Turkey River

Watershed Restoration and Management Plan

December 2021

Prepared for:

UPPER MERRIMACK WATERSHED ASSOCIATION

Prepared by:

COMPREHENSIVE ENVIRONMENTAL INC

CNHRPC

Acknowledgements

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Introduction

Turee Pond Boat Launch, Bow, NH

In 2020, the Upper Merrimack Watershed Association (UMWA) received funding from the New Hampshire Department of Environmental Services (NHDES) to develop a watershed restoration and management plan (WRMP) for the Turkey River watershed. The UMWA was formed in 2016 as a New Hampshire nonprofit to serve as manager of the initiatives of the Upper Merrimack River Local Advisory Committee (UMRLAC), including the Upper Merrimack Monitoring Program, the Upper Merrimack Winter Community Program, and other activities recommended in the Upper Merrimack Monitoring Program Fundraising Strategy (1997). UMRLAC was established in 1990 as the Upper Merrimack River communities' advisory board on its designation in the NH Rivers Management and Protection Program as well as the head of multiple projects and programs in the upper Merrimack watershed.

UMWA developed a project Steering Committee and selected Comprehensive Environmental, Inc. (CEI) to lead the development of this WRMP. The Central New Hampshire Regional Planning Commission (CNHRPC) provided support for this project, including assistance with engaging a diverse group of local stakeholders for development and future implementation of this WRMP. The project Steering Committee included the following individuals:

Turkey River WRMP Steering Committee	
Michele L. Tremblay	Upper Merrimack Watershed Association, President
Jeffrey Marcoux	NHDES Watershed Assistance Section, Project Manager
Steve Landry	NHDES Watershed Assistance Section, Supervisor
Michael Tardiff	Central New Hampshire Regional Planning Commission, Executive Director
Katie Nelson	Central New Hampshire Regional Planning Commission, Principal Planner
Craig Tufts	Central New Hampshire Regional Planning Commission, Principal GIS/Transportation Planner
Bob Hartzel	Comprehensive Environmental, Inc. (consulting team)

The 37.5-square mile Turkey River watershed (Figure 1) is located primarily within four municipalities: Bow, Concord, Dunbarton, and Hopkinton. Development of this WRMP included significant collaboration between these towns, the NHDES, and a variety of other government agencies, local stakeholder groups, and nonprofit organizations.

Figure 1

Turkey River Watershed

Legend

- ● Sample Station
- 〰 Stream, River
- ⬭ Lake, Pond, Reservoir
- ▭ Town Boundaries

SubWatershed

- ▭ Ash Brook
- 🟩 Bela Brook
- 🟥 Boutwell Mill Brook
- 🟪 Bow Brook
- ▭ One Stack Brook
- ▭ Turee Brook
- 🟨 Turee Pond
- 🟩 Turkey Pond/ Little Turkey Pond
- 🟪 Turkey River

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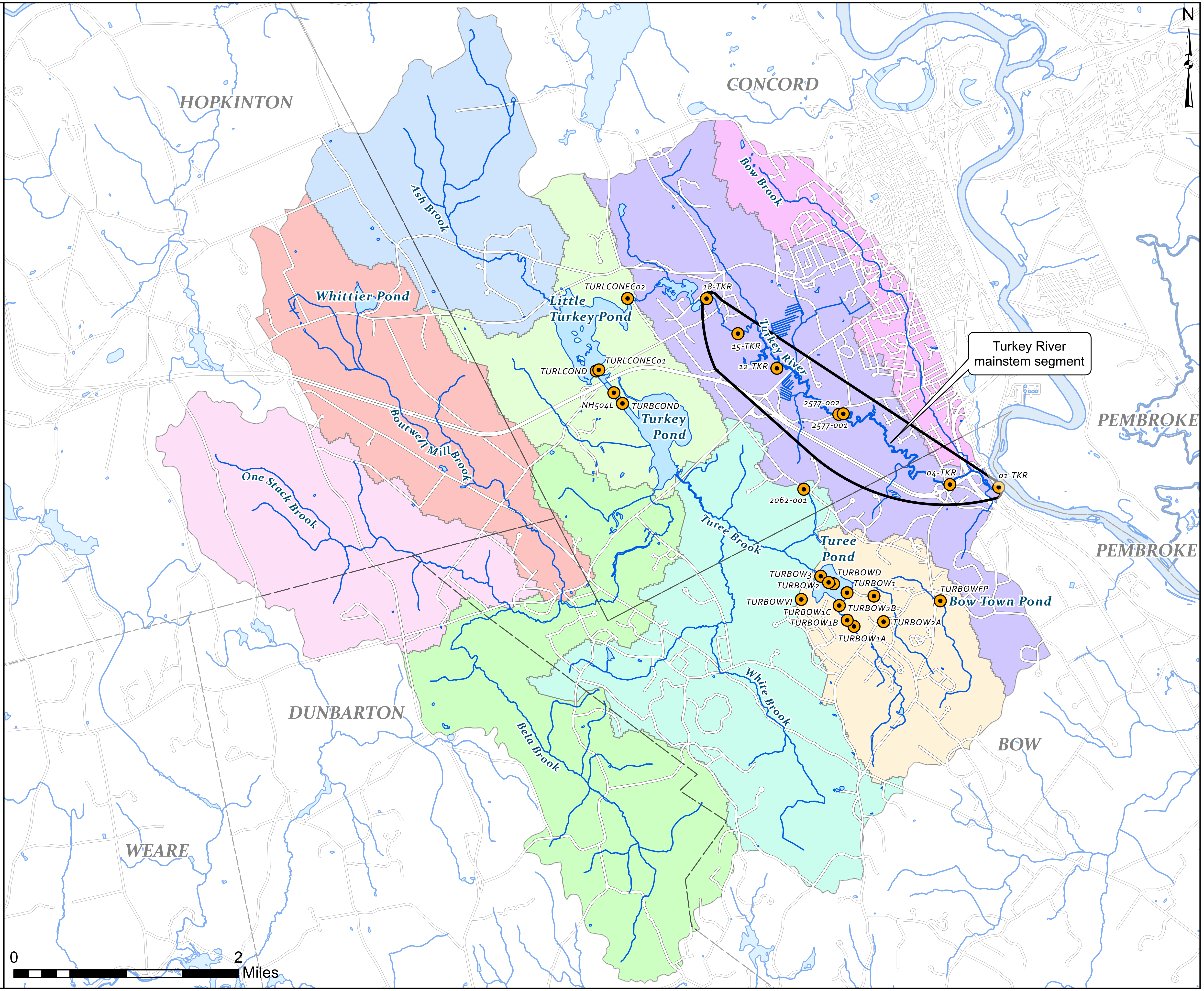

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The NHDES draft 303(d) list for 2020 contains multiple waterbodies in the Turkey River watershed where the designated use of Aquatic Life Integrity is not fully supported due to surface water quality criteria not being met for either one or a combination of benthic macroinvertebrate bioassessments, dissolved oxygen saturation, dissolved oxygen concentration, pH, and aluminum parameters. These impairments are associated with NPS pollution in stormwater runoff, aging or failing septic systems, contributions from internal loading of phosphorus from pond sediments, and impacts within impoundments as a result of riverine systems being partially blocked to either create or increase the surface areas of ponds.

As the Turkey River watershed contains a heterogeneous mix of impaired waters (lakes, ponds, and stream/river reaches) and high-quality coldwater streams ,the UMWA and its partners believe the Turkey River is in a unique position where targeted and coordinated efforts to eliminate water quality impairments (e.g., dissolved oxygen, bacteria, Chlorophyll-*a*, etc.) and restore habitat and geomorphic connectivity can result in a highly functional and productive watershed that is resilient against future disturbances as climate change and further build-out of the watershed.

The primary goal of this WRMP is to assess the Turkey River watershed and provide a plan for implementing actions that will result in measurable improvements in water quality and aquatic habitat. To achieve this goal, this WRMP was developed to include the following nine elements in conformance with the United States Environmental Protection Agency's (USEPA) guidance for watershed-based plans:

USEPA Watershed-Based Plan Elements		WRMP Section
Element A	Identify causes and sources of pollution that need to be controlled.	Sections 1-3
Element B	Determine pollutant load reductions needed to meet water quality goals.	Sections 1-3
Element C	Develop management measures to achieve water quality goals.	Section 4
Element D	Technical and financial assistance needed.	Section 5
Element E	Public information and education	Section 4.3.1
Element F	Implementation schedule	Section 6
Element G	Interim measurable milestones	Section 6
Element H	Criteria to measure progress	Section 7
Element I	Monitoring	Section 7

Recommended actions to restore water quality and meet long-term water quality goals established through this WRMP include a variety of structural and non-structural practices as described in Section 4. These practices include:

- Stormwater management improvements designed to reduce nutrient loading;
- Culvert improvements to restore natural stream morphology and aquatic organism passage;
- Non-structural practices, including specific recommendations for public education, land conservation, regulatory tools, and changes to institutional practices;
- Wastewater management strategies.

A recommended schedule for implementing these watershed management actions over the next five years is provided in Section 6. Successful implementation of the WRMP will require continued collaboration and partnerships between the watershed communities, state and federal government agencies, local stakeholder groups, and nonprofit organizations such as the UMWA and local land trusts.

1 Turkey River Water Quality Data

1.1 SAMPLING DATA AND LOCATIONS

CEI compiled and assessed existing water quality data for the Turkey River. The goals of this task were to characterize current water quality conditions and historic trends, and identify data gaps and potential opportunities for further monitoring.

Data used to analyze the water quality of the Turkey River was obtained from the 2020 NHDES Surface Water Quality Assessment. Water quality data relevant to this study has been collected by various projects, including the National Rivers and Streams Assessment, HUC 10 Targeted River Monitoring, and Ambient River Monitoring Program. As shown in Figure 1, water quality monitoring stations are located throughout the watershed.

UMWA and the project team determined that the river's downstream mainstem segment (from the outlet of Library to its confluence with the Merrimack River) would be used as the basis for water quality goal setting and associated data analysis. Using this downstream segment provides a conservative approach which reflects the nutrient inputs of the entire watershed, which is most heavily developed in its downstream segment. The downstream segment has four water quality monitoring stations with total phosphorus (TP) data (18-TKR, 15-TKR, 04-TKR, and 01-TKR). The median TP concentration from these stations from the 2000-2017 was 30.5 ug/L (Figure 2). Note: An interquartile range test was conducted to identify outliers, resulting in removal of the 82 µg/L sample from 01-TKR on 7/27/2000).

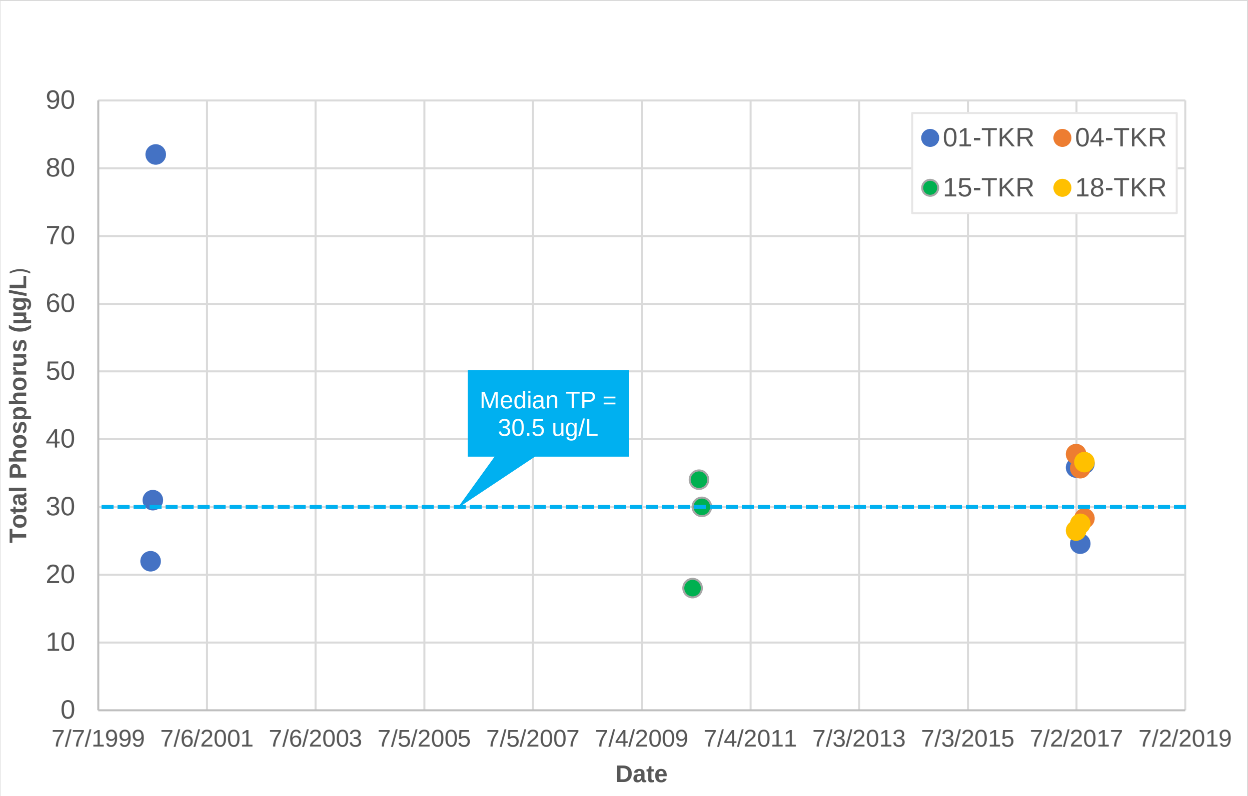
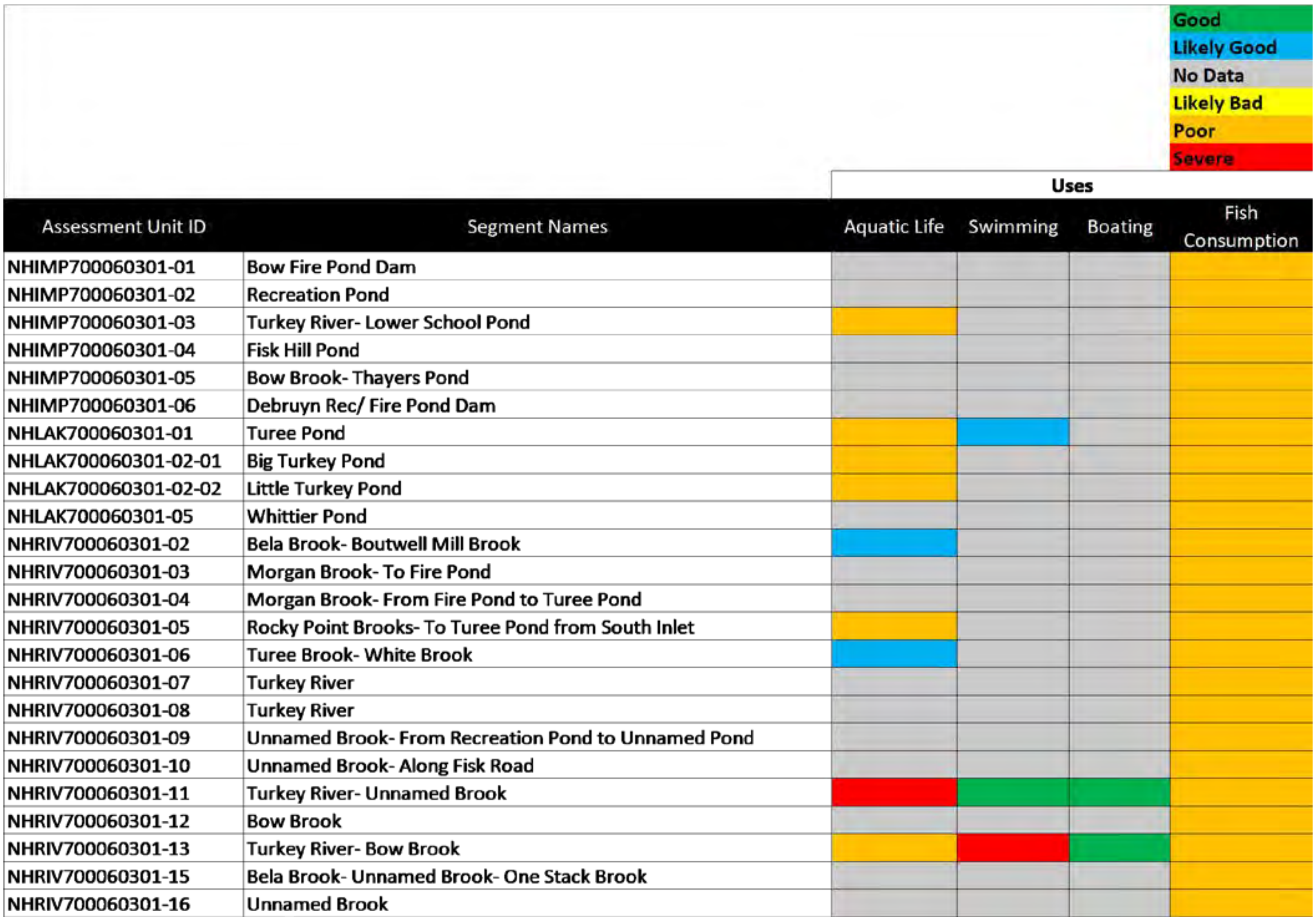


Figure 2. Total Phosphorus Measurements from Turkey River Mainstem Monitoring Stations

1.2 SUMMARY OF WATER QUALITY IMPAIRMENTS

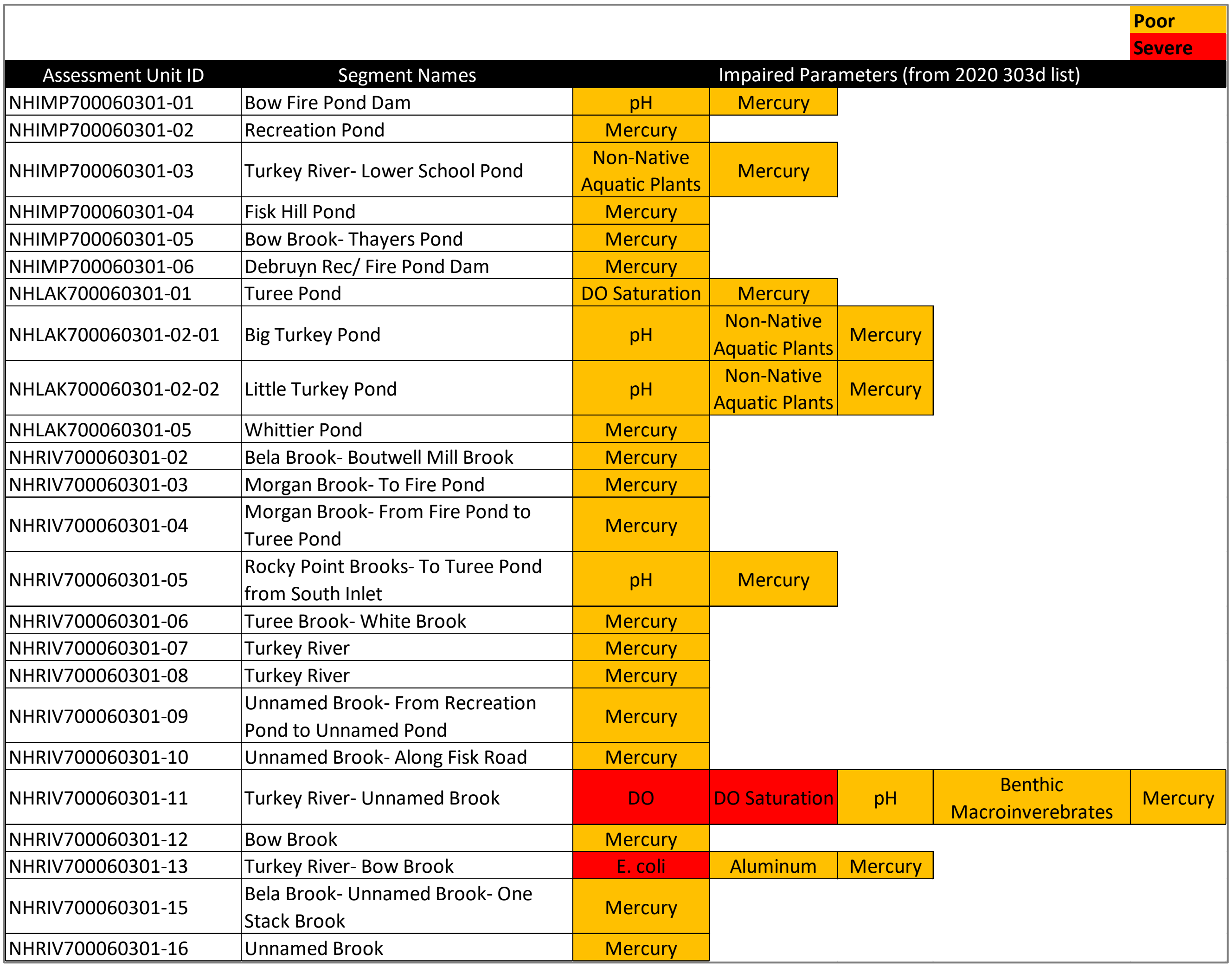
A summary of existing water quality impairments for assessed segments of the Turkey River and its tributaries is provided below in Figure 3 (Impairments to Designated Uses) and Figure 4 (Impaired Parameters), based on the NHDES 2020 303d List.



- 🟩 Good
- 🟦 Likely Good
- ⬜ No Data
- 🟨 Likely Bad
- 🟧 Poor
- 🟥 Severe

		Uses			
Assessment Unit ID	**Segment Names**	**Aquatic Life**	**Swimming**	**Boating**	**Fish Consumption**
NHIMP700060301-01	Bow Fire Pond Dam	⬜	⬜	⬜	🟧
NHIMP700060301-02	Recreation Pond	⬜	⬜	⬜	🟧
NHIMP700060301-03	Turkey River- Lower School Pond	🟧	⬜	⬜	🟧
NHIMP700060301-04	Fisk Hill Pond	⬜	⬜	⬜	🟧
NHIMP700060301-05	Bow Brook- Thayers Pond	⬜	⬜	⬜	🟧
NHIMP700060301-06	Debruyn Rec/ Fire Pond Dam	⬜	⬜	⬜	🟧
NHLAK700060301-01	Turee Pond	🟧	🟦	⬜	🟧
NHLAK700060301-02-01	Big Turkey Pond	🟧	⬜	⬜	🟧
NHLAK700060301-02-02	Little Turkey Pond	🟧	⬜	⬜	🟧
NHLAK700060301-05	Whittier Pond	⬜	⬜	⬜	🟧
NHRIV700060301-02	Bela Brook- Boutwell Mill Brook	🟦	⬜	⬜	🟧
NHRIV700060301-03	Morgan Brook- To Fire Pond	⬜	⬜	⬜	🟧
NHRIV700060301-04	Morgan Brook- From Fire Pond to Turee Pond	⬜	⬜	⬜	🟧
NHRIV700060301-05	Rocky Point Brooks- To Turee Pond from South Inlet	🟧	⬜	⬜	🟧
NHRIV700060301-06	Turee Brook- White Brook	🟦	⬜	⬜	🟧
NHRIV700060301-07	Turkey River	⬜	⬜	⬜	🟧
NHRIV700060301-08	Turkey River	⬜	⬜	⬜	🟧
NHRIV700060301-09	Unnamed Brook- From Recreation Pond to Unnamed Pond	⬜	⬜	⬜	🟧
NHRIV700060301-10	Unnamed Brook- Along Fisk Road	⬜	⬜	⬜	🟧
NHRIV700060301-11	Turkey River- Unnamed Brook	🟥	🟩	🟩	🟧
NHRIV700060301-12	Bow Brook	⬜	⬜	⬜	🟧
NHRIV700060301-13	Turkey River- Bow Brook	🟧	🟥	🟩	🟧
NHRIV700060301-15	Bela Brook- Unnamed Brook- One Stack Brook	⬜	⬜	⬜	🟧
NHRIV700060301-16	Unnamed Brook	⬜	⬜	⬜	🟧

Figure 3. Turkey River Watershed – Impairments to Designated Uses



Poor
Severe

Assessment Unit ID	Segment Names	Impaired Parameters (from 2020 303d list)				
NHIMP700060301-01	Bow Fire Pond Dam	pH	Mercury			
NHIMP700060301-02	Recreation Pond	Mercury				
NHIMP700060301-03	Turkey River- Lower School Pond	Non-Native Aquatic Plants	Mercury			
NHIMP700060301-04	Fisk Hill Pond	Mercury				
NHIMP700060301-05	Bow Brook- Thayers Pond	Mercury				
NHIMP700060301-06	Debruyn Rec/ Fire Pond Dam	Mercury				
NHLAK700060301-01	Turee Pond	DO Saturation	Mercury			
NHLAK700060301-02-01	Big Turkey Pond	pH	Non-Native Aquatic Plants	Mercury		
NHLAK700060301-02-02	Little Turkey Pond	pH	Non-Native Aquatic Plants	Mercury		
NHLAK700060301-05	Whittier Pond	Mercury				
NHRIV700060301-02	Bela Brook- Boutwell Mill Brook	Mercury				
NHRIV700060301-03	Morgan Brook- To Fire Pond	Mercury				
NHRIV700060301-04	Morgan Brook- From Fire Pond to Turee Pond	Mercury				
NHRIV700060301-05	Rocky Point Brooks- To Turee Pond from South Inlet	pH	Mercury			
NHRIV700060301-06	Turee Brook- White Brook	Mercury				
NHRIV700060301-07	Turkey River	Mercury				
NHRIV700060301-08	Turkey River	Mercury				
NHRIV700060301-09	Unnamed Brook- From Recreation Pond to Unnamed Pond	Mercury				
NHRIV700060301-10	Unnamed Brook- Along Fisk Road	Mercury				
NHRIV700060301-11	Turkey River- Unnamed Brook	DO	DO Saturation	pH	Benthic Macroinverebrates	Mercury
NHRIV700060301-12	Bow Brook	Mercury				
NHRIV700060301-13	Turkey River- Bow Brook	E. coli	Aluminum	Mercury		
NHRIV700060301-15	Bela Brook- Unnamed Brook- One Stack Brook	Mercury				
NHRIV700060301-16	Unnamed Brook	Mercury				

Figure 4. Turkey River Watershed Impaired Parameters

2 Water Quality Goals

The sections below summarize water quality goal considerations and recommendations provided to UMWA and the project Steering Committee in a technical memorandum dated March 12, 2021. The memorandum provided (1) CEI's review of water quality data for the mainstem segment of the Turkey River and (2) related analysis to support the process of setting a water quality goal for total phosphorus (TP) for the Turkey River, and (3) a summary of the water quality goal setting meeting held on March 1, 2021.

2.1 WATER QUALITY GOAL SETTING - OVERVIEW

New Hampshire has numeric nutrient criteria for lakes, but not for rivers. NHDES is currently in the process of reviewing, updating, or evaluating nearly every aspect of numeric nutrient criteria development, but it is expected that this process will take several years to complete[1]. The following non-numeric water quality indicator is established at Env-Wq 1703.14:

> "*Class B water shall contain no phosphorus or nitrogen in such concentrations that would impair any existing or designated uses, unless naturally occurring.*"

Correlations between phosphorus and nitrogen concentrations in surface waters make it difficult to statistically separate the independent effects of each nutrient on designated uses. Because of this uncertainty, a common approach to water quality goal setting is to focus on the limiting nutrient in a system, which is typically phosphorus in freshwater systems. As such, the water quality goal setting process for the Turkey River is focused on total phosphorus (TP), as specified in Section 7 of the Site Specific Project Plan (SSPP) for this project.

The Turkey River is not a 303(d)-listed waterbody for impairment due to phosphorus. As such, there is no state or USEPA requirement to develop a load reduction target or Total Maximum Daily Load (TMDL) allocations for phosphorus. Water quality goals established in the Turkey River WRMP should be based on stakeholder consensus with regard to protection of the ecological health, functions, and values of the river and its receiving water, the Merrimack River. These collectively established goals can serve as guidelines for planning purposes, but are not regulatory requirements or enforceable on any party.

2.2 PHOSPHORUS DATA AND RELEVANT CRITERIA

UMWA and the project team determined that the river's downstream mainstem segment (from the outlet of Library Pond at Library Road in Concord to its confluence with the Merrimack River) would be used as the basis for water quality goal setting and associated data analysis (Figure 1).

Using this downstream segment provides a conservative approach which reflects the nutrient inputs of the entire watershed, which is most heavily developed in its downstream segment. The downstream segment has four water quality monitoring stations with TP data (18-TKR, 15-TKR, 04-TKR, and 01-TKR), which are summarized as follows:

- The median TP concentration for the 1996-2017 period of record was 30.5 ug/L for the four Turkey River mainstem stations. This segment **exceeds the 75th percentile** of statewide distribution for river TP concentration (22 ug/L)[1].
- For comparison:
    - The median TP for the six river sampling stations **upstream of the mainstem segment** was 10 ug/L. It is important to note that these riverine stations (TURBOW1A, TURBOW1B,

TURBOW1C, TURBOW2A, TURBOW2B, and TURBOWWVI) are not well-distributed throughout the watershed, as they all are located within tributaries to Turee Pond.

- The statewide median for **all New Hampshire river data** (1990-2016) is 14 ug/L1.
- TP data from **in-pond locations** should be used with caution as a point of comparison to riverine data, due to settling effects and seasonal factors associated with summer thermal stratification and internal phosphorus loading from sediments. With these caveats in mind, the median pond TP levels were as follows:
  - Turee Pond: 14.0 ug/L (epilimnion median); 17.9 ug/L (hypolimnion median)
  - Big Turkey Pond (22 ug/l, epilimnion median)
  - Little Turkey Pond (23.0 ug/L (epilimnion median); 31.0 ug/L (hypolimnion median)

In absence of regulatory numeric criteria for phosphorus, the following provide some useful points of reference when considering a TP water quality goal for the Turkey River:

- ***National Guidance*****:** The most recent national guidance on nutrient standards is provided by the USEPA in Quality Criteria for Water (1986). According to this guidance, total phosphorus should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir.
- ***Other State Criteria*****:** As listed in Table 1, state phosphorus criteria for rivers and streams vary widely, and many states still lack numeric nutrient criteria. The criteria ranges in Table 1 reflect that states often have multiple standards that are applicable only to specified rivers segments or regions. Only Vermont currently has statewide standards that are specific to classes of rivers that have similar characteristics to the Turkey River (warm-water, medium-gradient streams, WWMG).

