Final Nitrogen Control Plan

Town of Newmarket, New Hampshire

September 2018

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LIST OF ACRONYMS

AOC	Administrative Order of Consent
BMP	best management practice
EPA	Environmental Protection Agency
GBNNPSS	Great Bay Nitrogen Non-Point Source Study
lb/yr	pounds per year
LOT	limit of technology
MGD	million gallons per day
mg/L	milligram per liter
MS4	municipal separate storm sewer system
NCP	Nitrogen Control Plan
NHDES	New Hampshire Department of Environmental Services
NPDES	National Pollution Discharge Elimination System
PLER	pollutant load export rate
PREP	Piscataqua Region Estuaries Partnership
PTAPP	Pollutant Tracking and Accounting Pilot Project
SRF	State Revolving Fund
TMDL	total maximum daily load
TN	total nitrogen
UNH	University of New Hampshire
WP	Wright-Pierce
WQAL	Water Quality Analysis Lab
WWTF	wastewater treatment facility

Final Nitrogen Control Plan

Town of Newmarket, New Hampshire

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

Section D.4 of the Administrative Order on Consent (AOC) requires the Town of Newmarket (Town) to submit to EPA and NHDES a total nitrogen non-point and point source stormwater control plan ("Nitrogen Control Plan"), including a schedule of at least five (5) years for implementing specific control measures to address identified non-point source and stormwater point source nitrogen loadings in the Town that contribute total nitrogen to the Great Bay estuary, including the Lamprey River. This document serves as the means for the Town to meet this requirement of the AOC.

1.2 Purpose and Organization

The purpose of this Nitrogen Control Plan (NCP) is to provide EPA and NHDES with an understanding of the existing contributing nitrogen load from the Town to the Great Bay estuary, including the Lamprey River. The NCP presents an implementation plan and schedule for how the Town plans to address non-point source and stormwater point source nitrogen loadings from the Town over the next five (5) years.

The NCP is organized into the following sections:

- Section 1 – Executive Summary, describes the purpose of the NCP, relevant work previously completed, conclusions and recommendations.
- Section 2 – Baseline Loadings, describes the Town's contributing total nitrogen load from both non-point and point sources.
- Section 3 – Regulatory Framework, describes the total nitrogen targets for Great Bay estuary and Lamprey River subestuary.
- Section 4 – Evaluate of Nitrogen Reduction Alternatives, describes the point and non-point source reduction strategies and the alternatives evaluated by the Town.
- Section 5 – Implementation Plan, describes the schedule the Town will follow to implement the NCP.
- Section 6 – Tracking, Accounting and Monitoring, describes how the Town will demonstrate the effectiveness of the selected nitrogen reduction alternative.
- Section 7 – References

1.3 Relevant Work Completed Previously

The Town's wastewater treatment facility (WWTF) was upgraded in July 2017 to a four-stage Bardenpho process preceded by primary clarifiers. The process was designed to achieve an effluent total nitrogen (TN) limit of less than 8 milligrams per liter (mg/L), at annual average design flows

(0.85-million gallons per day (MGD)) without supplemental carbon. Current flows (0.49 MGD for the period of 2015 through 2017) are well below the annual average design flow and therefore, performance of the upgrade has exceeded the design performance, achieving an average effluent nitrogen concentration of 5.86-mg/L from August 2017 through December 2017. In 2018, effluent concentrations as low as 1.40-mg/L have been observed, with an average of effluent nitrogen concentration of 3.55-mg/L from January 2018 through June 2018.

1.4 Expected Outcomes

Over the past 5 years, the Town has made substantial efforts to reduce total nitrogen load to the Lamprey River through upgrades made that their wastewater treatment facility. As outlined in this NCP, the Town is committing to implement total nitrogen load reduction strategies to reduce the Town's total nitrogen load to the Lamprey River and ultimately to the Great Bay estuary. These strategies include:

- Infrastructure maintenance program
- Organic waste and leaf litter collection program
- Enhanced street and pavement cleaning program
- Stormwater structural best management practices

To monitor the effectiveness and in-stream water quality response from implementation of the NCP, the Town is also committing to develop and implement a water quality monitoring program

Efforts by the Town to date and implementation of the NCP are expected to result in the following outcomes:

- An annual TN load reduction of 63% to the Lamprey River and ultimately to the Great Bay, based on:
    - An annual TN load reduction of 86% from the WWTF, based on data collected from August 2017 through December 2017 and the potential to reduce this load even greater based on data collected in 2018.
    - An annual TN load reduction of 6% from non-point source loads, through implementation of Alternative 1.
- The Town will implement a Water Quality Monitoring Program (WQMP), including an adaptive management approach to review empirical observations over time to understand the scientific uncertainty of the water quality criteria and both short-and-long-term effects of the implementation of this NCP. The WQMP will cost the Town approximately $182,000 from 2019 – 2022.
- Investment of approximately $23,622,000 in stormwater, wastewater and monitoring over the next 20 years, which is expected to result in approximately 53,800 pounds of nitrogen removed per year from the Lamprey River.
    - This includes an estimated $241,000 annually to implement non-point source strategies, on top of the $933,000 annual investment into upgrades at the WWTF, which will actually continue out 25 years.
- Preparation of an Engineering Evaluation due at the end of 2022.

2.0 BASELINE LOADING

2.1 Introduction

The purpose of this section is to summarize the baseline nitrogen load contributions from the Town to its receiving waters and ultimately to the Great Bay. This section also summarizes the loads from the contributing watershed to the Lamprey River subestuary and Great Bay estuary. To establish a baseline condition, nitrogen pollutant load models along with existing regional studies to estimate the baseline nitrogen load from stormwater, groundwater (septic and non-septic), and wastewater source pathways. Specific details of the modeling effort can be found in Attachment A.

2.2 Data Set and Project Area

The following studies and methods were used in developing the baseline conditions model:

- Great Bay Nitrogen Non-Point Source Study (GBNNPSS) (Trowbridge et al., 2014);
- Twenty-Year Water and Wastewater System Build-Out Study (Wright-Pierce, 2017); and
- New Hampshire 2017 Final Municipal Separate Storm Sewer System (MS4) Permit, Appendix F, Attachment 3, Draft (EPA, 2017).

Data sources associated with each of the nitrogen pollutant load model sources are summarized below:

- Stormwater Load Model (Unattenuated) (EPA, 2017);
- Septic System Load Model (GBNNPSS);
- Pollutant Load Export Rates (PLERs) (EPA, 2017);
- Wastewater Treatment Facility Load (Wright-Pierce, 2018; Attachment A); and
- Attenuation in pathways in groundwater and surface water (GBNNPSS).

The model estimates the total load of nitrogen deposited on land surface. The initial load represents pollutants from the following sources:

- Atmospheric deposition;
- Human application of pesticides and fertilizers on agricultural land;
- Residential land and managed open space (e.g., golf courses and ball fields);
- Pet waste from both domestic and farm animals; and
- Natural deposition from leaf litter, grass clippings, wetlands and forests.

From these sources, a stormwater and groundwater load was estimated. The stormwater load represents the portion of the source load transported during a rain event from the land surface directly to a storm drain or receiving water. The stormwater load is based on PLERs, which are derived from land use specific water quality data to determine an aggregate nitrogen export rate for all sources. The PLER approach is consistent with methodology used by Region 1 EPA for compliance under the MS4 permit. The groundwater load represents the portion of the load on the land surface which infiltrates during a rain event plus the human waste load from septic systems. The wastewater load represents the nitrogen load discharged from the wastewater treatment facility (WWTF).

2.2.1 Project Area

The Town of Newmarket is located in seacoast New Hampshire and includes 9,080 acres in land area. Land use in the Town is divided as follows: 40% forested; 20% residential; 12% wetland; 11% water; 7% agriculture; 3% outdoor (i.e., parks, cemeteries, etc.); 2% transportation, commercial, services, and institutional, communications and utilities; and ≤less 1% of industrial, barren, transitional, industrial and commercial complexes, vacant, and mixed use developments (Figure 1).

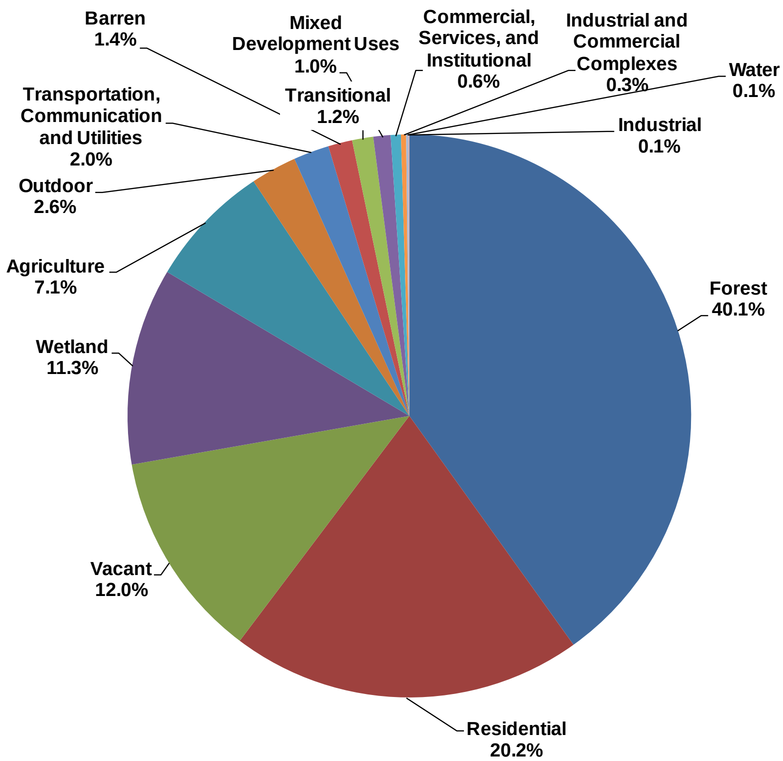

Figure 1: Town of Newmarket Land Use

Based on 2015 impervious area data from the New Hampshire Geographic Information Clearinghouse (GRANIT), 6.4% of the Town is impervious (579 acres of impervious cover out of 9,080 total acres). Of the estimated 579 impervious acres, approximately 58% is residential; 26% transportation (i.e., roads), communications and utilities; and 6% represents commercial, services, and institutional. Each of the remaining land use categories makes up 10% of the impervious area. Refer to Figure 2 for a summary of impervious area by land use.

