# Kennedy Brook

## Watershed Description

This TMDL applies to the entire 1.75 mile length of Kennedy Brook, which lies entirely in the city of Presque Isle, Maine. Kennedy Brook begins in a wooded wetland in the eastern agricultural area of Presque Isle. The brook flows westerly before being impounded, creating Mantle Lake. It then flows through a residential area before crossing under Route 1 where the watershed is dominated by heavy development. Kennedy Brook is highly channelized in this lower stretch. While not shown on the maps in this document, a small but significant tributary, Alder Brook, originates south of the urbanized area, flows north through agricultural land, the University of Maine at Presque Isle, and residential development before discharging to Kennedy Brook just above Route 1. The Kennedy Brook watershed covers an area of 2.7 square miles.

- Kennedy Brook is on the list of Maine's Impaired Streams as referenced in the 2016 Integrated Report (Maine DEP, 2018).
- Runoff from row crop agriculture (potatoes, broccoli, grain) and hay fields is likely one of the largest contributors of nutrients to Kennedy Brook. Agricultural land use comprises a full 48% of the watershed with most of the agricultural land in the upper or eastern portion and southern watershed area (Figure 1).
- Developed areas occupy 32% of the watershed and are mostly in the lower half of the watershed. Developed areas contain impervious surfaces (rooftops) and home septic systems and when in close proximity to the stream will impact water quality.
- The remainder of the watershed is 11% wooded and 8% wetlands.

### 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:** ME0101000412_140R05

**Towns:** Presque Isle, ME

**County:** Aroostook (central)

**Impaired Segment Length:** 1.75 mi

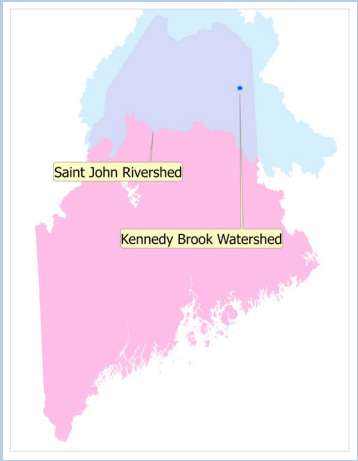
**Classification:** Class B

**Direct Watershed:** 2.7 $mi^2$ (1,728 acres)

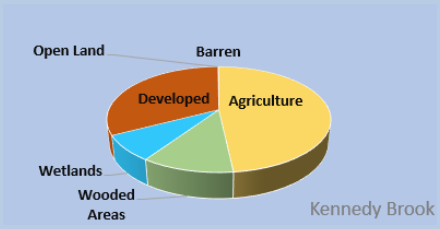
**Impairment Listing Cause:** Periphyton

