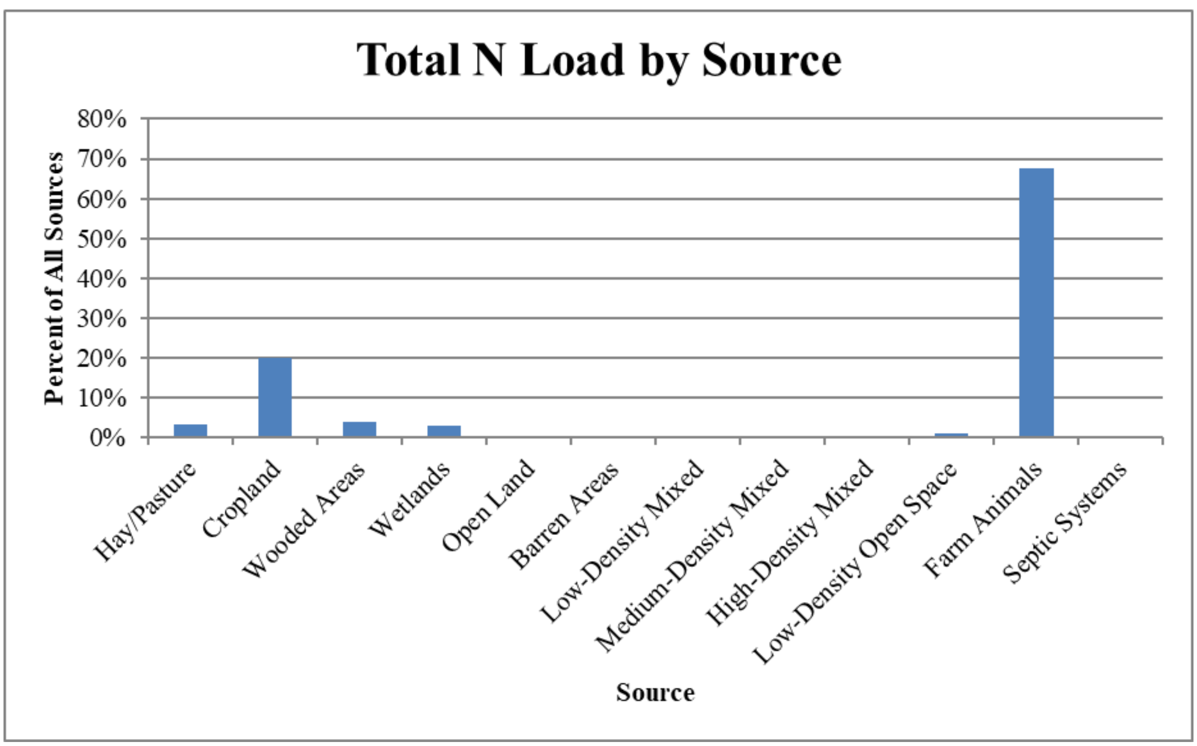


Figure 6: Total Nitrogen Load by Source in the French Stream Watershed

Total Phosphorus

Phosphorus loading within the watershed is attributed primarily to farm animals and cropland with combined agricultural sources accounting for almost 96% of the total phosphorus load to French Stream. This load calculation incorporated the exceptional waste management of the large dairy farm. The number of farm animals and high density and large size of croplands account for these sources. Phosphorus loads are presented in Table 7 and Figure 7.

Note that total loads by mass cannot be directly compared between watershed TMDLs due to differences in watershed area. See section *TMDL: Target Nutrient Levels for French Stream* below for loading estimates that have been normalized by watershed area.

Table 7: Total Phosphorus Load by Source

French Stream	Total P (kg/year)	Total P (%)
Source Load		
Hay/Pasture	316.3	9.3%
Cropland	966.2	28.3%
Wooded Areas	54.8	1.6%
Wetlands	41.4	1.2%
Open Land	2.4	0.1%
Barren Areas	0.3	0.01%
Low-Density Mixed	15.1	0.4%
Medium-Density Mixed	9.5	0.3%
High-Density Mixed	1.8	0.1%
Low-Density Open Space	26.6	0.8%
Farm Animals	1,984.4	58.0%
Septic Systems	0	0
Source Load Total:	**3,418.8**	**100%**
Pathway Load		
Stream Bank Erosion	228.0	-
Subsurface Flow	362.8	-
Total Watershed Mass Load:	**4,010**	