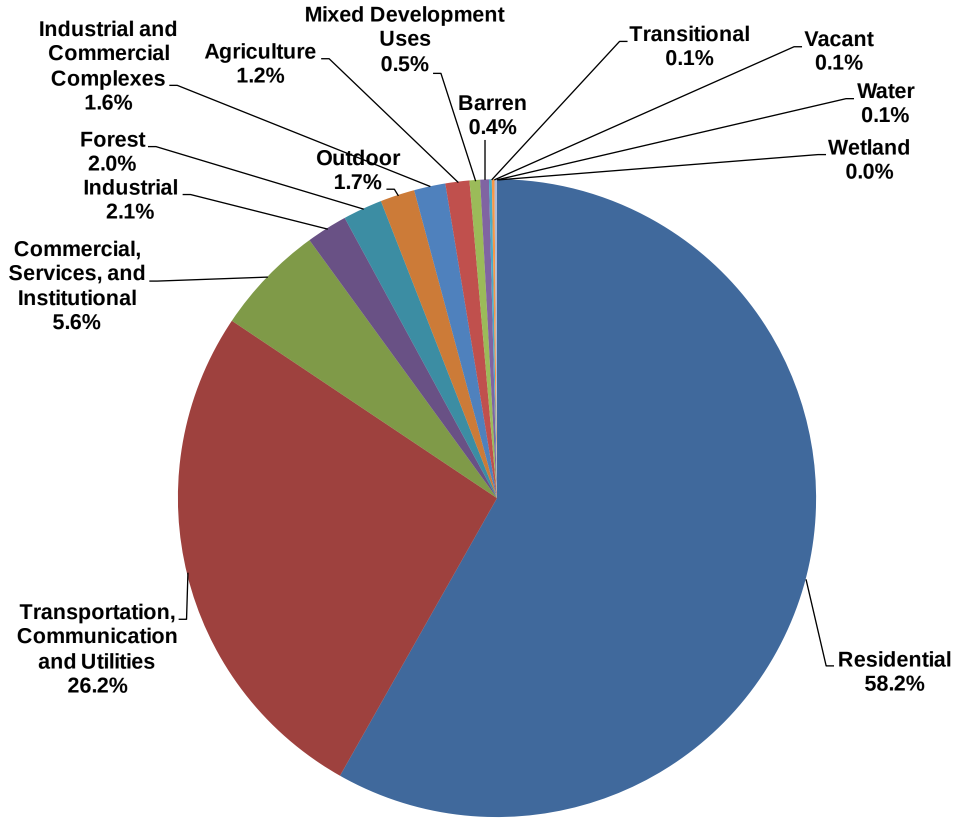

Figure 2: Town of Newmarket Impervious Area.

2.3 Town Baseline Nitrogen Load

To establish a baseline condition, nitrogen pollutant load models along with existing regional studies were used to estimate the baseline nitrogen load from stormwater, groundwater (septic and non-septic), and wastewater source pathways.

2.3.1 Stormwater Load

PLERs were used to estimate the annual pollutant load from stormwater. This approach uses the methodology developed by EPA (2017), which uses hydrologic response units (HRUs) and PLERs to calculate an initial and delivered annual baseline nitrogen load. The initial load, or unattenuated load, represents available pollutant load on the land surface. When precipitation falls on the land surface, natural attenuation of nitrogen occurs as water travels across pervious surfaces and vegetated buffers, through streams and natural waterways. Attenuation is caused by particulate settling, filtering, and biological uptake. By accounting for natural attenuation, the pollutant load that ultimately arrives at the receiving water (the delivered load) can be estimated. As part of the GBNNPSS, approximately 87% of nitrogen traveling in stormwater through surface water pathways will be transported from its origin to the receiving waters, and 13% is attenuated along the way (Trowbridge et al., 2014). The delivered stormwater load is presented in Table 1.

Table 1: Total Nitrogen Stormwater Pollutant Load by Land Use for Town.

LAND UES TYPE	INITIAL (UNATTENUATED) N LOAD (LBS/YR)	DELIVERED (ATTENUATED) N LOAD (LBS/YR)
DEVELOPED LAND		
Agriculture	1,240	1,079
Commercial, Services, and Institutional	295	256
Industrial	81	71
Industrial and Commercial Complexes	26	23
Mixed Development Uses	31	27
Outdoor	402	349
Residential	2,835	2,467
Transportation, Communications, and Utilities	1,331	1,158
Vacant	24	21
TOTAL DEVELOPED LAND LOAD:	**6,265**	**5,450**
UNDEVELOPED LAND		
Barren	170	148
Forest	1,802	1,567
Transitional	48	42
Water	0	0
Wetland	536	466
TOTAL UNDEVELOPED LAND LOAD:	**2,555**	**2,223**
TOTAL INITIAL LOAD:	**8,820**	**7,673**

Approximately 7,673 pounds (3.8 tons) per year of nitrogen is delivered in stormwater to the receiving waters in the Town of Newmarket. Of the delivered stormwater nitrogen load, approximately 29% is from natural or undeveloped sources (i.e., barren, forested, transitional, water, and wetlands). The remaining 71% is from developed sources with the largest load from residential development, which is 45% of the total developed load. Transportation and agricultural land uses contribute approximately 21% and 20% of the total developed load, respectively.

2.3.2 Groundwater Load

The amount of the nitrogen load deposited on the pervious land surface that makes its way to groundwater is quantified as the "groundwater non-septic system load". Nitrogen that leaches from septic systems is quantified as the "groundwater septic system load".

Septic System Load

The estimated annual nitrogen load derived from the use of septic systems is based on estimates from GBNNPSS. The estimated direct load to the receiving water from septic systems is based on the distance of the septic system to the receiving water body. GBNNPSS quantifies population and associated septic systems within 200 meters of a 5th order stream and the number of systems located beyond that distance. Scientific literature suggests that systems within 200 meters of a 5th order stream or estuary assessment unit contribute a greater proportion of nitrogen to the Great Bay estuary than those septic systems located outside of 200 meters (NHDES, 2014).

Table 3 presents the unattenuated nitrogen load estimates for septic systems from the GBNNPSS for the Town. Septic systems within the Town contribute approximately 24,761 pounds of total nitrogen per year, 93% of which is from septic systems located more than 200 meters from a 5th order stream, and 7% is from septic systems located less than 200 meters from a 5th order stream.

Table 2: Groundwater Septic System Unattenuated Total Nitrogen Load by Town

METRIC	LOCATION		
	INSIDE 200 M	OUTSIDE 200 M	TOTAL
Estimated No. of Systems	72	993	1,065
Initial (unattenuated) Load (lbs N/yr)	1,661	23,100	24,761
Delivery Factor	60%	26%	
Delivered (attenuated) Load (lbs N/yr)	997	5,946	6,943

The delivered load from septic systems was multiplied by a delivery factor to account for natural attenuation of nitrogen within the groundwater pathway (Trowbridge et.al, 2014). For septic systems located within 200 meters of a 5th order stream, a delivery factor of 60% was applied. For septic systems located more than 200 meters from a 5th order stream, a delivery factor of 26% was applied (Table 2). Using these delivery factors, the total delivered load is 6,943 pounds per year.

Non-Septic System Load

The annual unattenuated load to groundwater from non-septic system sources (i.e., infiltration) is estimated by subtracting the stormwater and groundwater septic load from the total source load deposited on the surface, as estimated in the GBNNPSS. The GBNNPSS used the Nitrogen Load Model (Valiela, et al., 1997) to quantify nitrogen inputs from atmospheric deposition, chemical fertilizers, septic systems and groundwater and calculate the total source load. To estimate the unattenuated groundwater load from non-septic system sources, the stormwater load (8,820 pounds) and septic system load (24,761 pounds) were subtracted from total source load (101,841 pounds) (Table 3).

Table 3: Calculation of Groundwater Non-Septic Unattenuated Total Nitrogen Load.

METRIC	TOTAL SOURCE LOAD		STORMWATER		GROUNDWATER SEPTIC		GROUNDWATER NON-SEPTIC
Initial (unattenuated) Load (lbs N/yr)	101,841	-	8,820	-	24,761	=	**68,260**
Delivery Factor							**15%**
Delivered (attenuated) Load (lbs N/yr)							**10,239**

The nitrogen load delivered to the receiving water from non-septic sources originates from deposition on the ground surface in rainfall that infiltrates. This is different from surface runoff, which ultimately makes its way through the soil layers and into a groundwater aquifer. To estimate the amount of total nitrogen that is not "lost" during this transport pathway through the soil layers to an aquifer, a delivery factor is applied. Based on the GBNNPSS, a range of groundwater delivery factor for non-septic system groundwater are available depending on nitrogen input source and land use type (9 to 15%). A delivery factor of 15%, the most conservative value, was applied in order to estimate the delivered groundwater load from the aquifer to the receiving waters (Table 3). Using this delivery factor, the total delivered load is approximately 10,239 pounds per year.

2.3.3 Wastewater Treatment Facility

The baseline nitrogen loading from the Newmarket WWTF was 61,000 lb/year (30.5 tons/year), as determined by NHDES in the Draft Analysis of Nitrogen Loading Reductions for Wastewater Treatment Facilities and Non-Point Sources in the Great Bay estuary Watershed (NHDES, 2010). The value is based on WWTF effluent data collected from 2003 to 2008 (Table 4).