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1 New Hampshire Department of Environmental Services. Water Monitoring Strategy Condition Report: Status and trends of water quality indicators from the River Monitoring Network. May 2019. R-WD-19-21. https://www.des.nh.gov/organization/divisions/water/wmb/documents/r-wd-19-21.pdf

Table 1. Existing U.S. State and Territory Total Phosphorus Criteria[2]

State	Statewide/ Partial	TP Criteria for Freshwater Rivers/Streams
Arizona	partial	8 – 1000 ug/L (site-specific)
California	partial	5 – 300 ug/L (site-specific)
Florida	partial	10 – 490 ug/L (site-specific)
Hawaii	statewide	30-80 ug/L (dry season); 50-150 ug/L (wet season)
Minnesota	statewide	50-150 ug/L (region-specific)
Montana	partial	20 – 150 ug/L (site-specific)
Nevada	partial	50 – 330 ug/L (site-specific, most at 100 ug/L)
New Jersey	statewide	100 ug/L
New Mexico	partial	100 ug/L (site-specific)
Oklahoma	partial	37 ug/L (for “scenic rivers”)
Utah	partial	50 ug/L (Class 3a/3b - Aquatic Life; Class 2a/2b – Recreation/Aesthetics)
Vermont	partial	9 ug/L: classes A(1)/B(1) medium, high-gradient streams 10 ug/L: classes A(1)/B(1) small, high-gradient streams 12 ug/L: classes A(2)/b(2) small, high-gradient streams 15 ug/L: classes A(2)/B(2) medium, high-gradient streams 18 ug/L: class A(1) warm-water, medium-gradient streams 21 ug/L: class B(1) warm-water, medium gradient streams 27 ug/L: classes Aa(2)/B(2) warm-water, medium gradient streams
Wisconsin	statewide	75 ug/L (specified rivers and their impounded flowing waters) 100 ug/L (streams and their impounded flowing waters)

Note: *Although New Hampshire does not have numeric TP criteria, the state is working on developing such criteria. NHDES staff have reported3 that 30 ug/L has been considered as a potential riverine TP standard. This value represents the 85th percentile of median TP values for New Hampshire rivers.*

2.3 WATER QUALITY GOAL RECOMMENDATIONS

Based on review of the state criteria listed above, CEI recommends that Vermont’s TP criteria for WWMG streams provide standards that are most appropriate to the region and stream type of the Turkey River (Table 2). These TP standards and the primary difference in the aquatic habitat management objectives for Vermont’s Class A(1), B(1), and B(2) WWMG streams are as follows:

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[2] From USEPA website listing *State Progress Toward Developing Numeric Nutrient Water Quality Criteria for Nitrogen and Phosphorus.* https://www.epa.gov/nutrient-policy-data/state-progress-toward-developing-numeric-nutrient-water-quality-criteria

[3] Email dated January 15, 2021 from David Neils (NHDES Chief Aquatic Biologist) to Steven Landry (NHDES Watershed Assistance Section Supervisor).

Table 2. Vermont WWMG TP and Aquatic Habitat Criteria

VT Stream Class	TP Criteria	Aquatic Habitat Criteria[3]
A(1) WWMG	18 ug/L	…achieve and maintain **excellent quality** aquatic habitat.
B(1) WWMG	21 ug/L	…achieve and maintain **very high quality** aquatic habitat.
B(2) WWMG	27 ug/L	…achieve and maintain **high quality** aquatic habitat.

Using the Vermont WWMG standards as a guide, several options for establishing a TP goal for the Turkey River are provided in Table 3 for consideration by UMWA and watershed stakeholders.

Table 3. Potential TP Goals for the Turkey River

TP Goal	% Reduction from Current Mainstem Median TP (30.5 ug/L)	% Reduction from Predicted Mainstem TP at Buildout (39.3 ug/L)	Discussion
30 ug/L	1.6%	23.7%	This goal would focus on staying below the TP threshold that has been discussed by NHDES as a potential state TP standard for rivers. Although the least aggressive water quality goal presented in this table, it would require significant ongoing effort to achieve a 23.7% reduction in the mainstem TP concentration estimated at buildout.
27 ug/L	11.5%	31.3 %	The Vermont Class B(2) WWMG standard would provide a challenging target that would require continued efforts for years to come as the watershed continues to develop. CEI notes that if this goal is achieved, it would provide 10% assimilative capacity if the 30ug/L standard discussed above is eventually adopted by the state.
21 ug/L	31.1%	46.6 %	The Vermont Class B(1) WWMG standard would provide an aggressive goal. CEI recommends that this goal may be very challenging to achieve and maintain, particularly as the watershed continues to develop.
18 ug/L	41.0%	54.2 %	CEI recommends that the Vermont Class A(1) WWMG standard may be unrealistic to achieve for the Turkey River mainstem segment, given current and projected watershed development.

2.4 SUMMARY OF WATER QUALITY GOAL SETTING MEETING

A meeting was hosted by the Upper Merrimack River Watershed Association (UMWA) on March 1, 2021 for the purpose of discussing and establishing a TP water quality goal for the mainstem segment of the Turkey River. Meeting participants are listed in Table 4.

Table 4. Water Quality Goal Setting Meeting Participants (March 1, 2021)

Name	Organization
Michele L. Tremblay	UMWA
Steve Landry	UMWA
Gary Lynn	UMWA
Tom O'Donovan	New Hampshire Department of Environmental Services (NHDES)
Jeff Marcoux	NHDES
Rob Livingston	NHDES
Mike Tardiff	Central New Hampshire Regional Planning Commission (CNHRPC)
Craig Tufts	CNHRPC
Mike Bartlett	Trout Unlimited, Basil W. Woods, Jr. Chapter (Concord)
Sandy Crystall	Bow Conservation Commission/ Bow Planning Board
Bob Ball	Bow Conservation Commission
Chantal Maguire	Upper Merrimack Monitoring Program volunteer
Jerry King	Local volunteer
Bob Hartzel	Comprehensive Environmental, Inc.

Discussion during the goal setting meeting is summarized as follows:

- The meeting started with a presentation by CEI which summarized the water quality data and relevant criteria for TP.
- The meeting participants agreed that the range of potential goals presented in Table 3 provided a reasonable range for discussing a TP goal specific to the Turkey River.
- Jeff Marcoux noted that the % TP reduction required to meet a goal of 27 ug/L was relatively high, but not inconsistent with other watershed-based plans for New Hampshire water bodies.
- Participants discussed the estimated increases in TP load at watershed buildout and the locations in the watershed where the largest load increases are expected to occur. CEI stated that the pending Lake Loading Response Model (LLRM) results would present this information, which estimates the largest load increases from the subwatersheds that are currently the least developed. This load increase is mostly associated with conversion of forest and other types of open land to low-density residential land use.
- Michele Tremblay noted the importance of focusing watershed protection actions on future developments (through improved local bylaws, improved stormwater management, public education, land conservation efforts, etc.), to protect water quality in the mainstem Turkey River and its tributaries.

- There was a general discussion about the merits of setting a TP goal at either 27 ug/l, 21 ug/L, or at an approximate midpoint of 24.3 ug/L (which would represent 10% assimilative capacity for a target of 27 ug/L).
    - Although each of these goals may be challenging to achieve and maintain as the watershed continues to develop, some participants felt that 27 ug/L may be more realistically achievable, and would therefore have the potential to incentivize future water quality protection efforts and funding as the river got closer to achieving this goal.
    - Other participants felt that it was preferable to set a higher standard at 21 ug/L, to ensure that long-term efforts are focused on achieving the best possible water quality and habitat in the river.
- CEI noted that the current understanding of median TP concentration in the Turkey River mainstem (30.5 ug/L) is based on very limited sampling data, and subject to change based on future sampling. The group agreed that any goal set for TP would be considered an interim goal that may be modified in the future based on new sampling data and TP response to water quality protection actions.
- Following the discussion described above, the group reached consensus (with no objections) on a **TP goal of 27 ug/L** for the mainstem segment of the Turkey River.

3

Nutrient Load Modeling

This section presents the methodology and results for development of current and future pollutant load estimates for the Turkey River. Comparative estimates were developed for existing conditions and potential future build-out conditions by subwatershed and by source (i.e., land uses, septic systems) to better prioritize and direct TP reduction efforts.

3.1 METHODS

3.1.1 Model Overview

The Lake Loading Response Model (LLRM) was used to develop TP loading estimates. LLRM is a spreadsheet-based model used to evaluate nutrient loading to a waterbody and the consequences of that loading in terms resulting concentration. The LLRM model is configured for a period of interest based on user-specified inputs such as watershed boundaries, land cover, and precipitation. Embedded calculations are then executed based on reference equations and commonly used coefficients from scientific literature to predict subwatershed runoff, resulting nutrient loads, and other variables.

3.1.2 Data Collection

Data collection, model setup, and calibration was performed in accordance with the approved Site Specific Project Plan (SSPP). Data needed for input to the LLRM includes water quality monitoring data (TP); discharge (if available); land use data; subwatershed land area delineations; precipitation data; and information on the location of septic systems.

Daily precipitation data was acquired from the National Climatic Data Center (NCDC) gauge in Concord, NH. The Central New Hampshire Regional Planning Commission provided land use data for both current and future buildout conditions. Water quality monitoring data was obtained from the 2020 NH DES Surface Water Quality Assessment. See Section 2 for more information on water quality data used for specific model inputs.

3.1.3 Subwatershed Delineations

Subwatersheds were delineated to represent watersheds for the primary tributaries to the Turkey River, including several major pond watersheds, as shown on Figure 1. The watershed was divided into nine subwatersheds based on boundaries from the National Hydrography Dataset Plus (NHDPlus).

3.1.4 Observed Water Quality Data

Water quality data obtained from the 2020 NHDES Surface Water Quality Assessment (as described in Section 1) was applied to the LLRM model for calibration purposes.

3.1.5 Model Inputs

A time period of 2000-2017 was selected for the analysis based on available water quality data. All corresponding inputs were computed during the specified time period. Select inputs were modified during the calibration process as discussed in Section 3.2.

Precipitation

Annual average precipitation data from 2000-2017 was compiled and calculated from Global Historical Climatology Network (GHCN) station USW00014745 in Concord, NH, approximately 2.7 miles east of Turkey River. This is the closest available station to Turkey River with daily precipitation data available from 2000-2017. The calculated annual average precipitation during this period was 1.12 m (Table 5).

Table 5. Annual Precipiation Totals

Year	Precipitation (m)
2000	0.96
2001	0.79
2002	1.01
2003	1.14
2004	1.07
2005	1.45
2006	1.40
2007	1.12
2008	1.47
2009	1.20
2010	0.96
2011	1.39
2012	1.01
2013	1.04
2014	1.17
2015	0.97
2016	0.84
2017	1.12
Overall Average:	**1.12**

Subwatersheds

The area of each delineated subwatershed was calculated using GIS tools (Table 6).

Table 6. Calculated Subwatershed Area

Subwatershed	Subwatershed Area (ha)
W1: Turkey River	1,580
W2: Bow Brook	459
W3: Turkey Ponds	819
W4: Ash Brook	984
W5: Turee Brook	1,462
W6: Turee Pond	713
W7: Bela Brook	1,517
W8: Boutwell Mill Brook	1,075
W9: One Stack Brook	1,086
Totals:	**9,695**

Land Use

LLRM includes 14 pre-defined land use categories (Table 7). Each land use category is assigned a series of runoff and baseflow export coefficients to enable calculation of nutrient export (i.e., kg/ha/yr). Land use data were obtained from CNHRPC on 1/9/2021. GIS tools were used to apply the land use data to each delineated subwatershed and to calculate the area and percentage comprised by each category (Table 8).

Table 7. LLRM Specified Land Uses

LLRM Land Use Classification	Land Use Description
Urban 1 (LDR)	Low density residential (>1 ac lots)
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial
Urban 4 (Ind)	Industrial
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)
Agric 3 (Grazing)	Agricultural pasture with livestock
Agric 4 (Feedlot)	Concentrated livestock holding area
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)
Open 3 (Barren)	Mining or construction areas, largely bare soils

Table 8. Subwatershed Area (ha) Based on LLRM Land Use Classification - Existing Conditions

LLRM LU Classification	W1	W2	W3	W4	W5	W6	W7	W8	W9	Total	Percent
Urban 1 (LDR)	124.9	2.9	43.5	71.2	280.1	138.6	170.5	149.3	88.4	1069.4	11.0%
Urban 2 (MDR/Hwy)	104.2	121.5	12.0	10.4	7.6	8.1	25.0	4.7	0.0	293.5	3.0%
Urban 3 (HDR/Com)	109.1	120.3	14.8	7.4	19.7	29.1	12.8	19.3	11.1	343.5	3.5%
Urban 4 (Ind)	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0%
Urban 5 (P/I/R/C)	124.0	68.8	5.1	5.1	2.3	45.0	2.2	8.8	4.6	265.9	2.7%
Agric 1 (Cvr Crop)	80.0	3.2	41.8	63.7	9.8	2.9	38.8	62.3	7.4	310.0	3.2%
Agric 2 (Row Crop)	69.2	0.0	0.5	51.2	16.6	0.0	0.5	8.4	0.0	146.3	1.5%
Agric 3 (Grazing)	0.0	0.0	0.0	8.5	1.9	0.0	2.3	3.2	16.9	32.8	0.3%
Agric 4 (Feedlot)	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	2.8	3.2	0.0%
Forest 1 (Upland)	841.9	131.2	467.9	701.2	847.2	396.6	1049.8	674.7	754.7	5865.3	60.5%
Forest 2 (Wetland)	53.0	5.2	22.2	26.3	14.2	11.1	35.9	26.9	19.1	213.9	2.2%
Open 1 (Wetland/Lake)	28.5	2.1	206.2	32.2	256.5	79.2	148.6	69.6	145.5	968.4	10.0%
Open 2 (Meadow)	42.0	2.1	2.1	6.0	6.2	2.4	30.8	48.2	33.9	173.7	1.8%
Open 3 (Barren)	3.4	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.6	7.6	0.1%
Totals	**1580.2**	**459.1**	**818.8**	**983.5**	**1462.0**	**712.9**	**1517.2**	**1075.4**	**1086.0**	**9695.1**	**100%**

Table 9. Subwatershed Area (ha) Based on LLRM Land Use Classification - Potential Buildout Conditions

LLRM LU Classification	W1	W2	W3	W4	W5	W6	W7	W8	W9	Total	Percent
Urban 1 (LDR)	216.4	26.9	98.1	232.6	439.3	196.9	281.3	315.5	212.5	2019.6	20.8%
Urban 2 (MDR/Hwy)	115.6	131.2	12.0	10.4	7.6	8.1	25.0	4.7	0.0	314.5	3.2%
Urban 3 (HDR/Com)	140.8	121.6	14.8	7.4	19.7	29.1	12.8	19.3	11.1	376.6	3.9%
Urban 4 (Ind)	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0%
Urban 5 (P/I/R/C)	125.9	71.4	5.1	5.1	6.5	45.0	2.2	8.8	4.6	274.6	2.8%
Agric 1 (Cvr Crop)	66.8	1.8	36.6	51.9	7.5	1.8	35.6	46.9	5.7	254.7	2.6%
Agric 2 (Row Crop)	68.8	0.0	0.5	45.0	9.6	0.0	0.5	6.6	0.0	130.9	1.3%
Agric 3 (Grazing)	0.0	0.0	0.0	8.5	1.3	0.0	1.9	2.4	13.3	27.4	0.3%
Agric 4 (Feedlot)	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	2.8	3.2	0.0%
Forest 1 (Upland)	723.7	95.3	418.5	558.1	695.3	339.7	943.8	530.1	640.2	4944.7	51.0%
Forest 2 (Wetland)	53.0	5.2	22.2	26.3	14.2	11.1	35.9	26.9	19.1	213.9	2.2%
Open 1 (Wetland/Lake)	28.5	2.1	206.2	32.2	256.5	79.2	148.6	69.6	145.5	968.4	10.0%
Open 2 (Meadow)	37.7	1.9	2.1	5.8	4.5	2.1	29.6	44.6	29.5	157.9	1.6%
Open 3 (Barren)	2.9	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.6	7.1	0.1%
Totals	**1580.2**	**459.1**	**818.8**	**983.5**	**1462.0**	**712.9**	**1517.2**	**1075.4**	**1086.0**	**9695.1**	**100%**

Notes:

1. Includes land use results from buildout analysis;
2. See Section 3.1.6.

Precipitation Coefficients

Runoff and baseflow precipitation coefficients are assigned to each land use category to indicate the fraction of overall rainfall that is converted to overland flow ("runoff") or baseflow, respectively (0 = none; 1 = all). LLRM provides default coefficients for each land use category from the published scientific literature. Default LLRM values were used for initial model inputs (AECOM, 2009).

Phosphorus Export Coefficients

Phosphorus and nitrogen export coefficients are assigned to each land use category to enable estimation of phosphorus and nitrogen export via runoff and baseflow. LLRM provides default coefficients for each land use category, including an overall range from the published scientific literature. Default coefficients were used for most initial model inputs for both runoff and baseflow based on the median value (AECOM, 2009). Due to a lack of variation between median urban land use runoff values, urban coefficients were proportionally adjusted from the medium density residential value based on the 2016 EPA Small NH MS4 Permit. For example, the MS4 high density residential coefficient is 18% higher than the medium density residential coefficient so the LLRM high density coefficient was raised by 18%. **Table** 10 provides a summary of the urban land use runoff modifications.

Table 10. Initial Phosphorus Runoff Coefficients Adjustment

Land Use	LLRM Median Coefficient (kg/ha/yr)	MS4 Coefficient (kg/ha/yr)	MS4 Percent Difference	Adjusted LLRM Coefficient (kg/ha/yr)
Urban 1 (LDR)	1.1	1.7	-29%	0.78
Urban 2 (MDR/Hwy)	1.1	2.2	0%	1.10
Urban 3 (HDR/Com)	1.1	2.6	18%	1.30
Urban 4 (Ind)	1.1	2.0	-9%	1.00
Urban 5 (P/I/R/C)	1.1	1.7	-29%	0.78

Notes:

1. MS4 Percent Difference is relative to medium density residential land use.
2. See **Table 12** for initial export coefficients as input into the model.

Waterfowl Loading and Atmospheric Deposition

LLRM allows for the input of data to estimate the amount of average annual mass contributed by waterfowl. Data of this type was not readily available for the Turkey River watershed, and as such the TP load from waterfowl was incorporated into the model calibration process.

The model also allows for the atmospheric deposition of TP to be input. LLRM is limited to only allowing the input of atmospheric deposition data to the final receiving water in the watershed, typically a lake. In order to account for atmospheric deposition throughout the watershed, this load was incorporated into the calibration process.

Septic Loading

Septic systems located in close proximity to receiving waters can significantly contribute to nutrient loading. The purpose of this calculation is to estimate the amount of annual nutrient loading from septic systems within approximately 200 feet of receiving waters within the watershed. LLRM provides default estimates of factors that contribute to septic systems (AECOM, 2009). For existing conditions, approximately 151 year-round homes potentially have septic systems with an estimated occupancy of 2.5 people per home (Table 11). This number increases to approximately 290 for potential buildout conditions (see "Buildout Analysis" for more discussion on the buildout analysis methods). Default LLRM median estimates were used to estimate septic loading from homes based on an assumed initial concentration, people per home, occupancy days per year, and attenuation factor (i.e., portion of load that reaches the river). Septic loading represents a small fraction of nutrient loading to Turkey River.

Table 11. TP Load Contributed by Septic Systems

Subwatershed	**Existing Conditions**		**Potential Buildout Conditions**	
	Septic Systems within 200' of Waterbody	Septic P Load (kg/yr.)	Septic Systems within 200' of Waterbody	Septic P Load (kg/yr.)
Turkey River	14	2.6	31	5.7
Bow Brook	7	1.3	10	1.8
Turkey Ponds	17	3.1	28	5.1
Ash Brook	11	2.0	27	4.9
Turee Brook	32	5.8	61	11.1
Turee Pond	23	4.2	33	6.0
Bela Brook	22	4.0	34	6.2
Boutwell Mill Brook	21	3.8	51	9.3
One Stack Brook	4	0.7	15	2.7
TOTALS	**151**	**27.6**	**290**	**52.9**

Notes**:**

1. Number of septic systems represent buildings within 200' of a waterbody with no sewer access.

2. Additional buildout septic systems were based on predicted parcels within 200' of a waterbody with no sewer access.

3. Data compiled by CNHRPC.

Subwatershed Routing

LLRM includes a subwatershed routing mechanism for nutrients, baseflow, and runoff. Since attenuation in a downstream subwatershed can affect inputs from an upstream subwatershed that passes through the downstream subwatershed, the model must be directed as to where to apply attenuation factors and additive effects. Subwatershed routing was assigned based on review of delineated subwatersheds.

3.1.6 Buildout Analysis

A buildout analysis was performed by CNHPRC to estimate the effects of potential increases in urbanization within the watershed. Parcels were determined to be buildable only if they included upland forest, agricultural, or open land uses that were (1) not in protected status (e.g., conservation land) and (2) met the town minimum lot size requirements. These parcels were subdivided into lots based on local town zoning laws. With the exception of projects currently in development, such as a solar farm or new subdivision, the majority of buildable lots were projected as low density residential based on current and anticipated development trends.

To estimate the increased P load from septic systems at buildout, septic systems were assigned to each potentially buildable lot. No sewer expansion projects are currently planned, so only lots on streets that currently have sewer infrastructure were assumed to not require a septic system. Septic systems located within approximately 200 feet of receiving waters in the watershed were used for the purposes of this modeling effort.

After the model was calibrated to current conditions (see Section 3.2), the results of the buildout analysis were applied to a second iteration of the model. Land use inputs were updated to reflect the changes predicted by the buildout analysis. Septic systems were also increased based on the buildout results. Model inputs from the buildout analysis can be viewed in Table 9. A summary of potential changes from the buildout analysis is as follows:

- A majority of the land use change at buildout is projected to come from the conversion of upland forest to urban land use. Approximately 921 hectares (2,276 acres) of upland forest could be converted into low density residential or other urbanized areas.
- Septic systems within 200 feet of receiving waters within the watershed could potentially increase from 151 to 290, an increase of 139 (Table 11).

3.2 CALIBRATION

Once model inputs were configured, initial model outputs were evaluated relative to available monitoring data. Available water quality data shows the Turkey River mainstem TP concentration to be 30.5 µg/L as compared to the initially predicted concentration of 89.0 µg/L. Inputs were adjusted as described below to obtain a more reasonable output.

3.2.1 Flow

Estimates of average annual outflow (runoff plus baseflow) from each subwatershed were first reviewed to determine if it was necessary to adjust precipitation runoff coefficients or assign water attenuation factors to account for mechanisms such as depression storage, wetlands, or infiltration. Long-term flow observations were not available to compare with LLRM model predictions. In lieu of this, outflow predictions from each subwatershed were compared with a standard water yield of 1.5 cfs per upstream square mile – this standard water yield value is on the low end for typical for New England rivers. The predicted outflow from all subwatersheds was within 10% of the standard water yield. Flow attenuation factors were therefore not used.

3.2.2 Nutrient Attenuation

Based on LLRM guidance, nutrient attenuation can vary widely based on removal processes such as infiltration and filtration provided by wetlands, ponds, and other features. Nutrient attenuation within an individual subwatershed can range from 10% removal to 60% removal. Based on this guidance, attenuation factors were assigned to each subwatershed based on review of the relative extent of major visible attenuation features as follows: 1) Minimal Attenuation: 0%; Low Attenuation: 10%; Moderate Attenuation: 20%; Highest Attenuation: 30%. Attenuation factors for each subwatershed and tributary are summarized by Table 12.

Table 12. Subwatershed Nutrient Attenuation Factors

Subwatershed	**Tributary**	**Name**	**Wetland Area (%)**	**Potential Attenuation**	**Assigned Attenuation Factor**
W1	Proximal	Turkey River	5%	Small	0.90
W2	Bow Brook	Bow Brook	2%	None	1.00
W3	Turkey Ponds	Turkey Ponds	28%	Large	0.70
W4	Ash Brook	Ash Brook	6%	Small	0.90
W5	Turee Brook	Turee Brook	19%	Large	0.70
W6	Turee Brook	Turee Pond	13%	Medium	0.80
W7	Bela Brook	Bela Brook	12%	Medium	0.80
W8	Bela Brook	Boutwell Mill Brook	9%	Medium	0.80
W9	Bela Brook	One Stack Brook	15%	Large	0.70

Notes:

1. Potential attenuation assigned based on review of relative extent of major visible attenuation features (i.e., wetlands / ponds).

2. Attenuation factor indicates % of nutrients that pass through each subwatershed.

3. Wetland area includes Forest 2 and Open 1 land uses.

4. Assigned attenuation bins: None: <2% wetland; Small: 2-7% wetland; Medium: 7-13% wetland; Large: >13% wetland.

3.2.3 Phosphorus Coefficients

Nutrient runoff and baseflow export coefficients for each land use classifications were initially input into the LLRM model based on the median LLRM default values (Table 13**).** These coefficients can vary widely based on site-specific factors. The initial model output for the Turkey River mainstem before the confluence with the Merrimack River predicted phosphorus concentrations to be 89 µg/L as compared to the observed median concentration of 30.5 µg/L from available water quality data. To refine predicted concentrations to more accurately reflect this water quality data, export coefficients were iteratively adjusted to obtain reasonable results (Table 13).

Table 13. LLRM Export Coefficients

LLRM Export Coefficients LLRM LU Classification	**P Runoff Export Coefficient (kg/ha/yr)**				
	LLRM Minimum	LLRM Median	LLRM Maximum	Initially Selected Value	Adjusted Calibration Value
Urban 1 (LDR)	0.2	1.1	6.2	0.8	**0.8**
Urban 2 (MDR/Hwy)	0.2	1.1	6.2	1.1	**1.1**
Urban 3 (HDR/Com)	0.2	1.1	6.2	1.3	**1.3**
Urban 4 (Ind)	0.2	1.1	6.2	1.0	**1.0**
Urban 5 (P/I/R/C)	0.2	1.1	6.2	0.8	**0.8**
Agric 1 (Cvr Crop)	0.1	0.8	2.9	0.8	**0.4**
Agric 2 (Row Crop)	0.3	2.2	18.6	2.2	**1.1**
Agric 3 (Grazing)	0.1	0.8	4.9	0.8	**0.4**
Agric 4 (Feedlot)	21.3	224.0	795.2	224.0	**21.3**
Forest 1 (Upland)	0.0	0.2	0.8	0.2	**0.1**
Forest 2 (Wetland)	0.0	0.2	0.8	0.2	**0.1**
Open 1 (Wetland/Lake)	0.0	0.2	0.8	0.2	**0.1**
Open 2 (Meadow)	0.0	0.2	0.8	0.2	**0.2**
Open 3 (Barren)	0.1	0.8	4.9	0.8	**0.6**

3.3 RESULTS

This section presents results from the calibrated model. Results are configured to show comparisons between existing conditions and potential buildout conditions, and are summarized as follows:

- Annual average TP exported from the Turkey River watershed under current conditions is estimated to be 1,629 kg/yr. This estimate represents the TP load delivered from the Turkey River to the Merrimack River at its confluence just downstream of sampling station 01-TKR.
- Under estimated buildout conditions, the annual average TP load exported from the Turkey River watershed is expected to increase by 409 kg/yr to a total of 2,038 kg/yr.
- The resulting TP concentration is expected to increase from **30.5** µg/L to **39.3** µg/L. This increase is attributed to the estimated 1,013-hectare (2,503-acre) expansion of urban land uses. See Table 8 and Table 9 to compare land use changes from existing conditions to buildout conditions.

3.3.1 Phosphorus Loading by Source

An increase in low density residential land use is expected to cause the largest increase in watershed TP loading. Figure 5 shows how each land use load is estimated to change between current and buildout conditions (*Note: Figure 5 shows total, unattenuated TP loads from each land use.)* Low density residential areas currently contribute the largest of TP load (841 kg/yr). This load is expected to nearly double to 1,568 kg/yr at watershed buildout, with corresponding load reductions in forested and agricultural land as these areas become developed. Although septic systems make up a small portion of the current TP load, this load is expected to roughly double at buildout. The remaining land uses are predicted to experience a less than 10% increase in total annual phosphorus load.