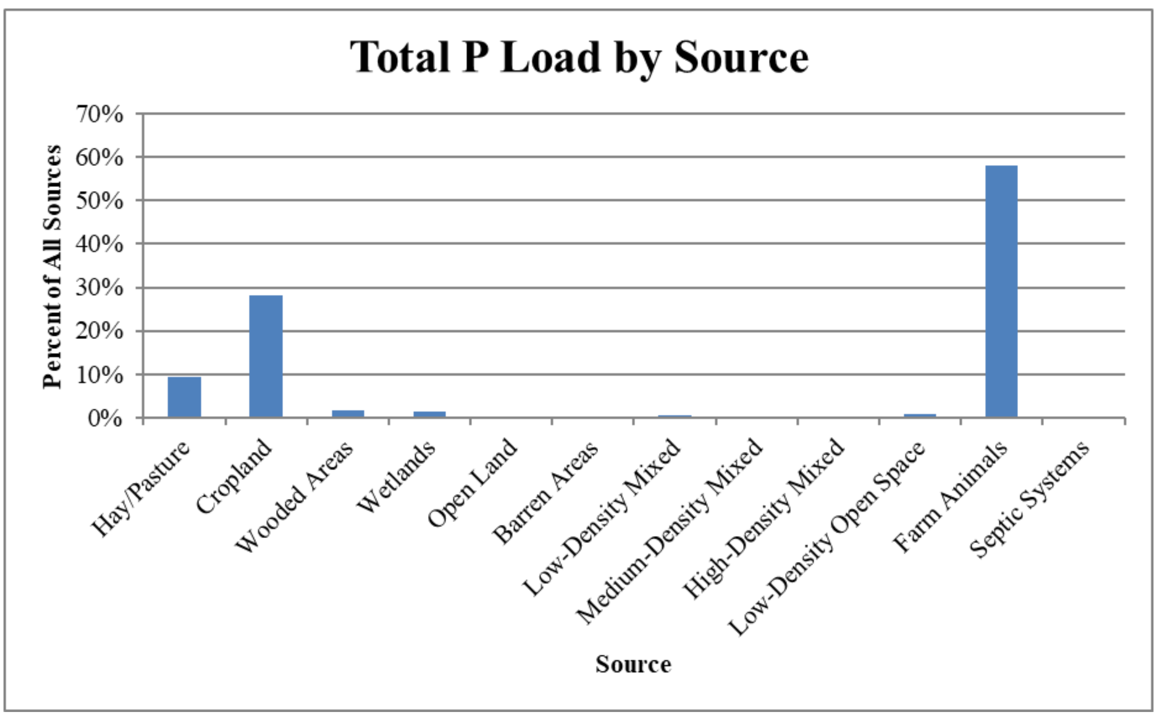


Figure 7: Total Phosphorus Load by Source in the French Stream Watershed

TMDL: TARGET NUTRIENT AND SEDIMENT LEVELS FOR FRENCH STREAM

The existing loads for nutrients and sediments in the impaired segment of French Stream are listed in Table 8, along with the TMDL (the allowable load) which was calculated from the average loading estimates of five attainment watersheds throughout the state. Table 8 also shows required reductions (as a percent) for each of sediment, total N, and total P pollutants. Table 9 presents a more detailed view of the modeling results and calculations used to compute the existing loads in Table 8. An annual time frame provides a mechanism to address the daily and seasonal variability associated with nonpoint source loads.

Table 8: French Stream Pollutant Loading Compared to TMDL Targets

French Stream			
Pollutant Load	**Existing Load**	**TMDL**	**Reduction Required**
Total Annual Load per Unit Area		Attainment Streams	
Sediment (kg/ha/yr)	80.1	65.72	17.9%
Total N (kg/ha/yr)	3.92	2.46	37.3%
Total P (kg/ha/yr)	0.41	0.16	60.9%

Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. Expansion of agricultural and development activities in the watershed have the potential to increase runoff and associated pollutant loads to French Stream. To ensure that the TMDL targets are attained, future agricultural activities will need to meet the TMDL targets. Between 2012 to 2017 in Penobscot County, the growth in agricultural lands was decreasing, with an 11.2% decrease in the total number of farms and a 6.6% decrease in total farm area. However, a 4.8% increase in the average farm size occurred in this time period. These values are extracted from the most recent (2017) Census of Agriculture (USDA 2017). Human population in Penobscot County declined by slightly more than 1% from 2000 to 2019 (US Census 2020). Future activities and BMPs that achieve TMDL reductions are addressed below.

Next Steps

The use of agricultural and developed area Best Management Practices (BMP's) can reduce sources of polluted runoff in French Stream. It is recommended that municipal officials, landowners, and conservation stakeholders in Exeter 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 French Stream;
- Run a "Hot-Spot Analysis" in *Model My Watershed* to determine sub-watershed locations of higher existing contributions of sediment and nutrients to the outlet of French Stream watershed; then focus BMP mitigation in these hot-spot sub-areas of the watershed;
- Address existing nonpoint source problems in the French Stream watershed by instituting BMPs where necessary; and

- Prevent future degradation of French Stream through the development and/or strengthening of local Nutrient Management Ordinance.

Table 9: Annual Loads by Land Use, Other Sources, and Pathways for French Stream Based on Modeling

French Stream				
	Area (ha)	**Sediment** (1000 kg/yr)	**Total N** (kg/yr)	**Total P** (kg/yr)
Land Uses				
Hay/Pasture	760	7.1	942	316.3
Cropland	979	278.3	5,645	966.2
Wooded Areas	5,943	2.2	1,085	54.8
Wetlands	1,647	0.7	852	41.4
Open Land	53	0.6	70	2.4
Barren Areas	12	0.003	9	0.3
Low-Density Mixed	143	3.7	156	15.1
Medium-Density Mixed	23	3.1	103	9.5
High-Density Mixed	4	0.6	20	1.8
Low-Density Open Space	249	6.5	274	26.6
Total Area	9,812			
Other Sources				
Farm Animals		0.0	19,156	1,984.4
Septic Systems		0.0	82	0.0
Pathway Load				
Stream Bank Erosion		483.0	875	228.0
Subsurface Flow		0.0	9,168	362.8
Total Annual Load		786	38,436	4,010
Total Annual Load per Unit Area		0.080	3.92	0.41
		1000 kg/ha/yr	kg/ha/yr	kg/ha/yr

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