

Maine Impervious Cover TMDL for Impaired Streams Addendum Draft

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INTRODUCTION

This is an addendum to the *Maine Statewide Impervious Cover Total Maximum Daily Load (IC TMDL)*, which was prepared by the Maine Department of Environmental Protection (MDEP) and approved by the U.S. Environmental Protection Agency (USEPA) in 2012. The IC TMDL and all appendices are available on the MDEP webpage (<https://www.maine.gov/dep/water/monitoring/tmdl/tmdl2.html>). As stated in Section 2.4 Future TMDL Applicability of the 2012 TMDL, DEP may submit additional TMDLs to EPA for specific waterbodies to be added for IC TMDL coverage without resubmitting the approved core document. This addendum contains the information to develop TMDLs for one additional impaired stream (Table 1).

This report:

- Contains the watershed-specific information necessary to add this IC TMDL to the existing 2012 TMDL Report.
- References the basic background information and required TMDL elements from the 2012 TMDL Report.

Table 1. Summary information for impaired streams included in this addendum (from Maine DEP 2018/2020/2022 Integrated Water Quality Monitoring and Assessment Report Appendices).

Streams	Town	Segment ID	Class	Listing Causes
Penjawoc Stream and Meadow Brook	Bangor	ME0102000513_226R03	B	Benthic Macroinvertebrate Bioassessments, Dissolved Oxygen, Habitat Assessment, Periphyton (Aufwuchs) Indicator Bioassessments

This stream is listed on Maine’s 303(d) list of impaired waters in Maine DEP’s *2018/2020/2022 Integrated Water Quality Monitoring and Assessment Report* (MDEP, 2022). It has been assessed by DEP as not meeting Maine’s water quality standards for aquatic life use based on the results of various assessment criteria for aquatic life use in freshwater streams, including dissolved oxygen, benthic-macroinvertebrate bioassessment, periphyton indicator bioassessment, and habitat assessment. TMDLs are required under the U.S. Clean Water Act for all impaired waters on the 303(d) list, and this TMDL will be added to the existing 2012 IC TMDL.

The IC TMDL provides a framework for addressing aquatic life and habitat impairments in streams. Developed areas and associated impervious cover result in increased stormwater volume and pollutant loads to receiving waterbodies. A combination of pollutants found in stormwater, including sediment and nutrients, contribute to aquatic life impairments in streams, along with habitat loss and unstable stream banks caused by excessive amounts of runoff. Increasing the percentage of total impervious cover (% IC) in a watershed is linked to decreasing stream health (CWP, 2003). Because aquatic life impairment associated with stormwater is not always caused by a single pollutant, % IC has been selected and applied as a representative measure of the mix of pollutants and other impacts associated with excessive stormwater runoff and urban development. The IC TMDL estimates the effective % IC target for the watershed of each impaired surface water addressed by the TMDL. The ultimate achievement of the TMDL will be assessed by the waterbody meeting water quality standards. The Load Allocation & Waste Load Allocation (WLA & LA) target is intended to guide the development of a Watershed-Based

Management Plan (WBP) that will apply appropriate Best Management Practices (BMPs) and Low Impact Development (LID) techniques to achieve water quality standards.

Table 2. Elements of a TMDL

TMDL Element	Definitions	Stream Goals
Goal (End Point)	Achieve water quality consistent with Maine’s Class A, B or C standards	A biological community consistent with Maine’s Class A, B or C standards
TMDL Target (Loading Capacity)	Maximum loading of pollutants that attains the goal	Analysis of Maine’s biomonitoring data indicate that a watershed with characteristics of X% IC would achieve the goal
Margin of Safety (MOS)	The MOS accounts for uncertainty in target-setting and adds a safety factor to increase the likelihood of attainment	A 1% or 2% IC reduction is reserved from the target as a MOS
Load Allocation (LA) & Waste Load Allocation (WLA) Target	Maximum allowable pollutant load that can be allocated to various watershed sources and still achieve the water quality target and goal	X% IC Target - MOS, which represents an approximate % reduction in stormwater runoff volume and associated pollutants when compared to existing pollutant loads
Future Actions or Watershed Management Plan	Actions or engineered BMPs that are designed to achieve water quality standards	A Watershed-Based Management Plan and/or BMP implementation plan may be developed to determine the relative contributions and the best approach to solutions