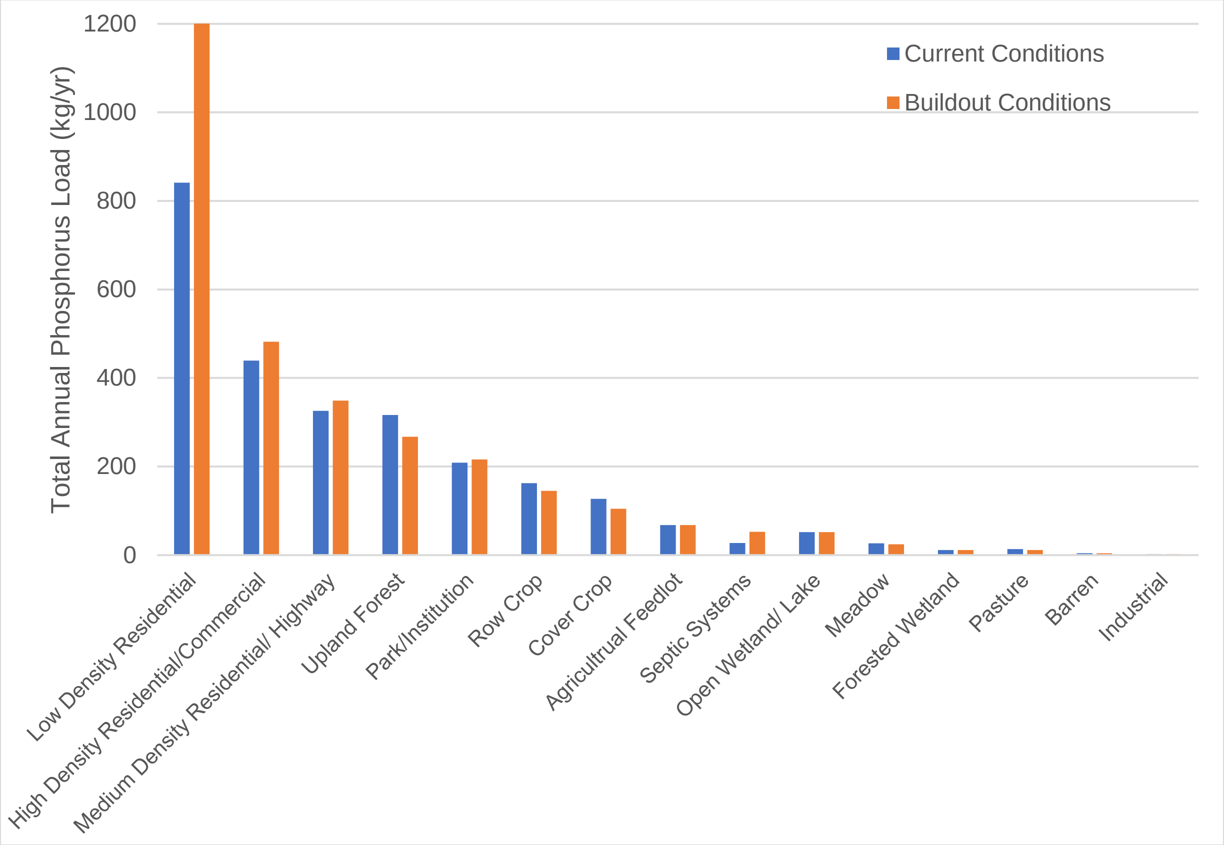


Figure 5. Estimated Total Annual Phosphorus Load from Land Uses

3.3.2 Phosphorus Loading by Subwatershed

A comparative summary of TP loading for each subwatershed under existing conditions and buildout conditions is provided in Table 14. The Bow Brook watershed is estimated to be the largest contributor to the TP concentration under both existing and buildout conditions. The Bow Brook watershed is also expected to see the smallest increase in TP concentration because it is projected to have the smallest increase in urban area. Other more heavily developed subwatersheds, like Turkey River and Turee Pond, are also expected to have less future development and smaller associated increases in TP concentrations.

Subwatersheds with the highest percent increase of development are predicted to experience the largest TP load increases. Watersheds with a predicted increase in urban land use of over 50% are also expected to see at least a 20% increase in TP load. The heavily forested subwatersheds in the northwestern section of the Turkey river watershed (Boutwell Mill Brook, Ash Brook, and One Stack Brook) are expected to have the largest increases in TP concentration. The Ash Brook subwatershed is projected to experience the largest increases in land development and TP concentration. Refer to Figure 6 for a visual depiction of these results.

Table 14. Estimated Calibrated TP Loading by Subwatershed (Existing Conditions and Potential Buildout Conditions)

Subwatershed	**Area (ha)**	**Discharge (hm^3/y)**	**Existing Conditions**			**Potential Buildout Conditions**			**Estimated Percent Increase**		
			Urban LU (ha)	TP Load (kg/yr)	TP Conc. (µg/L)	Urban LU (ha)	TP Load (kg/yr)	TP Conc. (µg/L)	Urban LU (ha)	TP Load (%)	TP Conc. (%)
Bow Brook	459.1	0.25	315.2	357.3	143.2	352.9	388.7	157.0	12%	9%	10%
Turee Pond	712.9	0.37	220.7	178.0	47.7	279	213.3	57.5	26%	20%	21%
Turkey River	1580.2	5.24	462.2	1629.4	31.0	598.7	2037.7	39.3	30%	25%	27%
Turee Brook	1462.0	1.17	309.7	366.9	31.5	473.1	473.1	41.1	53%	29%	30%
Turkey Ponds	818.8	4.15	75.4	831.7	20.1	130	1137.3	27.7	72%	37%	38%
Bela Brook	1517.2	1.99	210.5	492.7	24.7	321.3	683.8	34.6	53%	39%	40%
One Stack Brook	1086.0	0.59	104.1	149.5	25.3	228.2	212.9	36.4	119%	42%	44%
Boutwell Mill Brook	1075.4	0.58	182.1	193.7	33.5	348.4	287.1	50.3	91%	48%	50%
Ash Brook	983.5	0.55	94.1	197.6	36.3	255.5	297.0	55.3	172%	50%	53%

Notes:

1. Time period is 2000-2017.
2. Load and concentration predictions include Septic System (27.6 kg/yr) predictions for Total Phosphorus
3. Urban Land Use (LU) is comprised of low density residential, medium density residential/ highway, high density residential/ commercial, industrial and parks/ institutions.
4. Predicted TP Concentration Increase:

🟩 Lowest (0-29%)
🟨 Medium (30-40%)
🟥 Highest (>40%)

Figure 6
Estimated Increase in Annual Average TP Concentration per Subwatershed from Potential Buildout

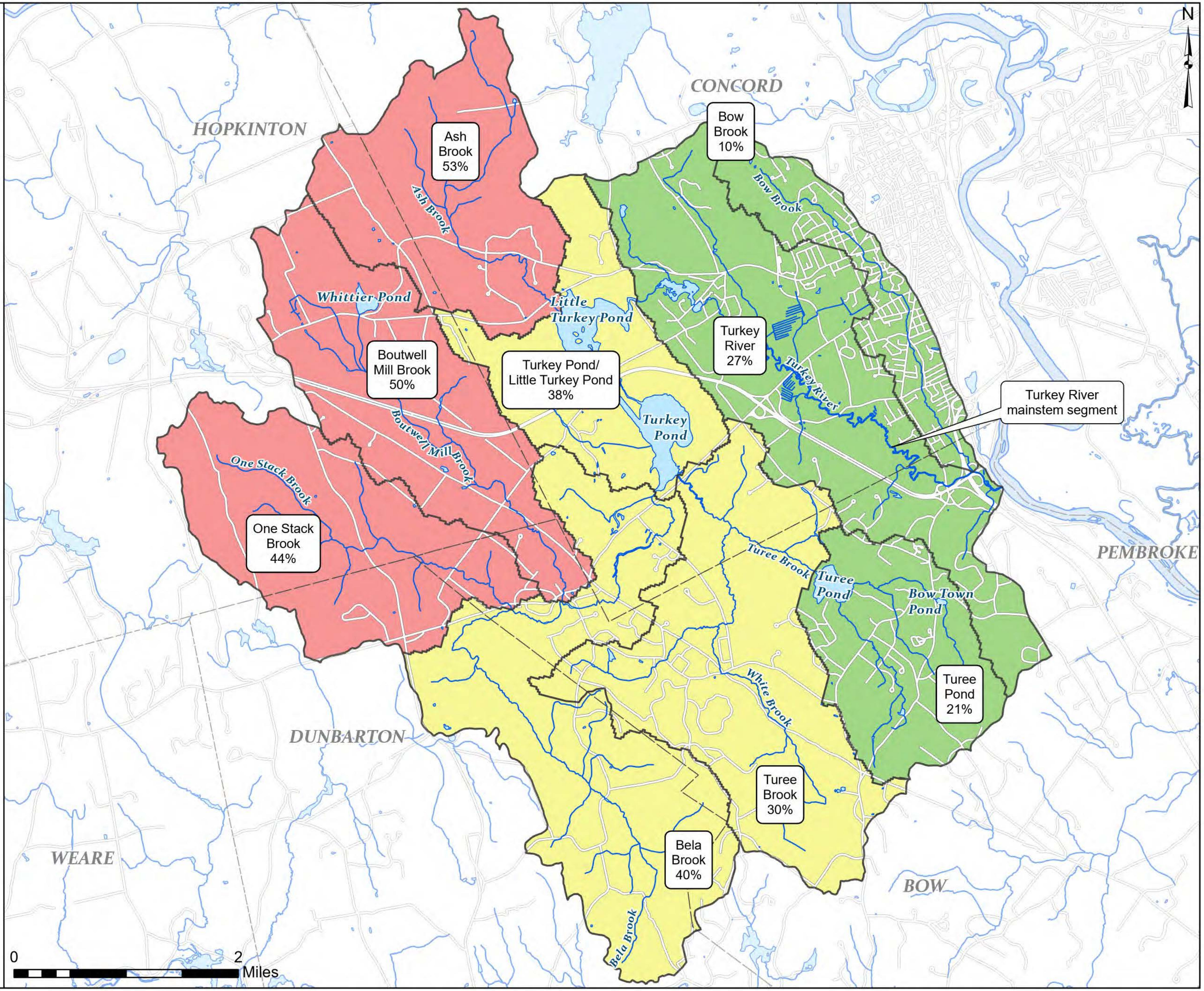
Turkey River Watershed

Comprehensive
Environmental
Incorporated

Legend

Predicted P Concentration Increase:

🟩 Lowest (0-29%)
🟨 Medium (30-40%)
🟥 Highest (>40%)
Subwatershed Boundaries
Lake, Pond, Reservoir
Stream, River
Road



8/13/2021

3.4 SUMMARY OF FINDINGS

- Buildout conditions are estimated to increase urban area by 2,503 acres.
- Most of the TP load increases are expected to result from low density residential land uses. The increased septic system load is expected to remain a small part of the overall TP load.
- The mainstem Turkey River TP concentration is projected to increase from 30.5 µg/L to 39.3 µg/L at buildout.
- The largest TP load and concentration increases are expected to occur in the headwater subwatersheds.
- Future watershed management efforts should consider focusing on implementing stormwater control measures to reduce TP loading in developed areas (e.g., the Bow Brook subwatershed), while also encouraging use of non-structural approaches (e.g., regulatory tools, zoning ordinances, public education/outreach, etc.) to protect water quality in the headwaters subwatersheds. See Section 4 for a discussion of structural and non-structural measures that can be used to meet the water quality goals for the Turkey River watershed.

4 Watershed Management

This section of the Turkey River WRMP presents recommended best management practices (BMPs) according to the following categories:

- Structural Best Management Practices (Section 4.1)
- Wastewater Management (Section 4.2)
- Non-structural Best Management Practices (Section 4.3)

Section 4.4 provides tables that summarize and provide a prioritization ranking of the recommended BMPs based on BMP categories. These tables allow for comparison of recommended BMPs within each category, and includes a description of prioritization ranking factors for each category.

4.1 STRUCTURAL BEST MANAGEMENT PRACTICES

4.1.1 Field Watershed Investigation

CEI conducted a watershed field investigation on April 30, 2021 to identify locations where structural BMPs and other restoration practices could be implemented to reduce pollutant loads within the Turkey River Watershed. To identify known problem areas within the watershed, reconnaissance efforts were conducted before the CEI watershed investigation by UMWA volunteers, CNHRPC staff, and municipal officials. Based on this information, CEI conducted both a desktop analysis and on the ground reconnaissance throughout the watershed. CEI identified potential structural BMP locations based on the following factors:

- Connectivity to the Turkey River, its tributaries and wetlands;
- Existing “available” space (i.e., land without buildings or other structures);
- Parking lot configuration/traffic flow (i.e., how much parking is currently provided?; are there paved medians?; would improvement impact or alter traffic patterns?);
- Entrances to the site and buildings (i.e., highly visible areas);
- Below-ground infrastructure/utilities;
- Site drainage patterns and proximity to existing inlets to enable overflow drainage;
- Potential for disconnecting and routing roof drains/headers or other catchment areas to structures;
- Locations with existing infrastructure in poor condition where strategic improvements can be made to serve dual benefits (e.g., replace crumbling walkway or asphalt with permeable pavement);
- Constructability concerns (proximity to foundations, overhead utilities, wetland resource areas and other permitting constraints, etc.); and
- Proximity to cultural/historical areas that may require special conditions.

The potential structural BMP locations described in the sections below are not intended to be an all-inclusive listing of potential structural retrofit improvements possible within the watershed.

4.1.1.1 Summary of BMP Recommendations

Potential BMP improvement sites were identified based on findings from the field watershed investigation as summarized by Figure **7**. A detailed description of each BMP recommendation is provided in Section 4.1.1.3, including:

- A site summary that describes the current conditions and stormwater drainage patterns;
- A description of proposed structural BMP(s);
- Estimated costs;
- Estimated annual phosphorus, nitrogen, and TSS load reduction for the proposed structural BMP, assuming that the practice is properly designed, installed, maintained according to guidelines provided in the New Hampshire Stormwater Handbook (NHDES, 2008); and
- Recommended priority for BMP implementation (low, medium or high).

Refer to Table 15 for a summary of estimated costs, estimated nutrient load reductions, and recommended priority for each proposed BMP. Construction of all of the proposed BMPs would reduce the annual total phosphorus load to the watershed by an estimated 7.4 pounds per year at an estimated cost range of $680,960 to $1,021,040. Proposed BMPs for the High Priority sites would reduce annual total phosphorus loading by approximately 5 pounds at an estimated cost of $281,120 to $421,680.

As described in the methodology section below, costs are conservatively estimated and include a contingency. Conservative cost estimates are particularly important for grant projects to leave room in the budget to accommodate any changes or unknowns that may come up during the design process. Proposed improvements may be designed and constructed sequentially or all at once. Overall project costs may be reduced if multiple improvement sites are designed and constructed at the same time. Section 4.1.1.2 describes the methodology that was followed to compile these recommendations.

Figure 7

Proposed Structural BMP Locations

Comprehensive
Environmental
Incorporated

Legend

● BMPs

Watershed Boundary

Site ID	Coordinates	Location
1	43.155968, -71.550860	Turee Pond Boat Launch on Falcon Way
2	43.154876, -71.535516	Bow Parks & Rec Dept. Building Parking Lot
3	43.169089, -71.525098	Grappone Toyota Service Center; Rte. 3A near Turkey River confluence with Merrimack River
4a	43.193918, -71.578870	St Paul's School, Sites 4a-4d
4b	43.193034, -71.578479	
4c	43.192602, -71.578723	
4d	43.191634, -71.578592	
5	43.183819, -71.594177	Turkey Ponds Boat House
6	43.170172, -71.533145	Hampton Inn Parking Lot
7	43.194370, -71.543858	Concord District Courthouse
8	43.199953, -71.548721	Concord High School Parking Lot
9	43.182199, -71.594389	Pedestrian Bridge over Little Turkey Pond, (adjacent to I-89)
10	43.191426, -71.637496	Whittier Pond
11	43.171142, -71.622934	Boutwell Mill Brook at Farrington Corner Road (near Brockway Road)
12	43.161189, -71.636776	One Stack Brook at Jewett Road
13	43.129170, -71.594207	Bela Brook at Grapevine Road
14	43.145162, -71.573864	White Brook at Page Road
15	43.170155, -71.535991	Turkey River near Chen Yang Li Restaurant
16	43.188773, -71.540925	Abbot Downing School

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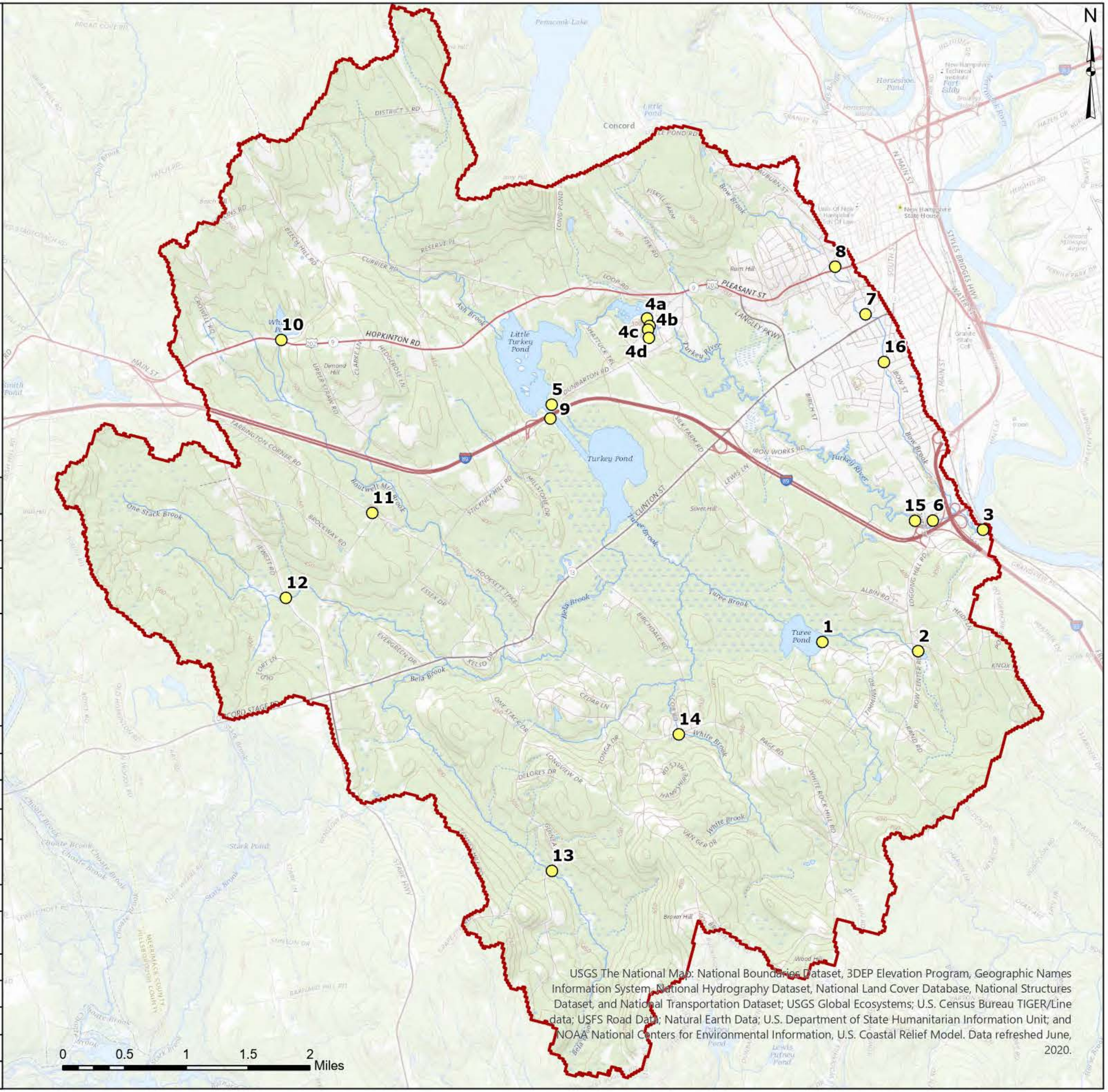

USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program, Geographic Names Information System, National Hydrography Dataset, National Land Cover Database, National Structures Dataset, and National Transportation Dataset; USGS Global Ecosystems; U.S. Census Bureau TIGER/Line data; USFS Road Data; Natural Earth Data; U.S. Department of State Humanitarian Information Unit; and NOAA National Centers for Environmental Information, U.S. Coastal Relief Model. Data refreshed June, 2020.

Table 15. Structural BMP Scoring and Prioritization Summary

BMP Priority Ranking

L = Low	M = Medium	H = High

Area ID	Location	Existing Issues	Proposed Improvements	Estimated Load Reduction			Construction Cost ($)	Engineering Cost ($)	Capital Cost Range		Ranking Factors / Scoring					Score	Site Priority
				TP (lb/yr)	TN (lb/yr)	TSS (ton/yr)					TP Removal	Capital Cost	Waterbody Proximity	Imp. Complexity	Public Visibility		
1	Turee Pond Boat Launch on Falcon Way	Eroding parking area near boat launch.	Pave boat ramp and parking area and install tree box filter.	0.22	1.64	0.06	$65,000	$26,000	$72,800	$109,200	M	L	H	M	H	65	Medium
2	Bow Parks and Rec Dept. Building Parking Lot	Eroding sandy slope and runoff discharge from parking lot into Bow Town Pond .	Stabilize/armor eroding slope (appx. 2,200 sf), repave parking lot, install series of 3 treebox filters, and improve vegetated buffer.	1.50	6.50	1.18	$195,000	$78,000	$218,400	$327,600	H	L	H	L	H	70	High
3	Grappone Toyota/Service Center	Gully erosion along bank at access point to Turkey River.	Stabilize eroding bank (appx. 600 sf) with native vegetation plantings and bio-stabilization techniques.	1.00	2.00	1.10	$15,000	$6,000	$16,800	$25,200	H	M	H	H	M	85	High
4a	St. Paul's School	Narrow buffer adjacent to Library Pond.	Enhance buffer along the shoreline with double row of shrub plantings (appx. 2,000 sf). Stabilize walking path upgradient of narrow buffer with pea gravel.	-	-	-	$23,000	$9,200	$25,760	$38,640	L	M	H	M	M	60	Medium
4b		Unstabilized bank and narrow buffer adjacent to Library Pond.	Stabilize appx. 700 sf area using biostabilization techniques.	0.20	0.60	0.40	$7,000	$2,800	$7,840	$11,760	M	H	H	H	M	85	High
4c		Narrow buffer along appx. 100 ft of shoreline receives runoff from paved Rectory Rd.	Enhance buffer along the shoreline with double row of shrub plantings (appx. 2,100 sf)	0.70	1.30	0.80	$12,000	$4,800	$13,440	$20,160	M	H	H	M	M	75	High
4d		An unpaved footpath discharges directly into southern side of Library Pond.	Install waterbars to redirect runoff away from Pond and reduce erosion. Enhance appx. 375 sf buffer area with woody plantings.	1.55	4.10	1.73	$16,000	$6,400	$17,920	$26,880	H	M	M	H	M	75	High
5	Crumpacker Boathouse	Eroding dirt road and minimal buffer adjacent to Little Turkey Pond.	Install waterbars to direct runoff away from Pond and reduce erosion. Enhance 2,100 sf buffer with double row of shrubs/trees.	0.12	0.90	0.0	$21,000	$8,400	$23,520	$35,280	L	M	M	M	M	50	Low
6	Hampton Inn Rear Parking Lot	N/A - opportunistic implementation area.	Install appx. 1,000 sf infiltration basin or rain garden in center of the parking lot.	0.31	2.60	0.04	$27,000	$10,800	$30,240	$45,360	M	M	L	L	L	40	Low
7	Concord District Court	Minimal buffer along Bow Brook. Areas of erosion observed at culvert.	Develop a 20-ft “no-mow” zone along appx. 1,000 ft of Bow Brook. Stabilize eroding area near culvert with riprap (appx. 500 sf)	-	-	-	$6,000	$2,400	$6,720	$10,080	L	H	H	H	M	80	High
8	Concord High School Parking Lot	N/A - opportunistic implementation area.	Install infiltration trench (appx. 80 ft long) along western edge of parking lot.	0.96	8.70	0.11	$28,000	$11,200	$31,360	$47,040	H	M	M	L	M	60	Medium
9	Footpath Along Interstate-89	Runoff from concrete foot bridge enters Little Turkey Pond.	Install infiltration steps to slow runoff velocity and promote infiltration. Armor downgradient shoreline to prevent erosion.	0.056	0.44	0.01	$13,000	$5,200	$14,560	$21,840	L	H	M	L	L	50	Low
10	Currier Road Culvert near Whittier Pond	Areas of erosion adjacent to culvert headwall and road shoulder. Sediment buildup downstream of culvert.	Armor headwall slopes to limit erosion. Install depressed riprap forebay and lined riprap channel downstream of culvert to prevent further erosion.	-	-	-	$13,000	$5,200	$14,560	$21,840	L	H	M	L	L	50	Low
11	Boutwell Mill Brook	Runoff from the roadway and parking area enter Boutwell Mill Brook.	Stabilize side of Farrington Corner Road with riprap. Install treebox filter to collect runoff from unpaved parking area.	0.16	1.47	0.03	$27,000	$10,800	$30,240	$45,360	L	M	H	L	L	50	Low
12	Jewett Road Culvert Over One Stack Brook	Erosion of headwall embankment caused by runoff from road.	Install riprap along headwall and wingwall embankment areas to limit erosion caused by surface runoff.	-	-	-	$5,000	$2,000	$5,600	$8,400	L	H	H	M	L	65	Medium
13	Grapevine Road Culvert Over Bela Brook	Unstabilized area and erosion directly adjacent to Bela Brook from Grapevine Rd.	Stabilize existing area with riprap. Create small riprap lined energy dissipation area (110 sf) around existing catch basin.	0.06	0.11	0.07	$9,000	$3,600	$10,080	$15,120	L	H	M	H	L	65	Medium
14	Page Road Culvert Over White Brook	Roadside erosion of sandy soils on the southern side of Page Road.	Armor area surrounding culvert inlet and outlet, including embankment, to prevent erosion. Establish vegetated buffer along roadway (appx. 150 ft) consisting of shrubs and hearty grasses.	0.34	0.68	0.40	$18,000	$7,200	$20,160	$30,240	M	M	H	M	L	60	Medium
15	Turkey River Near Chen Yang Li Restaurant	Embankment adjacent to Turkey River is getting undercut from parking lot runoff.	Stabilize embankment with gabion wall (appx. 10 ft tall by 100 ft long). Enhance stream buffer with native woody plantings (appx. 2,800 sf).	-	-	-	$86,000	$34,400	$96,320	$144,480	L	L	M	L	L	35	Low
16	Abbot-Downing School	N/A - opportunistic implementation area.	Armor unpaved footpath with gravel to limit erosion. Direct runoff from upgradient parking area to approx. 300 sf raingarden.	0.20	1.68	0.03	$22,000	$8,800	$24,640	$36,960	M	M	M	L	H	55	Low
			TOTALS	**7.4**	**32.7**	**6.0**	**$608,000**	**$243,200**	**$680,960 -**	**$1,021,440**							

4.1.1.2 Methodology

Potential sizing, costs, and pollutant load reductions were calculated for each recommended BMP based on a combination of tools, as summarized below.

- **Step 1 – Delineate Drainage Area and Determine Land Use Information**. Where applicable, the drainage area to proposed BMPs was delineated using two-foot contours obtained from the NH Granit GIS Clearinghouse, aerial imagery, and best professional judgement based on field observations (e.g., observed drainage patterns, roadway grading, etc.). The land use / cover type within each delineated drainage area was estimated using classifications from the National Land Cover Database (NLCD) using GIS tools. Soil types within each delineated drainage area were determined by using the National Resources Conservation Service (NRCS) online Web Soil Survey (WSS) tool.

- **Step 2 – Determine Design Criteria for Sizing.** Each proposed BMP was designed to capture and treat as much site runoff as possible based on site constraints. A design objective for each proposed BMP should be to size the BMP to treat and potentially infiltrate the water quality volume (WQV) to the maximum extent practicable. The WQV is the minimum amount of stormwater runoff from a rainfall event that should be captured and treated to remove a majority of target stormwater pollutants on an average annual basis. The WQV is defined in the New Hampshire Stormwater Manual (NH DES, 2008) as the volume of runoff associated with the first one-inch of rainfall, which is equivalent to capturing and treating the runoff from the 90th percentile of all rainfall. However, each proposed BMP should be designed to get the most treatment that is practical given the size and constraints of each site.

- **Step 3 – Perform BMP Sizing**. Applicable structural BMPs were sized using Watershed Based Plans Tool (WBPT)[4] developed by the Massachusetts Department of Environmental Protection (MassDEP). Required inputs include: BMP Type, storm size (i.e., treated runoff depth), drainage area, and land use. Outputs include: anticipated BMP footprint based on a typical cross section; estimated construction cost; and estimated load reduction for Total Suspended Solids (TSS), Total Phosphorus (TP), and Total Nitrogen (TN). All applicable BMPs were sized to treat a 1 inch or greater WQv.

- **Step 4 – Calculate Potential Pollutant Load Reductions.** The WBPT provides estimated pollutant load reductions for structural BMPs that have sufficient performance data. Pollutant loading estimates were calculated based on the WBPT for supported BMP types (i.e., bioretention). Structural BMPs not supported by the MassDEP WBPT (e.g., bank stabilization) where calculated based on the EPA Region 5 Spreadsheet Model for Estimating Load Reductions[5] or best professional judgement.

- **Step 5 – Estimate Costs.** Construction costs for structural BMPs were first estimated using output from the MassDEP WBPT, then adjusted based on best professional judgement based on site size and complexity (i.e., inflated upwards for conservatism). BMPs not supported by the MassDEP WBPT were estimated using inflation-adjusted unit pricing from past projects. Once construction costs were calculated, engineering and design costs were conservatively calculated to be 40% of the estimated construction cost. Engineering and design costs represent approximate costs for engineering design and analysis, survey, design drawing preparation, and permitting. The 40% estimate may vary on a site-specific basis. An overall capital cost range for each structural BMP was then estimated by summing estimated construction and engineering costs and applying a contingency factor of ± 20%.

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[4] MassDEP WBPT, Element C BMP Selector Tool: http://prj.geosyntec.com/MassDEPWBP/Home.

[5] EPA Region 5 Load Reduction Model: http://it.tetratech-ffx.com/steplweb/models$docs.htm.

Cost estimates do not include engineering services related to bidding and construction quality assurance.

- **Step 6 – Perform scoring and prioritization.** BMP recommendations were scored and prioritized based on factors described by Table 16. The lowest possible BMP score is 30 points, while the highest is 100 points. The top third of BMPs were assigned a priority ranking of "High", the middle third were assigned a priority ranking of "Medium", and the bottom third were assigned a priority ranking of "Low".

Table 16. Structural BMP Scoring Criteria

Factor	**Criteria**			**Score**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**
TP Removal	< 0.2 lb/yr	0.2 to 0.75 lb/yr	> 0.75 lb/yr	10	15	25
Capital Cost[1]	> $50k	$25k - $50k	< $25k	10	15	25
Waterbody Proximity	Not Near Waterbody	Within 100-ft of Waterbody	Within 50-ft of Waterbody	5	10	20
Implementation Complexity[2]	High	Moderate	Low	5	10	20
Public Visibility / Outreach	Low Potential Visibility	Moderate Potential Visibility	High Potential Visibility	0	5	10

Notes:

1. Capital cost is based on the high end of the estimate with a contingency factor of 20% applied.
2. Implementation complexity is a qualitative indicator based on the following criteria: property ownership, site access, potential for underground utility conflicts, potential for tree removal, potential for traffic impacts, and potential for wetland permitting. Scored based on professional judgement.

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4.1.1.3 Site-Specific BMP Recommendations

AREA 1: Turee Pond Boat Launch and Parking Area

Location:	Turee Pond Boat Launch	**Subwatershed**:	Turee Pond
Owner:	New Hampshire Dept. of Fish and Game	**Priority**:	Medium

Site Description

A New Hampshire Fish and Game boat ramp at the end of Falcon Way provides boat access to Turee Pond. The parking area is unpaved and slopes down to the waters edge, with multiple points for kayak and canoe access including a concrete block boat ramp as well as grassy areas with little to no buffer. The parking area shows signs of erosion from stormwater runoff and sediment deposition is visible in the pond. Portions of the existing concrete block boat ramp have begun to become undercut.