Table 4. Baseline Effluent WWTF Nitrogen Load

PRE-WWTF UPGRADE (2003 – 2008)	EFFLUENT TOTAL NITROGEN	
	(LB/D)	(LB/YR)
Daily Average	167	61,000

2.3.4 Total Baseline Load

For the baseline assessment, the total nitrogen unattenuated (initial) load from the Town is estimated at 162,841 pounds (81.4 tons) per year (Figure 3). Of the total baseline unattenuated load, approximately 42% is from groundwater non-septic (68,260 lbs TN/yr) followed by 38% (61,000 lbs TN/year) is from the wastewater treatment facility, 15% (24,761 lbs TN/year) from groundwater due to septic systems, 5% (8,820 lbs TN/year) from stormwater.

For the baseline assessment, the total nitrogen delivered load from the Town is estimated at 85,855 pounds (42.9 tons) per year (Figure 4). Of the total baseline delivered load, approximately 71% (61,000 lbs TN/year) is from the wastewater treatment facility followed by 12% (10,239 lbs N/year) from groundwater non-septic, 9% (7,673 lbs TN/year) from stormwater, and 8% (6,943 lbs TN/year) from groundwater due to septic systems.

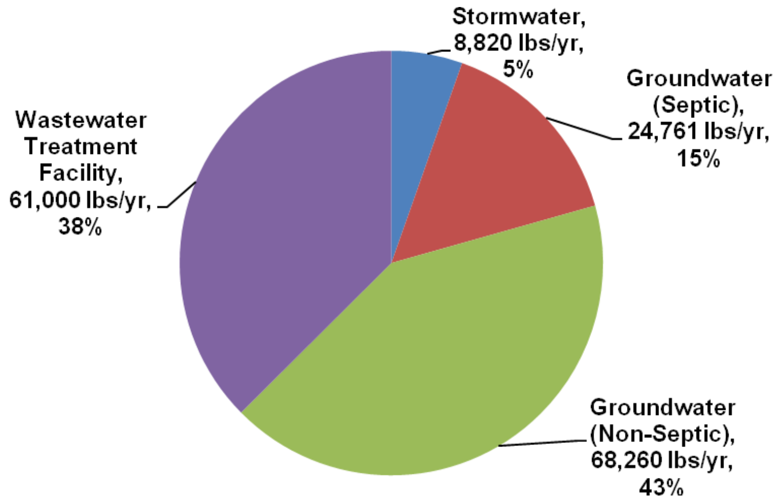

Figure 3. Baseline Unattenuated Total Nitrogen Load from Town

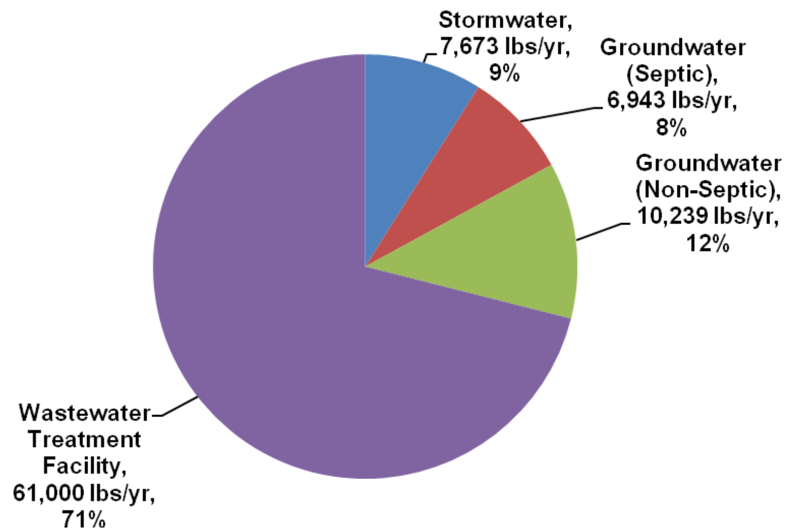

Figure 4. Baseline Delivered Total Nitrogen Load from Town

2.4 Great Bay Watershed

The Great Bay Watershed is made up of 52 communities in New Hampshire and Maine. The Great Bay receives approximately 1,285 tons of nitrogen per year (NHDES, 2010; Trowbridge, et.al. 2014) of which 30% is from WWTF and 70% from non-point sources. The Town's estimated delivered load to the Great Bay is approximately 42.9 tons per year or 3.3% of the total load.

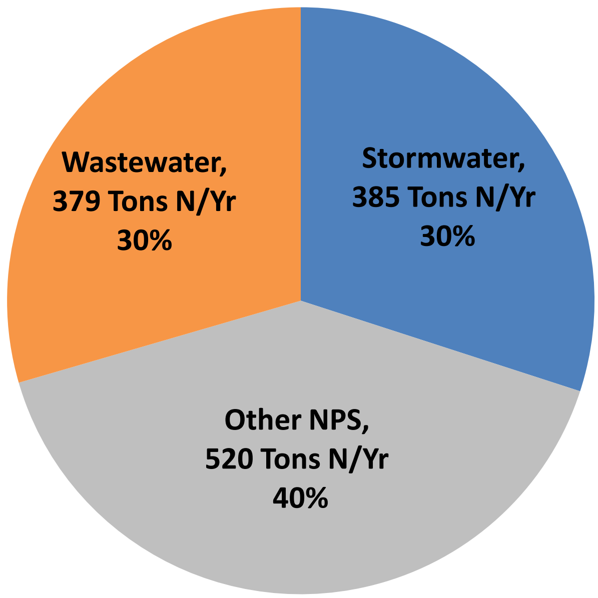

Figure 5. Great Bay Watershed Load by Source

2.5 Lamprey River Watershed

The Lamprey River Watershed is made up of fifteen (15) communities (Figure 6). Of the 15 communities two contribute point source loads from wastewater treatment facilities (WWTF), Epping and Newmarket. Both the Epping and Newmarket plants are regulated under the National Pollution Discharge Elimination System (NPDES) program. Non-point sources are intended to be regulated through the NPDES Municipal Separate Storm Sewer System (MS4) program. Of the 15 communities, four (4) are regulated MS4 communities, seven (7) received MS4 compliance waivers from EPA, and the remaining 4 are unregulated communities which do not meet the threshold for compliance under the MS4 program (Figure 7).