**Watershed Agricultural Land Use:** 48%

**Major Drainage Basin:** Saint John River




**Watershed Land Uses**



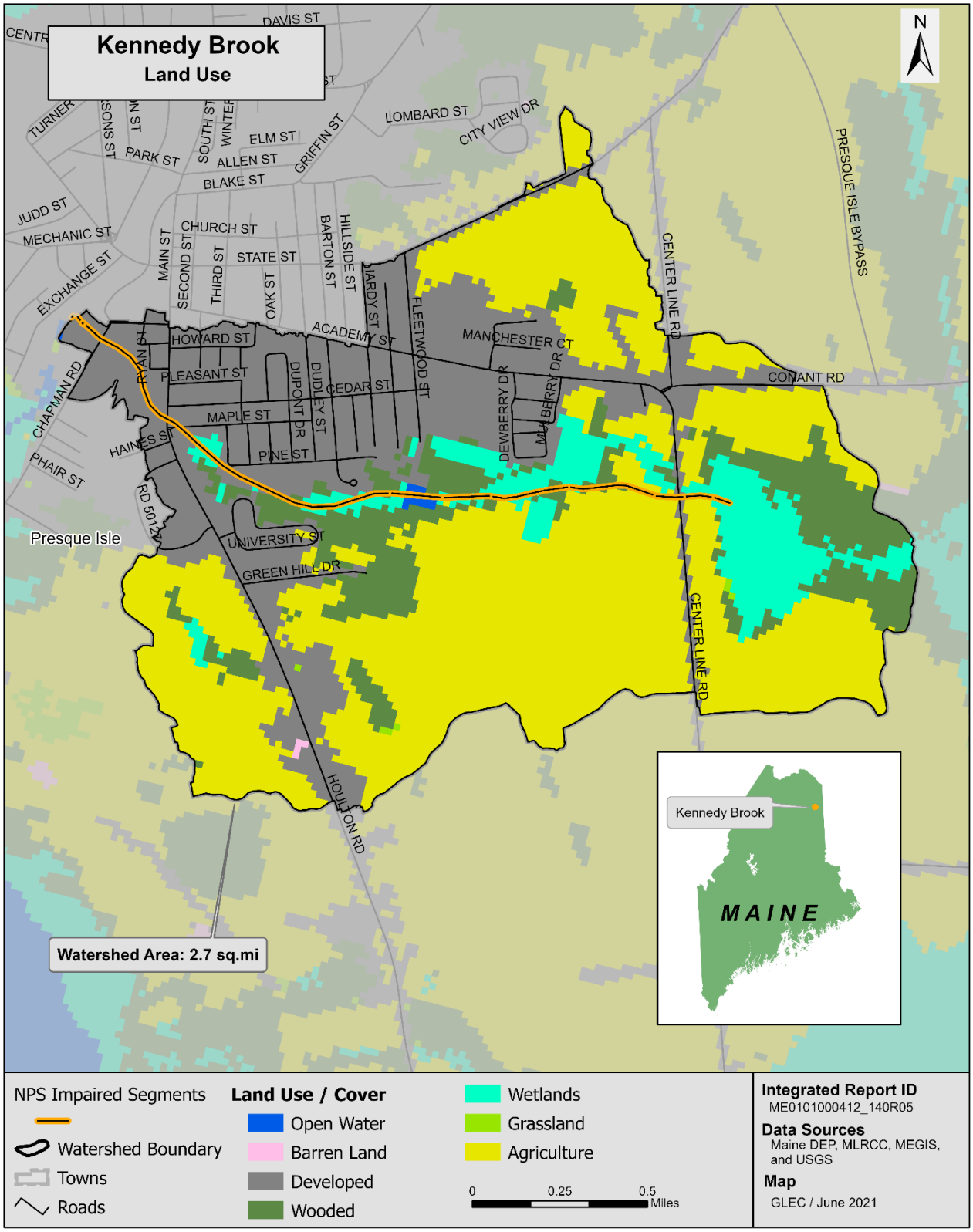



**Figure 1:** Land Use and Land Cover (from 2016) in the Kennedy Brook Watershed

## WHY IS A TMDL ASSESSMENT NEEDED?

Kennedy Brook is a Class B stream and 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.

Agriculture (cropland and hay/pasture) in the Kennedy Brook watershed comprises 48% (34% cropland) of the land area. However, developed land also occupies a large amount of watershed area (32%). The industrialized area east of Route 1 contains several industries that have the potential to contribute significant nutrients and toxic chemicals (e.g., agricultural equipment manufacturer, farm chemical distribution center, rail yard). This area has significant impervious areas and no stormwater treatment systems. Any spill or accident is likely to discharge directly into Kennedy Brook.

Agriculture is likely to be the largest contributor of sediment and nutrient enrichment to the brook. Concentrated flow in and around cropland (34% of the watershed) further increases the likelihood that nutrients and sediment will reach Kennedy Brook.

***Kennedy Brook*** *looking upstream at the upper part of the assessed segment and just downstream of the community park footbridge. Photo: GLEC 2021*

***Kennedy Brook*** *in the middle of the assessed segment showing woody debris, which was observed with heavy density throughout the assessed segment. Photo: GLEC 2021*

## 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 Kennedy Brook is based on periphyton (algae) data collected from 2009 and 2014. Kennedy Brook has a Class B designation. Station S-646 exists just upstream of the Chapman Road bridge and downstream of the railroad thruway (Figure 3). Here periphyton did not meet class in either 2009 or 2014.

## 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

Habitat assessment surveys were conducted on both impaired and attainment streams (Figure 2). 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 1) general description of the site and physical characterization and a 2) visual assessment of in-stream and riparian habitat quality. For both impaired and attainment streams, the assessment locations are typically near a road crossing for ease of access.

Kennedy Brook is an impaired segment (ME0101000412_140R05; Class B) and was surveyed just upstream (approximately 100 m) from the Chapman Road bridge crossing for a length of 100 m. The starting point of the surveyed reach was 20 m upstream of the biological monitoring station and just 10 m upstream of a recent footbridge that crosses Kennedy Brook. The upstream-most point was approximately 20 m downstream of a culvert that lies under multiple railroad track bed. The surveyed reach was clear of any obvious habitat alteration due to the footbridge structure at its downstream and culvert at its upstream terminals. Based on the higher frequency of riffles versus runs or pools, a *high gradient* habitat assessment was performed on this 100 m length of stream segment. Kennedy Brook at the footbridge is approximately 265 m upstream from its confluence with Presque Isle Stream.

The habitat survey for this impaired segment was located in a narrow corridor of vegetated riparian cover and this represents a quarter of its entire length. The wooded corridor becomes increasingly wide travelling upstream approximately 5 km to its headwater area. Beyond this wooded riparian corridor, the overall watershed land use contains considerable area of cropland and pasture and mixed development.

Figure 2 (right) shows the range of habitat assessment scores for all attainment and impaired streams, as well as for Kennedy Brook segment discussed here.

Based on the *Rapid Bioassessment Protocols*, Kennedy Brook earned a score of 146. A higher score indicates better habitat. The range of habitat scores for attainment streams was 155 to 179.

Habitat parameters that scored low for Kennedy Brook include sediment deposition, bank stability, channel alteration, and especially riparian vegetative zone width. The sole parameter that scored high was protection of the immediate bank by vegetation.

Habitat appears to be an issue in the impairment of Kennedy Brook. However, 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 Kennedy Brook watershed as potential sources of NPS pollution contributing to the water quality impairment.