Photo 1-1: Boat ramp extending into Turee Pond.

Photo 1-2: Concrete block boat ramp undercut.

Photo 1-3: Dirt parking area eroding and washing into pond.

Proposed Area 1 Improvements (see Photo 1-4)

1. Pave the parking area and boat launch area. Install a trench drain above the boat launch to capture runoff before it enters Turee Pond.
2. Install treebox filter north of the boat ramp to capture runoff from the trench drain and the remaining runoff from the parking lot area.
3. Address undercut conditions at the existing boat ramp and ensure that proper maintenance is conducted to prevent future issues.

Estimated Costs: **$72,000 - $109,000**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	0.06 ton/yr
• Total Phosphorus:	0.2 lb/yr
• Total Nitrogen:	1.64 lb/yr

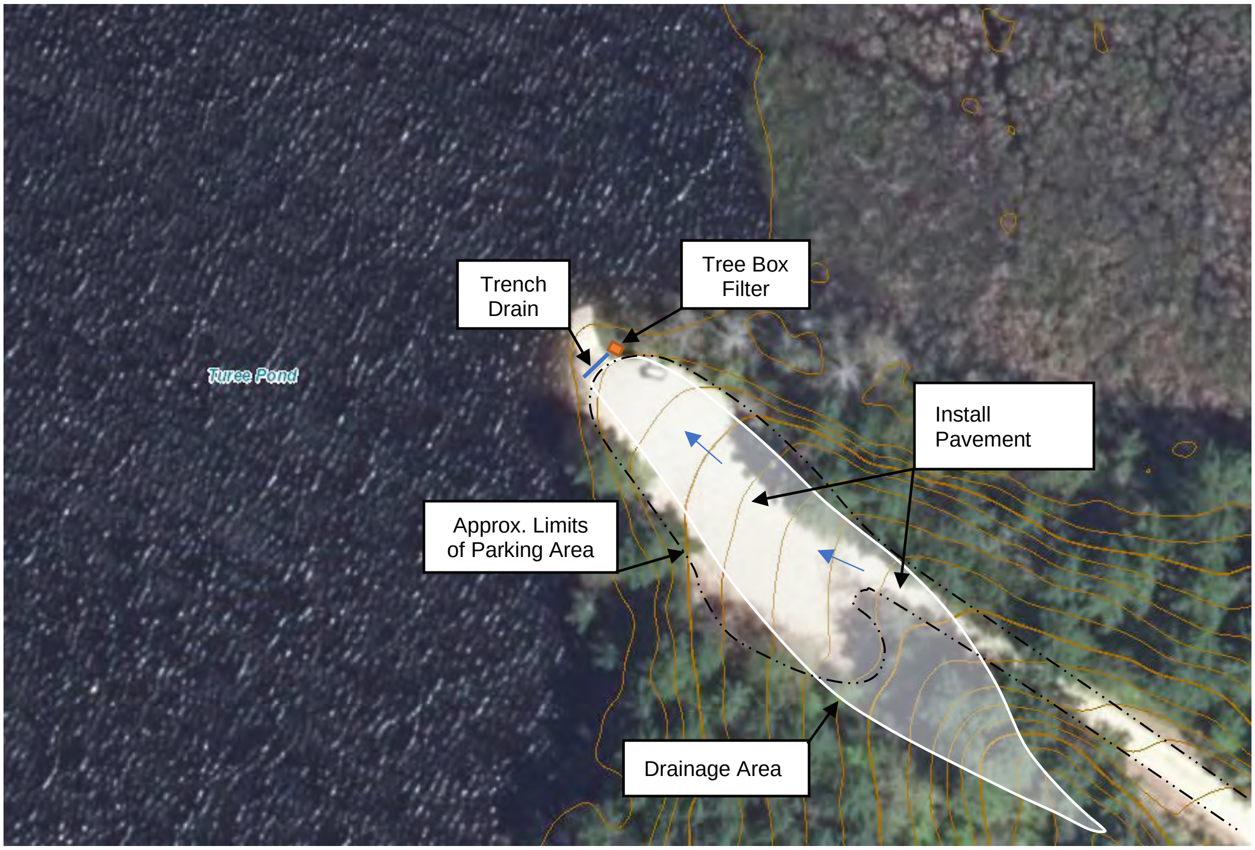

Photo 1-4: BMP configuration for Turee Pond boat launch/parking area.

AREA 2: Bow Parks and Recreation Parking Lot

Location: Bow Parks and Recreation Building
Subwatershed: Turee Pond
Owner: Town of Bow
Priority: High

Site Description

The area behind the Bow Parks and Recreation Building provides recreation access to Bow Town Pond. The building's parking lot is paved with multiple catch basins directing runoff to the pond. The parking lot grades are uneven in multiple locations, casuing pooling of water throughout the parking lot and areas where runoff bypasses the catch basins and flows directly to the unvegetated area around the pond. On the northeast side of the building, runoff from Knox Road flows down a steep, unvegetatedslope, causing sediment to wash into the parking lot and into catch basins. A submerged pipe end was located in the pond, but it was unclear where the parking lot catch basins discharge.

Photo 2-1: Sandy areas adjacent to parking lot wash into Bow Town Pond during rain events.

Photo 2-2: Sandy slope in north portion of parking lot, washes into catch basins.

Photo 2-3: Small vegetated buffer on shoreline.

Proposed Area 2 Improvements (See Photo 2-4)

1. Install cape cod berm along south side of parking lot to discourage runoff from entering the pond. Direct runoff into a series of treebox filters.
2. Repave and regrade parking lot to eliminate ponding and unwanted flow channels, promoting positive drainage to tree box filters.Tree box filters would overflow to pond.
3. Increase vegetated buffer along shoreline areas with a double row of shrub plantings.
4. Stabilize steep slope with riprap armoring stone, natural stabilization techniques, or both.
5. Install sediment traps in existing catch basins.

Estimated Costs:	**$218,000 - $327,000**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	1.18 ton/yr
• Total Phosphorus:	1.5 lb/yr
• Total Nitrogen:	6.5 lb/yr

Photo 2-4: Proposed BMP configuration for Bow Parks and Recreation Parking Lot

AREA 3: Turkey River Historic Landing

Location:	Grappone Toyota Service Center	**Subwatershed**:	Turkey River
Owner:	Bow Junction Associates Inc.	**Priority**:	High

Site Description

A historic river landing located on private property owned by the Bow Junction Associates Inc. serves as a public access point to the Turkey River at the southern edge of the Grappone Toyota Service Center parking lot. Severe erosion has developed along the sides of the access stairway due to a steep slope and the proximity of the parking lot.

Photo 3-1: Severe erosion adjacent to water access point.

Photo 3-2: Loose stone and sand on slope.

Photo 3-3: Severe erosion adjacent to water access point.

Proposed Area 3 Improvements

1. Stabilize existing eroding bank (appx. 30’ x 20’) with native vegetation plantings and bio-stabilization techniques. Pedestrian access point to remain.

Estimated Costs: **$16,800 - $25,200**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	1.1 ton/yr
• Total Phosphorus:	1.0 lb/yr
• Total Nitrogen:	2.0 lb/yr

AREA 4: St. Paul’s School

Location:	Library Pond	**Subwatershed**:	Turkey River
Owner:	St. Paul’s School	**Priority**:	Varies (See Table 15)

Site Description

The St. Paul’s School is comprised of a 2000-acre campus, located in Concord, NH. The Turkey River is dammed along Library Road, forming Library Pond. Four locations for potential improvements were identified along the banks of Library Pond (4a – 4d, see folowing pages). In many locations, areas of insufficient vegetated buffer were observed, allowing runoff to flow freely into Library Pond.

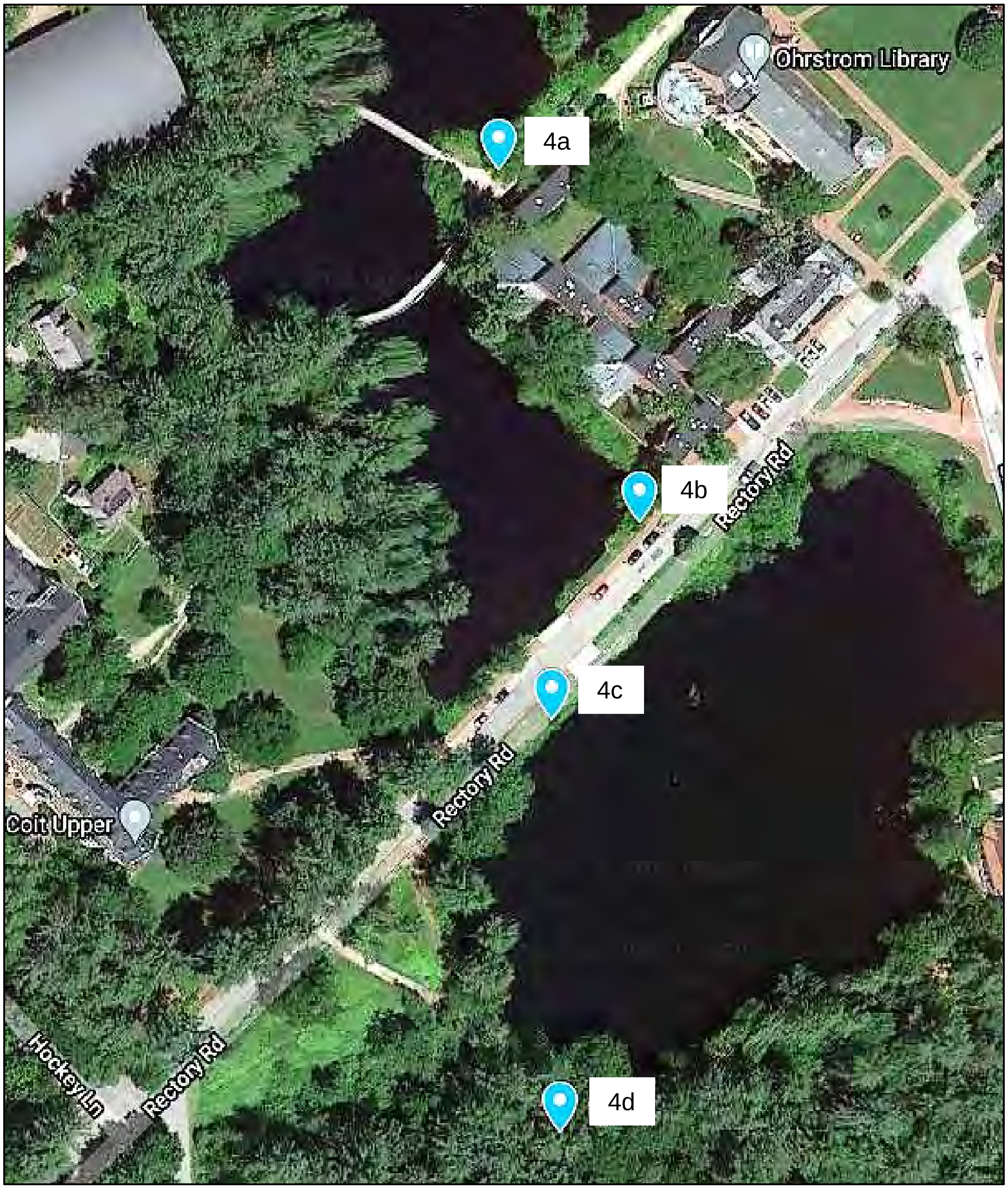

Photo 4-1: St. Paul’s School potential improvement sites (4a – 4d).

Summary of Proposed Area 4 Improvements (see Photo 4-14)

1. Enhance buffers with native tree and shrub plantings where feasible (specific locations shown below).
2. Stabilize eroding banks using biostabilization techniques (e.g. plantings within biodegradable erosion control blanket; coir logs with live staking, etc.) and a combination of stone stabilization and vegetation as needed. Where possible, native stone and vegetation should be used.
3. Re-grade dirt pathway near site 4d to promote drainage of runoff away from Library Pond.
4. Install two water bars or earthen berms, spaced 75-ft apart, on dirt footpath that comes down the hill in the direction of site 4d.

See the following pages for descriptions of sites 4a through 4d. See Table 15 for individual site estimates relative to costs and load reduction.

Site 4a – Improve Shoreline Buffer

Runoff from a small courtyard, roofs, and an unpaved footpath flow through a small vegetated area before entering Library Pond. This section of shoreline is approximately 100' in length. Consider the use of pea stone or gravel to replace the dirt surface of the footpath (approx. 3600-SF). Enhance the vegetated buffer along the shoreline with a double row of native trees and shrubs (approx. 2000-SF).

Photo 4-2: Lack of shoreline vegetated buffer at site 4a.

Photo 4-3: Lack of defined edge of dirt path allows for runoff to enter grassed area.

Photo 4-4: View of shoreline, buildings, and courtyard at site 4a.

Site 4b – Improve Buffer and Stabilize Eroding Bank

Two small sections of shoreline near Rectory Road are in need of stabilization. It is recommneded that the small stone area (Photo 4-5) near the bridge on Rectory Road be re-armored to prevent future erosion and to stabilize the bank. There is an adjacent dirt patch (Photo 4-6 and 4-7) that has minimal vegetated buffer, allowing for runoff to sheet flow into Library Pond unobstructed. Stabilize bank using biostabilization techniques (e.g., plantings within biodegradable erosion control blanket; coir logs with live staking, etc.) and a combination of stone stabilization and vegetation as needed (approx. 700-SF)

Photo 4-5: Riprap area in need of additional riprap to prevent future erosion.

Photo 4-6: Dirt area abutting Library Pond. Vegetated buffer should be established.

Photo 4-7: Dirt area abutting Library Pond. Vegetated buffer should be established.

Site 4c – Buffer Improvements

Approximately 100-ft of shoreline receives runoff from the paved Rectory Road. The shoreline in this area has grass and few trees The curb ends on the west side of the bridge, allowing runoff to enter the grassed area before flowing into Library Pond. Enhance the vegetated buffer in this area with a double row native tree and shurb plantings (approx. 2100-SF).

Photo 4-8: Lack of vegetated buffer.

Photo 4-9: Lack of vegetated buffer.

Photo 4-10: Lack of vegetated buffer.

Site 4d –Armoring and Runoff

An unpaved footpath wraps around the southern side of Library Pond. Photo 4-11 shows an area where armoring is needed to preserve the shoreline area from future erosion. The unpaved path (Photo 4-12) runs down a steep grade towards Library Pond (approx. 150-ft long). Install two waterbars to redirect runoff to adjacent vegetated area. Install depressed riprap aprons with level spreader at each waterbar discharge point to capture and infiltrate runoff and reduce erosion potential. Enhance buffer with native woody planting where feasible and stabalize bank (approx. 375-SF).

Photo 4-11: Shoreline erosion and lack of vegetated buffer.

Photo 4-12: Steep dirt path with runoff flowing directly towards Library Pond.

Photo 4-13: Shoreline erosion and lack of vegetated buffer.

Photo 4-14: Proposed BMP configuration for sites 4a - 4d.

AREA 5: Crumpacker Boathouse

Location:	Dunbarton Road, Concord, NH	**Subwatershed**:	Turkey Pond/Little Turkey Pond
Owner:	St. Paul's School	**Priority**:	Low

Site Description

Crumpacker Boathouse is owned by St. Paul's School and is used for boat access to Little Turkey Pond. An unpaved road south of the boathouse provides access to the pond and another boat storage area. Signs of erosion were observed within the roadway and on the edges of the roadway. A lack of vegetation was also observed near the water's edge.

Photo 5-1: Dirt road with signs of erosion.

Photo 5-2: Grassed area

Photo 5-3: Lack of vegetation along edge of water.

Proposed Area 5 Improvements (see Photo 5-4)

1. Install two runoff diversion water bars at approximately 100-ft apart along dirt road. Install depressed riprap aprons with level spreader at each discharge point to capture and infiltrate runoff and reduce erosion potential.

2. Improve the vegetated buffer along 150-ft of the shoreline using a double row of native shrubs and tree plantings. Maintain view lines to the pond with strategically planted lower-growing shrubs.

Estimated Costs:	**$23,520 - $35,280**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	0.03 ton/yr
• Total Phosphorus:	0.12 lb/yr
• Total Nitrogen:	0.9 lb/yr

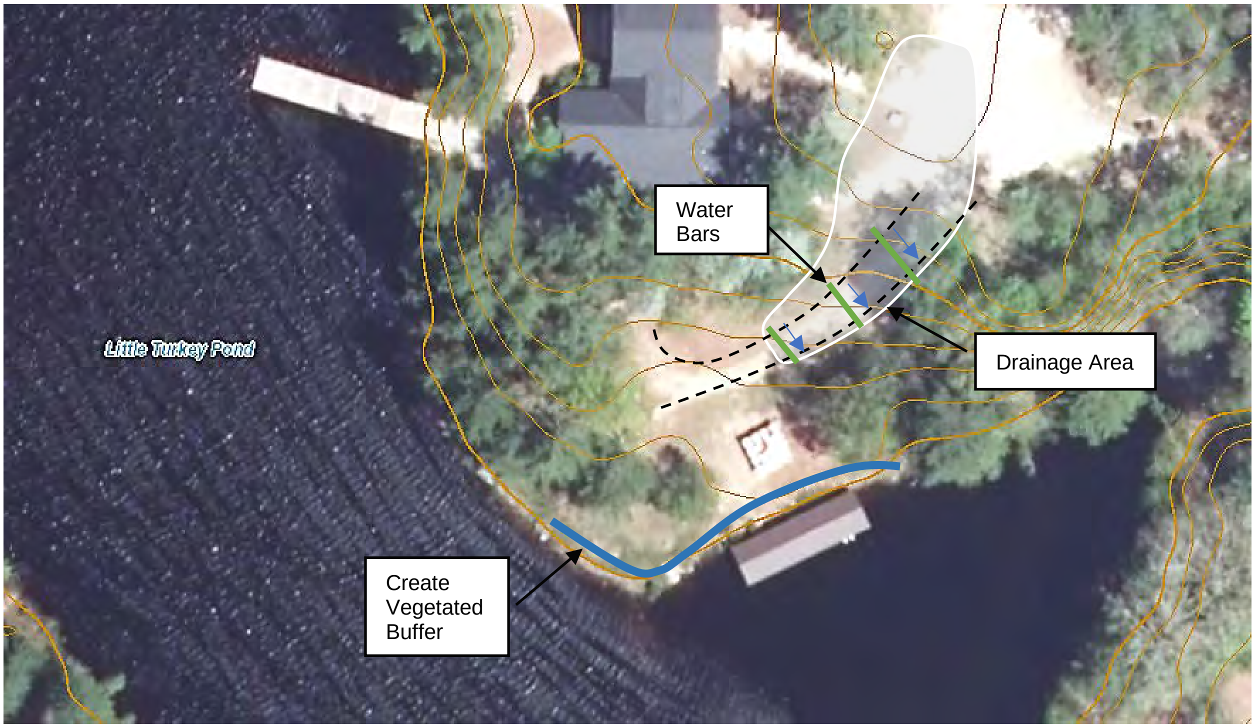

Photo 5-4: Proposed BMP configuration for Crumpacker Boathouse.

AREA 6: Hampton Inn Rear Parking Lot

Location: Hampton Inn

Owner: Giri Bow Inc.

Subwatershed: Turkey River

Priority: Low

Site Description

The Turkey River crosses under Interstate-89 and flows behind the Hampton Inn towards the Merrimack River. Parking lot runoff flows down the paved road along the side of the Hampton Inn and enters existing drainage structures through a series of catch basins into a wooded area adjacent to the stream. An unpaved island in the center of the back parking lot shows signs of erosion and has an existing catch basin structure in the center.

Photo 6-1: Impervious area within parking lot.

Photo 6-2: Final drainage structure before outfall.

Photo 6-3: Area for potential infiltration basin to treat runoff.

Proposed Area 6 Improvements (see Photo 6-4)

1. Repurpose the unpaved island (approx. 1000-SF) in the center of the back parking lot to allow for infiltration of runoff before it enters the existing stormwater infrastructure. This area could be developed as an infiltration basin or large rain garden with overflow to the existing infrastructure.

Estimated Costs: **$30,240 - $45,360**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	0.04 ton/yr
• Total Phosphorus:	0.31 lb/yr
• Total Nitrogen:	2.6 lb/yr

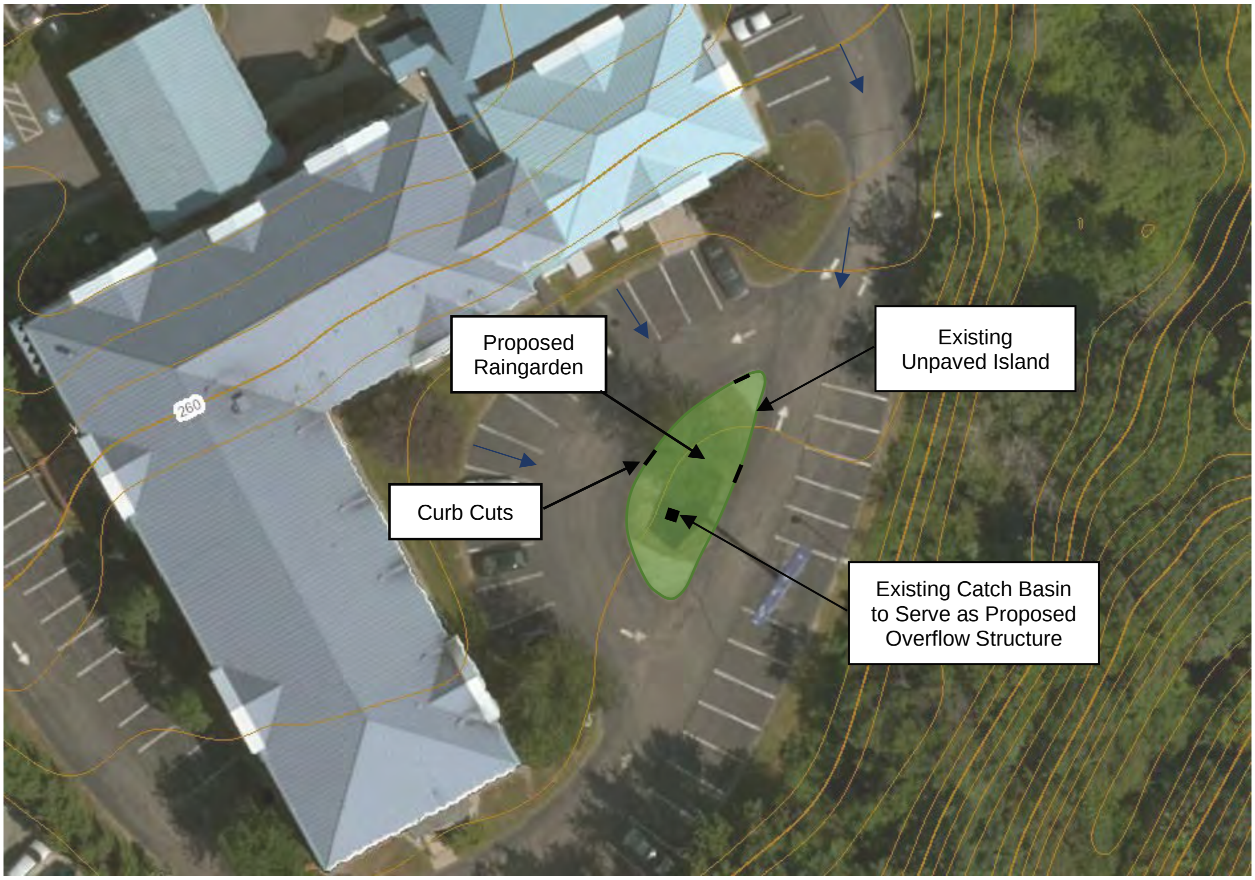

Photo 6-4: Proposed BMP configuration for the Hampton Inn.

AREA 7: Concord District Court

Location: Grassed Fields North of Court House

Subwatershed: Bow Brook

Owner: State of New Hampshire

Priority: High

Site Description

Bow Brook flows through a state-owned grassy field with minimal vegetated zones along the shoreline (i.e., predominantly mowed grass; very little woody vegetation). Bow Brook enters a culvert under an unnamed state access road and flows along the northern edge of the Concord District Court House parking lot. Areas of erosion near the culvert have developed as stormwater from the roadway flows towards Bow Brook.

Photo 7-1: Western portion of Bow Brook.

Photo 7-2: Edge of roadway erosion channel.

Photo 7-3: Eastern portion of Bow Brook

Proposed Area 7 Improvements

1. Develop a 20-ft "no-mow" zone along approximately 1000 feet of Bow Brook to allow both herbaceous and woody vegetation to grow, stabilizing the bank and increasing attenuation of stormwater pollutant loads to Bow Brook.
2. Address roadway erosion through the installation of riprap.

Estimated Costs: **$6,720 - $10,080**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	N/A
• Total Phosphorus:	N/A
• Total Nitrogen:	N/A

AREA 8: Concord High School Parking Lot

Location: Concord High School Parking Lot **Subwatershed**: Bow Brook
Owner: City of Concord **Priority**: Medium

Site Description

The Concord High School parking lot is located off of Pleasant Street. The site consists of an approximately one-acre paved parking lot that slopes directly toward Bow Brook. There are multiple catch basins located within the parking lot with an outfall pipe discharging directly into Bow Brook. Erosion was observed adjacent to a walking bridge near the western side of the parking lot.


Photo 8-1: Parking lot area with cracks in pavement.


Photo 8-2: Parking lot island.


Photo 8-3: Erosion from walking path down to brook.

Proposed Area 8 Improvements (see Photo 8-4)

1. Install riprap on sides of walking bridge to limit erosion from runoff.
2. Install infiltration trench (appx. 80-ft) along western edge of parking lot with proper subdrain piping and discharge pipe to treat runoff from parking lot that isn't captured by upgradient catch basins. Include a vegetated filter strip to pretreat runoff from shallow concentrated flow from the upgradient parking lot. Include a sediment forebay and level spreader on either end of the infiltration trench to pretreat and dissipate concentrated runoff from the longer flow paths in the parking lot.

Estimated Costs:	**$31,360 - $47,040**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	0.11 ton/yr
• Total Phosphorus:	0.96 lb/yr
• Total Nitrogen:	8.7 lb/yr

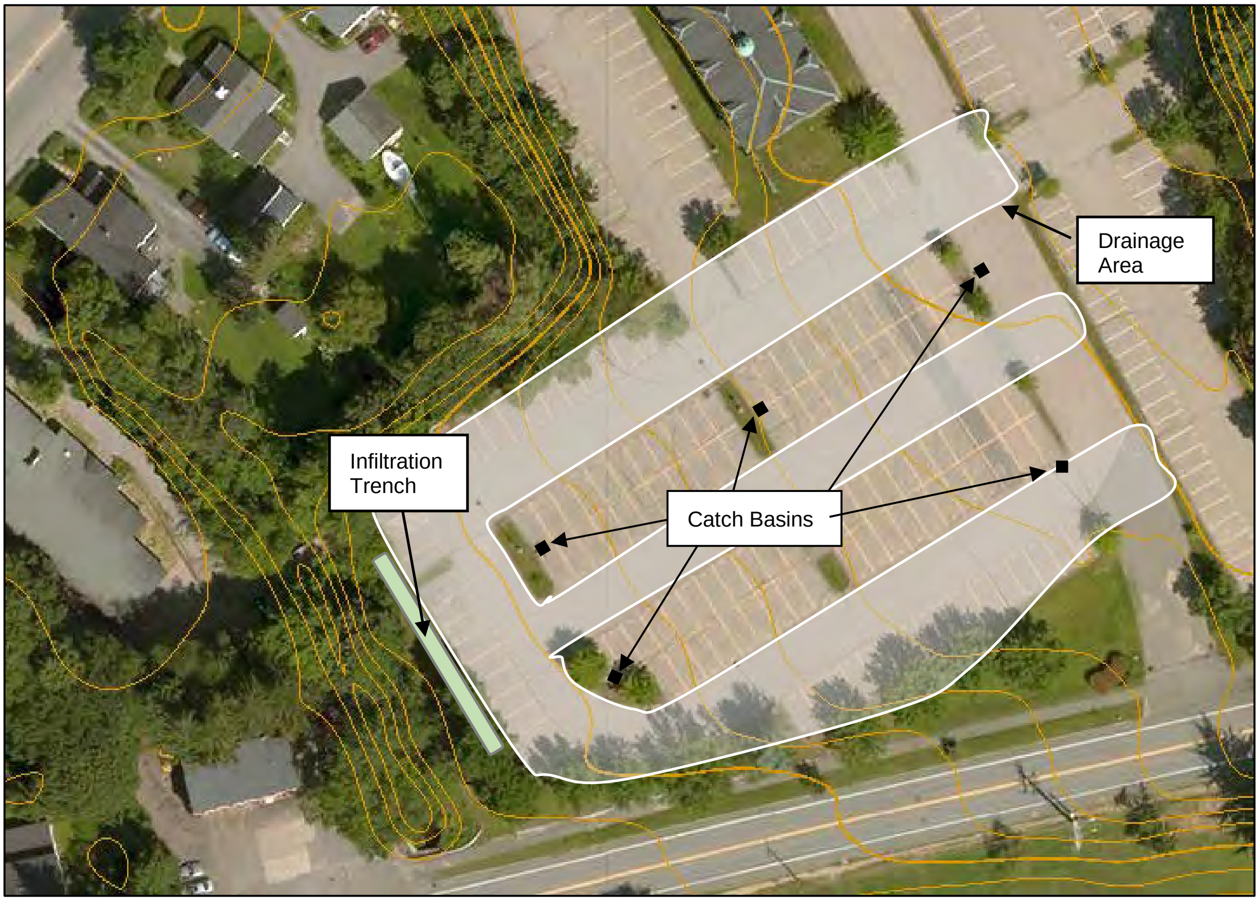

Photo 8-4: Proposed BMP configuration for Concord High School Parking Lot.