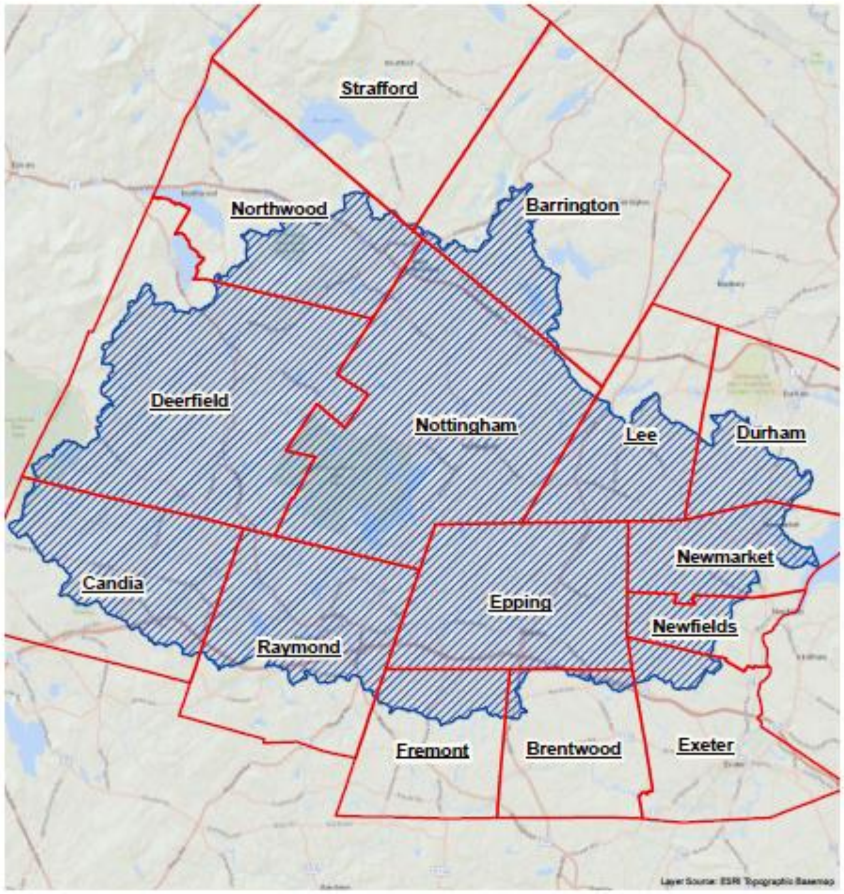

Figure 6. Lamprey River Watershed

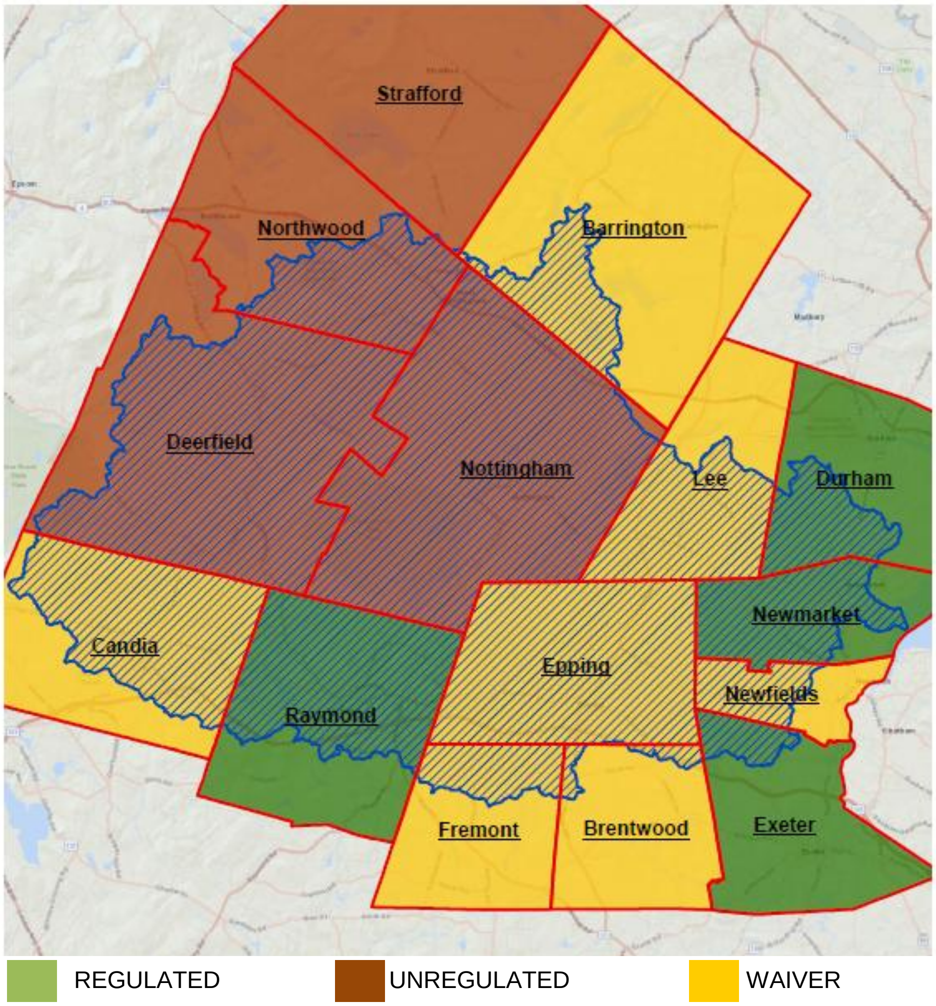

Figure 7. MS-4 Non-Point Source Regulation by Community

For communities other than Newmarket, estimates of the nitrogen non-point source (NPS) loads were taken from the Great Bay Nitrogen Non-Point Source Study (GBNNPSS) (NHDES, 2010). Point source load estimates for both Newmarket and Epping were taken from the Analysis of Nitrogen Loading Reductions for Wastewater Treatment Facilities and Non-Point Sources in the Great Bay estuary Watershed (NHDES, December 2010). Figure 8 presents the baseline total delivered nitrogen load from each of the communities within the Lamprey River Watershed. Of the 15 communities, Newmarket has the greatest total nitrogen delivered load (22% or 80,453 pounds per year, Figure 9) of which the wastewater treatment facility discharge makes up 76% of the total load. The Town's point source (WWTF) and NPS are both regulated under the NPDES program. Nottingham has the second largest contributing load (15% or 53,200 pounds per year) of which 100% is from non-point sources. Nottingham's non-point source loads are currently unregulated under the NPDES program. Epping has the third greatest contributing load (14% or 52,378 pounds per year) of which wastewater makes up 16% of the load. Epping's WWTF load is regulated under the NPDES program; however, it received a waiver for the NPS load under the MS4 program.

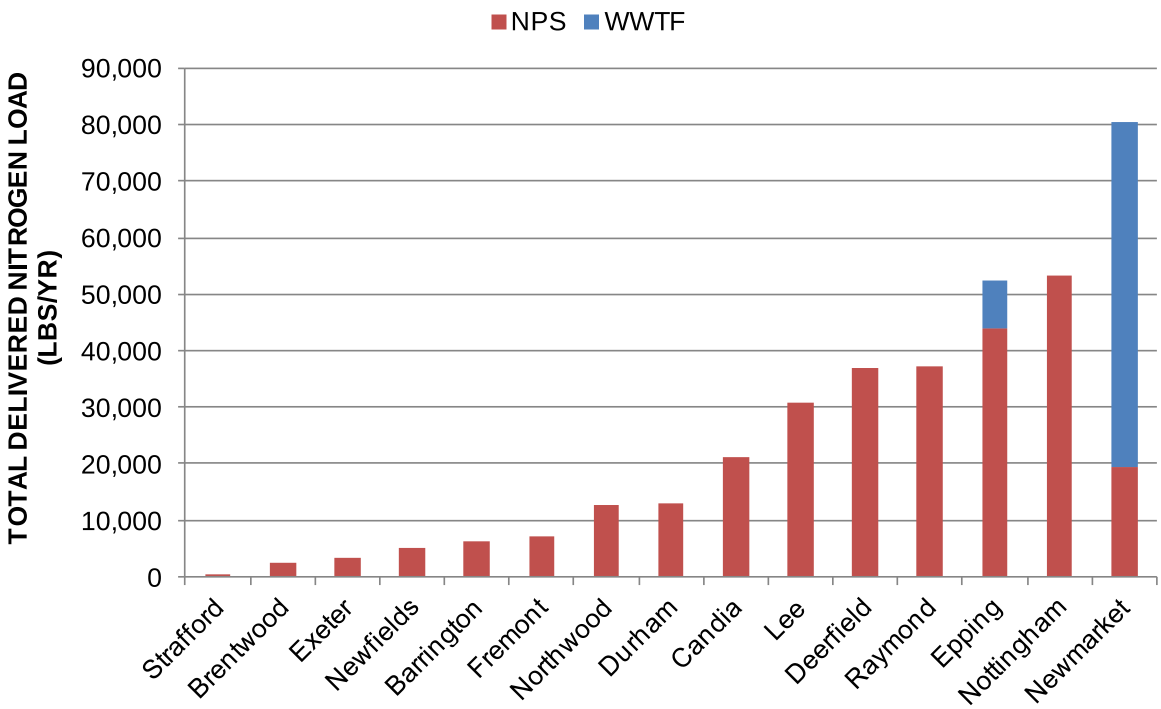

Figure 8. Lamprey River Watershed Baseline Total Nitrogen Delivered Load by Community

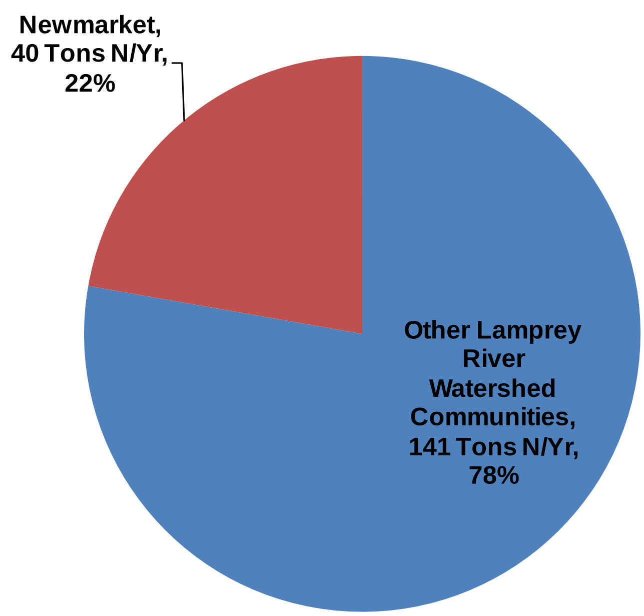

Figure 9. Total Nitrogen Delivered Load to Lamprey River Watershed from Newmarket

When looking at non-point source alone (Figure 10), Newmarket contributes 7% (19,453 pounds per year) of the total NPS load (292,345 pounds per year) to the Lamprey River. Nottingham contributes the greatest amount (18%), followed by Epping (15%) and Raymond and Deerfield (both 13%). Of the six communities that contribute greater estimated amounts of NPS to the Lamprey River, only one of the communities, Raymond, is currently regulated under the MS4 program. Three of the communities (Candia, Lee and Epping) received waivers and Nottingham and Deerfield are unregulated.

The Lamprey River Subestuary contributes approximately 14% or 181 tons of the total delivered nitrogen load per year to the Great Bay (Figure 11), while Newmarket contributes approximately 3% or 40 tons (Figure 12).