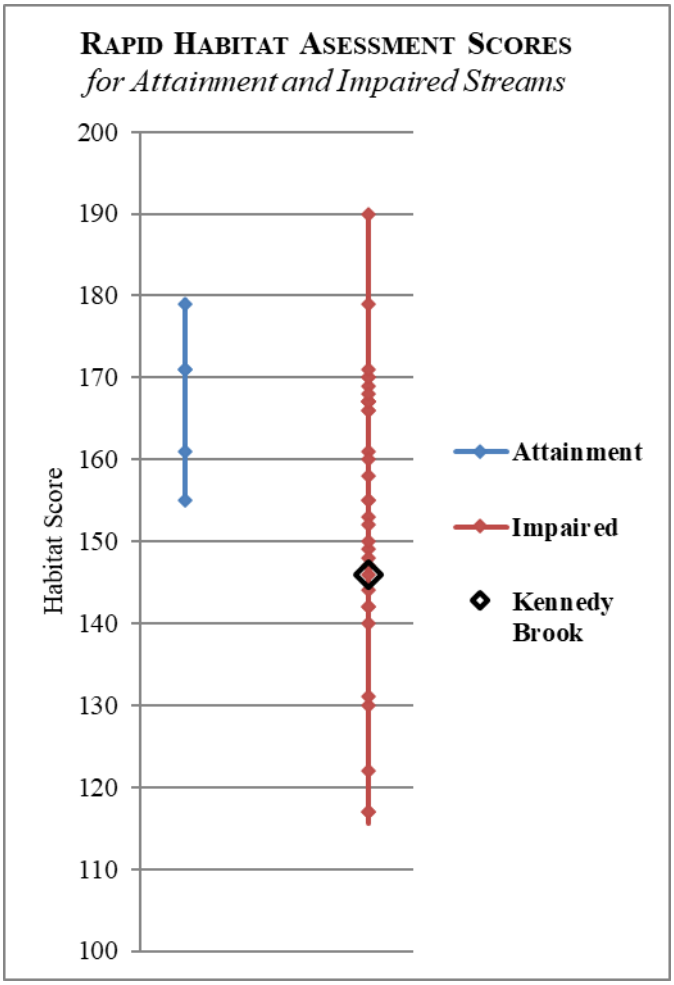



**Figure 2:** Habitat Assessment Score for Kennedy Brook (2021) Compared to Region

## Pollution Source Identification

Pollution source identification assessments were conducted in May 2021 for the entire Kennedy Brook watershed. Attainment stream watersheds were assessed in 2012. 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.

Based on the May 2021 field and desktop assessment, several generalizations on watershed land use for Kennedy Brook can be made (Table 2, Figure 3). The upper three-quarters of the impaired segment length is protected by a wide riparian corridor. But the lower quarter of the segment is extensively modified by culverting and commercial development. The brook is underground for a section immediately west of US 1 highway (Main Street in the City of Presque Isle).

Extensive residential development is situated in the northwestern section of the watershed. The stormwater collection system is a mix of open ditches, storm drains, and underground piping with nearly the entire northeast development area discharging to Kennedy Brook below Route 1 via two large stormwater discharge pipes. Residential lawns are modestly maintained suggesting that lawn chemicals are rarely applied.

About two-thirds of the watershed, eastern and southern, is in row-crop (potato and broccoli) agriculture Due to the short growing season, this often leaves large sections of the watershed with exposed soil from September through May or June.

US 1 highway (Main Street) is a commercial corridor that bisects the lower part of the watershed. The University of Maine at Presque Isle (UMPI) is located in the Alder Brook watershed, a tributary to Kennedy Brook. Although UMPI has extensive mowed lawns, the presence of numerous weeds suggest lawn chemicals are used at a minimum or not at all.

The northern part of the watershed has a large hospital, church, residential area and school farm. Both the church and hospital have stormwater treatment structures. As mentioned earlier there is an industrial section below Route 1 with numerous potential pollution sources.

**Table 2:** Potential Pollution Source ID Assessment (2021) for the Kennedy Brook Watershed

| Potential Source | | | Notes |
|---|---|---|---|
| **ID#** | **Location** | **Type** | |
| **1** | Main St (Houlton Rd or US 1) | Municipal | University of Maine – Presque Isle campus – mowed lawns – no apparent weed control used – extensive parking lots |
| **2** | Main St (Houlton Rd or US 1) | Neighborhood | Manicured lawns – none; approximately 15 acres; homes likely on municipal sewer system; no curbs or storm drains |
| **3** | Primarily east of US 1 extending to Center Line Rd and then east to watershed boundary; north of Academy St & Conant Rd | Agriculture | Extensive plowed fields – primarily row crops; soil often bare for 8 months of the year (crop canopy cover at best during June-September) |
| **4** | Main St (Houlton Rd or US 1) | Cemetery | Cemetery |
| **5** | Main St (Houlton Rd or US 1) | Commercial – Hotspot | Several commercial operations – truck and auto sales, truck maintenance, small hotel, agricultural department store; restaurants |
| **6** | Chapman Rd | Municipal | Public playfields (Bicentennial Park) – lawn chemicals on paved walkways |
| **7** | Center Line Rd | Agriculture | Pasture near veterinary services building |
| **8** | State St | Agriculture | School educational farm (orchards – fruits – vegetables) |
| **9** | Academy St | Commercial | Hospital – extensive parking lots, stormwater detention ponds, manicured lawns absent |
| **10** | Pine St | Municipal | School (elementary) building with a large parking lot and managed playfields |
| **11** | Fleetwood St | Church | Church with extensive area of managed lawn and large parking lot |
| **12** | Academy St south to Pine St; Main St (US 1) east to Fleetwood St | Neighborhood | Small to mid-size houses; curb-free; managed lawns absent; likely on municipal sewage system |
| **13** | Ryan St (near Main St) | Agriculture - Hotspot | Crop services industry – fertilizer, lime, grass seed |