AREA 9: Pedestrian Bridge over Little Turkey Pond, Near Interstate-89

Location:	Stickney Hill Road, Concord, NH	**Subwatershed**:	Turkey Pond/Little Turkey Pond
Owner:	State of New Hampshire	**Priority**:	Low

Site Description

A pedestrian foot bridge over Little Turkey Pond is located adjacent to Interstate 89. The site can be accessed by Stickney Hill Road. Runoff from a portion of the concrete foot bridge runs down the paved path seen in Photo 9-2 before flowing through an unpaved grassed area and into Little Turkey Pond.

Photo 9-1: Footpath for water access.

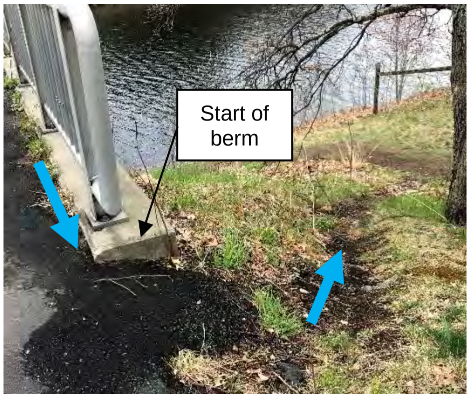

Photo 9-2: Paved drainage path leading to dirt open drainage.

Photo 9-3: Dirt open drainage leading to Turkey Ponds.

Proposed Area 9 Improvements (see Photo 9-4)

1. Install berm from the edge of the foot bridge down the foot path in order to divert runoff from the bridge to vegetated areas along the southern edge of the path. Install infiltration steps comprised of crushed stone and timber ties to slow runoff from the bridge.
2. Armor the shoreline with similar sized riprap to existing.

Estimated Costs:	**$14,560 - $21,840**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	0.013 ton/yr
• Total Phosphorus:	0.056 lb/yr
• Total Nitrogen:	0.44 lb/yr

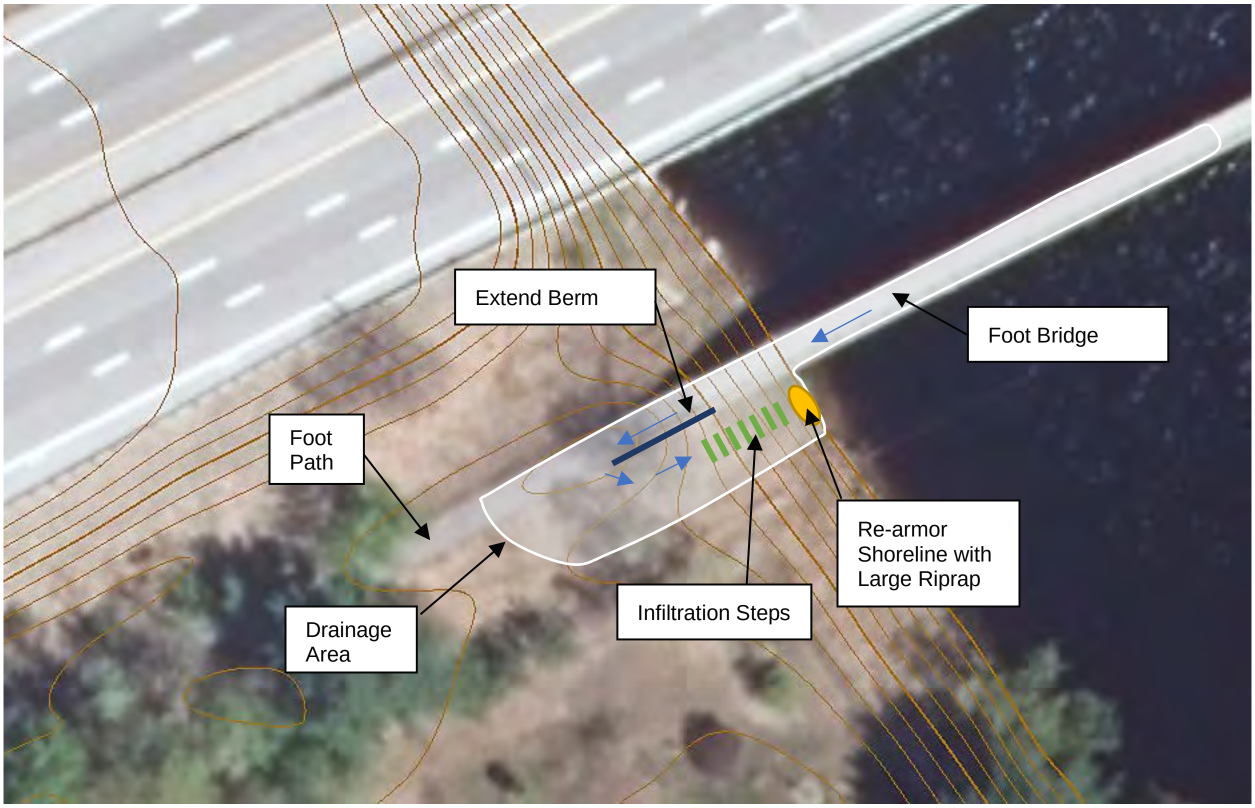

Photo 9-4: Proposed BMP configuration for Footpath Along Interstate-89

AREA 10: Currier Road Culvert near Whittier Pond

Location:	Intersection of Hopkinton Road and Currier Road	**Subwatershed**:	Boutwell Mill Brook
Owner:	Town of Hopkinton	**Priority**:	Low

Site Description

The culvert at the south side of Whittier Pond is currently under construction due to what appears to be a headwall failure. There is also a smaller outfall west of the culvert off of Currier Road. Areas of erosion were observed along the road shoulder between the failed culvert and the outfall. Significant sediment buildup was observed downstream of the outfall location.

Photo 10-1: Sediment buildup downstream of outfall.

Photo 10-2: Drainage outfall/headwall in need of repair.

Photo 10-3: Area east of headwall.

Proposed Area 10 Improvements (see Photo 10-4)

1. Armor slopes of abutting headwall with riprap to limit erosion (smaller culvert).
2. Install depressed riprap forebay with riprap overflow downstream of smaller culvert to limit the amount of sediment entering Whittier Pond.
3. Install riprap channel downgradient of forebay for conveyance into Whittier Pond.

Estimated Costs:	**$14,560 - $21,840**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	N/A
• Total Phosphorus:	N/A
• Total Nitrogen:	N/A

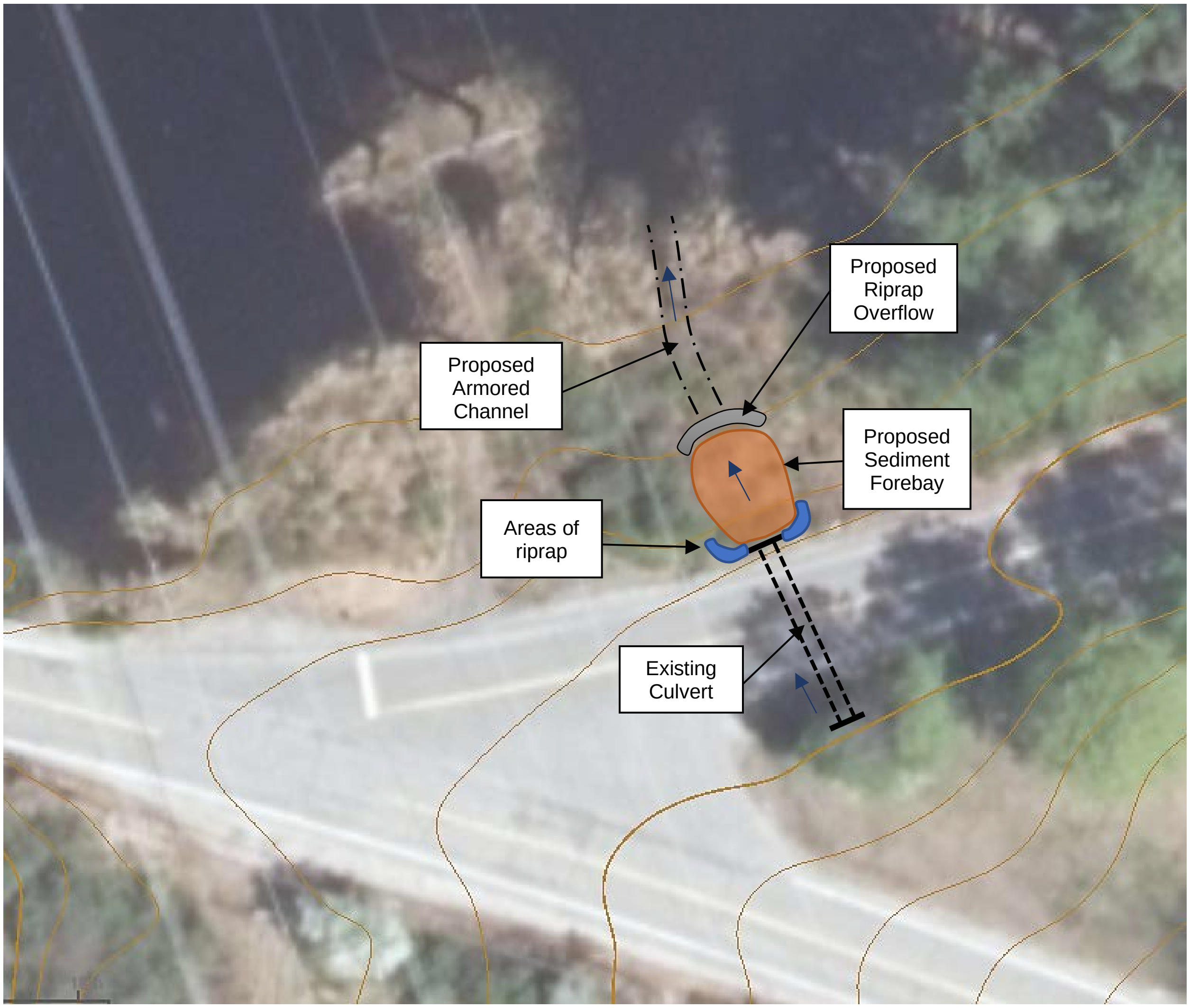

Photo 10-4: Proposed BMP configuration for intersection of Hopkinton Road and Currier Road.

AREA 11: Boutwell Mill Brook

Location: Boutwell Mill Brook Near Farrington Corner Road
Owner: Town of Hopkinton

Subwatershed: Boutwell Mill Brook
Priority: Low

Site Description

A small unpaved parking area off Farrington Corner Road allows for recreation access to trails along Boutwell Brook. Runoff from the roadway and parking area enter Boutwell Mill Brook.

Photo 11-1: Direct runoff into Boutwell Mill Brook.

Photo 11-2: Runoff from parking area into Brook.

Proposed Area 11 Improvements (see Photo 11-3)

1. Install berm (approx. 75-ft) and treebox filter along the edges of the unpaved parking area to limit runoff entering Boutwell Mill Brook.
2. Install riprap along the northern side of Farrington Corner Road to ensure proper bank and roadway stabilization and to limit runoff and erosional material from entering the Boutwell Mill Brook.

Estimated Costs:	**$30,240 - $45,360**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	0.03 ton/yr
• Total Phosphorus:	0.16 lb/yr
• Total Nitrogen	1.47 lb/yr

Photo 11-3: Proposed Area 11 BMP configuration.

AREA 12: Jewett Road Culvert Over One Stack Brook

Location: Jewett Road, Hopkinton, NH **Subwatershed**: One Stack Brook

Owner: Town of Hopkinton **Priority**: Medium

Site Description

The area around the Jewett Road culvert on One Stack Brook in Hopkinton, NH has signs of minor erosion and bank undercutting at the end of all four wingwalls. Stormwater from the road surface flows down the embankment and around the sides of both headwalls. Undercut areas were observed on the eastern side of the culvert, along the northern edge of the brook.

Photo 12-1: Erosion on the edge of wingwalls.

Photo 12-2: Undercut along northern stream channel edge.

Photo 12-3: Erosion on the edge of wingwalls.

Proposed Area 12 Improvement

1. Install riprap along headwall and wingwall embankment areas to limit the erosion caused by surface runoff (approx. 500-SF).

Estimated Costs: **$5,600 – $8,400**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	N/A
• Total Phosphorus:	N/A
• Total Nitrogen	N/A

AREA 13: Grapevine Road Culvert at Bela Brook

Location: Grapevine Road, Dunbarton, NH **Subwatershed**: Bela Brook

Owner: Town of Dunbarton **Priority**: Medium

Site Description

The Grapevine Road culvert crossing at Bela Brook is located in Dunbarton, NH. Runoff from the south side of the paved Grapevine Road flows over an unpaved area before entering Bela Brook. Obvious signs of erosion were observed in this area. A single catch basin is located adjacent to the roadway. The rim elevation of this catch basin was elevated above the surrounding area. Therefore, runoff will flow around the inlet structure and down the embankment to Bela Brook.

Photo 13-1: Edge of Grapevine Rd.

Photo 13-2: Elevated structure

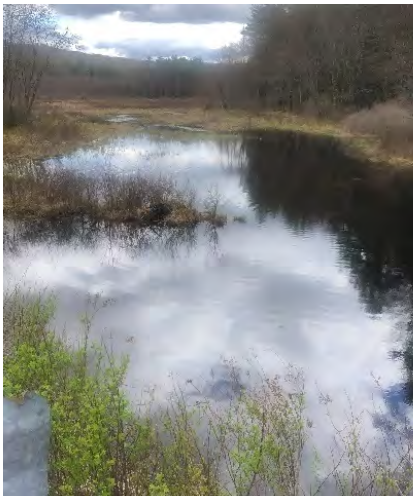

Photo 13-3: View of Bela Brook looking southwest.

Proposed Area 13 Improvement

1. Create small riprap lined energy dissipation area (approx. 110-SF) surrounding the existing catch basin. The catch basin will act as the overflow structure**.**

Estimated Costs: **$10,080 - $15,120**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	0.07 ton/yr
• Total Phosphorus:	0.06 lb/yr
• Total Nitrogen:	0.11 lb/yr

AREA 14: Page Road Culvert Over White Brook

Location:	Page Road, Bow, NH	**Subwatershed**:	Turee Brook
Owner:	Town of Bow	**Priority**:	Medium

Site Description

The Page Road culvert crossing at White Brook is located in Bow, NH. Roadside erosion of loose sandy soils was observed on the southern side of Page Road. Runoff from the roadway flows over loose sediment on the edge of the road before flowing into White Brook. A pile of crushed stone was observed around the culvert inlet.

Photo 14-1: Loose sandy soils observed near culvert inlet.

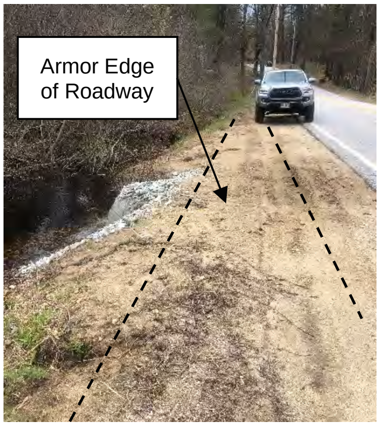

Photo 14-2: Loose sandy soils near edge of roadway

Photo 14-3: Stone surrounding culvert inlet

Proposed Area 14 Improvements

1. Armor the edges of Page Road with riprap, adjacent to wetland area (Approx. 150’). Armor the areas immediately surrounding the culvert inlet and outlet to prevent erosion.
2. Establish vegetated buffer zone along roadway (Approx. 150’) consisting of shrubs and hearty grasses.

Estimated Costs:	**$20,160 - $30,240**
Estimated Nutrient Load Reduction:	
• Total Suspended Solids:	0.4 ton/yr
• Total Phosphorus:	0.34 lb/yr
• Total Nitrogen:	0.68 lb/yr

AREA 15: Turkey River Near Chen Yang Li Restaurant

Location: 520 South Street, Bow, NH **Subwatershed**: Turkey River
Owner: JCW Real Estate LLC **Priority**: Low

Site Description

The Chen Yang Li Resturant is located off of South Street in Bow, NH. The large, paved parking lot behind the restaurant abuts the Turkey River. Runoff from the parking lot flows into Turkey River down a steep embankment that is beginning to show signs of becoming undercut. Areas of limited vegetation were also observed along the bank of the Turkey River.

Photo 15-1: Edge of parking lot and steep slope with obvious signs of erosion.

Photo 15-2: Areas of limited vegetation along stream.

Photo 15-3: Areas of limited vegetation along stream.

Proposed Area 15 Improvements (see Photo 15-4)

1. Install asphalt berm along edges of parking lot that are adjacent to the Turkey River. Runoff flow should enter drainage structures.
2. Install a 10’ – 12’ high gabion basket wall to stabilize 100’ of the slope west of the parking lot.
3. Enhance vegetated buffer along stream edge with native woody plantings.

Estimated Costs: **$96,320 - $144,480**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	N/A
• Total Phosphorus:	N/A
• Total Nitrogen:	N/A

Photo 15-4: Proposed Area 15 BMP configuration.

AREA 16: Abbot-Downing School

Location:	152 South Street, Concord, NH	**Subwatershed**:	Bow Brook
Owner:	City of Concord	**Priority**:	Low

Site Description

Bow Brook enters a long culvert at the Abbot-Downing School entrance and outlets to the southwest, across South Street. The inlet area has very steep side slopes with evidence of erosion from runoff. An adjacent dirt path contirbutes sediment to Bow Brook via direct runoff. The paved parking area for the school is sloped towards the culvert. A series of catch basins collectes runoff and discharges to Bow Brook.


Photo 16-1: Dirt footpath.


Photo 16-2: Steep stream embankment.


Photo 16-3: School parking and grassed area.

Proposed Area 16 Improvements (see Photo 16-4)

1. Armor the unpaved footpath down to the stream with gravel to limit erosion.
2. Direct runoff from the upgradient parking area along South Street to a rain garden (approx. 300 square feet), by installing curb cuts. The underdrains within the rain garden will be connected to the catch basin on the corner of South Street and the school entrance. The same catch basin will also serve as the overflow structure during high volume rain events.

Estimated Costs: **$24,640 - $36,960**

Estimated Nutrient Load Reduction:

• Total Suspended Solids:	0.03 ton/yr
• Total Phosphorus:	0.2 lb/yr
• Total Nitrogen:	1.68 lb/yr

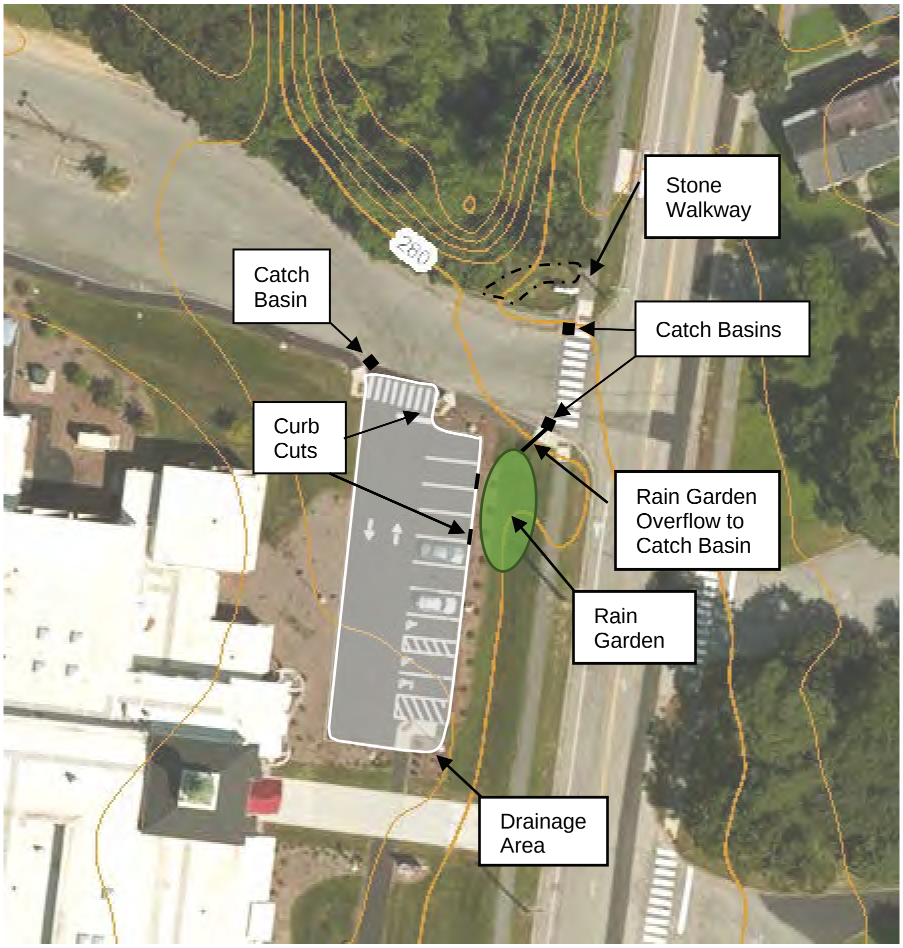

Photo 16-4: Proposed BMP configuration at Abbot-Downing School

4.1.2 Culvert Improvement Sites

Potential locations for improvements to stream crossing culverts in the Turkey River watershed were identified based on a review of information available from the New Hampshire Statewide Asset Data Exchange System (NH SADES). NH SADES includes a variety of stream crossing data from the New Hampshire Stream Crossing Initiative (NHSCI), an interagency effort led by the New Hampshire Geological Survey (NHGS) to assess and inventory the conditions of stream crossings statewide.

For the purpose of prioritizing culverts for improvement in the Turkey River Watershed, CEI and UMWA focused on four key culvert metrics from NH SADES which represent physical condition, in-stream habitat, stream geomorphic condition, and flood risk. These metrics are summarized below and culvert improvement prioritization rankings for 88 culverts in the watershed are presented in Table 17. Figure 8 shows the culvert locations.

Stream Crossing Structure Improvement Prioritization Metrics

1. **Structure Condition**

   - The NHSCI ranks culvert structure condition according to three categories (good, fair, and poor) based on field observations.
   - For the culverts in the Turkey River watershed, the NHSCI structure condition categories were converted into a prioritization ranking as listed below:

Priority	Structure Condition
High	Poor condition
Medium	Fair condition
Low	Good condition

Example of a corrugated metal culvert in deteriorated, poor condition. (CEI photo)

2. **Aquatic Organism Passage (AOP) Compatibility**
   (*Description adapted from the Aquatic Organism Passage Compatibility fact sheet prepared by the New Hampshire Stream Crossing Initiative)*

   - The AOP compatibility score is used to identify stream crossings that may not be capable of passing aquatic organisms from downstream to upstream. Within the NHSCI, the New Hampshire Department of Fish and Game (DFG) has responsibility for this compatibility scoring algorithm. Based on input from DFG, NHGS scores culverts for AOP compatibility and assigns four AOP categories (full passage, reduced passage, passage only for adult trout, and no passage).
   - For the culverts in the Turkey River watershed, the NHGS AOP categories were converted into a prioritization ranking as listed below:

Example of a perched culvert that prohibits upstream aquatic organism passage. (CEI photo)

Priority	AOP Compatibility
High	No passage
Medium	Reduced passage
Low	Full passage

Note: No culverts in the watershed were categorized by NHGS as "passage only for adult trout".

3. **Geomorphic Compatibility** (*description adapted from "General explanation of meaning of output from Geomorphic and Aquatic Organism Passage compatibility tools", NHGS, January 2020)*

   - The NHSCI geomorphic compatibility score represents a stream crossing's "fit" with natural stream channel form and sediment transport processes. Channel form refers to the shape of a stream channel in its floodplain and is determined by the slope of the channel and historical flow patterns. In the context of a stream crossing, the form of a channel refers to such features as the angle of entry approaching the crossing (is the channel relatively straight, or does it have bends), and integrity of the banks (held in place by vegetation, or exposed material able to be further eroded away). Stream crossings that are undersized or located on a sharp bend in the stream increase the potential for sediment or debris to accumulate in front of the culvert, reducing its ability to pass flow and increasing the risk of structural failure during a storm. Field data is collected to categorize stream crossings on a scale from "fully compatible" to "fully incompatible", with three intermediate levels of partial compatibility. The geomorphic compatibility categories apply only to stream crossings that are on flowing waterbodies (i.e., rivers and streams), and do not apply to crossings with wetlands on one or both sides of a crossing.

Example of an undersized culvert prone to clogging with sediment and debris. (CEI photo)

   - For the culverts in the Turkey River watershed, geomorphic compatibility categories were converted into a prioritization ranking as follows:

Priority	Geomorphic Compatibility
High	Fully or mostly incompatible
Medium	Partially compatible
Low	Fully or mostly compatible

4. **Hydraulic Vulnerability** *(description adapted from the "Hydraulic Vulnerability and Flood Resiliency" fact sheet prepared by the New Hampshire Stream Crossing Initiative)*

   - Hydraulic vulnerability describes how well a stream crossing conveys flows during storm events. The NHSCI uses hydraulic equations with environmental and structural data to estimate streamflow predictions for storm events. The results help predict a culvert's potential to sustain damage or overtop during a specific storm event.

- Data used by the NHSCI in the hydraulic capacity analysis includes both field-based data (i.e., culvert inlet shape and dimensions, structure material, and elevations relative to road surface) and watershed characteristics (i.e., drainage area, land cover, soil type, area of wetlands, precipitation during a storm).
- For the culverts in the Turkey River watershed, NHSCI hydraulic capacity analysis was converted into a prioritization ranking as follows:

Priority	**Hydraulic Vulnerability**
High	Overtops at 25-year storm or less
Medium	Overtops at 50- or 100-year storm
Low	Overtops at >100-year storm

Example road flooding
(Photo credit: NHDES)

Figure 8

Culvert Locations in the Turkey River Watershed

Legend

- ✚ Stream Crossing
- 〰 Stream, River
- ⬭ Lake, Pond, Reservoir
- ⬚ Town Boundaries

SubWatershed

- ▭ Ash Brook
- 🟩 Bela Brook
- 🟥 Boutwell Mill Brook
- ▭ Bow Brook
- ▭ One Stack Brook
- ▭ Turee Brook
- ▭ Turee Pond
- ▭ Turkey Pond/ Little Turkey Pond
- 🟪 Turkey River

UPPER MERRIMACK WATERSHED ASSOCIATION
PO Box 3019
Penacook NH 03303
MerrimackRivers.org

Prepared by:

Comprehensive
Environmental
Incorporated

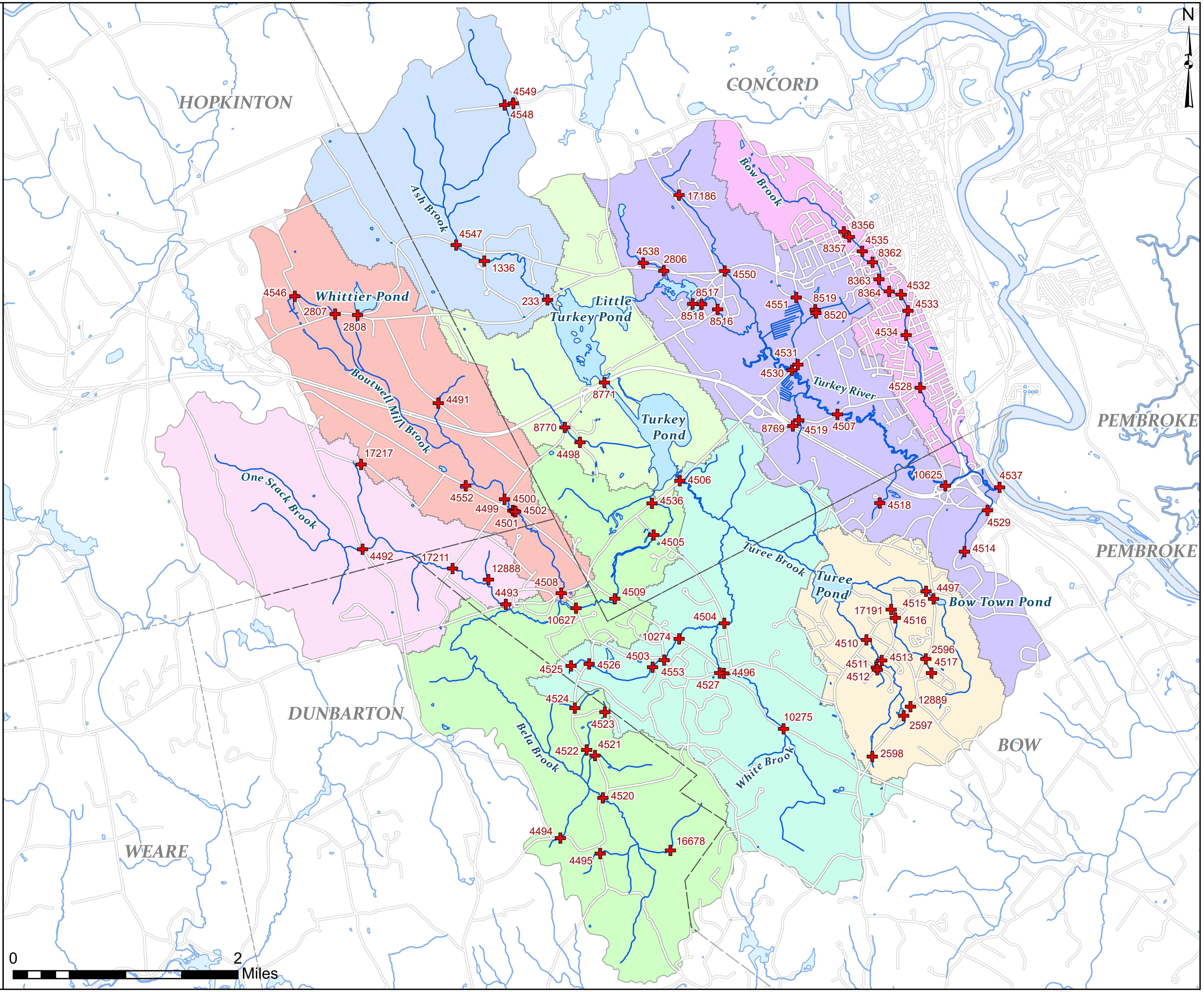

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Table 17. Turkey River Watershed - Culvert Ranking Prioritization