Under Maine’s Water Classification Program, the State of Maine has four tiers of water quality classifications for freshwater rivers and streams (AA, A, B, C), each with varying designated uses and water quality criteria providing different levels of protection. A guidance document developed by MDEP in 2011 outlines the methods used to determine the % IC values adequate to support aquatic life use in Maine’s waterbodies. The % IC guidelines are based on analyses of data collected in Maine streams at 148 sample locations across the state, representing the full range of impervious cover expected in Maine. Based on the combined information obtained in the study, the % IC guideline ranges specified in Table 3 represent the % IC values found sufficient to support water quality classes in Maine (MDEP, 2011).

Table 3. Percent impervious cover (% IC) guidance for expected attainment of Maine’s designated aquatic life uses (DEP, 2011).

	Class AA/A	Class B	Class C
IC TMDL TARGETS*	≤5%	≤9%	≤16%

* A 1% Margin of Safety (MOS) is applied to Class AA, A, and B waters; a 2% MOS is applied to Class C waters. The MOS for Penjajawoc Stream and Meadow Brook is 1%.

Impervious Cover Used for this Addendum

The waterbody-specific % IC target for this TMDL was determined based on the Class B value provided in Table 3. To calculate the current Penjajawoc watershed % IC, Maine DEP staff used the City of Bangor's impervious cover layer. The City of Bangor created this detailed impervious surface GIS data layer from high resolution aerial photography (City of Bangor, 2014).¹ This layer was determined to be the best available impervious cover dataset for the portion of the watershed located within the City of Bangor, which is the majority of the watershed. The very small portion of the watershed in Orono was determined to have no impervious cover. For the portion of the watershed in Veazie, the impervious cover dataset created by the State of Maine and Sanborn (Sanborn and State of Maine, 2007) was used as a base product. This layer was created from 2007 data, and therefore did not contain any impervious additions between 2007 and present. Additional impervious area was added to the Veazie dataset by DEP staff, using 2021 NAIP (National Agriculture Imagery Program) imagery with 1 meter resolution.

PUBLIC PARTICIPATION

Maine DEP staff have been in communication with the City of Bangor during the development of this addendum and the development of the Penjajawoc Stream Watershed-Based Management Plan.

This draft introduction and stream summary appendix was made available for public review and comment for thirty days beginning on October 23, 2023, on MDEP's 'Opportunity for Comment' webpage, <https://www.maine.gov/dep/comment/index.html>. Email notification was sent to a list of compiled stakeholders, along with any others who expressed interest, as well as to digital subscribers of the comment webpage.

A virtual informational meeting on the addition of Penjajawoc Stream and Meadow Brook to the Statewide IC TMDL is planned for November 8, 2023 at 2:00pm via Zoom. Notification of the meeting was included with notification of public review and comment of the TMDL addendum both on MDEP's website and via email.

All written public comments and responses will be submitted to the USEPA as part of the final TMDL submittal documents and posted on DEP's web page 'TMDL approved by EPA' at <http://www.maine.gov/dep/water/monitoring/tmdl/tmdl2.html>.

REFERENCES

City of Bangor, 2014. Impervious GIS layer. James Sewall Company 2009. Updated by KAPPA 2014.

Maine Department of Environmental Protection (MDEP), 2011. Impervious Cover Targets for Stream Restoration and Watershed Management. Thomas J. Danielson, Leonidas Tsomides, Doug Suitor.

¹ Bangor impervious data developed by James Sewall Company from ½ inch resolution aerial photography in November 2009. Data was updated in known changed areas in April 2014 by KAPPA mapping based on ¼ inch resolution photography provided by the Maine Geolibrary Board.