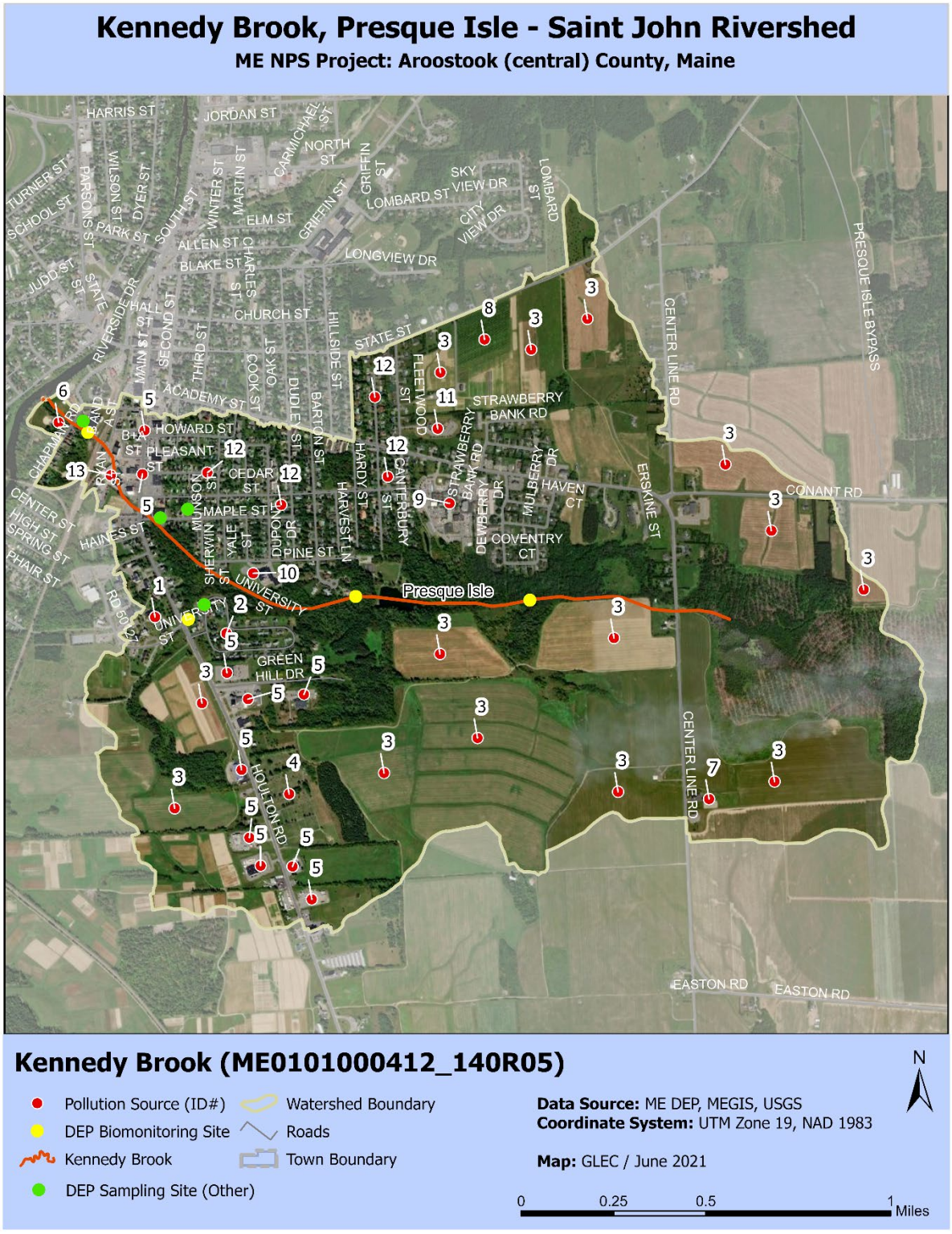



**Figure 3:** Aerial Photo of Potential Source Locations (identified in 2021) in the Kennedy Brook Watershed

## 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 Kennedy Brook watershed. The model estimated nutrient loads over a 12-year period (2009-2020), which was determined by local (Caribou Weather Forecast Office USW00014607) 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 2021 watershed 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 Kennedy Brook Watershed

| Type | Kennedy Brook |
|---|---|
| Dairy Cows | -- |
| Beef Cows | -- |
| Broilers | -- |
| Layers | 10 |
| Hogs/Swine | -- |
| Sheep | 10 |
| Horses | -- |
| Turkeys | -- |
| Other | -- |
| **Total** | **20** |

The May 2021 field survey, for the most part, supports the livestock totals estimated through NASS as shown in Table 3. However, a local agricultural advisor (described in BMPs below) stated that several small hobby farms having chickens and goats exist in the watershed. Hence, Table 3 and the model inputs were updated for layer chickens and sheep (a substitute for goats since they are not a livestock option in the model).

[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 cropland stream miles with and without vegetative buffers, and these estimates were directly entered into the model.

Kennedy Brook is a 1.75 mile-long impaired segment. The total stream miles (including tributaries) modeled within the watershed is 4.4 miles (i.e., no other tributaries were considered). Of this total, 0.77 stream miles (4,077 ft) are located within agricultural areas and 0.29 miles (1,534 ft) of that show a 98 foot or greater vegetated buffer (Table 4, Figure 4). From a watershed perspective, this equates to 0.48 miles or 10.9% 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 (calculated in 2012) 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.

**Table 4:** Summary of Vegetated Buffers in Agricultural Areas

| Kennedy Brook |
|---|
| • Agricultural Land Stream Length = 0.77 mi (4,077 ft) |
| • Agricultural Land Stream Length *with Buffer* = 0.29 mi (1,534 ft)<br>(or 37.6% of total agricultural land stream length) |
| • Percentage of total stream length flowing through non-buffered agricultural land = 10.9% |