Subwatershed	SADES ID	Town	Road Name	River/Stream Name	Structure Condition	AOP Compatibility	Geomorphic Compatibility	Hydraulic Vulnerability	SITE PRIORITY
Ash Brook	233	Concord	Hopkinton Rd	Ash Brook	Poor	Reduced Passage	*no score*	*no score*	**HIGH**
	1336	Concord	Shenondoah Drive	Ash Brook	Good	Full Passage	Mostly Incompatible	*no score*	**MEDIUM**
	4548	Concord	District 5 Road	Unnamed Tributary to Ash Brook	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4549	Concord	District 5 Road	Unnamed Tributary to Ash Brook	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	4547	Concord	Currier Road	Ash Brook	Good	Full Passage	Partially Compatible	*no score*	**LOW**
Bela Brook	4494	Dunbarton	Grapevine Drive	Unnamed Tributary to Bela Brook	Good	No Passage	Partially Compatible	High	**HIGH**
	4495	Dunbarton	Guinea Road	Unnamed Tributary to Bela Brook	Good	Reduced Passage	Partially Compatible	High	**MEDIUM**
	4520	Dunbarton	Grapevine Road	Bela Brook	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	10627	Bow	Page Road	Bela Brook	Fair	Reduced Passage	Partially Compatible	Medium	**MEDIUM**
	16678	Dunbarton	Stone Rd.	Unnamed Tributary to Bela Brook	Fair	Reduced Passage	Mostly Incompatible	*no score*	**MEDIUM**
	4521	Dunbarton	Grapevine Road	Unnamed Tributary to Bela Brook	Good	No Passage	Fully Compatible	Medium	**MEDIUM**
	4522	Dunbarton	Grapevine Road	Unnamed Tributary to Bela Brook	Good	Full Passage	Mostly Compatible	Medium	**MEDIUM**
	4523	Dunbarton	Zachary Drive	Unnamed Tributary to Bela Brook	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	4524	Dunbarton	Grapevine Road	Unnamed Tributary to Bela Brook	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4505	Concord	Birchdale Road	Bela Brook	Good	Full Passage	*no score*	*no score*	**LOW**
	4509	Concord	Hookset Tpk	Bela Brook	Good	Full Passage	*no score*	*no score*	**LOW**
	4536	Concord	Clinton Street	Bela Brook	Good	Full Passage	*no score*	*no score*	**LOW**
Boutwell Mill Brook	2807	Hopkinton	Hopkinton Rd	Boutwell Mill Brook	Fair	No Passage	*no score*	*no score*	**HIGH**
	2808	Hopkinton	Hopkinton Rd	Unnamed Tributary to Boutwell Mill Brook	Poor	*no score*	*no score*	*no score*	**HIGH**
	4491	Hopkinton	Upper Straw Road	Unnamed Tributary to Boutwell Mill Brook	Good	No Passage	Mostly Compatible	High	**HIGH**
	4501	Hopkinton	Branch Londonderry Tpk	Boutwell Mill Brook	Poor	Reduced Passage	*no score*	*no score*	**HIGH**
	4546	Hopkinton	Crowell Road	Boutwell Mill Brook	Good	No Passage	*no score*	*no score*	**MEDIUM**
	4552	Hopkinton	Farrington Corner Road	Unnamed Tributary to Boutwell Mill Brook	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4500	Hopkinton	Branch Londonderry Tpk	Boutwell Mill Brook	Good	No Passage	*no score*	*no score*	**MEDIUM**
	4499	Hopkinton	Stickney Hill Road	Boutwell Mill Brook	Good	Reduced Passage	Fully Compatible	Low	**LOW**
	4502	Hopkinton	Branch Londonderry Tpk	Boutwell Mill Brook	Good	Full Passage	*no score*	*no score*	**LOW**
	4508	Bow	Clinton Street	Boutwell Mill Brook	Good	Full Passage	Mostly Compatible	*no score*	**LOW**
Bow Brook	8363	Concord	Orchard Dr	Bow Brook	Good	No Passage	Mostly Compatible	High	**HIGH**
	8356	Concord	School St	Bow Brook	Fair	Full Passage	Partially Compatible	High	**MEDIUM**
	8362	Concord	Power Ln	Bow Brook	Good	No Passage	Mostly Compatible	*no score*	**MEDIUM**
	4528	Concord	Rockingham Street	Bow Brook	Good	No Passage	Partially Compatible	Medium	**MEDIUM**
	4532	Concord	Clinton Street	Bow Brook	Good	*no score*	Partially Compatible	*no score*	**MEDIUM**
	4533	Concord	Noyes Street	Bow Brook	Good	Reduced Passage	Mostly Incompatible	Medium	**MEDIUM**
	4534	Concord	Bow Street	Bow Brook	Good	Reduced Passage	Partially Compatible	*no score*	**MEDIUM**
	4535	Concord	Pleasant Street	Bow Brook	Good	Reduced Passage	Partially Compatible	High	**MEDIUM**
	8357	Concord	Woodman St	Bow Brook	*no score*	*no score*	*no score*	*no score*	**LOW**
	8364	Concord	Averill Dr	Bow Brook	Good	Full Passage	Fully Compatible	Medium	**LOW**
One Stack Brook	12888	Bow	Stickney Road	One Stack Brook	Poor	No Passage	*no score*	*no score*	**HIGH**
	4492	Hopkinton	Jewett Road	One Stack Brook	Good	No Passage	Partially Compatible	Low	**MEDIUM**
	4493	Bow	Clinton Street	One Stack Brook	Good	Full Passage	*no score*	*no score*	**LOW**
	17211	Bow	Stickney Hill Rd	One Stack Brook	Fair	Full Passage	*no score*	*no score*	**LOW**
	17217	Hopkinton	Brockway Rd	Unnamed Tributary to One Stack Brook	*no score*	*no score*	*no score*	*no score*	**LOW**
Turee Brook	4525	Bow	Stack Drive	Unnamed Tributary to White Brook	Good	No Passage	Mostly Compatible	High	**HIGH**
	4496	Bow	Branch Londonderry Tpk	White Brook	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4503	Bow	Beaver Brook Drive	Unnamed Tributary to White Brook	Good	Full Passage	Mostly Incompatible	*no score*	**MEDIUM**
	4504	Bow	Birchdale Road	White Brook	Poor	Full Passage	*no score*	*no score*	**MEDIUM**
	4553	Bow	Page Road	Unnamed Tributary to White Brook	Good	Reduced Passage	Partially Compatible	High	**MEDIUM**
	10274	Bow	Branch Londonderry Tpk. W	Unnamed Tributary to White Brook	Fair	Reduced Passage	*no score*	*no score*	**MEDIUM**
	10275	Bow	Branch Londonderry Tpk. W	White Brook	Poor	Reduced Passage	Partially Compatible	High	**MEDIUM**
	4526	Bow	Foote Road	Unnamed Tributary to White Brook	Good	No Passage	*no score*	*no score*	**MEDIUM**
	4527	Bow	Page Road	White Brook	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4506	Concord	Clinton Street	Turee Brook	Good	Full Passage	*no score*	*no score*	**LOW**
Turee Pond	2597	Bow	Bow Center Rd	Unnamed Tributary to Turee Pond	Poor	No Passage	*no score*	*no score*	**HIGH**
	4510	Bow	White Rock Hill Road	Unnamed Tributary to Turee Pond	Good	No Passage	Partially Compatible	High	**HIGH**
	4515	Bow	White Rock Hill Road	Unnamed Tributary to Turee Pond	Good	No Passage	Fully Incompatible	Medium	**HIGH**
	2596	Bow	Bow Center Rd	Unnamed Tributary to Turee Pond	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	2598	Bow	Bow Center Rd	Unnamed Tributary to Turee Pond	Fair	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4497	Bow	Bow Center Road	Unnamed Tributary to Turee Pond	Good	No Passage	*no score*	*no score*	**MEDIUM**
	4511	Bow	Timmins Road	Unnamed Tributary to Turee Pond	Good	Reduced Passage	*no score*	Medium	**MEDIUM**
	4513	Bow	Timmins Road	Unnamed Tributary to Turee Pond	Good	Reduced Passage	Partially Compatible	Medium	**MEDIUM**
	4516	Bow	White Rock Hill Road	Unnamed Tributary to Turee Pond	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	12889	Bow	Bow Center Road	Unnamed Tributary to Turee Pond	Good	No Passage	*no score*	*no score*	**MEDIUM**
	17191	Bow	Falcon Way	Unnamed Tributary to Turee Pond	Fair	Reduced Passage	*no score*	*no score*	**MEDIUM**
	4517	Bow	Clough Street	Unnamed Tributary to Turee Pond	Good	Reduced Passage	*no score*	High	**MEDIUM**
	4512	Bow	Wheeler Road	Unnamed Tributary to Turee Pond	Good	*no score*	*no score*	*no score*	**LOW**
Turkey Pond/ Little Turkey Pond	4498	Concord	Millstone Drive	Unnamed Tribtary to Turkey Pond	Good	No Passage	Mostly Compatible	Medium	**MEDIUM**
	8770	Concord	Stickney Hill Rd	Unnamed Tributary to Turkey Pond	Fair	*no score*	*no score*	*no score*	**LOW**
	8771	Concord	Stickney Hill Rd	Turkey Pond/Little Turkey Pond	Good	Full Passage	*no score*	*no score*	**LOW**
Turkey River	2806	Concord	Hopkinton Rd	Unnamed Tribtary to Turkey River	Poor	Reduced Passage	Mostly Incompatible	*no score*	**HIGH**
	4529	Bow	Grandview Road	Unnamed Tributary to Turkey River	Good	Reduced Passage	Mostly Incompatible	High	**HIGH**
	8517	Concord	Library Road	Turkey River	*no score*	No Passage	*no score*	*no score*	**HIGH**
	4514	Bow	Heidi Lane	Unnamed Tribtary to Turkey River	Good	Reduced Passage	*no score*	*no score*	**MEDIUM**
	4518	Bow	Wilderness Lane	Unnamed Tributary to Turkey River	Good	No Passage	*no score*	*no score*	**MEDIUM**
	4519	Concord	Iron Works Road	Unnamed Tributary to Turkey River	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4538	Concord	Loop Road	Unnamed Tributary to Turkey River	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	4550	Concord	Pleseant Street	Unnamed Tributary to Turkey River	Good	Reduced Passage	Partially Compatible	Low	**MEDIUM**
	4551	Concord	Langley Parkway	Unnamed Tributary to Turkey River	Good	Reduced Passage	Fully Compatible	Medium	**MEDIUM**
	4531	Concord	Clinton Street	Turkey River	Good	Reduced Passage	Mostly Compatible	High	**MEDIUM**
	10625	Bow	South Street	Turkey River	Good	Reduced Passage	Partially Compatible	*no score*	**MEDIUM**
	17186	Concord	Fiskhill Farm Rd	Unnamed Tributary to Turkey River	Poor	Reduced Passage	Mostly Compatible	Medium	**MEDIUM**
	4537	Bow	Route 3A	Turkey River	Good	Full Passage	*no score*	*no score*	**LOW**
	8516	Concord	Dunbarton	Turkey River	Good	Full Passage	Mostly Compatible	*no score*	**LOW**
	4530	Concord	Clinton Street	Turkey River	Good	Full Passage	*no score*	*no score*	**LOW**
	8518	Concord	Rectory Road	Turkey River	*no score*	*no score*	*no score*	*no score*	**LOW**
	8519	Concord	Langly Parway	Unnamed Tributary to Turkey River	*no score*	*no score*	*no score*	*no score*	**LOW**
	8520	Concord	Langley Road	Unnamed Tributary to Turkey River	Good	Full Passage	Mostly Compatible	Medium	**LOW**
	8769	Concord	Iron Works Rd / I-89 offramp	Unnamed Tributary to Turkey River	*no score*	*no score*	*no score*	*no score*	**LOW**
	4507	Concord	Iron Works Road	Turkey River	Good	Full Passage	*no score*	*no score*	**LOW**

Notes:

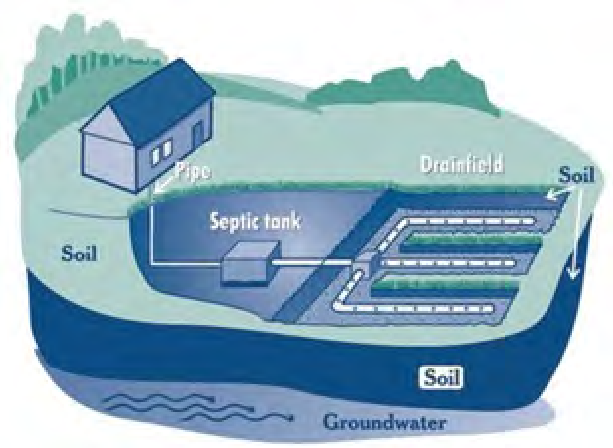
1. Hydraulic vulverability ranking based on:
   High = Overtops at 25-year storm or less
   Medium = Overtops at 50- or 100-year storm
   Low = Overtops at >100-year storm

4.2 WASTEWATER MANAGEMENT

This section provides an assessment and recommendations related to priority areas for potential subsurface wastewater management upgrades and wastewater alternative treatment strategies within the Turkey River Watershed. As described in Section 3, the watershed's population is served by a mix of sewer and on-site septic systems. Within the Turkey River watershed, approximately 2,251 parcels, or 48% of the parcels in the watershed, rely on septic systems. Though phosphorus loading from septic systems is a small portion of the total load, at full build-out conditions, this load is expected to double from approximately 28 kg/year to 53 kg/year (Table 11).

4.2.1 Background

Subsurface wastewater disposal septic systems provide a cost effective and efficient way of disposing of domestic waste. However, even properly designed, installed, and maintained septic systems provide inadequate treatment for nitrogen and phosphorus. Treatment of wastewater effluent is essential for the protection of ground and surface waters.



Conventional Septic System and Leachfield

A conventional septic system includes a septic tank that collects the effluent from a home or business and a drainfield that disperses the effluent to the subsurface. Septic systems receive effluent from a variety of sources including toilet flushing, sink and shower drains, and washing machines. In a conventional septic system, phosphorus removal begins with pretreatment in the septic tank as solids containing phosphorus settle to the bottom of the tank. Approximately 20-30 percent of phosphorus is removed in this process. Additional phosphorus removal occurs in the leaching field through absorption and retention in the soil. The amount of phosphorus removed in the leach field depends on the characteristics of the soil, depth to groundwater, and other factors.

4.2.2 New Hampshire State Regulations

Currently, septic systems are regulated by the State of New Hampshire under Chapter Env-Wq 1000 Subdivision; Individual Sewage Disposal Systems in the New Hampshire Code of Administrative Rules and promulgated under the authority of Statute Title 50, Water Management and Protection, Chapter 485A, Water Pollution and Waste Disposal. These regulations outline all aspects of septic system installation and maintenance. Some key regulations are summarized below.

- **Setbacks -** Chapter Env-Wq 1008 addresses setbacks for septic tanks and leachfields. These regulations require a setback of 75 feet from all surface waters (for both tank and leachfield) and a setback of 50 to 75 feet from all wetlands depending on the type of wetland soils.
- **Leachfields** - Chapter Env-Wq 1014 addresses the requirements for the leachfield including the requirements for the receiving soil layer. Chapter 1014.07 requires at least two feet of permeable soil above any impermeable sub-soil and four feet of soil above bedrock. The regulations do not specify the nature of the "permeable" soil although "impermeable" soil is defined as having a percolation rate of greater than 60 minutes per inch. Chapter 1014.08 addresses the distance above the seasonal high water table (SHWT) which is defined under Env-Wq 1002.61 as the level

at which the uppermost soil horizon contains 2% or more distinct or prominent redoximorphic features that increase in percentage with increasing depth. The state requires the bottom of the Effluent Disposal Area (EDA) to be at least four feet above the SHWT and in no case less than two feet above the SHWT if a conventional system is used.

- **Maintenance -** NH State Statute RSA-A:37 Maintenance and Operation of Subsurface Septic Systems requires that all subsurface septic systems must be operated and maintained to prevent a nuisance or potential health hazard due to a failing system. Further, the state and its agents may enter properties for the purpose of inspecting and evaluating the maintenance and operating conditions of all septic systems, and where appropriate, issue compliance orders.
- **Failure -** Chapter Env-Wq 1004.20: Replacement of Systems in Failure cites NH State Statute RSA 485-A:2, IV. Failure is defined as “the condition produced when a subsurface sewage or waste disposal system does not properly contain or treat sewage or causes the discharge of sewage on the ground surface or directly into surface waters, or the effluent disposal area is located in the seasonal high groundwater table. If a system is identified as failing, the use of the current septic system and leachfield must be stopped, and efforts to pump out and install a replacement system must be made.

4.2.3 Septic System Risk Analysis

An analysis of the location of septic systems within the Turkey River watershed was conducted to identify areas of the watershed more at risk for failure based on soil limitations and environmental factors. When properly installed and maintained, conventional septic systems are able to treat nutrients and other pollutants before entering nearby surface waters. However, some natural conditions may not provide for an adequate treatment area for the effluent.

For the Turkey River, the location of septic systems within the watershed was determined by CNRPC to complete the Buildout Analysis. As noted, approximately half of the parcels in the watershed rely on septic systems for their primary wastewater disposal and it is estimated that there are approximately 2,277 septic systems within the watershed (Table 18, Figure 9).

It has been shown that the density of septic systems in an area may overwhelm the carrying capacity for treatment because individual septic plumes may intermingle and pollute large areas of groundwater. Yates (1985)[6] has shown that areas with a density of more than 0.06 septic tanks per acre are potentially problematic for surface water quality. Mallin (2004)[7] has shown that a density of more than 0.26 septic tanks per acre can lead to fecal contamination.

In the Turkey River watershed, the average density of septic systems is 0.09 septic tanks per acre, which is higher than the 0.06 septic tanks for acre that has been shown to be problematic for surface water quality. For the individual sub-watersheds, the Turee Pond watershed had the highest density (0.19 tanks per acre) and the Bow Brook watershed had the lowest density (0.03 tanks per acre) (Table 18).

In addition to the location of septic systems, the following factors were analyzed to determine areas of the watershed potentially unsuitable for this type of wastewater treatment.

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[6] Yates, M. V., 1985. Septic tank density and ground-water contamination. *Ground Water*. Vol. 23, No. 5, Pg. 586-591. Sept.-Oct. 1985.

[7] Mallin, M.A., 2004. Septic Systems in the Coastal Environment: Multiple Water Quality Problems in Many Areas. Chapter 4. University of North Carolina Wilmington Center for Marine Science.

1. **Septic Tank Adsorption Rating (NRCS):** The Natural Resources Conservation Service Soils Data layer in GIS provides a Septic Tank Adsorption Rating for parcels within a watershed based on the following soil and environmental factors (as defined by NRCS) that may limit the effectiveness of conventional septic systems:

    - **Filtering capacity**: The saturated hydraulic conductivity of soil, known as Ksat, is an important physical property that influences the capacity of the soil to retain and transport water. The soil horizon with the maximum Ksat governs the leaching and seepage potential (or filtering capacity) of the soil. When this rate is high, transmission of fluids through the soil is unimpeded, and leaching and seepage may become an environmental, health, and performance concern.

    - **Flooding**: Flooding has the potential to transport agricultural waste off site and pollute surface waters. Flooding also limits building, recreational, and sanitary facility use and management of these soils.

    - **Ponding**: Ponding is the condition where standing water is on the soil surface for a given period of time. Soils that pond have restrictions that limit the installation and function of most land use applications. Soil features considered are ponding duration and frequency.

    - **Depth to bedrock**: The depth to bedrock restricts the construction, installation, and functioning of septic tank adsorption fields and other site applications. Shallow soils have limited adsorptive capacity and biologically active zones through which waste materials can percolate. These soils may pose environmental and health risks when used as filter fields.

    - **Slope**: Absorption fields cannot be located too close to cuts or on steep slopes as there is a danger that sewage can seep laterally out of the slope or cut before it has a chance to be fully treated. Septic systems can also cause slope failures if located in unstable slopes.

    - **Depth to saturated zone**: Soils with shallow depth to a water table may become waterlogged during periods of heavy precipitation and are slow to drain. These soils have the potential to contaminate groundwater, which may create health and environmental hazards.

    - **Seepage**: The soil's bottom layer Ksat (saturated hydraulic conductivity) governs the leaching and seepage potential of the soil. When this rate is high, transmission of fluids through the soil and underlying materials is unimpeded, and leaching and seepage may become an environmental, health, and performance concern.

    - **Restricted permeability**: The soil horizon with the minimum Ksat governs the rate of water movement through the whole soil. When this rate is low, transmission of fluids into and through the soil is impeded, and runoff, infiltration, and percolation of pollutants may result in environmental, health, and performance concerns.

    - **Too Steep**: For non-rated “rock outcrop” soil types, a risk score of five (which was the highest score among all soil types) was manually assigned on the basis that rock outcrops are extremely unsuitable for septic systems. For non-rated “urban land” soil types, the risk factor similar to surrounding rated soils was chosen. Generally, the highest score was chosen if there were multiple surrounding soil units (excluding waterbodies). The reason for choosing the highest of the scores is the proximity to properties and people, which elevates risk of harm if there is a wastewater failure.

2. **Proximity to Wetlands and Surface Waters:** The National Hydrography Dataset provides the location of all wetland and surface water areas in the watershed. All septic systems located within the 200-foot buffer to wetlands or surface water bodies were identified.

3. **Flood Zones:** Flood zones are geographic areas that the Federal Emergency Management Agency (FEMA) has defined according to varying levels of flood risk. Each zone reflects the severity or type of flooding that would be expected in the area. For this analysis, areas of the Turkey River with the most risk of flooding as determined by FEMA were identified. These areas, or Flood Zone A, have a 1% chance of flooding and a 26% chance of clouding over the life of a 30-year mortgage. The potential for the land to flood increases the likelihood of septic system failure or transfer of effluent to nearby waterbodies or wetlands.

Figure 9 depicts the location of parcels on septic system or connected to a sewer system in the Turkey River watershed. Of the 2,277 septic systems in the watershed, 2,248 are located in soils considered very limited by the NRCS and 151 are located within 200 feet of a waterbody or wetland. Of these, 10 septic systems are also located in an area considered most at-risk for flooding by FEMA (Table 18).

Table 18. Septic System Analysis for the Turkey River Watershed

Subwatershed	**Septic System Characteristics**		**Environmental Conditions of Septic Systems**			
	Total Number of Parcels on Septic Systems	Septic Density (tanks/acre)	Within 200 Feet of a Waterbody	With Very Limited Soil Absorption Rating	With Both Conditions	With Both Conditions and in a 1% FEMA Flood Zone
Turkey River	322	0.08	14	313	14	0
Bow Brook	37	0.03	7	37	7	0
Turkey Ponds	111	0.05	17	111	17	2
Ash Brook	127	0.05	11	124	9	0
Turee Brook	548	0.15	32	543	31	0
Turee Pond	331	0.19	23	327	23	0
Bela Brook	359	0.10	22	354	21	4
Boutwell Mill Brook	277	0.10	21	274	20	2
One Stack Brook	165	0.06	4	165	4	2
Total	**2,277**	**0.09 (Avg)**	**151**	**2,248**	**146**	**10**

Figure 9
Septic System Risk Analysis for the Turkey River Watershed

Legend

- Parcels with Septic Systems in Limited Soils, 1% FEMA Flood Zone, and 200' Buffer
- Parcels with Septic Systems in Limited Soils and 200' Buffer
- Parcels with Septic Systems in 200' Buffer
- Other Parcels with Septic Systems
- Parcels on Sewer
- Other Parcels
- Sub Watersheds
- Stream, River
- Lake or Pond
- Wetland
- Watershed Boundary
- Town Boundaries

Septic Tank Absorption Rating

- /// Very limited

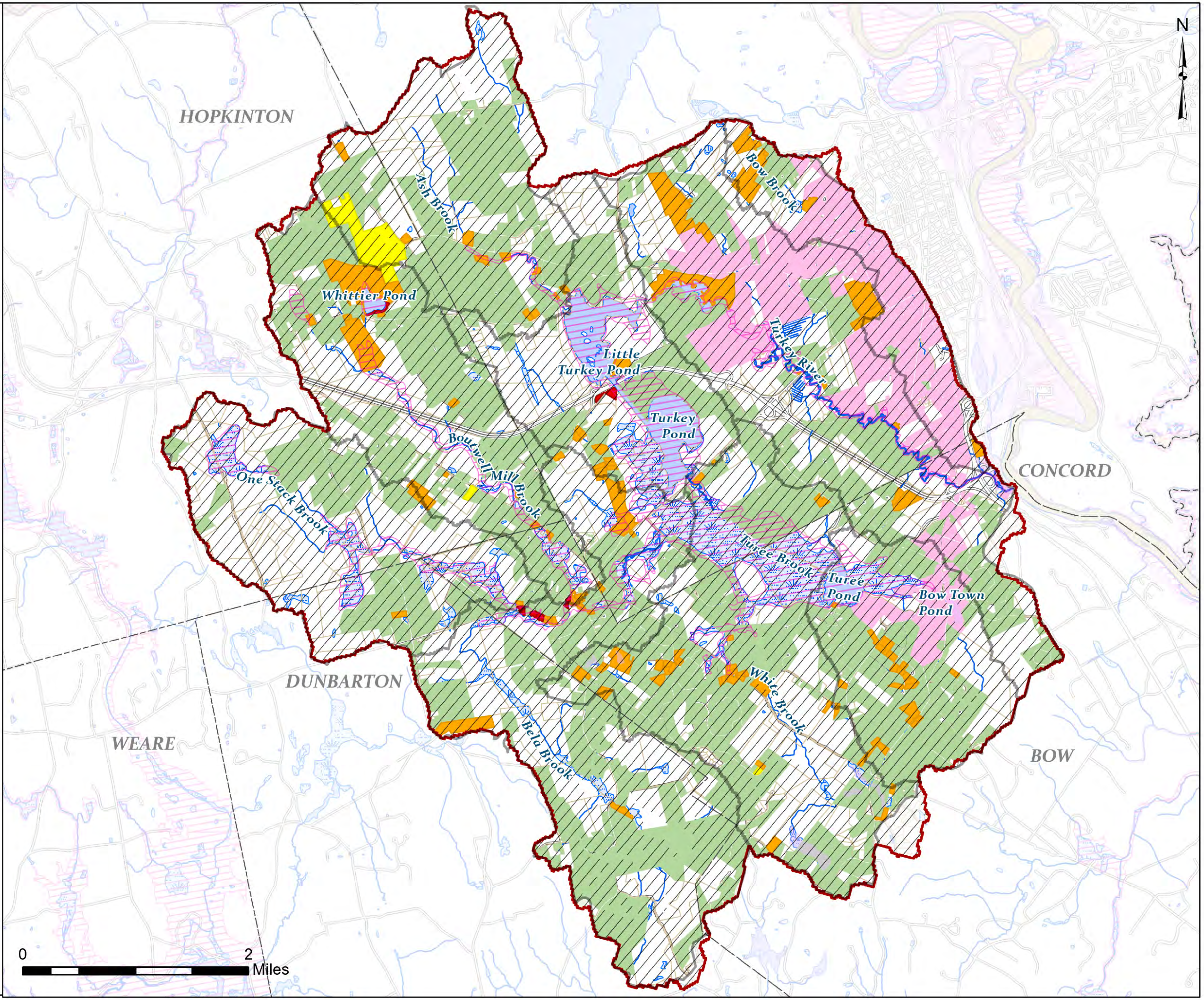
FEMA Flood Hazard

- 1% Annual Chance Flood Hazard

Note: Selected Areas are within 200 ft. of surface water or wetlands, in areas of 1% FEMA flood hazard, and/or areas where soils have a Very Limited Absorption Rating for septic systems.

Comprehensive Environmental Incorporated

Data Sources: GRANIT, CNHRPC, NRCS



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4.2.4 Alternative Treatment Systems

Alternative systems are typically upgraded from traditional septic systems by adding a component that reduces phosphorus concentrations from the effluent before it is discharged to the ground. They are installed at an individual home, or cluster of homes, and usually cost more to operate and maintain than a traditional septic system. The increased maintenance costs are due to power needs for the system (e.g., pumps, aerators), required water quality sampling, and other elements that are not needed for a traditional onsite system.

Advanced Onsite Treatment

Alternative treatment components can be added to a conventional system, often between the septic tank and the drainfield, to provide advanced treatment of phosphorus (Figure 10). Reactive media filters, such as sand or gravel filters, are often used as advanced treatment in septic systems. For phosphorus removal specifically, additional media such as iron, aluminum, or calcium compounds, are added to these systems with the goal of immobilizing phosphorus. These systems have been shown to reduce phosphorus by up to 90 percent.

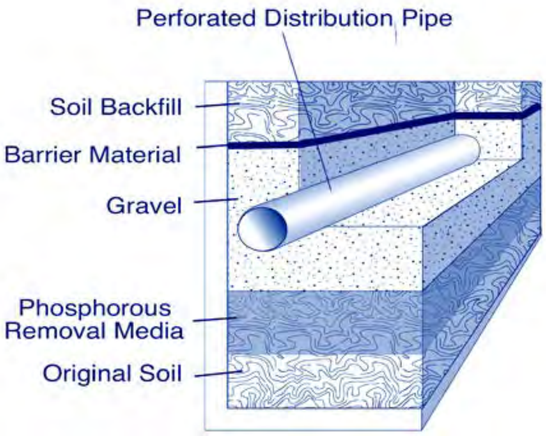

Figure 10. Alternative Onsite System with Phosphorus Treatment (Source: EPA, 2013)[8]

Alternative Toilets

Approximately 60 to 75 percent of phosphorus Is contained in toiled wastewater, also referred to as blackwater. Removing the blackwater from the septic tank influent will greatly reduce the amount of phosphorus in the effluent. Composting toilet systems offer a different solution to wastewater by eliminating much of the liquid waste. On a basic level, composting toilets retain solid and liquid excrement in a contained unit that facilitates the natural breakdown of material, or composting. Whether done completely within the eco-toilet unit, or transported and completed offsite, this process results in ‘finished’ compost free of pathogens and disease, with the potential to serve as a soil amendment. There are many different types of composting systems that range in cost, size, and maintenance requirements.

The cost of upgrading a residential property to alternative toilets varies greatly and is based on a number of factors including: number of bathrooms, extent of remodeling work required, greywater management

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[8] EPA. 2013. A Model Program for Onsite Management in the Chesapeake Bay Watershed*.* Office of Wastewater Management. June 2013.

(i.e., hand and dish washing, showers, laundry, etc.), permitting requirements, and the type of system. Table 19 summarizes the potential cost range of these factors.