Maine Department of Environmental Protection (MDEP), 2012. Maine Impervious Cover Total Maximum Daily Load (TMDL) for Impaired Streams. DEPLW-1239.

https://www.maine.gov/dep/water/monitoring/tmdl/2012/IC%20TMDL_Sept_2012.pdf

Maine Department of Environmental Protection (MDEP), 2012. Maine Impervious Cover Total Maximum Daily Load (TMDL) for Impaired Streams. DEPLW-1239. Appendix 3: Public Comments, Frequently Asked Questions and DEP Responses to Public Comments.

https://www.maine.gov/dep/water/monitoring/tmdl/2012/ICPublicComments&FAQs_Appendix3.pdf

Maine Department of Environmental Protection (MDEP), 2022. 2018/2020/2022 Integrated Water Quality Monitoring and Assessment Report. Bureau Water Quality, Augusta, ME.

<https://www.maine.gov/dep/water/monitoring/305b/>

Sanborn and State of Maine. 2007. Imperviousness change 2003-2007. Raster digital data.



TMDL ASSESSMENT SUMMARY

Penjajawoc Stream & Meadow Brook

Watershed Description

This Total Maximum Daily Load (TMDL) applies to a 5.2-mile section of Penjajawoc Stream, and a 1.5-mile section of Meadow Brook, located in the City of Bangor, Maine. The watershed is made up of four subwatersheds including the Upper Subwatershed, Middle Subwatershed, Meadow Brook Subwatershed, and Mt. Hope Subwatershed. The Upper Subwatershed drains a large 300-acre emergent freshwater marsh known as Penjajawoc Marsh. The Middle and Meadow Brook Subwatersheds drain the Bangor Mall and other intensely developed commercial areas on Stillwater Avenue and Hogan Road (Figure 1). Meadow Brook flows into Penjajawoc Stream just above Mt. Hope Avenue and then Penjajawoc Stream flows southeasterly into the Penobscot River. The Mt. Hope subwatershed drains the eastern portion of the watershed and joins Penjajawoc Stream a small distance before it flows into the Penobscot River. This subwatershed is primarily comprised of older, low-density residential development and a cemetery (Figure 2) (CH2MHILL, 2009; BSA, 2008).

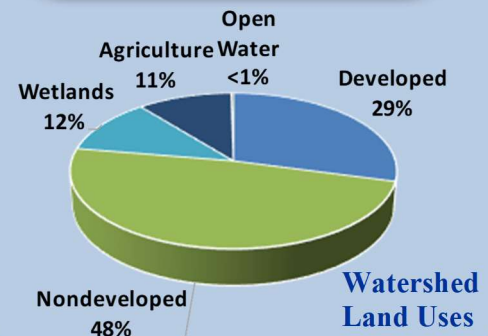
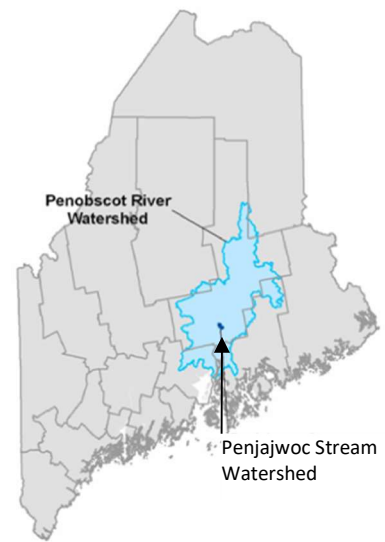
- Stormwater runoff from **impervious cover (IC)** flows quickly off impervious surfaces, carrying sediment, oils, metals, salt, and other pollutants. IC contributes to altered stream stability, in-stream habitat degradation, and impaired stream biological communities.
- The percent IC for the entire Penjajawoc watershed is 11%, but varies greatly among the four subwatersheds:
 - 3% in the Upper Subwatershed
 - 45% in the Middle Subwatershed
 - 25% in the Meadow Brook Subwatershed
 - 8% in the Mt. Hope subwatershed

Definitions

- **TMDL** is an acronym for **Total Maximum Daily Load**, representing the total amount of a pollutant that a water body can receive and still meet water quality standards.
- **Impervious cover (IC)** refers to landscape surfaces (e.g. roads, sidewalks, driveways, parking lots, and rooftops) that no longer absorb rain and may direct large volumes of stormwater runoff into the stream.