### *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 "Low-Density Mixed" areas, it is typically assumed that the populations therein are served by septic systems rather than centralized sewage systems. However in Kennedy Brook watershed, nearly all of the residential and small business structures are connected to public sewer. Hence, the model fraction setting was reduced to 10 percent of typical for this watershed. The 10 percent area is assumed to be connected to "normally functioning" septic 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. Information on BMP use was based on an interview with a local agricultural advisor in May 2021 who provided estimates for cover crops, conservation tillage, and strip

cropping. Information on BMP use for the attainment watersheds was based on interviews from two sources (both made in February 2021). Estimates for attainment watersheds were based on typical New England watersheds and derived from information available from Vermont. An upper limit of BMP use in attainment watersheds 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, from the local interview source, at 50%. For the five attainment watersheds, an estimate of 25% was used and selected as the low end of the range (25 to 30 percent) expected for cropland in New England.
- *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, from the local interview source, to occur in none (0%) of cropland area. This same source also commented that uncontrolled gully erosion exists in the watershed. A value of 25% was assigned to the five attainment watersheds as suggested by the other (non-local) two interview sources named above.
- *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. The local interview source suggested this practice occurs in 15% of the cropland area in Kennedy Brook watershed. The Vermont and Chesapeake Bay (non-local) 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 for attaining 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. The local agricultural advisor did not suggest this practice in the Kennedy Brook watershed. The other (non-local) interview sources were not aware of this practice being active in New England watersheds. No BMP of this type was used in this modeling effort for both impaired and attaining watersheds.

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 Kennedy Brook watershed is 8% wetland and open water (0.2% is open water from Mantle Lake). Multiple wetlands surround most of the upper two-thirds of Kennedy Brook, with increasing area as one moves toward its headwaters (Figure 1). It is estimated that 16% 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 here. 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 Kennedy Brook indicate significant reductions of phosphorus and sediment are needed, and a moderately significant reduction in nitrogen is needed to improve water quality (Table 8). Below, loading for nitrogen, phosphorus and sediment are discussed individually. There are two categories of loads, sources and pathways.

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.

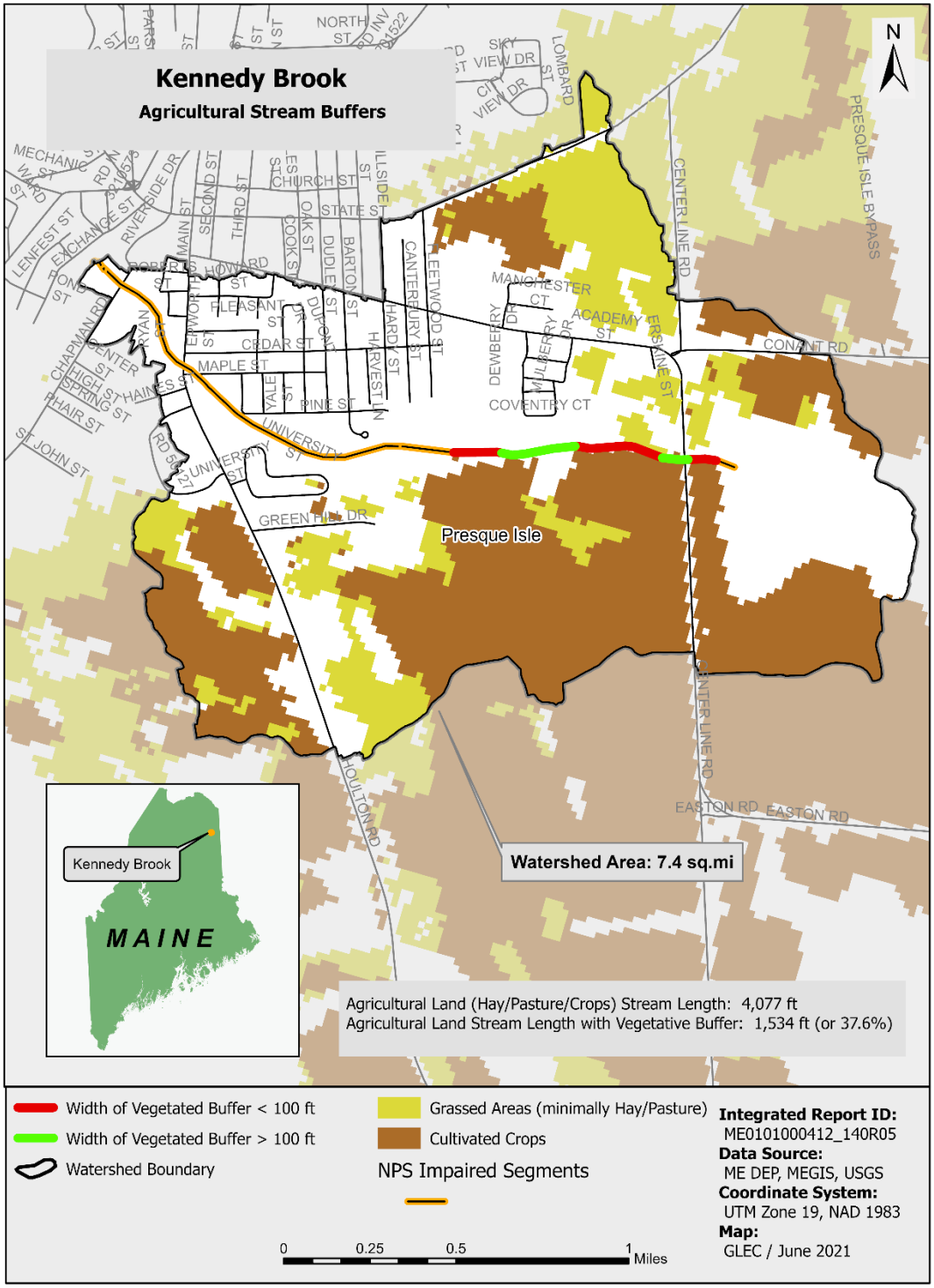



**Figure 4:** Agricultural Stream Buffers (from 2021) in the Kennedy Brook Watershed

### *Sediment*

Sediment loading in the Kennedy Brook watershed is primarily derived from cropland (80% of source load) (Table 5 and Figure 5). Developed land contributes almost 18% of the total source load. Of the entire watershed sediment load, stream bank erosion contributes 26% which originates mostly from developed land, and to some extent cropland.