Table 19. Estimated Alternative Toilet Cost (Source: EPA, 2013)

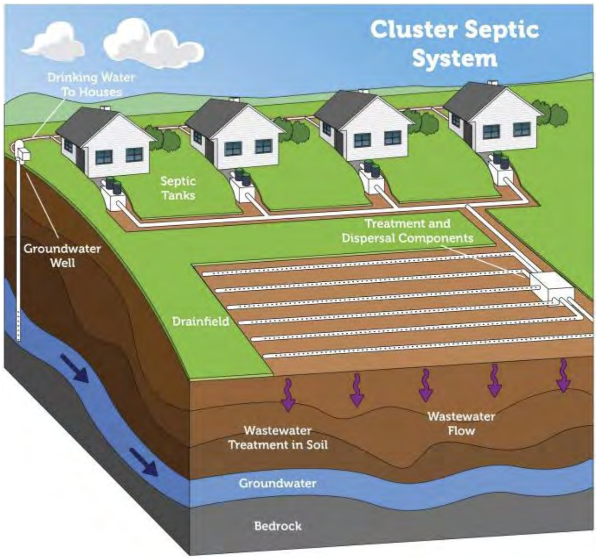
Cost Element	Cost Range
Materials	\$2,000 - \$10,000
Design and Installation	\$2,000 - \$4,000
Greywater Management	\$1,000 - \$5,000
Permitting	\$1,000 - \$3,000

Connection to Wastewater Treatment Facilities

Municipalities within the Turkey River watershed could consider the possibility and cost to connect to a local wastewater treatment facility. The City of Concord delivers wastewater from residential, commercial, and industrial properties to the Hall Street Wastewater Treatment Plant or the Penacook Wastewater Treatment Plant. Portions of Bow, NH also utilize the Hall Street Wastewater Treatment Plan. The Town of Hopkinton has its own wastewater treatment facility.

Connection to area treatment plants typically requires substantial capital and infrastructure and most often is more expensive that advanced onsite treatment. For a preliminary study completed for the City of Rochester, New Hampshire, the average cost per household to connect to the local sewer system was between \$20,000 and \$45,000, which does not include the additional operation and maintenance costs per year around \$800-\$1,200 per household.

Cluster or Neighborhood Treatment Systems



Cluster or shared systems provide an opportunity for cost savings in both the construction and operation of the system. Building and operating one larger system is often less expensive than operating many small individual systems unless the homes using the system are far apart and the costs to connect them by sewer are high. Cluster systems also provide an opportunity to offset nitrogen discharges from other systems where upgrades are less feasible.

While cluster systems can be easily implemented for new development, retrofitting an existing area to a cluster system may pose both financial and engineering challenges. For example, the cost of piping the wastewater from each individual property to the cluster system could be a significant expense, particularly in low density areas. The construction of new collection systems and the availability of land for cluster systems also pose engineering challenges. Dense areas or areas with historical failures might provide the most opportunities for retrofitting conventional systems to cluster systems.

The cost for implementation of a cluster system to meet the current state-of-the-practice is approximately $35,000 to $48,000 per property served (HW, 2015[9]; CCC, 2013[10]) and $52,000 per property served if optimized for nitrogen (CCC, 2013). These cost estimates are highly dependent on site-specific factors.

4.2.5 Recommendations for Wastewater Management

Approximately 2,277 parcels within in the Turkey River Watershed are served by on-site septic systems. The phosphorus load from septic systems is expected to double under full build-out conditions.

Management strategies associated with septic systems are anticipated to be an important part of the long-term approach to achieving and maintaining the nitrogen concentration goals established as part of this watershed plan. Using the management strategies described above, reduction of the phosphorus load from septic systems is achievable. Septic systems are currently regulated at the State level and alternative treatment practices have not yet been approved. Therefore, regulatory changes at the State level are needed to allow for implementation of alternative treatment practices.

Establishment of a tiered approach to addressing onsite subsurface wastewater systems is recommended, based on system proximity to a waterbody. The following actions are recommended:

1. Systems identified as “at-risk” based on soils and environmental factors should be further analyzed to begin to develop a septic system database for the watershed. Other information for these systems can be collected from town and state records and used to populate the database with information such as age of home, type of system, and age of septic system.
2. The municipalities that comprise the Turkey River Watershed should consider establishing town regulations which do the following:
    a. Enable and encourage the installation of alternative wastewater treatment systems based on system proximity to a waterbody for new development, redevelopment and replacement of failed system.
    b. Require all septic systems to be pumped on a regular basis (i.e., three years).
3. Identify areas of the watershed that may be candidates for alternative treatment systems including cluster or neighborhood systems, composting toilets, and connections to existing wastewater treatment facilities.
4. Develop public education and outreach materials with a focus on care and maintenance of septic systems and distribute to homes identified as “at-risk.”

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[9] Horsley Witten Group, Inc.. 2015. Pleasant Bay Nitrogen Management Alternatives Analysis Report. Brewster, MA. March 2015.

[10] Cape Cod Commission. 2013. Regional Wastewater Management Plan, Understanding the Cost Factors of Wastewater Treatment and Disposal. Cape Cod. March 2013.

4.3 NON-STRUCTURAL BEST MANAGEMENT PRACTICES

Unlike structural BMPs, non-structural BMPs do not involve construction of site-specific infrastructure and generally focus on reducing pollutant loads through the following:

1. **Public Information and Education:** Changing behavior and land use patterns through efforts to inform, educate, and engage the public on issues related to protection of water quality and aquatic habitat.
2. **Land Conservation:** Reducing pollutants at the source through natural systems, such as land conservation and protection of sensitive land areas through purchase, easements, etc.;
3. **Regulatory Tools:** Changing behavior and land use patterns through regulation (e.g., state laws, municipal ordinances)
4. **Institutional Practices and Programs:** Reducing pollutant loads through improved institutional practices such as enhanced street sweeping, catch basin cleaning, leaf litter pickup programs, etc.

The pollutant load reductions associated with non-structural measures are generally more difficult to estimate than those for structural BMPs. Strategies for reducing pollutant loads in the Turkey River watershed through non-structural BMPs are discussed in the sections below.

4.3.1 Public Information and Education

Public outreach of the WRMP is important to both educate the public about NPS pollution and the Turkey River watershed and coordinate efforts of the various entities working within the watershed. Many current programs have an education and outreach component with the same goal as that of the WRMP. In many of these cases, education and outreach efforts may be more effective if complementary programs work together. Additionally, many priorities identified during the planning process require collaboration with other entities. Public information and education (I/E) efforts associated with the Turkey River WRMP are expected to include the following:

Watershed Programs

Specific education and outreach programs will be developed for the Turkey River watershed. These programs will build off of existing programs and are expected to include the following:

Watershed Steward™ Program

The Watershed Steward™ Program (WSP) (a program of the New Hampshire Rivers Council), will be implemented by UMWA and its partners to engage local residents and others in watershed outreach and protection activities.

The *Watershed Steward Program*™ is a voluntary, recognition-based program that works with property owners to protect water quality by helping them improve their property management techniques.

To learn more about how you can become a Watershed Steward, visit the **New Hampshire Rivers Council at NHRivers.org.**

Example Watershed Steward Sign

The WSP provides local groups with a promotional brochure, Water Quality Report Card, a companion booklet, and signage. The WSP includes conducting a homeowner visit to assess land management practices and other personal choices that affect water quality, such as lawn/landscaping fertilizer use, septic system maintenance, and disposal of household chemicals. Recommendations and resources are provided to homeowners. When WSP criteria are met, the homeowner is certified as a Watershed Steward™ for a five-year period and signage is provided. Watershed Stewards are encouraged to work with friends and neighbors to increase program participation in the watershed.

UMWA anticipates that WSP outreach activities and homeowner property assessments in the Turkey River watershed will be conducted annually between April and October during the 5-year WRMP planning period. After the initial homeowner visits and WSP certification process, UMWA will provide follow-up communications and visits with homeowners to provide technical assistance on land management practices and promote participation in related programs (e.g., septic system management programs). This process is expected to continue throughout the five-year WRMP planning period.

Workshop: Low Impact Development for Homeowners

The UMWA could provide a public education workshop geared towards property owners in the Turkey River watershed. This type of workshop would focus on the concepts of low impact development (LID) and ways that homeowners can implement LID on their properties, such as raingardens, bioretention, rain barrels, infiltration trenches, low- or no-phosphorus fertilizers, etc. Specific topics addressed during the workshop could include:

- Stormwater and LID concepts
- Why LID? Case study of benefits and costs
- LID Practices (including step-by step instruction on how to design and build a residential raingarden)
- Recommended native plantings
- Tools for estimating cost and pollutant load reductions
- Construction Do's and Don'ts

Example Residential Raingarden

NHDES Soak up the Rain

Soak up the Rain NH is a voluntary program managed by NHDES. The goal of this program is to engage home and small business owners to do their part to help protect and restore clean water in the state's lakes, streams, and coastal waters from the negative impacts of stormwater pollution. The program provides information about stormwater pollution and how to prevent it with rain gardens, infiltration trenches, and other practices on their website and builds partnerships with local watershed groups by providing messaging, training, and assistance to promote and install practices to reduce stormwater runoff. The UMWA will work with the Soak up the Rain program to identify specific projects in the Turkey River watershed.

NHDES Green SnowPro

The Green SnowPro Certification program is offered by NHDES for Commercial Salt Applicators to obtain a NHDES Salt Applicator Certification. The program offers information on Best Management Practices for winter road, parking lot, and sidewalk maintenance developed by the University of New Hampshire Technology Transfer program with the goal of reducing use of de-icing salt in New Hampshire. Commercial Salt Applicators certified by NHDES Green SnowPro and the property owners or managers who hire them are granted limited liability protection against damages arising from snow and ice conditions. The UMWA will work with the Green SnowPro program to provide information to commercial property owners about the program to promote sensible salt application in the Turkey River watershed.

Coordination Meetings

Municipal Department of Public Works Meetings

The UMWA and its project partners will conduct meetings with the DPWs of the four watershed municipalities (Bow, Concord, Dunbarton, and Hopkinton). The goal of these meetings with DPW staff (and staff of other relevant departments) is to discuss stormwater management efforts, capital improvement plans, other funding opportunities, and strategies for coordinating (e.g., project prioritization, timing, etc.) to implement the recommendations of this WRMP. This series of meetings will allow project resources to focus specifically on setting the stage for plan implementation.

New Hampshire Stream Crossing Initiative

The New Hampshire Stream Crossing Initiative is an interagency work group to collaboratively mange New Hampshire's stream crossing assessment efforts. The work group is comprised of representatives from NHDES, NHDOT, the New Hampshire Fish and Game Department, and the Division of Homeland Security and Emergency Management. The UMWA will work with the work group to review the results of the culvert assessment (Section 4.2.1) and identify next steps.

New Hampshire Department of Transportation Meetings

The UMWA and its project partners will attend NHDOT Natural Resource Agency Coordination Meetings to discuss the implementation of the Turkey River WRMP and related projects that involve NHDOT jurisdiction. In advance of these meetings (held monthly in Concord), the UMRA will request that the relevant projects are included on the meeting agenda and will prepare materials for advance distribution to the meeting group. These meetings will promote coordination among project proponents, NHDOT, and other state agencies, in the interest of developing support and momentum for plan implementation. As needed, UMWA will also coordinate and meet with NHDOT regional staff regarding routine repairs, maintenance, and smaller-scale projects.

4.3.2 Land Conservation

Land conservation efforts can include strategies to protect and limit future development of highly sensitive parcels through purchase, donations, conservation easements, deed restrictions, and other real estate legal agreements.

As presented in Section 3.3.1, low density residential land uses are currently contributing the largest TP load to Turkey River and that load is expected to nearly double in full build-out conditions. A subsequent decline in TP load from agricultural and forested land uses are expected as residential areas increase. Efforts to protect land from future development can contribute to the long-term water quality goals established in this WRMP by reducing these projected load increases associated with land development.

Silk Farm Wildlife Sanctuary, Concord

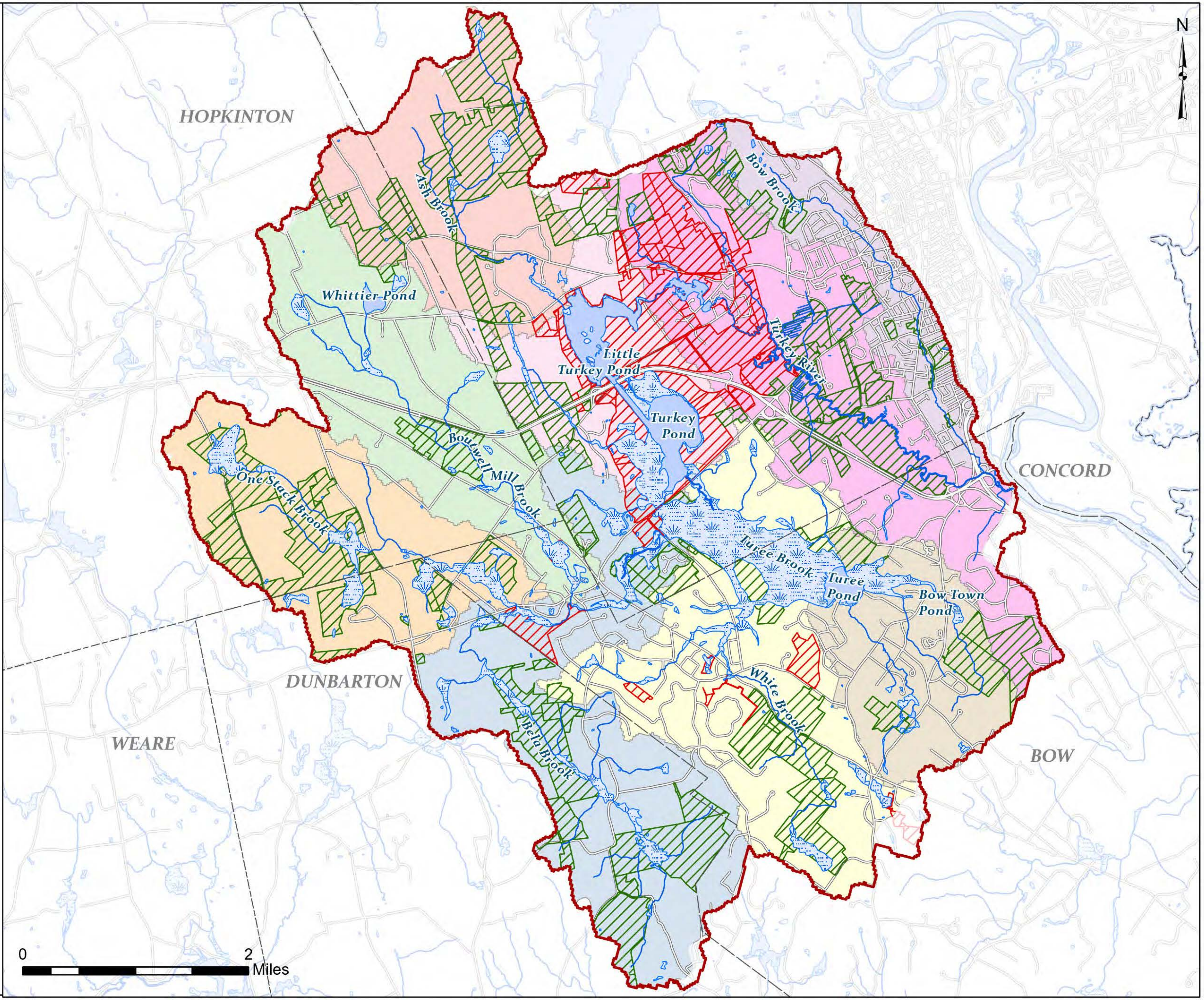
Although the process of prioritizing specific parcels for land conservation is beyond the scope of this WRMP project, an analysis of the location of conservation land throughout the Turkey River watershed was conducted. As shown in Table 20 and Figure 11, approximately 3,000 hectares, or 32% of the Turkey River watershed is currently under conservation. The majority of this conservation land is located in the Turkey River subwatershed where over 45% of the sub-watershed is under conservation. While the Turkey Ponds sub-watershed has over 55% of its land in conservation, over 73% of this land does not have a formal conservation easement, making it at-risk for future development. These lands include the St. Paul’s School land which is considered low-risk for development.

Table 20. Conservation Land in the Turkey River Watershed

Subwatershed	Total Subwatershed Area	Total Conservation Land (ha)	% of Subwatershed Area	Municipality (Conservation Land in ha by subwatershed)				Total Conservation Land without Easement (ha)	% of Conservation Land without Easement
				Bow	Concord	Dunbarton	Hopkinton		
Turkey River	1,564	704	45%	57	646	0	0	314	45%
Bow Brook	454	48	11%	0	48	0	0	0	0%
Turkey Ponds	809	446	55%	0	446	0	0	325	73%
Ash Brook	971	410	42%	0	338	0	73	5	1%
Turee Brook	1,447	394	27%	307	80	7	0	39	10%
Turee Pond	705	109	15%	109	0	0	0	0	0%
Bela Brook	1,502	490	33%	29	128	333	0	74	15%
Boutwell Mill Brook	1,065	78	7%	3	12	0	63	3	4%
One Stack Brook	1,074	362	34%	34	0	65	263	0	0%
TOTAL	**9,590**	**3,041**	**32%**	**539**	**1,698**	**405**	**399**	**761**	**25%**

Figure 11

Land Conservation Areas for the Turkey River Watershed



Legend

- ▨ Conservation Land
- ▨ Conservation Land without Formal Easement

Subwatersheds:

- Ash Brook
- Bela Brook
- Boutwell Mill Brook
- Bow Brook
- One Stack Brook
- Turee Brook
- Turee Pond
- Turkey Pond/ Little Turkey Pond
- Turkey River
- Stream, River
- Lake or Pond
- Wetland
- Watershed Boundary
- Town Boundaries

Comprehensive Environmental Incorporated

Data Sources: GRANIT, CNHRPC, NRCS

8/13/2021

4.3.3 Regulatory Tools

Local ordinances can provide effective protection against nonpoint source pollution and other factors that impact water quality. This section provides examples of model ordinances that can be used to regulate and improve the quality of stormwater runoff from developed areas, and a summary of the status of local stormwater regulations in the Turkey River Watershed.

Zoning

Zoning ordinances are used to specify and regulate land use activities that are permitted in each section of a town, as well as the allowable density of development. Zoning typically applies only to future site development and redevelopment, and does apply to existing land uses. Table 21 provides a list of examples zoning ordinances that may be used to protect water resources.

Table 21. Examples of Zoning Ordinances to Protect Water Resources

Example Ordinance	Web Link
Post-Construction Stormwater Management Standards for Site Plan Review Regulations (Rockingham Planning Commission and UNH Stormwater Center, 2017)	https://scholars.unh.edu/cgi/viewcontent.cgi?article=1034&context=stormwater
Cobbett's Pond and Canobie Lake Watershed Protection Ordinance, Windham, NH; (*see page 60*)	https://www.windhamnh.gov/DocumentCenter/View/365/Zoning-Ordinance
Aquifer Protection: Stratham, NH Aquifer Protection District Ordinance (*see page 137*)	www.stormwatercenter.net/Model%20Ordinances/Source_Water_Protection/Aquifer%20district%20ordinance.htm
Model Groundwater Protection Ordinance (NHDES/NHOEP)	https://www.nh.gov/osi/planning/resources/documents/model-groundwater-protection-ord-wd-06-41.pdf
Subsurface Wastewater Disposal Regulations (Meredith, NH)	https://www.meredithnh.org/sites/g/files/vyhlif4681/f/uploads/septic_regs_.pdf
New Hampshire Model Floodplain Ordinances	www.nh.gov/oep/planning/programs/fmp/regulations.htm
Impervious Surface Zoning Bylaw (Based on Town of Mashpee, MA zoning bylaw)	www.mass.gov/eea/agencies/massdep/water/drinking/sample-impervious-surface-zoning-bylaw.html
Open Space Design / Natural Resource Protection Zoning Bylaw (MA Smart Growth/Smart Energy Toolkit)	https://www.mass.gov/service-details/case-studies-open-space-design-osdnatural-resource-protection-zoning-nrpz
Additional Related Resources	
Limiting Impervious Surface Cover and Protecting Water Resources through Better Site Design and Planning (Rockingham Planning Commission)	http://scholars.unh.edu/cgi/viewcontent.cgi?article=1198&context=prep
Innovative Land Use Planning Techniques: A Handbook for Sustainable Development (NHDES, et al.)	https://www.nh.gov/osi/planning/resources/documents/ilupt-front-cover.pdf
Massachusetts Citizen Planner Training Collaborative - Publications	https://masscptc.org/docs/publications.html

Table 22 summarizes a comparison of municipal regulations in the Turkey River watershed to model Post-Construction Stormwater Management Standards developed by the Southeast Watershed Alliance (SWA) in cooperation with the UNH Stormwater Center and Rockingham Planning Commission. These model standards were developed to help guide the development of stronger municipal stormwater standards for protection of surface waters for New Hampshire communities and should be discussed further with municipal Planning Boards for adoption of potential amendments to local regulations.

Table 22. Comparison of Selected SWA 2017 Post-Construction Stormwater Standards to Municipal Stormwater Regulations in the Turkey River Watershed

		Selected 2017 Post-Construction Stormwater Standards (SWA)				
		Minimum Thresholds for Applicability	**Exemption Threshold**	**Treatment of Runoff from Impervious Surfaces (IC)**	**LID Design Requirements**	**Post-Development Peak Runoff Standards**
Relevant Municipal Regulations		Any development or redevelopment subject to Site Plan Review that disturbs **more than 5,000 square feet** or disturbs more than **2,500 square feet** within 100 feet of a surface water body.	For disturbances **< 5,000 square feet**, Town may grant an exemption if total site impervious cover created does not exceed **1,000 square feet** (*Note: must meet performance standards*)	Runoff from IC shall be treated to achieve **≥ 80%** TSS removal and **≥ 60%** removal of both total nitrogen and total phosphorus	LID design strategies **must be used to the maximum extent practicable** to reduce runoff volumes, protect water quality, and maintain predevelopment site hydrology.	Control post-development peak runoff rate to not exceed pre-development runoff. Drainage calculations shall compare pre- and post-development stormwater runoff rates and volumes for the **1-inch rainstorm and 2-year, 10-year, 25-year, and 50-year 24-hour storm events**.
Concord	Concord Site Plan Regulations (May 2019) Section 22 Concord Subdivision Regulations (July 2016) Section 23	Standards apply to all projects requiring Planning Board review and approval, including General Requirements and additional separate Storm Water Design Standards for (1) Site Plans with Significant Impact and (2) Minor Impact Site Plans.	General Requirements apply to all site plans, with thresholds for additional Storm Water Design Standards as follows: 1. **Site Plans with Significant Impact**: 20,000 square feet or greater of disturbed land area; 2. **Minor Impact Site Plans:** Between 2,000-20,000 square feet of site disturbed land area.	No numeric performance standard for IC pollutant removal. IC treatment volume specified as follows: - The volume of water to be treated shall be the first one (1) inch of runoff from the total impervious surface area.	All reasonable efforts shall be made to incorporate low-impact, non-structural site design techniques to minimize runoff due to development such as maintaining natural buffers, minimizing site disturbance, minimizing impervious cover, using pervious pavement or grassed pavers, and minimizing soil compaction.	1. **Site Plans with Significant Impact**: For new development, the volume of off-site discharge after project development shall not exceed the volume of discharge before development for the 10-year storm event. The peak rate of discharge after project development shall not exceed the peak rate of discharge before development for the **2-year, 10-year, 25-year and 100- year storms**. 2. **Minor Impact Site Plans:** For new development, the volume of off-site discharge after development shall not exceed the volume of discharge before development for the 10-year storm event. The peak rate of discharge after project development shall not exceed the peak rate of discharge before development for the **2-year and 10-year storms**.
Bow	Bow Zoning Ordinance, Aquifer Protection District (March 2020) Bow Site Plan Review Regulations (October 2016) Bow Subdivision Regulations (October 2015)	No relevant standard, except for within the Aquifer Protection District: For any use that will render impervious **more than 15% or 2,500 square feet** of any lot, whichever is greater, a stormwater management plan shall be prepared which…is consistent with NH Stormwater Manual.	No relevant standard	No relevant standard	No relevant standard	Hydrological calculations shall analyze **10, 25, and 50-year storm events**…The developer shall provide…detention and groundwater recharge facilities to assure that existing flow quantities or velocities will not be exceeded and existing groundwater recharge will be maintained. **Specific Design Standards**: Drainage Structures shall be designed to accommodate storms of the following frequency: Bridges: 50 years Culverts; Storm Drains (depressed sections): 25 years Storm Drains: 10 years Detention Ponds / Structures, Curbed Roadways, and Roadside Ditches: 10 years
Dunbarton	Dunbarton Site Plan Review Regulations (October 2009) Section VII. P. Stormwater Management	Standards are applicable to "*all construction activities*" subject to site plan review by the Planning Board.	No relevant standard	No numeric standard. Section VII. G (Groundwater) states, "Post-development groundwater recharge levels shall have no off-site adverse impact… To the extent feasible, all runoff from impervious surfaces shall be recharged to groundwater on-site. Recharge impoundments shall have vegetative cover for surface treatment and infiltration, and will be depicted on site plans.	Stormwater shall be retained and managed on site using the natural flow patterns of the site to the greatest extent possible. The Planning Board requires that plans utilize **natural infiltration best management practices** (i.e., bio-retention areas, expanded engineered swales). Other infiltration practices (i.e., infiltration trenches) shall be permitted with an acceptable maintenance plan…".	Measures shall be taken to control the **post-development peak rate of runoff so that it does not exceed pre-development runoff** for future flow estimates utilizing methods from the Stormwater Management and Erosion and Sediment Control Handbook for Urban and Developing Areas in New Hampshire ("Green Book"), 1992, or another more current source as cited.
Hopkinton	Hopkinton Site Plan Review Regulations (April 2012) Hopkinton Subdivision Regulations (April 2012)	Subdivision regulations apply to "all land within the boundaries of the Town of Hopkinton".	No relevant standard	No relevant standard	No relevant standard	***Site Plan Review Regulations****:* The standards for stormwater management …shall be, at a minimum, those standards outlined in the New Hampshire Stormwater Manual. ***Subdivision Regulations****:* Require calculation of stormwater run-off quantity and a statement from the applicant's engineer certifying the adequacy of the proposed drainage facilities to handle such run-off. Design storm frequency is (a) major streams, rivers, bridges, culverts: 50-year storm and flood of record; (b) minor brook culverts: 25-year storm; and (c) storm sewers:10-year storm.

Lawn Fertilizer Reduction Regulations and Programs

Landscaping fertilizers can be a significant source of phosphorus and nitrogen from areas of residential development and other areas where turf grass lawns are maintained (e.g., golf courses, office parks, schools, sports fields, etc.). The New Hampshire Fertilizer Law (RSA:431) helps to limit the impacts of fertilizer use by limiting the allowable content of nitrogen and phosphorus in turf fertilizer sold at retail.

The towns that comprise the Turkey River Watershed could develop municipal landscaping fertilizer ordinances to further reduce the use of fertilizers or restrict the use of fertilizer in sensitive areas. There are numerous successful regulations that limit the use fertilizer on lawns, including statewide programs in Maine and Minnesota and county programs in Dane County (WI), Muskegon County (MI), and Ottawa County (MI). Several New England examples include:

- Bridgewater, NH Zoning Ordinance. Includes a fertilizer prohibition zone as part of the *Pemigewasset River Shoreline Protection* regulations: http://www.bridgewater-nh.com/docs/planning_docs/masterordinances-d-revised-02-26-18.pdf
- 2016 zoning regulations adopted by Exeter, NH. These regulations incorporated fertilizer prohibition zones into the town's Shoreland Protection District and Aquifer Protection District, with these zones varying from 150-300 feet depending on the water body. http://exeternh.gov/sites/default/files/fileattachments/building/page/13081/2016_final.pdf
- Town of Orleans, MA *Fertilizer Nitrogen and Phosphorus Control Bylaw*: http://ecode360.com/28460572.
- Town of Brewster, *MA Fertilizer Nutrient Control Bylaw* https://ecode360.com/29998492

In addition to using regulatory tools, public education programs can also play an important role in curbing nutrient loads from landscaping fertilizers. Fertilizers are often over-applied in areas where soils naturally have adequate nutrient content to support landscaping needs. Education and outreach efforts such as are recommended as part of the long-term approach to reducing this source of pollutants. Soil testing can also be done through the University of New Hampshire Cooperative Extension - Soil Testing Services. Soil tests provide home owners with provides soil analysis and nutrient recommendations for lawns that are in compliance with the New Hampshire Fertilizer Law.

4.3.4 Institutional Practices and Programs

Of the four municipalities within the Turkey River watershed, only Bow is regulated under the US EPA's 2017 National Pollutant Discharge and Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Permit. This permit addresses stormwater pollution from the storm drain system and requires permitted communities to develop programs to address this type of pollution through implementing institutional practices and programs that reduce pollutant loading. The other three communities could implement similar practices as described below.

Catch Basin Cleaning

Catch basin cleaning is an infrastructure maintenance practice that can used to reduce pollutant discharge to receiving waters. Frequent clean-out can retain the volume in the catch basin sump available for capture of suspended sediments and treatment of stormwater flows. At a minimum, catch basins should be cleaned once or twice per year. Increasing the frequency of clean-out can improve the performance of catch basins, particularly in industrial or commercial areas. Although literature on this topic is relatively scarce, a frequently cited study of the benefits of catch basin cleaning (Mineart, P. and S. Singh. 1994. Storm Inlet Pilot Study) found that monthly cleaning yielded the best results in terms of pollutant removal per cleaning. This study concluded that the pollutant removal benefit of more frequent clean outs should be balanced against the associated increases in municipal costs.

The MS4 Permit requires communities to develop and implement a catch basin cleaning schedules with a goal of ensuring no catch basin is more than 50 percent full. The requirement includes documenting catch basins inspections, cleaning, and calculating the total mass removed and the disposal method. A similar approach could be taken in non-MS4 communities. By working with local DPWs, Highway Departments, and NHDOT, a more frequent catch basin cleaning schedule could be implemented. Local residents can contribute by clearing catch basin grates of debris and sediment after large storm events. To maintain sump capacity for proper catch basin performance, it is preferable to clean catch basins before they have accumulated sediment to half of capacity.