Waterbody Facts

- **Segment ID:** ME0102000513_226R03
- **City:** Bangor, ME
- **County:** Penobscot
- **Impaired Segment Length:** 6.76 miles
- **Classification:** Class B
- **Direct Watershed:** 8.8 mi² (~5,600 acres)
- **Watershed Impervious Cover:** 11%
- **Major Drainage Basin:** Penobscot River



Why is a TMDL Assessment Needed?

Penjajawoc Stream and Meadow Brook have been assessed by DEP as not meeting water quality standards for Class B freshwater streams. Penjajawoc Stream violates water quality standards for dissolved oxygen and aquatic life use, causing it to be listed on Maine’s 303(d) list of impaired waters. The Clean Water Act requires that all 303(d)-listed waters undergo a TMDL assessment that describes waterbody impairments and establishes a target to guide the measures needed to restore water quality. The goal is to bring listed waterbodies back into attainment with Maine water quality standards.



Penjajawoc Stream flows through the highly developed Bangor Mall area. (Photo: DEP)

The IC TMDL assessment for Penjajawoc Stream and Meadow Brook addresses water quality impairments for dissolved oxygen and aquatic life use (benthic-macroinvertebrate, periphyton (algae), and stream habitat assessments). These impairments are associated with a variety of pollutants in urban stormwater as well as erosion, habitat loss, and unstable stream banks caused by excessive amounts of runoff.

Sampling Results & Pollutant Sources

Sampling Station	Statutory Class	Sample Result by Sample Date							
		2008	2009	2011	2012	2014	2015	2016	
314	B	C		C/C ^a	NA				
315	B	NA		C/C ^a				NA/NA ^a	
511	B	C	C	C/C ^a				NA	
513	B	C			NA			NA/C ^a	
918	B	C	C						
927	B	C	NA						
1045	B					C			
1079	B							NA	

Recent DEP biomonitoring results for Penjajawoc Stream.
 NA = Non Attaining. Does not meet Class A, B, or C criteria.
^a = Algae assessment result. All others benthic macroinvertebrate results.

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 criteria. 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. Both benthic macroinvertebrate and algae biomonitoring assessments were conducted at

various sampling stations since 1997, with the most recent assessments in 2016. Data indicate that Class B Penjajawoc Stream did not attain its statutory class at any of the eight sampling locations.

Impervious Cover Analysis

To calculate the Penjajawoc Stream watershed percent impervious cover (% IC), Maine DEP staff used the City of Bangor's IC layer. The City of Bangor created this detailed impervious surface GIS data layer from high resolution aerial photography (City of Bangor, 2014).¹ This layer was determined to be the best available IC dataset for the the portion of the watershed located within the City of Bangor, which is the majority of the watershed. The very small portion of the watershed in Orono was determined to have no IC. For the portion of the watershed in Veazie, the IC dataset created by the State of Maine and Sanborn (Sanborn and State of Maine, 2007) was used as a base product. This layer was created from 2007 data, and therefore did not contain any impervious additions between 2007 and present. Additional impervious area was added to the Veazie dataset by DEP staff, using 2021 NAIP (National Agriculture Imagery Program) imagery with 1 meter resolution.