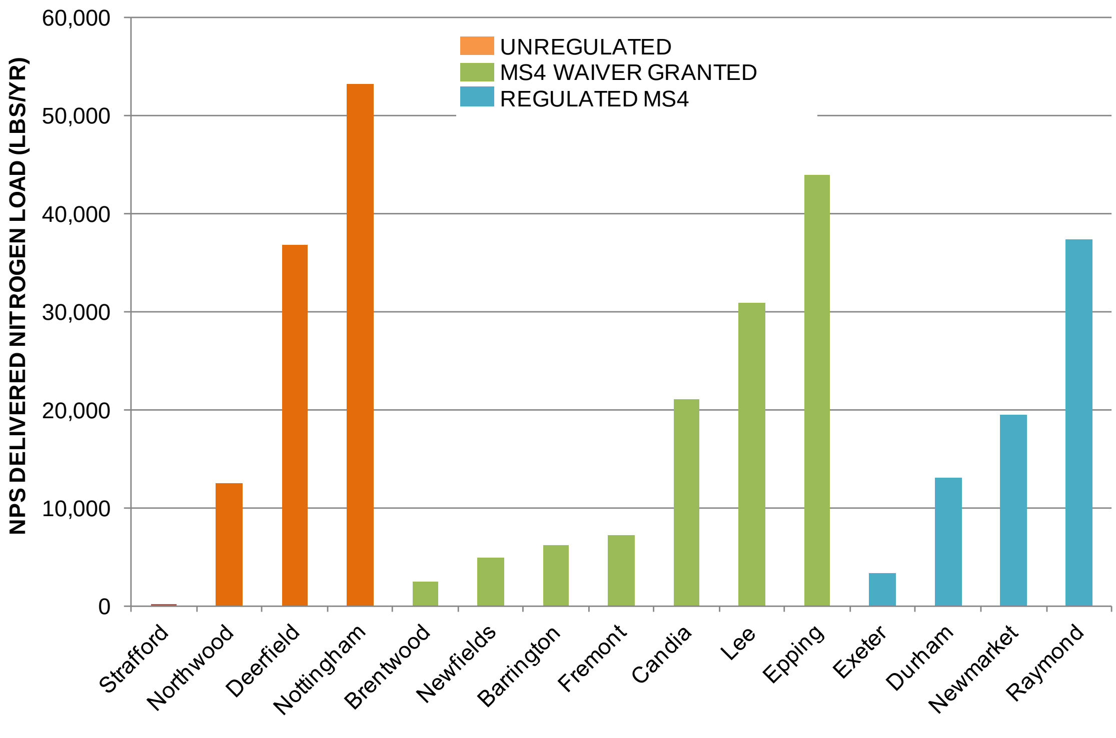

Figure 10. Community NPS Delivered Load by Regulation Designation

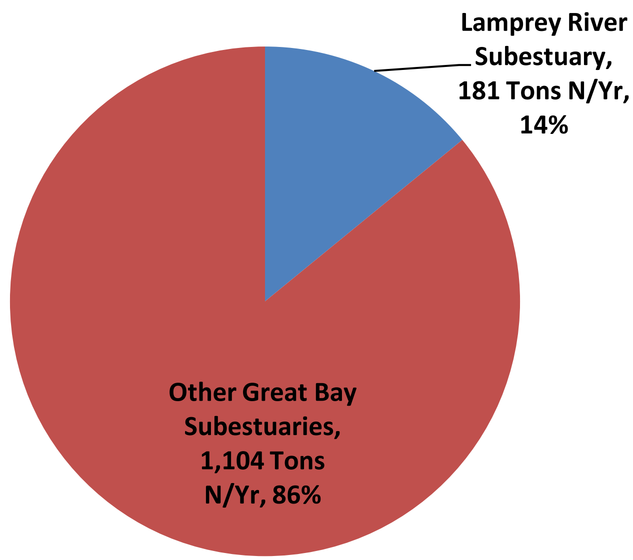

Figure 11. Portion of Lamprey River Load in Great Bay

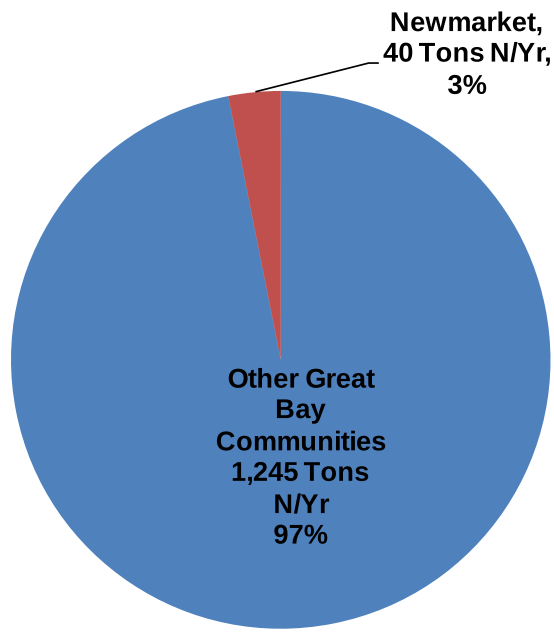

Figure 12. Total Nitrogen Delivered Load to Great Bay from Newmarket

3.0 REGULATORY FRAMEWORK

3.1 Introduction

The purpose of this section is to summarize the Town's current regulatory obligations related to management of total nitrogen and point and non-point source stormwater activities.

3.2 Nitrogen Load Reduction Targets

A "target load" is the load below which water quality goals are presumed or expected to be met. Typically, a target load would be established by a Total Maximum Daily Load (TMDL) Study. To date, a TMDL Study has not been completed and is not being contemplated in the near term. To date, the only document which identifies target loads is the NHDES 2010 Analysis of Nitrogen Loading Reductions document (NHDES, 2010). These target loads are based on the Numeric Nutrient Criteria for the Great Bay (NHDES, 2009). The 2009 Numeric Nutrient Criteria document recommended the following criteria:

- Criteria to Prevent low D.O. – 0.45 mg N/L
- Criteria to Protect Eelgrass Habitat – 0.30 mg N/L

The NHDES 2010 Analysis of Nitrogen Loading Reductions identified the following target loads for the Lamprey River subestuary:

- 226.1 tons of nitrogen per year to prevent low dissolved oxygen conditions in the river;
- 140.1 tons of nitrogen per year to protect eelgrass in the subestuary; and
- 182.4 tons of nitrogen per year to protect eelgrass in the downstream Great Bay sub-estuaries.

These values will be used for planning purposes in this Plan; however, it is essential to note that the 2009 Numeric Nutrient Criteria document underwent a peer review by collaborative agreement between NHDES and the Cities of Dover, Rochester and Portsmouth. The results of the peer review are documented in the 2014 Peer Review Panel Report (NHDES, 2014). On the basis of this peer review, NHDES and the Cities of Dover, Rochester and Portsmouth agreed that NHDES will no longer use the numeric nutrient criteria in its Section 305(b) and 303(d) water quality assessment for the Great Bay estuary (Settlement Agreement, Docket 2013-0119). Accordingly, the target values noted above should be considered the best available guidance at this time and that the criteria values may change in the future.

3.3 NPDES Permit and Administrative Order on Consent

The Town was issued a NPDES WWTF effluent discharge permit (effective date February 1, 2013) to address nitrogen loadings to the Lamprey River watershed. The permit imposed a stringent seasonal total nitrogen (TN) NPDES WWTF discharge limit of < 3 mg/L, effective annually from April 1 through October 31. The permit limit (3 mg/L) is based on the limit of technology (LOT), as the nitrogen load reduction targets for Lamprey River are greater than the WWTF total load. The Town negotiated an Administrative Order on Consent (AOC) with the EPA, dated May 10, 2013, which included an interim seasonal TN limit of 8 mg/L following the completion of the WWTF upgrade.

Based on these regulatory requirements, the Town constructed a WWTF upgrade (substantially complete by September 9, 2017) to meet the interim TN limit (< 8 mg/L) and provide the flexibility to meet potential future TN limit (< 3 mg/L) with additional process upgrades if deemed necessary in the future.

The AOC also requires the Town to meet the following activities related to non-point source and stormwater point source:

- Section D.1 requires that the Town track and account all activities within the Town that affect the total nitrogen to the Great Bay estuary. This includes new/modified septic systems, decentralized wastewater treatment faculties, changes to the amount of effective impervious cover, changes to the amount of disconnected impervious cover, conversion of existing landscape to lawns/turf and any new or modified Best Management Practices (BMPs).

- Section D.2 requires that the Town shall coordinate with NHDES, other Great Bay communities, and watershed organizations in NHDES's efforts to develop and utilize a comprehensive subwatershed-based tracking/accounting system for quantifying the total nitrogen loading changes associated with all activities within the Town that affect the total nitrogen load to the Great Bay estuary.

- Section D.3 requires the Town to coordinate with NHDES to develop a subwatershed community-based total nitrogen allocation.

- Section D.4 requires the Town of Newmarket (Town) to submit to EPA and NHDES a total nitrogen non-point and point source stormwater control plan ("Nitrogen Control Plan"), including a schedule of at least five (5) years for implementing specific control measures to address identified non-point source and stormwater point source nitrogen loadings in the Town that contribute total nitrogen to the Great Bay estuary, including the Lamprey River.

3.4 NPDES Phase II Municipal Separate Storm Sewer System (MS4) Permit

EPA issued the 2017 New Hampshire Small Municipal Separate Storm Sewer System (MS4) permit on January 18, 2017 with an effective date of July 1, 2018[1]. The Town will be a new permittee covered under this permit. The permit regulates stormwater discharges from the Town's urbanized area as defined by the 2010 Decennial Census by the Bureau of Census or a geographic area designed by EPA. Under the permit, the Town will be required to implement the six (6) minimum control measures (MCM):

- MCM 1 – Public Education and Outreach
- MCM 2 – Public Involvement and Participation
- MCM 3 – Illicit Discharge Detection and Elimination (IDDE)
- MCM 4 – Construction Site Stormwater Runoff Control
- MCM 5 – Stormwater Management in New Development and Redevelopment

[1] NH MS4 Permit https://www.epa.gov/npdes-permits/new-hampshire-small-ms4-general-permit[2] PTAPP Website https://www.unh.edu/unhsc/ptapp

- MCM 6 – Good Housekeeping and Pollution Prevention for Municipal Operations

The Town will also implement the necessary best management practices (BMPs) to meet the requirements in Appendix H related to Water Quality Limited Waters.

The Town (with numerous other NH communities) is legally contesting the MS4 permit, so it is uncertain when/if all the requirements under the current permit will be required. Currently, the Town is preparing their Notice of Intent (NOI), which will be filed with EPA at the end of September 2018.

4.0 EVALUATION OF NITROGEN REDUCTION ALTERNATIVES

4.1 Introduction

The purpose of this section is to describe the nitrogen reduction strategies and alternatives which the Town could implement to reduce their baseline total nitrogen load to the Great Bay estuary, including the Lamprey River.

4.2 Wastewater Treatment Facility Reduction Measures

Since current flows (0.49 MGD for the period of 2015 through 2017) are well below the annual average design flow capacity of the facility, the performance of the upgrade has exceeded the design performance, achieving an average effluent nitrogen concentration of 5.86 mg/L from August 2017 through December 2017. Based on the baseline load of 61,000 lbs TN/yr, current operation of the plant at this concentration achieves an annual load of 8,740 lbs TN/yr or an 86% reduction in TN load to the Lamprey River.

In 2018, effluent concentrations as low as 1.40 mg/L have been observed, with an average of effluent nitrogen concentration of 3.55 mg/L from January 2018 through June 2018. Based on the baseline load of 61,000 lbs TN/yr, operation at this concentration achieves an annual load of 5,295 lbs TN/yr or a 91% reduction in TN load to the Lamprey River.

As flows and loads increase closer to the facility design capacity (0.85 MGD), effluent nitrogen levels will also increase, and additional upgrade and operational measures can be considered to maintain effluent nitrogen levels at or near the 3 mg/L LOT level.

Additional upgrade and operational measures may include a supplemental carbon source addition to consistently achieve WWTF effluent TN levels below 6 mg/L. Using wastewater process modeling it is estimated that supplemental carbon addition would allow the WWTF to achieve effluent TN levels of 3.5 mg/L at the design loading capacity. Tertiary filters would be required in tandem with the supplemental carbon addition to reach the LOT level of 3 mg/L. For additional details on these methods, refer to the WWTF Nitrogen Control Measures Memorandum in Attachment B.