If contracted out to a private firm, catch basin cleaning will typically cost an estimated average of $30 per catch basin. A planning-level cost estimate for increased catch basin cleaning is $4,500 per year, based on 2 extra cleanings per year for 75 catch basins in Concord, Bow, Dunbarton, and Hopkinton. Based on this estimate, the cost would be $1,500 annually per town for 25 catch basins each.

The water quality benefits (i.e., pollutant reduction) of catch basin cleaning will vary considerably, depending on site-specific conditions such as land use, the size of the drainage area contributing to each basin, catch basin sump volume, extent of localized erosion, time elapsed since last cleaning, etc. As a reference, the 2017 New Hampshire Small MS4 General Permit (Appendix F, Attachment 2) provides a method for calculating phosphorus and nitrogen reduction credits for catch basin cleaning, as follows:

$$\text{Credit}_{\text{P CB}} = \text{IA}_{\text{CB}} \text{ x } \text{PLER}_{\text{IC-land use}} \text{ x } \text{PRF}_{\text{CB}}$$

$$\text{Credit}_{\text{N CB}} = \text{IA}_{\text{CB}} \text{ x } \text{NLER}_{\text{IC-land use}} \text{ x } \text{PRF}_{\text{CB}}$$

Where

$\text{Credit}_{\text{CB}}$ = Amount of phosphorus load removed by catch basin cleaning (lb/year)

IA_{CB} = Impervious drainage area to catch basins (acres)

$\text{PLER}_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (*see Table 2-1**)

$\text{NLER}_{\text{IC-land use}}$ = Nitrogen Load Export Rate for impervious cover and specified land use (lb/acre/yr) (*see Table 2-2**)

PRF_{CB} = Phosphorus Reduction Factor for catch basin cleaning *(see Table 2-4*)*

NRF_{CB} = Nitrogen Reduction Factor for catch basin cleaning (see Table 2-4*)

** Table references are to Appendix F, Attachment 2 of 2017 NH MS4 General Permit*

Enhanced Street /Pavement Cleaning Programs

Street sweeping can be an effective practice to reduce watershed nutrient loading. Street sweeping provides cleanup and removal of solids, including organic debris (leaves, pine needles), sand, and fines that accumulate on roadways. In absence of street sweeping, these materials contribute nutrients and other pollutants such as salt to receiving waters, and increase the frequency of maintenance required to maintain performance of catch basins and other storm water infrastructure.

The MS4 Permit requires all curbed streets to be swept a minimum of once a year with additional requirements for streets adjacent to an impaired waterbody. Enhancements to municipal and NHDOT street sweeping programs are recommended, with a focus on increased frequency in the spring and summer months when buildup of organic materials on roads tends to be highest. The benefits of increased street sweeping will also be greatest in areas with highest tree canopy cover, as these areas produce the most leaves that can contribute nutrient to surface waters through decomposition. Specific target areas and sweeping frequencies should be established based on coordination with municipal DPWs, Highway Departments, and NHDOT.

As a reference, the 2017 New Hampshire Small MS4 General Permit (Appendix F, Attachment 2) provides a method for calculating phosphorus and nitrogen reduction credit for enhanced street sweeping, as follows:

The credit shall be calculated by using the following equations:

$$\text{Phosphorus Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \text{ x } \text{PLER}_{\text{IC-land use}} \text{ x } \text{PRF}_{\text{sweeping}} \text{ x AF}$$

$$\text{Nitrogen Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \text{ x } \text{NPLER}_{\text{IC-land use}} \text{ x } \text{NRF}_{\text{sweeping}} \text{ x AF}$$

Where

$\text{Credit}_{\text{sweeping}}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)

IA_{swept} = Area of impervious surface that is swept under the enhanced sweeping program (ac)

$\text{PLER}_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (*see Table 2-1**)

$\text{NLER}_{\text{IC-land use}}$ = Nitrogen Load Export Rate for impervious cover and specified land use (lb/acre/yr) (*see Table 2-2*)*

$\text{PRF}_{\text{sweeping}}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency. (*see Table 2-4)*

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0

** Table references are to Appendix F, Attachment 2 of 2017 NH MS4 General Permit*

Enhanced Organic Waste and Leaf Litter Collection Programs

Enhanced organic waste and leaf litter collection programs are similar and complementary to street sweeping programs, in that they remove organic material that can decompose and contribute nutrients and other pollutants to surface waters. These programs typically include regular gathering, removal, and disposal of landscaping wastes, organic debris, and leaf litter from roads and parking lots. The City of Concord has a curbside leaf litter collection program. The towns of Bow, Dunbarton, and Hopkinton do not currently have programs to collect organic waste and leaf litter, and development of such programs is recommended.

As a reference, the 2017 New Hampshire Small MS4 General Permit (Appendix F, Attachment 2) provides a method for calculating phosphorus and nitrogen reduction credits for enhanced organic waste and leaf litter collection programs. The credit formula below applies to programs that collect organic waste and leaf litter at least once per week during the period of September 1 to December 1 of each year:

$$\text{Credit P}_{\text{leaf litter}} = (\text{IA}_{\text{leaf litter}}) \text{ x } (\text{PLER}_{\text{IC-land use}}) \text{ x } (0.05)$$

$$\text{Credit N}_{\text{leaf litter}} = (\text{IA}_{\text{leaf litter}}) \text{ x } (\text{NLER}_{\text{IC-land use}}) \text{ x } (0.05)$$

Where

$\text{Credit}_{\text{leaf litter}}$ = Amount of nutrient load reduction credit for organic waste and leaf litter collection program (lb. /year)

$IA_{\text{leaf litter}}$ = Impervious area (acre) in applicable watersheds that are subject to enhanced organic waste and leaf litter collection program

$PLER_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lbs./acre/yr.) (*see Table 2-1*)

$NLER_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lbs./acre/yr.) (*see Table 2-1*)

0.05 = 5% nutrient reduction factor for organic waste and leaf litter collection program in the applicable watershed

** Table references are to Appendix F, Attachment 2 of 2017 NH MS4 General Permit*

Table 23 presents a summary and prioritization ranking of the recommended non-structural BMPs discussed in this section.

Table 23. Non-Structural BMP Prioritization Summary

BMP Priority Ranking Factors*

L = Low	M = Medium	H = High

** For cost factors, lower cost = higher priority*

Non-structural BMP Category	BMP Description	Relevant Authorities	How BMP Achieves Pollutant Load Reductions or Other WRMP Goals	Pollutant Load Reduction Potential	Anticipated Costs	Feasibility	PRIORITY
Public Information and Education	Watershed Steward Program^{TM} property assessments and related outreach	UMWA, NHRC, watershed homeowners	Reduces pollutant (P,N, and bacteria) loading by improved land management, such as reduced fertilizer use, improved septic system maintenance, stabilization of eroding areas, pet waste management, etc.	M	H	H	**High**
	Meetings with town DPW staff and staff of NHDOT and the NHSCI to coordinate WRMP implementation	UMWA, town DPWs, NHDOT, NHDES	Reduces pollutant (P,N, and bacteria) loading by improving coordination with agencies that are critical to BMP implementation. Improves schedule coordination, BMP prioritization, and BMP implementation logistics.	M	H	H	**High**
	Updates to the UMWA website to update public on the Turkey River WRMP and implementation efforts	UMWA	Serves as the primary clearinghouse for web-based information on progress to develop, implement, and update the WRMP.	L	H	H	**Medium**
	Conduct LID for Homeowners workshop	UMWA, watershed homeowners	Reduces pollutant (P and N) loading by educating homeowners and promoting adoption of LID practices such as raingardens, vegetated buffers, etc.	L	H	H	**Medium**
Land Conservation	Coordinate with local conservation groups to prioritize land conservation goals/target parcels. (land trusts, town planning/conservation staff, CNHRPC, UMWA, NHDES)	UMWA, CNHRPC, town planning staff, and other local land conservation orgs.	Prevents increases in pollutant loading associated with land development.	H	H	H	**High**
Regulatory Tools	Strengthen town stormwater regulations based on SWA model standards	Concord, Bow, Dunbarton, and Hopkinton Planning Boards and Boards of Selectmen	Reduces future increases in pollutant (P, N, and bacteria) loading associated with land development by improving regulatory performance standards for new development and redevelopment projects.	H	H	M	**High**
	Develop landscaping fertilizer ordinances	Concord, Bow, Dunbarton, and Hopkinton Planning Boards and Boards of Selectmen	Reduces P and N loading from landscaping fertilizer applications.	H	L-M	M	**Medium**
	Establish town regulations to enable/promote installation of alternative wastewater treatment systems based on proximity to a waterbody (i.e., 200 meters) for new development, redevelopment and replacement of failed systems.	Concord, Bow, Dunbarton, and Hopkinton Planning Boards and Boards of Selectmen	Reduces nutrient and bacteria loading from wastewater sources.	**H**	**H**	M	**High**
Institutional Practices	Increase frequency of catch basin cleaning (2 additional cleanings per year)	Town DPW/Highway Depts., NHDOT	Reduces P and N load as calculated according to NH Small MS4 General Permit formulas for each practice.	M	L	M	**Medium**
	Develop Enhanced Street/Pavement Cleaning Programs	Town DPW/Highway Depts., NHDOT		M	L-M	M	**Medium**
	Develop Enhanced Organic Waste and Leaf Litter Collection Programs	Town DPW/Highway Depts., NHDOT		M	L-M	M	**Medium**

5

Summary of Technical and Financial Support

5.1 TECHNICAL SUPPORT

The structural BMPs described in Section 4.1 will require varying levels of technical support related to implementation complexity. Implementation complexity is a qualitative indicator based on the level of detail required for engineering designs (e.g., conceptual designs vs. detailed site design plan prepared by a registered professional engineer), construction (e.g., underground utility conflicts, site access, traffic impacts, etc.), and other factors (e.g., property ownership, potential for wetland permitting). The proposed stormwater improvement sites from Section 4.1 are listed in Table 24 according to the anticipated level of required technical support.

Table 24. Level of Technical Support Anticipated for Stormwater Structural BMP Sites

LOW	MODERATE	HIGH
Area 3	Area 1	Area 2
Area 4 (SP-2)	Area 4 (SP-1)	Area 6
Area 7	Area 4 (SP-3)	Area 8
Area 13	Area 4 (SP-4)	Area 9
-	Area 5	Area 10
-	Area 12	Area 11
-	Area 14	Area 15
-	-	Area 16

In addition to the technical support described above, construction of some of the proposed BMPs may require a Minimum Impact Wetlands Application to NHDES. Wetlands were not delineated as part of this WRMP project. As such, technical support from a New Hampshire certified wetland scientist would be required on sites where wetlands are present for wetland delineation and permitting support.

Improvements related to the wastewater management alternatives in Section 4 require a high degree of technical support from a wastewater engineering firm. Such support is expected to include a feasibility study with detailed site investigations and recommendations on siting options and costing for the proposed wastewater treatment systems. Detailed engineering plans for the systems would be required.

Other types of technical support that may be required for the nonstructural measures in Section 4.3 include:

- graphic design and printing support for public outreach and educational materials;
- qualified staff to conduct homeowner assessments through the Watershed Steward™ Program;
- septic system inspection services;
- legal assistance for conservation land real estate transactions and development of regulatory language for future municipal ordinances.

5.2 FINANCIAL SUPPORT

Site improvements and management recommendations described in Section 4 will require funding for implementation, including construction and ongoing maintenance. Likely sources of funding include, but are not limited to, federal Section 319 Nonpoint Source Pollution Program funds, which are distributed by NHDES through the Watershed Assistance Grants Program.

Brief descriptions of potential grant funding sources are provided in Table 25. Additional resources can be found on the NHDES Loans and Grants webpage. Although NHDES updates this page regularly, please note that funding programs are constantly changing.

Table 25. Summary of Funding Programs (*adapted from NHDES summary*)

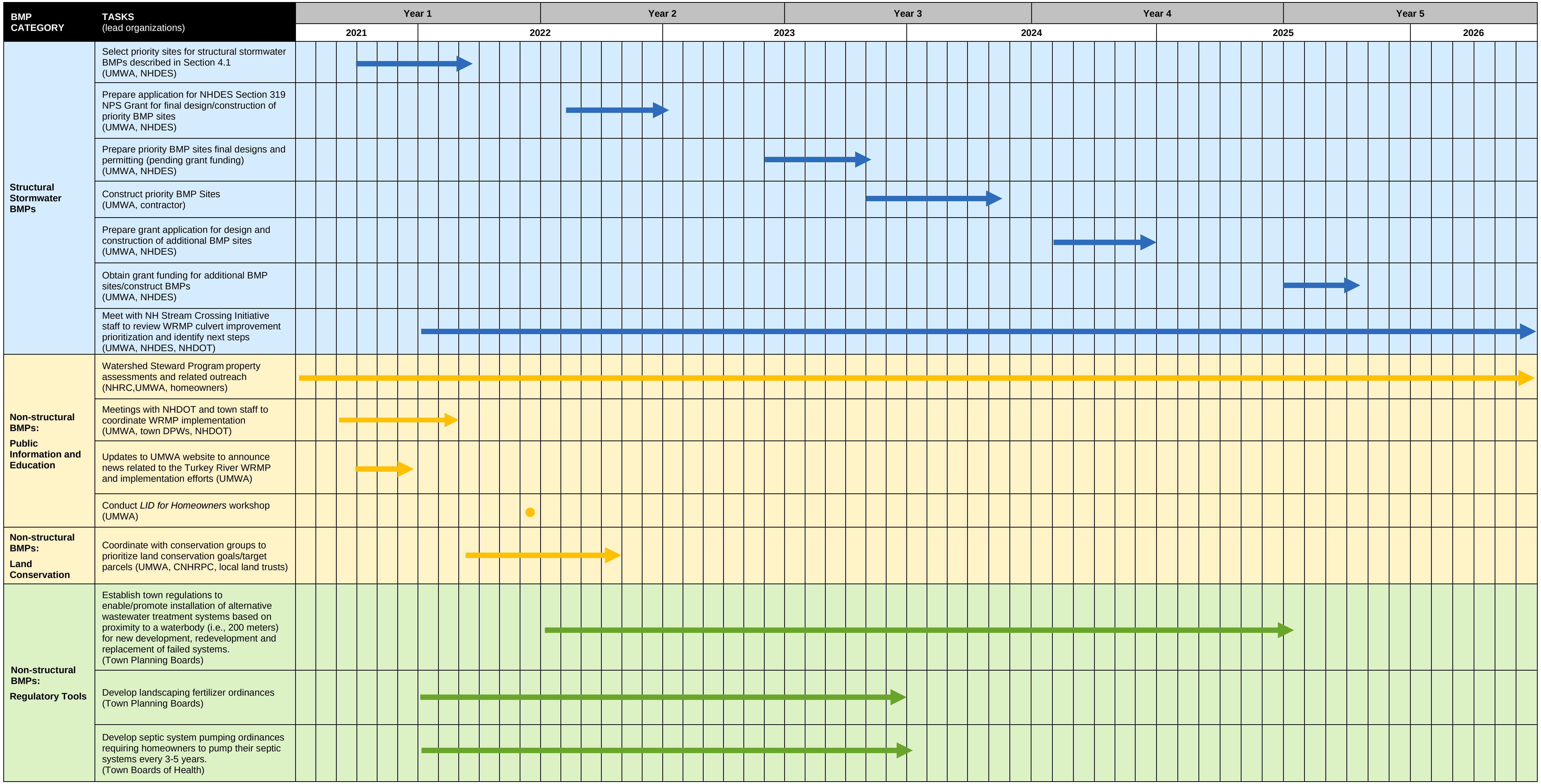
Funding Program	**Description**
Aquatic Resource Mitigation Fund Program	Focuses on projects to restore natural resources within the context of a proposed land conservation effort. NHDES encourages projects providing connectivity to other protected resources or in close proximity to wetland impacts. Projects to benefit rare resources are viewed favorably.
American Rivers - NOAA Community-Based Restoration Program Partnership	Grant funding provided for stream barrier removal projects that help restore riverine ecosystems, enhance public safety and community resilience, and have clear and identifiable benefits to diadromous fish populations.
Boston Foundation Fund for the Environment - Open Door Grants	Grants focus on protection of bird habitat. The grant program is an open process and responds to the expressed ideas and needs of the community.
Center for Land Conservation Assistance	Funds transaction costs for permanent land protection projects within NH's coastal watershed area. Funding level: up to $3,000
Community Grants	Funds projects that are actively engaged with the ecosystem and that work to increase the understanding of environmental sustainability.
Conservation Grant Program (Moose Plate)	Funding focus includes: preservation, protection, and conservation of water quantity and quality; restoration, enhancement, or conservation of wildlife habitat; soil erosion prevention; flood mitigation; installation of BMPs for agriculture; forestry; stormwater management; and land protection.
Davis Conservation Foundation	Supports organizations with projects related to wildlife, wildlife habitat, environmental protection, or outdoor recreation. Projects that strengthen volunteer activity and community involvement in these categories are of particular interest. Funding range: $2,000 - $150,000; average $10,000.
Fields Pond Foundation	Funds trail making and other enhancement of public access to conservation lands, land acquisitions for conservation, and establishing funds for stewardship. Funding levels: $25,000 maximum, $2,000 - $10,000 typical.
Land and Community Heritage Investment Program (LCHIP)	The LCHIP is an independent state authority that makes matching grants to NH communities and non-profits to conserve and preserve New Hampshire's most important natural, cultural and historic resources.
National Fish and Wildlife Foundation (NFWF), *Five Star and Urban Waters Restoration Program*	Provides funds to local partnerships for wetland, forest, riparian and coastal habitat restoration, with a focus on urban waters and watersheds. Average grants are between $25,000 to $35,000, with a 1:1 match requirement.
National Park Service – Rivers and Trails Program	Funds projects focused on protection of natural resources and enhancement of outdoor recreational opportunities.

Natural Resource Conservation Service (NRCS)	NRCS offers financial/technical assistance to landowners and agricultural producers for conservation practices to address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest.
New England Grassroots Environmental Fund	Funds projects focused on forestry and trails, with a focus on community-based environmental work. Funding level: $500 - $2,500
New England Forests and Rivers Fund	Dedicated to restoring and sustaining healthy forests and rivers that provide habitat for diverse native bird and freshwater fish populations in New England. Annually awards grants ranging from $50,000 to $200,000 each.
Norcross Wildlife Foundation	While the Norcross board has decided to suspend the unsolicited grants program for the foreseeable future, Norcross will continue to support conservation efforts via the land loan program, wildlife sanctuary, and various partnerships with conservation and environmental organizations.
Profits for the Planet	Stonyfield Farm's Profits for the Planet supports efforts to protect and restore the environment and generate measurable results.
Shared Earth Foundation Category: Non-Federal	Funds projects that promote protection and restoration of habitat for the broadest possible biodiversity. Funding level $5,000 - $20,000.
Tom's of Maine- Corporate Giving	Funds projects focused on protection and conservation of natural resources, wildlife and wildlife habitat. Funding level: $500 - $5,000
Trout Unlimited (TU) Embrace-A-Stream Grant Program	Provides grants for coldwater fisheries conservation projects to address the needs of native and wild trout.
U.S. Fish and Wildlife Service, Division of Bird Habitat Conservation: U.S. Standard Grants	This competitive, matching grants program supports public-private partnerships for projects in that further the goals of the North American Wetlands Conservation Act. Projects must involve long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats for the benefit of all wetlands-associated migratory birds.
NHDES Watershed Assistance Grants	Water Quality Planning and 604(b) grants are available for water quality planning purposes. Eligible projects include water quality monitoring, stormwater retrofits, green infrastructure projects, adopting ordinances, meeting MS4 permit requirements to address priority water quality planning concerns, and development of watershed-based plans (WBPs). NHDES also provides funding appropriated through the USEPA under Section 319 of the Clean Water Act for projects to restore impaired waters or protect high quality waters. 319-grant funds are targeted toward implementation of completed WBPs. 40% non-federal match is required.
NHDES Clean Water State Revolving Fund	The SRF Clean Water program provides low-cost financial assistance for planning, design, and construction projects to communities, nonprofits, and local government entities for wastewater infrastructure projects (collection systems, pumping stations, and wastewater treatment) and water pollution control projects (nonpoint source, watershed protection/ restoration).
NHDES Drinking Water Ground Water Trust Fund	Provides grants and low interest loans for the protection, preservation, and enhancement of all drinking water and groundwater resources of the state. Projects include infrastructure improvement and land conservation.

6 Schedule and Interim Milestones

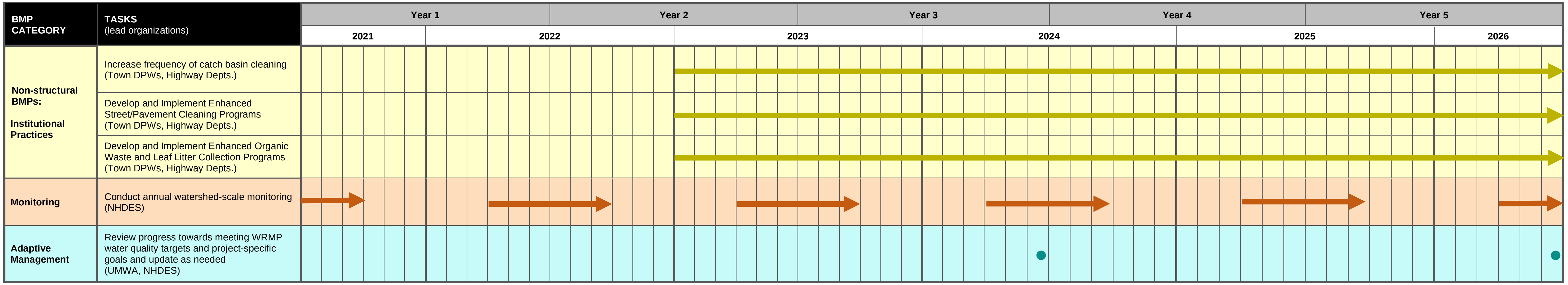
The schedule below is based on a five-year planning and implementation period from September 2021 to September 2026.

Table 26. Schedule and Interim Milestones



BMP CATEGORY	TASKS (lead organizations)
Structural Stormwater BMPs	Select priority sites for structural stormwater BMPs described in Section 4.1 (UMWA, NHDES)
	Prepare application for NHDES Section 319 NPS Grant for final design/construction of priority BMP sites (UMWA, NHDES)
	Prepare priority BMP sites final designs and permitting (pending grant funding) (UMWA, NHDES)
	Construct priority BMP Sites (UMWA, contractor)
	Prepare grant application for design and construction of additional BMP sites (UMWA, NHDES)
	Obtain grant funding for additional BMP sites/construct BMPs (UMWA, NHDES)
	Meet with NH Stream Crossing Initiative staff to review WRMP culvert improvement prioritization and identify next steps (UMWA, NHDES, NHDOT)
Non-structural BMPs: **Public Information and Education**	Watershed Steward Program property assessments and related outreach (NHRC,UMWA, homeowners)
	Meetings with NHDOT and town staff to coordinate WRMP implementation (UMWA, town DPWs, NHDOT)
	Updates to UMWA website to announce news related to the Turkey River WRMP and implementation efforts (UMWA)
	Conduct *LID for Homeowners* workshop (UMWA)
Non-structural BMPs: **Land Conservation**	Coordinate with conservation groups to prioritize land conservation goals/target parcels (UMWA, CNHRPC, local land trusts)
Non-structural BMPs: **Regulatory Tools**	Establish town regulations to enable/promote installation of alternative wastewater treatment systems based on proximity to a waterbody (i.e., 200 meters) for new development, redevelopment and replacement of failed systems. (Town Planning Boards)
	Develop landscaping fertilizer ordinances (Town Planning Boards)
	Develop septic system pumping ordinances requiring homeowners to pump their septic systems every 3-5 years. (Town Boards of Health)

Table 26. Schedule and Interim Milestones *(continued)*



BMP CATEGORY	TASKS (lead organizations)	Year 1	Year 2	Year 3	Year 4	Year 5	
		2021	2022	2023	2024	2025	2026
Non-structural BMPs: **Institutional Practices**	Increase frequency of catch basin cleaning (Town DPWs, Highway Depts.)			→	→	→	→
	Develop and Implement Enhanced Street/Pavement Cleaning Programs (Town DPWs, Highway Depts.)			→	→	→	→
	Develop and Implement Enhanced Organic Waste and Leaf Litter Collection Programs (Town DPWs, Highway Depts.)			→	→	→	→
Monitoring	Conduct annual watershed-scale monitoring (NHDES)	→	→	→	→	→	→
Adaptive Management	Review progress towards meeting WRMP water quality targets and project-specific goals and update as needed (UMWA, NHDES)				●		●

7 Evaluation Criteria and Monitoring

This Section of the Turkey River WRMP addresses Elements H and I of the USEPA requirements for a watershed-based plan, as defined below.

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "***how will you know if you are making progress towards water quality goals?***" The criteria established to track progress can be direct measurements (e.g., *E. coli* bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "***how, when, and where will you conduct monitoring?***"

7.1 EVALUATION CRITERIA

Evaluation criteria (Element H) for the Turkey River Watershed include the categories presented below.

- **Water Quality Targets:** Section 2 of the WRMP presents a summary of existing water quality impairments in the Turkey River Watershed, and a target TP concentration of 0.027 mg/L was selected for the mainstem segment of the Turkey River.

- **TMDL Criteria:** Although no TMDLs currently exist in the watershed for TP listed above, this WRMP should be updated as needed to reflect TMDL criteria if established in the future.

- **Project-Specific Indicators:** The project-specific performance indicators listed in Table 27 may be used as criteria for activities recommended in this WRMP. These project-specific indicators are generally intended to quantify an activity and, whenever possible, explain how that activity achieves load reductions for targeted pollutants. In cases where it is not possible to quantify a pollutant load reduction, the project-specific indicator states the target pollutant(s) expected to be reduced as a result of the activity.

Table 27. Project-Specific Indicators for Turkey River Watershed Restoration and Management Plan

BMP Type	Quantified Activity	How Activity Achieves Pollutant Load Reductions or Other WRMP Goals
Structural Stormwater BMPs and Culvert Upgrades	Number of structural stormwater BMPs implemented; annual P load reduced	Pollutant (P) load reductions from specific structural BMPs as presented in Section 4.
	Number of culvert improvement projects implemented.	Miles of restored stream connectivity for fish and aquatic organism passage (see Section 4); Length of restored stream channel
Nonstructural BMPs: **Public Information and Education**	Number of Watershed Steward Program^{TM} property assessments: Number of property owners certified as Watershed Stewards	Reduces pollutant (P,N, and bacteria) loading by improved land management, such as reduced fertilizer use, improved septic system maintenance, stabilization of eroding areas, pet waste management, etc.
	Conduct *LID for Homeowners* Workshop: Number of watershed residents who attended workshop	Reduces pollutant (P and N) loading by educating homeowners and promoting adoption of LID practices such as raingardens, vegetated buffers, etc.
	Meetings with municipal DPW/Highway departments and NHDOT to coordinate WRMP implementation.	Reduces pollutant (P,N, and bacteria) loading by improving coordination with agencies that are critical to BMP implementation. Improves schedule coordination, BMP prioritization, and BMP implementation logistics.
	Project updates posted to UMWA project website: Number of project updates and associated news releases.	Serves as the primary clearinghouse for web-based information on progress to develop, implement, and update the WRMP.
Nonstructural BMPs: **Land Conservation**	Coordination via meetings) with UMWA, CNHRPC, state/local agency staff, and local conservation groups to prioritize land conservation goals and target parcels.	Contributes to the long-term water quality goals established in this WRMP by reducing pollutant load increases associated with land development.
	Acres of land protected through land acquisition, conservation easements, or other real estate conservation tools.	Prevents increases in pollutant loading associated with land development.
Nonstructural BMPs: **Regulatory Tools**	Number of watershed towns with strengthened stormwater regulations based on SWA model standards	Reduces future increases in pollutant (P,N, and bacteria) loading associated with land development by improving regulatory performance standards for new development and redevelopment projects.
	Number of municipal fertilizer ordinances drafted and adopted by watershed towns; Quantify area (acres) within in community that is regulated by each ordinance.	Reduces P and N loading from landscaping fertilizer applications.
	Establish town regulations to enable/promote alternative wastewater treatment systems based on proximity to a waterbody (i.e., 200 meters) for new development, redevelopment and replacement of failed systems.	Reduces nutrient and bacteria loading from wastewater sources.
Nonstructural BMPs: **Institutional Practices**	Number of catch basins included in enhanced catch basin cleaning program, and increase in frequency of cleaning.	Reduces P and N load as calculated according to NH Small MS4 General Permit formulas for each practice.
	Number of road miles where enhanced street sweeping was conducted each year, and increase in frequency.	
	Number of road miles/area covered under enhanced organic waste and leaf litter collection programs.	

7.2 MONITORING

Continued watershed-scale water quality monitoring is recommended to address Element I requirements and help document the extent to WRMP implementation efforts are succeeding. The results and locations of past monitoring efforts are summarized in Section 1 of this WRMP.

Monitoring Recommendations:

1. Continue monitoring at the four existing stations within the Turkey River downstream mainstem segment (01-TKR, 04-TKR, 15-TKR, and 18-TKR). Data from these stations should continue to serve as the basis for comparison to the TP water quality goal established by this WRMP (27 ug/L).

   As noted in Section 2, the current understanding of the median TP concentration in the Turkey River mainstem (30.5 ug/L) is based on very limited monitoring data (see Figure 2). More frequent TP monitoring (e.g., annual summer monitoring) would help to strengthen the basis for future water quality goal setting and/or adaptive management.

2. The six existing riverine monitoring stations upstream of the mainstem segment are not well distributed throughout the watershed, as they are all located within tributaries to Turee Pond. The water quality goal setting process described in Section 2.4 recognized that an important goal of WRMP is to protect water quality of the mainstem Turkey River and its tributaries. As such, it is recommended that water quality monitoring stations be established at the downstream reach of Ash Brook, Boutwell Mill Brook, One Stack Brook, Bela Brook, White Brook, and Bow Brook. Water quality data from these tributaries will help to characterize nutrient dynamics within the watershed as a whole, and will help to track tributary water quality response both to management measures and continued land development.

7.3 ADAPTIVE MANAGEMENT

If, after 5 years of WRMP management measure implementation, the direct measurements and indirect indicators do not show progress towards meeting the water quality targets established in this WRMP, the management measures and water quality targets should be revisited and modified accordingly.