Increasing % IC in a watershed is linked to decreasing stream health (CWP, 2003). Because the impairment in Penjajawoc Stream and Meadow Brook is not caused by a single pollutant, % IC is used for this TMDL to represent the mix of pollutants and other impacts associated with excessive stormwater runoff. The Penjajawoc Stream watershed (including Meadow Brook) has a % IC of **11%** (Figure 1). A TMDL is defined as $TMDL = WLA + LA + MOS$. DEP has found that in order to support Class B aquatic life use, the Penjajawoc Stream watershed needs to have the characteristics of a watershed with 9% IC (DEP, 2012). The IC TMDL has set an explicit Margin of Safety (MOS) for Class B waters at 1% IC, making 8% IC the combined Wasteload (WLA) and Load (LA) Allocation for the Penjajawoc Stream and Meadow Brook watersheds. This TMDL target of 9% is intended to guide the application of Best Management Practices (BMPs) and Low Impact Development (LID) techniques to reduce the *impact* of impervious surfaces. Ultimate success of the TMDL will result in Penjajawoc Stream and Meadow Brook's compliance with Maine's water quality criteria for aquatic life, dissolved oxygen, and habitat.

It should be noted that while the overall % IC for the Penjajawoc Stream watershed is only slightly higher than the TMDL % IC target for the watershed, the IC in the various subwatersheds within the overall Penjajawoc Stream watershed are not uniform (Figure 1). The Upper Subwatershed of Penjajawoc Stream is comprised largely of wetlands and other undeveloped land – much of it undevelopable or preserved – and has a % IC of 3%. The Mt. Hope subwatershed, which is largely rural and drains the eastern section of the watershed, has a % IC of 8%. However the Middle Subwatershed, where the Bangor Mall and other development along Stillwater Ave. are located, has a % IC of 45% and the Meadow Brook subwatershed has a % IC of 25%. Due to this variability, the whole watershed % IC value likely underestimates the effect of the imperviousness on the stream and the % IC values of the Middle and Meadow Brook subwatersheds likely overestimate the effect. It should be noted that while determining the % IC of the watershed and subwatersheds is part of the TMDL process, the path toward achieving water quality criteria will depend on locating and identifying the specific stressors to the aquatic community and addressing them where they occur.

¹ Bangor impervious data developed by James Sewall Company from ½ inch resolution aerial photography in November 2009. Data was updated in known changed areas in April 2014 by KAPPA mapping based on ¼ inch resolution photography provided by the Maine Geolibrary Board.