At the current influent loadings it is not possible to significantly improve the WWTF treatment performance, which is approaching the LOT. In the future when loadings increase and nitrogen treatment performance diminishes, consideration of supplemental carbon addition will likely provide the most cost effective means to reduce nitrogen loadings to the watershed. The WWTF Nitrogen Control Measures Memorandum (Attachment B) describes a pilot testing protocol to determine the effectiveness and cost of this approach.

4.3 Non-Point Source Reduction Strategies

A variety of non-point source (stormwater and groundwater) nitrogen reduction strategies were evaluated as part of the NCP. The expected total nitrogen load reductions and associated costs to implement these strategies was evaluated and described in detail in Attachment C. The strategies evaluated include the following:

- Atmospheric Deposition. Based on available literature, an 18% reduction in total nitrogen load falling on the land surface could be expected. Implementation of this strategy would be at no cost to the Town.
- Agricultural Nutrient Management Program. This strategy would result in a 15% reduction of the agricultural load.
- Residential Fertilizer Program. This strategy would result in a 9% reduction in the pervious residential load.
- Enhanced Street/Pavement Cleaning Program. This strategy would result in a 2% reduction in the directly connected impervious area load.
- Infrastructure Operations and Maintenance Program. This strategy would result in a 6% reduction of TN from the directly connected impervious area load.
- Enhanced Organic Waste and Leaf Litter Collection Program. By performing gathering, removal and proper disposal of landscaping waste, organic debris. This strategy would result in a 5% reduction of TN from the directly connected impervious area load.
- Advanced On-Site Septic Systems. This strategy would convert traditional septic systems to advanced systems to remove TN and would result in 65% reduction of TN.
- Targeted Extension Sewer Infrastructure. The strategy would extend sewer infrastructure to connect homes with traditional septic systems to the wastewater treatment facility. This strategy would result in an estimated 76% and 45% reduction in delivered load to the receiving water, for septic systems inside or outside 200 meters of a stream, respectively.
- Stormwater Structural Best Management Practices (BMPs). This strategy would result in on average an estimated 90% load reduction when infiltration BMPs are installed and on average an estimated 53% reduction when biofiltration BMPs are installed.

4.4 Composite Alternatives

The Town evaluated three (3) alternatives to determine the estimated load reduction in pounds of nitrogen per year and the cost to implement each alternative. All of the alternatives assume that the wastewater treatment plant has been upgraded and operating at 5.86 mg/L at a flow of 0.49 MGD. Details of each of the alternatives are summarized in Attachment C.

4.4.1 Alternative 1

Alternative 1 represents the level of nitrogen non-point source strategy implementation and associated cost to develop and implement an organic waste and leaf litter collection program, infrastructure maintenance program and an enhanced street/pavement cleaning program. This Alternative also includes reviewing properties the Town owns for retrofit potential to mitigate the pollutant impacts from impervious area with storwmater structural BMPs. This alternative also assumes that there would be reductions in atmospheric deposition over the 20-year implementation period. The estimated nitrogen load reduction and a planning-level cost to implement this alternative is presented in Table 5.

Table 5. Alternative 1: Estimated Load Removal and Cost

STRATEGY	ESTIMATED DELIVERED LOAD REMOVED (LBS N/YR)	ESTIMATED 20-YEAR LIFE-CYCLE COST	EQUIVALENT ANNUAL COST
Atmospheric Deposition	1,289	$ -	$ -
Infrastructure Maintenance Program	54	$ 377,000	$ 19,000
Organic Waste and Leaf Litter Collection Program	45	$ 2,801,000	$ 141,000
Enhanced Street/ Pavement Cleaning Program	18		
Stormwater Structural BMPs	140	$ 1,616,000	$ 81,000
NPS TOTAL	**1,545**	**$ 4,794,000**	**$ 241,000**
Wastewater Treatment Facility Upgrade[1]	52,260	$ 18,646,000	$ 933,000
TOTAL	**53,805**	**$ 23,440,00**	**$ 1,174,000**

1. Actual costs of the WWTF upgrade are on a 25-year loan term, with a total lifecycle cost of $22,819,000.

This alternative removes an estimated 1,545 pounds of nitrogen per year from the total non-point source delivered load to the receiving water for an estimated 20-year life-cycle cost of $4,794,000 at $241,000 annually. This represents a 6% reduction in the total non-point source delivered load. With the upgrades made to the WWTF this alternative removes approximately 53,800 pounds of nitrogen per year for an estimated 20-year life-cycle cost of $23,440,000 at $1,174,000 annually, which provides a total nitrogen delivered load reduction of 63%.

4.4.2 Alternative 2

Alternative 2 represents the level of nitrogen non-point source strategy implementation as described under Alternative 1 plus an additional annual investment of approximately $75,000. The additional investment would include development of a residential lawn fertilizer program and treatment of directly connected impervious cover with stormwater structural BMPs.

The estimated nitrogen load reduction and a planning-level cost to implement this alternative is presented in Table 6. This alternative removes an estimated 1,832 pounds of nitrogen from the delivered load to the receiving water for an estimated 20-year life-cycle cost of $6,245,000 or $314,000 annually. This alternative would cost the Town an additional $73,000 per year, when compared to Alternative 1. The load reduction results in a 7% reduction in the total baseline non-point source delivered load. With the upgrades made to the WWTF this alternative removes approximately 54,100 pounds of nitrogen per year for an estimated 20-year life-cycle cost of $24,891,000 at $1,247,000 annually, which provides a total nitrogen load reduction of 63%.

Table 6. Alternative 2: Estimated Load Removal and Cost

STRATEGY	ESTIMATED DELIVERED LOAD REMOVED (LBS N/YR)	ESTIMATED 20-YEAR LIFE-CYCLE COST	EQUIVALENT ANNUAL COST
Atmospheric Deposition	1,289	$ -	$ -
Infrastructure Maintenance Program	54	$ 377,000	$ 19,000
Organic Waste and Leaf Litter Collection Program	45	$ 2,801,000	$ 141,000
Enhanced Street/ Pavement Cleaning Program	18		
Stormwater Structural BMPs	241	$ 2,789,000	$ 140,000
Residential Fertilizer Program	186	$ 278,000	$ 14,000
NPS TOTAL	**1,832**	**$ 6,245,000**	**$ 314,000**
Wastewater Treatment Facility Upgrade	52,260	$ 18,646,000	$ 933,000
TOTAL	**54,092**	**$ 24,891,000**	**$ 1,247,000**

1. Actual costs of the WWTF upgrade are on a 25-year loan term, with a total lifecycle cost of $22,819,000.

4.4.3 Alternative 3

Alternative 3 is the implementation of a combination of nitrogen reduction strategies to achieve a reduction of 4,250 pounds per year, which is the equivalent amount of nitrogen that would be removed by providing tertiary treatment at the WWTF to achieve a 3-mg/L effluent concentration. For Alternative 3, it is assumed that the Town would implement all non-structural programmatic strategies as described in Alternative 1 with the addition of the residential lawn fertilizer program, additional treatment of directly connected impervious cover with stormwater structural BMPs, extending sewer service to the Birch Drive development and upgrading septic systems to advanced systems.

The estimated nitrogen load reduction and a planning-level cost to implement this alternative is presented in Table 7.

Table 7. Alternative 3: Estimated Load Removal and Cost

STRATEGY	ESTIMATED DELIVERED LOAD REMOVED (LBS N/YR)	ESTIMATED 20-YEAR LIFE-CYCLE COST	EQUIVALENT ANNUAL COST
Atmospheric Deposition	1,289	$ -	$ -
Infrastructure Maintenance Program	54	$ 377,000	$ 19,000
Organic Waste and Leaf Litter Collection Program	45	$ 2,801,000	$ 141,000
Enhanced Street/ Pavement Cleaning Program	18		
Stormwater Structural BMPs	932	$ 11,077,000	$ 554,000
Residential Fertilizer Program	186	$ 278,000	$ 14,000
Birch Drive Sewer Extensions	250	$ 2,517,000	$ 126,000
Septic System Upgrades	1,478	$ 10,092,000	$ 505,000
NPS TOTAL	**4,250**	**$ 27,142,000**	**$ 1,359,000**
Wastewater Treatment Facility Upgrade	52,260	$ 18,646,000	$ 933,000
TOTAL	**56,510**	**$ 45,788,000**	**$ 2,292,000**

1. Actual costs of the WWTF upgrade are on a 25-year loan term, with a total lifecycle cost of $22,819,000.

This alternative removes an estimated 4,250 pounds of nitrogen from the total non-point source delivered load to the receiving water for an estimated 20-year life-cycle cost of $27,142,000 or $1,359,000 annually. This alternative would cost the Town an additional $1,118,000 and $1,045,000 per year when compared to Alternative 1 and 2, respectively. The load reduction results in a 17% reduction in the baseline non-point source delivered load. With the upgrades made to the WWTF this alternative removes approximately 56,500 pounds of nitrogen per year for an estimated 20-year life-cycle cost of $45,788,000 at $2,292,000 annually, which provides a total nitrogen load reduction of 66%.

5.0 IMPLEMENTATION PLAN

5.1 Introduction

The purpose of this section is to detail how the Town intends to implement the selected composite alternative to reduce total nitrogen from the Town to the Great Bay estuary, including the Lamprey River.

5.2 Selected Composite Alternative

Based on the alternatives analysis (Section 4) the Town has selected Alternative 1 as a starting point for implementation under this NCP. These requirements are detailed in Section 5.2.1, below. The Town will also continue optimization efforts at the WWTF to maintain reduced total effluent nitrogen loads to the Lamprey River, as described in Section 4.2. The Town also plans to invest in a robust in-stream monitoring program (described in Section 5.2.7) to monitor the response of the Lamprey River to its implementation efforts. The Town will also continue to participate in PTAPP (Section 5.2.3) and coordinate with NHDES to develop a subwatershed allocation (Section 5.2.4).

This selected alternative and implementation of the in-stream monitoring program will result in the Town investing approximately $23,622,000 in stormwater, wastewater and monitoring. This investment is expected to result in approximately 53,800 pounds of nitrogen per year over the twenty year period.