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 Kennedy Brook* below for loading estimates that have been normalized by watershed area.

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

| Kennedy Brook | Sediment (1000 kg/year) | Sediment (%) |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 3.0 | 2.2% |
| *Cropland* | 107.1 | 79.9% |
| *Wooded Areas* | 0.1 | 0.0% |
| *Wetlands* | 0.1 | 0.1% |
| *Open Land* | 0.0 | 0.0% |
| *Barren Areas* | 0 | 0 |
| *Low-Density Mixed* | 4.3 | 3.2% |
| *Medium-Density Mixed* | 11.2 | 8.3% |
| *High-Density Mixed* | 5.6 | 4.2% |
| *Low-Density Open Space* | 2.8 | 2.1% |
| *Farm Animals* | 0 | 0 |
| *Septic Systems* | 0 | 0 |
| ***Source Load Total:*** | **134.1** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Bank Erosion* | 46.4 | - |
| *Subsurface Flow* | 0 | - |
| | | |
| ***Total Watershed Mass Load:*** | **180** | |

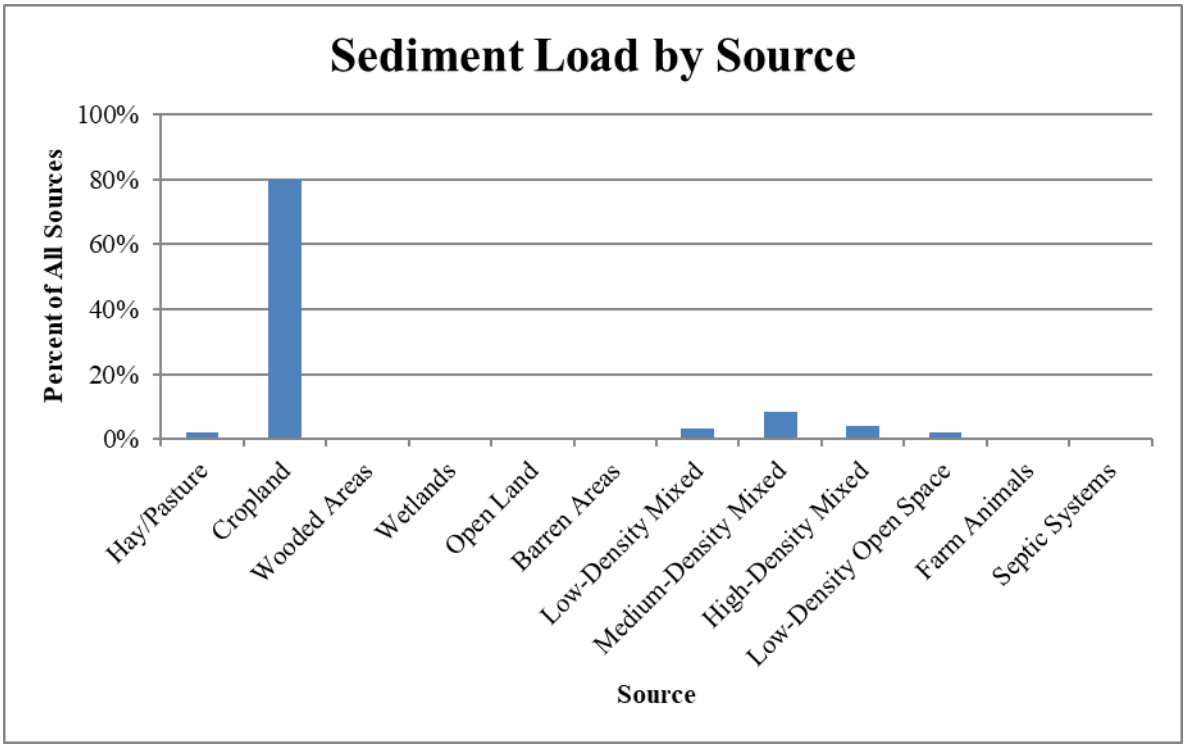



**Figure 5:** Total Sediment Load by Source in the Kennedy Brook Watershed

### *Total Nitrogen*

Nitrogen loading is attributed primarily to cropland (55.7%). Developed land contributes 38.5% through overland flow (Table 6 and Figure 6). Because most of the residences and small businesses are connected to public sewer, the load from septic systems is rather small.

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 Kennedy Brook* below for loading estimates that have been normalized by watershed area.

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

| Kennedy Brook | Total N (kg/year) | Total N (%) |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 17 | 1.0% |
| *Cropland* | 922 | 55.7% |
| *Wooded Areas* | 15 | 0.9% |
| *Wetlands* | 39 | 2.4% |
| *Open Land* | 1 | 0.1% |
| *Barren Areas* | 0 | 0 |
| *Low-Density Mixed* | 130 | 7.9% |
| *Medium-Density Mixed* | 281 | 17.0% |
| *High-Density Mixed* | 140 | 8.5% |
| *Low-Density Open Space* | 86 | 5.2% |
| *Farm Animals* | 5 | 0.3% |
| *Septic Systems* | 20 | 1.2% |
| ***Source Load Total:*** | **1,655** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Bank Erosion* | 43 | - |
| *Subsurface Flow* | 1,012 | - |
| | | |
| ***Total Watershed Mass Load:*** | **2,710** | |