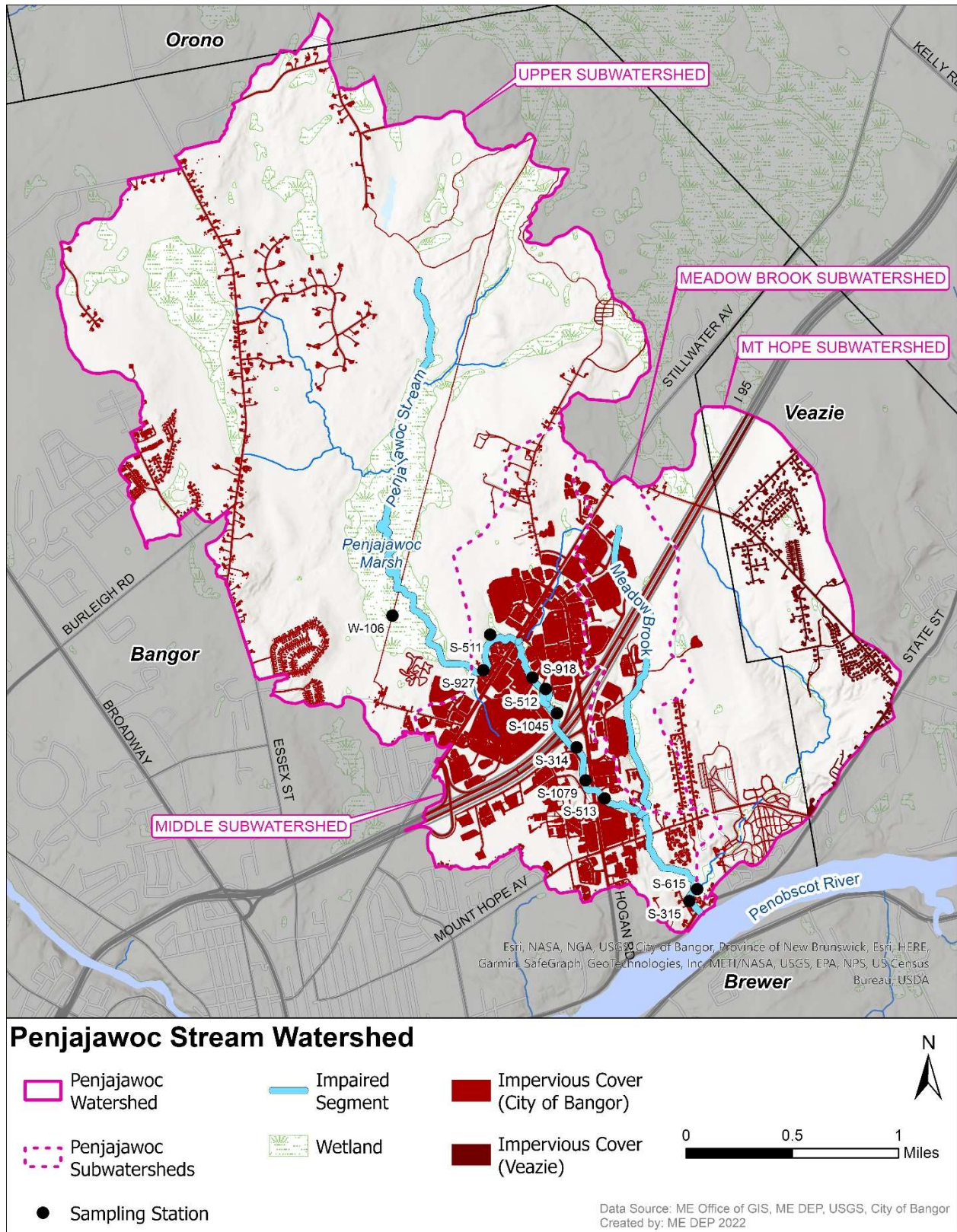


Figure 1: Penjajawoc Stream Watershed Impervious Cover (City of Bangor, 2014 and updated Sanborn and State of Maine, 2007).

Next Steps

The City of Bangor completed a Watershed-Based Management Plan (WBP) for Penjajawoc Stream, approved by DEP, in 2008. Following the approval of this WBP, six of the highest priority projects were implemented. In 2015, the City of Bangor drafted a WBP as an update to the 2008 plan and submitted it to the Maine DEP in 2017. This WBP was not approved because it did not address high chloride levels during baseflow conditions.

The City of Bangor is subject to the General Permit for the Discharge of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4s). The City anticipates revising and resubmitting the Penjajawoc Stream WBP as part of the 2022-2027 MS4 permit cycle. Following approval the WBP will be implemented. Additionally, the MS4 General Permit contains specific requirements for Urban Impaired Streams, which includes Penjajawoc Stream and tributaries. The MS4 Stormwater Management Plan (SMP) identifies three BMPs that will be implemented to meet the Urban Impaired Stream requirement of the 2022 MS4 General Permit. These BMPs include, an education campaign to raise citizens' awareness of Urban Impaired Streams in Bangor, inspection of publicly owned ditches within the right-of-way in Urban Impaired Stream watersheds, and implementation of structural BMPs in Urban Impaired Stream watersheds.

Future planning projects that will benefit both Penjajawoc Stream and Meadow Brook include:

- Update Watershed-Based Management Plan (including addition of high chloride levels in baseflow and a strategy for addressing this stressor).
- Implement Watershed-Based Management Plan recommendations.
- Implement the requirements of the the 2022 MS4 permit and Stormwater Management Plan.