5.2.1 Stormwater Strategies

The Town is committing to implement the non-point and point source stormwater strategies described in Table 8 as part of this NCP.

Table 8. Implementation Plan Stormwater Components

STRATEGY	DESCRIPTION OF IMPLEMENTATION
Infrastructure Maintenance Program	The Town will develop and implement a program detailing the activities and procedures to maintain storm drainage infrastructure in a timely manner. The program will include routine inspections, cleaning and maintenance of catch basins to maintain 50% free-storage capacity in the catch basin sump. The Town will continue to operate and maintain a vacuum truck and clean catch basins twice per year in the spring and fall.
Organic Waste and Leaf Litter Collection Program	The Town will perform gathering, removal and proper disposal of landscaping wastes, organic debris, and leaf litter from impervious roadways and parking lots. The gathering and removal will occur immediately following any landscaping activities. The Town will dispose of these materials at the Town Transfer Station.

STRATEGY	DESCRIPTION OF IMPLEMENTATION
Enhanced Street/ Pavement Cleaning Program	The Town will develop and implement a sweeping program to clean all curbed impervious cover (i.e., directly connected impervious cover) two times per year (spring and fall). The Town will use a high-efficiency regenerative air-vacuum sweeper to implement the program.
Identify Stormwater Structural BMP Sites	The Town will evaluate opportunities on existing capital improvement projects and Town owned properties where stormwater BMPs can be installed to reduce the frequency, volume and pollutant loads of stormwater discharges.
Atmospheric Deposition	The Town will work with NHDES and University of New Hampshire (UNH) to understand how levels of nitrogen from atmospheric deposition are changing over time.

5.2.2 Wastewater Strategies

As stated in Section 4.2, the post-upgrade performance of the WWTF has exceeded design performance achieving an average effluent concentration of 5.86 mg/L from August through December of 2017. The consistency of this performance is dependent on the relatively low flows and loads to the facility. Once flows and loads increase closer to the facility design capacity, additional measures such as supplemental carbon and tertiary filtration can be considered.

The Town will continue to monitor the WWTF loadings and TN treatment performance. If the performance declines, additional investigation of these operational and facility upgrade alternatives will be completed, including pilot testing of supplemental carbon addition to assess the effectiveness and cost of this technology.

5.2.3 Implement PTAPP

NHDES and the University of New Hampshire (UNH) are working with Great Bay communities to develop guidelines and recommendations for tracking and accounting systems and developing a database that will enable communities to perform a quantitative assessment of pollutant load reductions associated with non-point source management activities in the Great Bay. These guidelines, recommendations and database are being developed as part of the Pollutant Tracking and Accounting Pilot Project (PTAPP)[2].

The Town has been working with NHDES and UNH in this process and will continue to participate in PTAPP and using the database to input data to quantify the total nitrogen load changes associated with all activities within the Town that affect the total nitrogen load to the Great Bay estuary. The Town will use this database in their annual reporting.

5.2.4 Coordinate with NHDES for Watershed Allocation

The Town will continue to coordinate with NHDES to develop a subwatershed community-based total nitrogen allocation in accordance with Section D.3 of the AOC. To date, NHDES has not

[2] PTAPP Website https://www.unh.edu/unhsc/ptapp

developed a subwatershed community-based allocation for the Lamprey River subwatershed and for the Town of Newmarket. Therefore, Newmarket does not have a nitrogen load reduction target.

Through its current efforts, the Town has reduced their total delivered nitrogen load to the Lamprey River subestuary by 65% through upgrades made at the WWTF. Figure 13 presents the total delivered load to the Lamprey River subwatershed, including the reductions from the Town's upgrades at the WWTF. It should be noted that reductions made by other regulated communities are not captured in this figure. However, with the Town's current reduction efforts, the Town's delivered load is less than those of two unregulated communities, one regulated community and two communities that have received waivers under the NPDES MS4 program. Through implementation of this NCP, the Town will continue to reduce its total delivered load to the Lamprey River subestuary, whereas the unregulated and communities with waivers will remain the same or increase. Therefore, it is critical for NHDES to look at contributions to the watershed as a whole to ensure that efforts that the Town is implementing don't go unnoticed when other subwatershed communities with greater contributing load are unobligated to be investing in reducing their load and improving water quality in the Lamprey River.

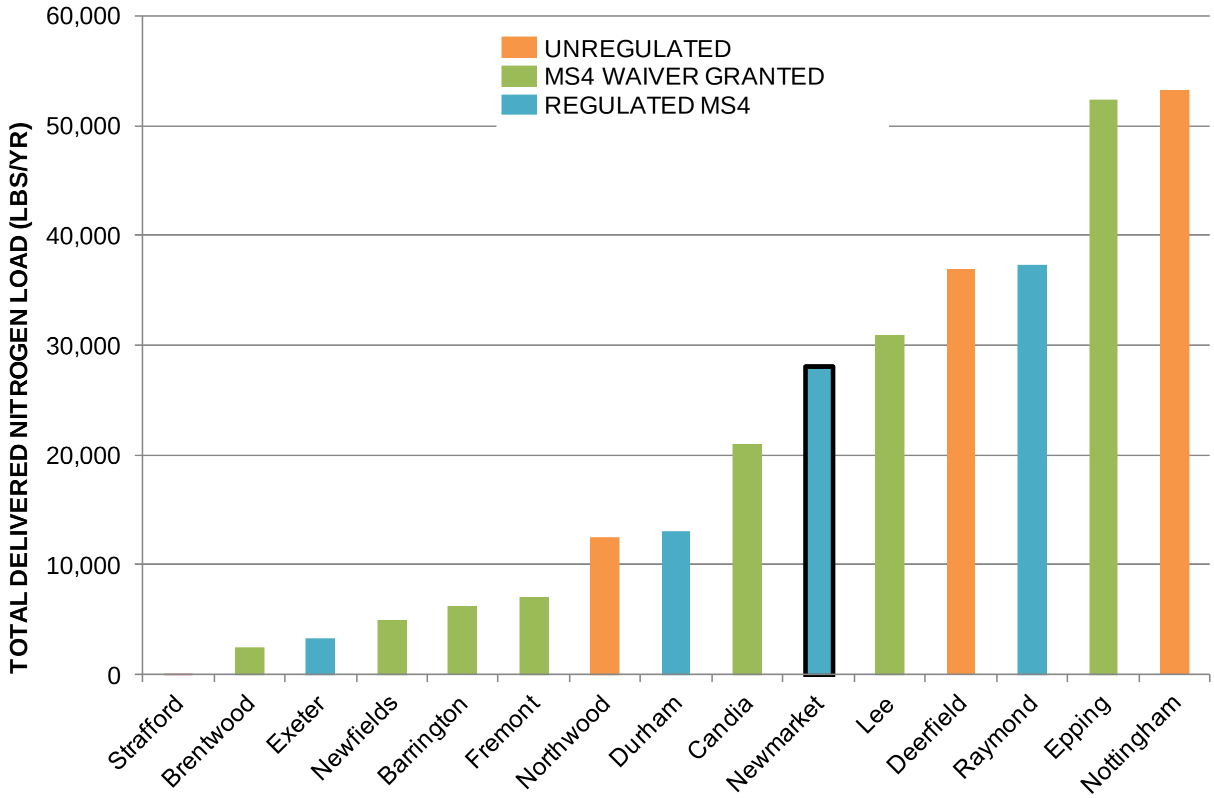

Figure 13. Lamprey River Watershed Total Delivered Load by Community (Post-WWTF Upgrade in Newmarket)

5.2.5 Assess Long-Term Funding Mechanisms

On an annual basis in the fall, the Town will review the NCP to determine the funding necessary to implement the plan. The Town will develop a budget and evaluate alternative funding sources (i.e., grants, loans) to aid the Town in implementation of the NCP. The Town will ensure that they have adequate funding secured to implement the NCP and will continue to evaluate funding sources on an annual basis.

5.2.6 Engineering Evaluation

Section E.2 of the AOC requires the Town to submit an Engineering Evaluation that includes recommendations for the implementation of any additional measures necessary to achieve compliance with the NPDES WWTF Permit, or a justification for leaving the interim discharge limit (8.0 mg/L) or a lower interim limit below 8.0 mg/L but still above the 3.0 mg/L final permit limit, beyond the date of the permit. The justification should analyze whether:

- Total nitrogen concentrations in the Lamprey River and downstream waters are trending towards nitrogen targets;
- Significant improvements in dissolved oxygen, chlorophyll a, and macroalgae levels have been documented; and
- Non-point source and stormwater point source reductions achieved are trending towards allocation targets and appropriate mechanisms are in place to ensure continued progress.

An Engineering Evaluation will be completed by the end of 2022 which reviews the effects of implementation of the NCP on the water quality of the Lamprey River. This evaluation will recommend the implementation of any additional measures necessary to achieve compliance with the <3 mg/L limit, or justification to keep the 8 mg/L interim limit or a different limit in between 3 and 8 mg/L. Per the AOC, the evaluation will include discussion of the TN concentration in the Lamprey River and downstream waters, any improvements made in the monitored parameters (especially dissolved oxygen, chlorophyll a, and macroalgae), and any non-point source and stormwater point source reductions achieved. The ultimate outcome of the Engineering Evaluation will be to provide the basis for the future TN discharge limit for the WWTF.

5.2.7 Implement Water Quality Monitoring Program

The Town is currently developing a Water Quality Monitoring Program (WQMP) to assist the Town in developing a justification to keep the 8 mg/L interim limit or a different limit in between 3 and 8 mg/L in the Engineering Evaluation. The written WQMP will be completed in 2018 and provided to EPA and NHDES for approval. The Town will use the WQMP and an adaptive management approach, which is intended to allow empirical observations over time to better understand the scientific uncertainty of the water quality criteria and both short-and-long-term effects of any load reductions completed by the Town.