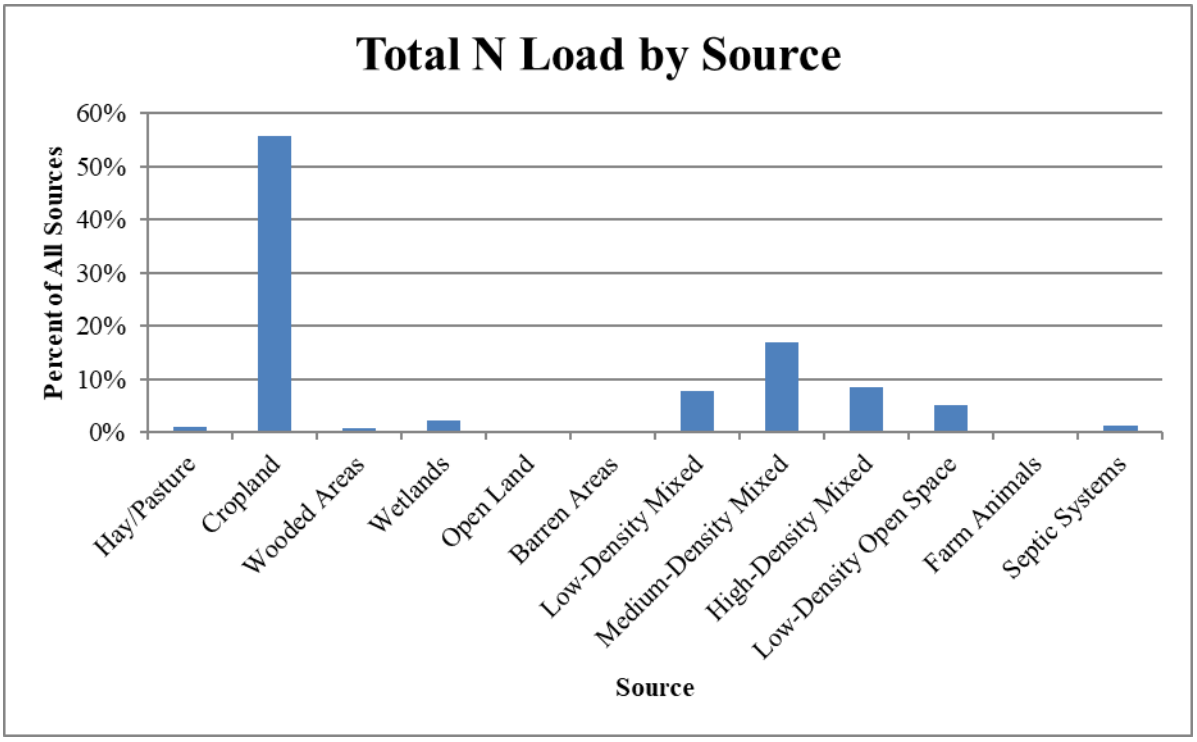



**Figure 6:** Total Nitrogen Load by Source in the Kennedy Brook Watershed

### *Total Phosphorus*

Agricultural cropland contributes 79.3% of the phosphorus load. Development contributes just under 17%. 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 Kennedy Brook* below for loading estimates that have been normalized by watershed area.

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

| Kennedy Brook | Total P (kg/year) | Total P (%) |
|---|---|---|
| **Source Load** | | |
| *Hay/Pasture* | 10.2 | 2.7% |
| *Cropland* | 304.1 | 79.3% |
| *Wooded Areas* | 0.8 | 0.2% |
| *Wetlands* | 2.1 | 0.5% |
| *Open Land* | 0 | 0 |
| *Barren Areas* | 0 | 0 |
| *Low-Density Mixed* | 13.5 | 3.5% |
| *Medium-Density Mixed* | 28.1 | 7.3% |
| *High-Density Mixed* | 14.0 | 3.7% |
| *Low-Density Open Space* | 8.9 | 2.3% |
| *Farm Animals* | 1.7 | 0.4% |
| *Septic Systems* | 0 | 0 |
| ***Source Load Total:*** | **383.4** | **100%** |
| | | |
| **Pathway Load** | | |
| *Stream Bank Erosion* | 23.0 | - |
| *Subsurface Flow* | 33.6 | - |
| | | |
| ***Total Watershed Mass Load:*** | **440** | |