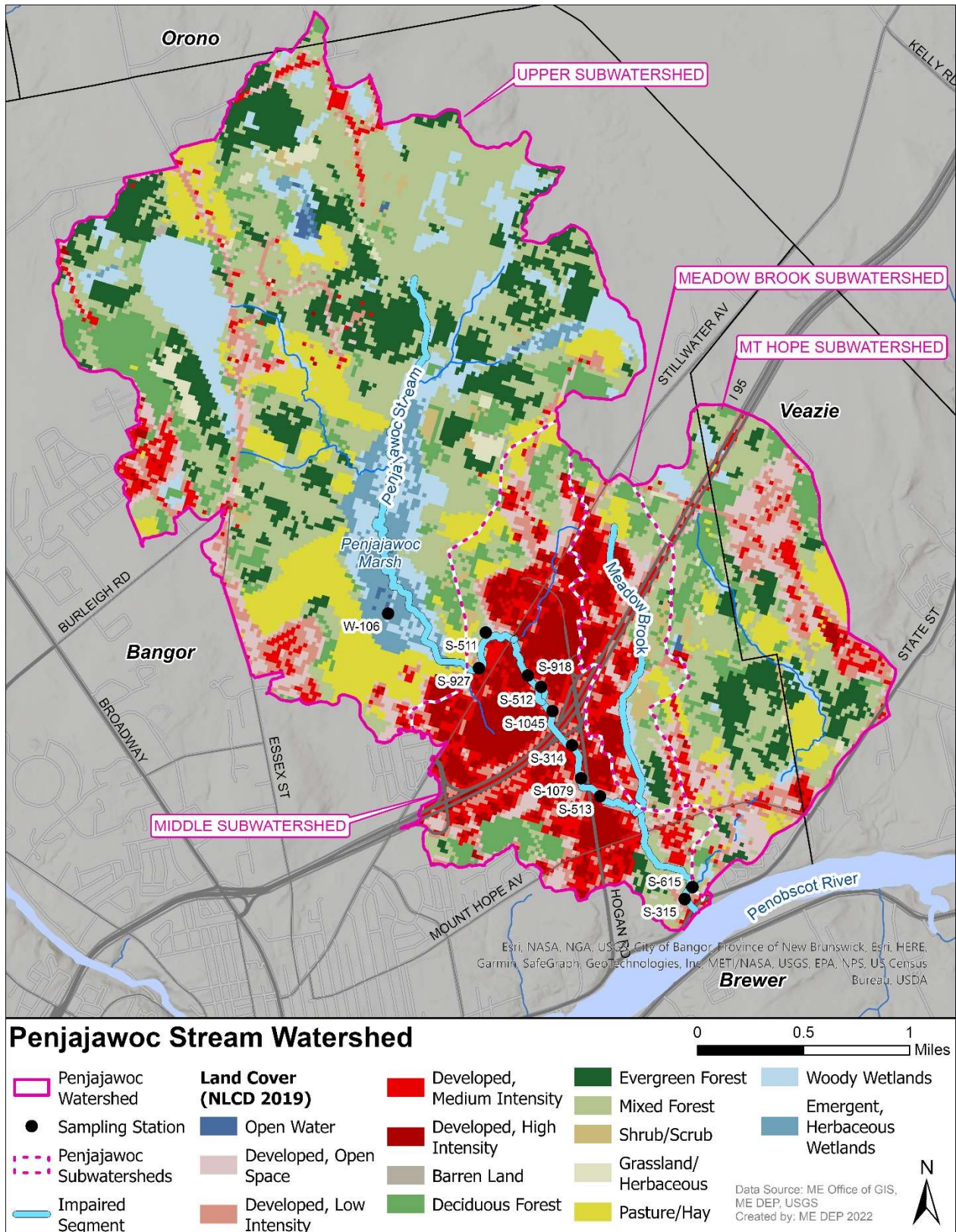


Figure 2. Penjajawoc Stream Watershed National Land Cover Database 2019 Land Cover.

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