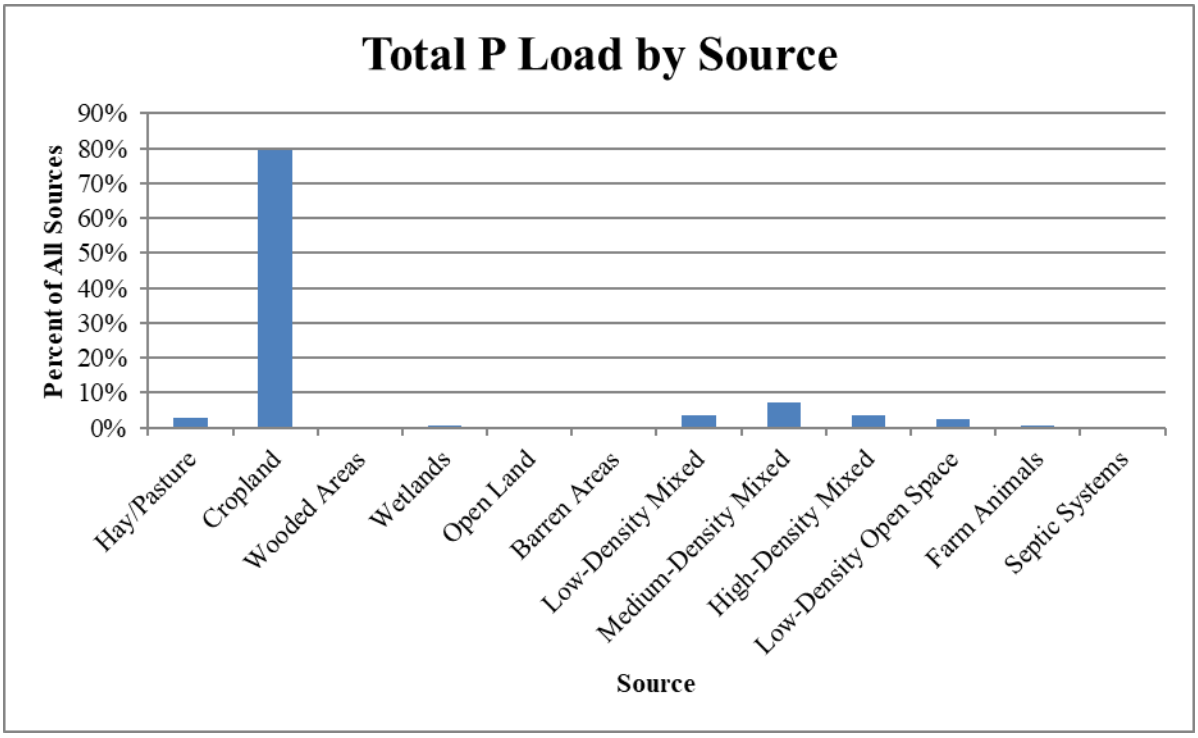



**Figure 7:** Total Phosphorus Load by Source in the Kennedy Brook Watershed

## TMDL: TARGET NUTRIENT AND SEDIMENT LEVELS FOR KENNEDY BROOK

The existing loads for nutrients and sediments in the impaired segment of Kennedy Brook 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:** Kennedy Brook Pollutant Loading Compared to TMDL Targets

| Kennedy Brook | | | |
|---|---|---|---|
| **Pollutant Load** | **Existing Load** | **TMDL** | **Reduction Required** |
| Total Annual Load per Unit Area | | Attainment Streams | |
| Sediment (kg/ha/yr) | 254.6 | 65.72 | 74.2% |
| Total N (kg/ha/yr) | 3.82 | 2.46 | 35.8% |
| Total P (kg/ha/yr) | 0.62 | 0.16 | 74.3% |

### Future Loading

The prescribed reduction in pollutants discussed in this TMDL reflects reduction from estimated existing conditions. With farmable land area at a premium and under high demand it is very likely that any tillable acreage in Kennedy Brook watershed is already in production. Between 2012 to 2017 in Aroostook County, the number of farms decreased by 14.4% and the number of acres decreased by 9.6% (USDA 2017). However, the average farm size increased by 5.6% in this time period. The County has seen a consolidation of farmland under fewer landowners with farms becoming larger. Human population in Aroostook County decreased by 6.48% from 2000 to 2019 (US Census 2020). To meet TMDL targets, current and future farm management practices will need to employ a combination of conservation practices.

### Next Steps

The use of agricultural and developed land best management practices (BMP's) can reduce sources of polluted runoff in Kennedy Brook. It is recommended that municipal officials in Presque Isle and central Aroostook county, landowners, and conservation stakeholders work together to:

- Implement the Kennedy Brook Watershed Based Plan (2018);
- Reach out to landowners and make them aware of impairment issues and actions they can take to protect and improve Kennedy Brook water quality;
- Encourage greater citizen involvement through the development of a watershed coalition to ensure the long-term protection of Kennedy Brook;
- 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 Kennedy Brook watershed; then focus BMP mitigation in these hot-spot sub-areas of the watershed;

- Address existing nonpoint source problems in the Kennedy Brook watershed by working with Central Aroostook Soil and Water Conservation District and the Natural Resource Conservation Service to access technical assistance, CWA 319 grant funds and EQIP to encourage BMPs; and
- Prevent future degradation of Kennedy Brook through the development and/or strengthening of a local ordinances.

**Table 9:** Annual Loads by Land Use, Other Sources, and Pathways for Kennedy Brook Based on Modeling

| Kennedy Brook | | | | |
|---|---|---|---|---|
| | **Area** (ha) | **Sediment** (1000 kg/yr) | **Total N** (kg/yr) | **Total P** (kg/yr) |
| **Land Uses** | | | | |
| *Hay/Pasture* | 99 | 3.0 | 17 | 10.2 |
| *Cropland* | 243 | 107.1 | 922 | 304.1 |
| *Wooded Areas* | 80 | 0.1 | 15 | 0.8 |
| *Wetlands* | 56 | 0.1 | 39 | 2.1 |
| *Open Land* | 1 | 0.0 | 1 | 0.0 |
| *Barren Areas* | 0 | 0.000 | 0 | 0.0 |
| *Low-Density Mixed* | 88 | 4.3 | 130 | 13.5 |
| *Medium-Density Mixed* | 56 | 11.2 | 281 | 28.1 |
| *High-Density Mixed* | 28 | 5.6 | 140 | 14.0 |
| *Low-Density Open Space* | 58 | 2.8 | 86 | 8.9 |
| **Total Area** | 709 | | | |
| **Other Sources** | | | | |
| *Farm Animals* | | 0.0 | 5 | 1.7 |
| *Septic Systems* | | 0.0 | 20 | 0.0 |
| | | | | |
| **Pathway Load** | | | | |
| *Stream Bank Erosion* | | 46.4 | 43 | 23.0 |
| *Subsurface Flow* | | 0.0 | 1,012 | 33.6 |
| | | | | |
| **Total Annual Load** | | 180 | 2,710 | 440 |
| **Total Annual Load per Unit Area** | | 0.255 | 3.82 | 0.62 |
| | | 1000 kg/ha/yr | kg/ha/yr | kg/ha/yr |

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