The WQMP will include the use of historical data to establish a baseline for the Lamprey River prior to nitrogen removal efforts (pre-WWTF upgrade). This data includes two downstream datasonde/sampling locations (LAMP-01 and LAMP-02) deployed by EPA in 2016 and 2017, and one upstream datasonde/sampling location deployed by Piscataqua Region Estuaries Partnership (PREP). As part of the WQMP the Town will partner with UNH to complete monitoring at one location on the Lamprey River, located downstream of the WWTF outfall. This location will be between the two EPA monitoring locations (LAMP-01 and LAMP-02), which were used in the 2016 and 2017 sampling seasons.

In general, the monitoring will consist of both continuous datasonde monitoring and monthly grab samples. Two datasondes will be purchased by the Town, to provide UNH with the redundancy needed to maintain the continuous monitoring at one location from April through October.

Once per month, UNH will measure the water column conditions using a handheld meter and light attenuation. Two grab samples per month (one at high tide and one at low tide) will also be collected at the datasonde location, from April through December. Sample analyses will be completed by the Water Quality Analysis Lab (WQAL) at UNH (also used by PREP).

Macroalgae monitoring will not be completed by the Town. Instead, the Town will rely on ongoing monitoring in the nearby Lubberland Creek by PREP. Funding for this effort has been secured by PREP for 2018, with the hopes of securing funding to continue the effort in future years. If funding cannot be secured by PREP for 2019 through 2021, the Town will reevaluate how to procure this data.

To implement the WQMP, the Town will need to invest $182,000 for sampling between 2019 and 2022. This represents an average annual investment of $45,500. While the Town is developing the WQMP they are also looking to secure local and SRF funding (may receive up to 50% principal and interest forgiveness) for the monitoring effort. The Town anticipates implementation of the program in summer 2019, as reflected in the implementation plan schedule (Section 5.3).

5.3 Implementation Schedule

Table 9 presents the NCP implementation schedule that the Town will use to implement the strategies outlined in this plan. The schedule includes the projected planning and implementation schedule. During the planning periods, the Town will develop programs to ensure that implementation meets the regulatory requirements in order to receiving nitrogen load reduction credits. The planning period also allows the Town to budget and secure funding to support implementation of the management strategies.

Table 9. NCP Implementation Schedule

MANAGEMENT STRATEGY	2018				2019				2020				2021				2022			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
STORMWATER & NON-POINT SOURCE STRATEGIES																				
Infrastructure Maintenance Program			P	P	P	P	I			I	I			I	I			I	I	
Organic Waste and Leaf Litter Collection Program			P	P	P	P	I	I			I	I			I	I			I	I
Enhanced Street/ Pavement Cleaning Program			P	P	P	P	I			I	I			I	I			I	I	
Stormwater Structural BMPs			P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
MANAGEMENT STRATEGIES																				
Implement Water Quality Monitoring Program			P	P	P	P	I	I		I	I	I		I	I	I		I	I	I
Participate in PTAPP			ON-GOING BASED ON NHDES/UNH																	
Coordinate with NHDES for Watershed Allocation			ON-GOING BASED ON NHDES																	
Assess Long-Term Funding Mechanisms			P	P			P	P			P	P			P	P			P	P
Engineering Evaluation																	P	P	P	P
REPORTING																				
Total Nitrogen Annual Reporting					I				I				I				I			
NOTE: P = Planning; I = Implementation																				

6.0 TRACKING, ACCOUNTING AND REPORTING

6.1 Introduction

This purpose of this section is to describe how the Town will demonstrate the effectiveness of implementation of the selected alternative and associated strategies outlined in the NCP.

6.2 Reporting

Section E.1 of the AOC requires that the Town submit annual Total Nitrogen Control Plan Progress Reports to EPA and NHDES that address the following:

a. The pounds of total nitrogen discharged from the WWTF during the previous calendar year;
b. A description of the WWTF operational changes that were implemented during the previous calendar year;
c. The status of development of a total nitrogen non-point source and storm water point source accounting system;
d. The status of development of the non-point source and stormwater point source Nitrogen Control Plan;
e. A description and accounting of the activities conducted by the Town as part of its Nitrogen Control Plan; and
f. A description of all activities in the Town during the previous year that affect the total nitrogen load to the Great Bay estuary.

Since January 31, 2014, the Town has been submitting annual Progress Reports to EPA and NHDES and will continue to submit these reports and detail the implementation efforts summarized in this NCP.

6.3 Tracking and Accounting

Section D.1 of the AOC requires that the Town track and account all activities within the Town that affect the total nitrogen to the Great Bay estuary. The Town has been and will continue to track activities using the PTAPP database and internal spreadsheets developed by the Town to populate their annual Progress Reports.

At this time, PTAPP does not have an accounting portal to quantify the amount of nitrogen load reduction for implementation of non-point source strategies. NHDES and UNH are working with the Great Bay communities, including the Town, to develop an accounting framework for the PTAPP database. The Town intends to use the PTAPP database to account for the nitrogen load reductions, when it is made available. Until this time, the Town will continue tracking.

Empirical data (i.e. water quality data) will be used to track in stream water quality impacts of the load reduction efforts at the WWTF and non-point sources over the next few years. After the tracking period has been completed at the end of 2022, it will then be decided whether or not the water quality targets are being met or trending in a positive direction, or if further load reduction efforts are needed. This recommendation will be presented in the Engineering Evaluation, as required by Section E of the AOC.

7.0 REFERENCES

Bierman, V.J, Diaz, R.J, Kenworthy, W.J, and Reckhow, K.H. 2014. Joint Report of Peer Review Panel for Numeric Criteria for the Great Bay Estuary New Hampshire Department of Environmental Services, June 2009. February 13, 2014.

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NHDES. 2009. *Numeric Nutrient Criteria for the Great Bay Estuary*. June 2009.

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NHDES. 2012. Assessments of Aquatic Life Use Support in the Great Bay Estuary for Chlorophyll-a, Dissolved Oxygen, Water Clarity, Eelgrass Habitat, and Nitrogen. April 2012.

Trowbridge, P., M. Wood, J. Underhill, and D. Healy. 2014. Great Bay Nitrogen Non-Point Source Study. Report by the New Hampshire Department of Environmental Services. June 16. 82 p.

Wright-Pierce, 2017. Twenty-Year Water and Wastewater System Build-Out Study for the Town of Newmarket, New Hampshire. July 2017.

ATTACHMENT A:

Baseline, Pristine and Future Nitrogen Modeling Methodology and Results Memorandum

Horsley Witten Group
Sustainable Environmental Solutions
113 R2 Water Street • Exeter, NH • 03833
603-658-1660 • horsleywitten.com

MEMORANDUM

To: Sean Greig, Town of Newmarket

From: Renee L. Bourdeau, Horsley Witten Group

Date: March 6, 2018, Revised March 18, 2018

Re: Nitrogen Control Plan – Baseline, Pristine and Future Nitrogen Modeling Methodology and Results

cc: Neil Cheseldine & Tim Vadney, Wright-Pierce

1.0 PURPOSE

The purpose of this memorandum is to summarize the methodology and results for establishing the baseline, pristine, and future nitrogen load contributions (Task 2) for the Town of Newmarket (Town) and its four subwatersheds: Piscassic River (Lamprey River); Lower Lamprey River; Great Bay; and Squamscott River. We used nitrogen pollutant load models along with existing regional studies to estimate the baseline nitrogen load from stormwater, groundwater (septic and non-septic), and wastewater source pathways.

2.0 OVERVIEW

HW developed the nitrogen pollutant load model to account for surface water and groundwater loads to the Town's receiving waters and ultimately to the Great Bay estuary. Using the model and existing regional studies, HW calculated the following findings:

- For the baseline assessment, the total nitrogen delivered load from the Town is estimated at 85,855 pounds (42.9 tons) per year. Of the total baseline delivered load, approximately 71% (61,000 lbs TN/year) is from the wastewater treatment facility followed by 12% (10,239 lbs N/year) from groundwater non-septic 9% (7,673 lbsTN/year) from stormwater, and 8% (6,943 lbs TN/year) from groundwater due to septic systems.

- In 2037, future land use changes and population growth would result in an annual increase of approximately 5,500 pounds of total nitrogen delivered to the receiving waters from the stormwater pathway if left unmanaged. An additional 1,700 pounds of total nitrogen would be added annually from septic systems. However, due to upgrades at the WWTF load, the WWTF load will decrease by 54,138 pounds per year.

2.1 Data Sources

We used the following studies and methods in developing the model:

- Great Bay Nitrogen Non-Point Source Study (GBNNPSS) (Trowbridge et al., 2014);

- Twenty-Year Water and Wastewater System Build-Out Study (Wright-Pierce, 2017); and
- New Hampshire 2017 Final Municipal Separate Storm Sewer System (MS4) Permit, Appendix F, Attachment 3, Draft (EPA, 2017).

Data sources associated with each of the nitrogen pollutant load model sources are summarized below:

- Stormwater Load Model (Unattenuated) (EPA, 2017);
- Septic System Load Model (GBNNPSS);
- Pollutant Load Export Rates (PLERs) (EPA, 2017);
- Wastewater Treatment Facility Load (Wright-Pierce, 2018; Attachment A); and
- Attenuation in pathways in groundwater and surface water (GBNNPSS).

The model estimates the total load of nitrogen deposited on land surface. The initial load represents pollutants from the following sources:

- Atmospheric deposition;
- Human application of pesticides and fertilizers on agricultural land;
- Residential land and managed open space (e.g., golf courses and ball fields);
- Pet waste from both domestic and farm animals; and
- Natural deposition from leaf litter, grass clippings, wetlands and forests.

From these sources, we estimated a stormwater load and a groundwater load. The stormwater load represents the portion of the source load transported during a rain event from the land surface directly to a storm drain or receiving water. The stormwater load is based on a pollutant load export rate (PLER), which is derived from land use specific water quality data to determine an aggregate nitrogen export rate for all sources. The PLER approach is consistent with methodology used by Region 1 EPA for compliance under the MS4 permit. The groundwater load represents the portion of the load on the land surface which infiltrates during a rain event plus the human waste load from septic systems.

The wastewater load represents the nitrogen load discharged from the wastewater treatment facility (WWTF).

2.2 Data Set

The data for this modeling effort was collected from 2015 to 2017; accordingly, the “baseline year” is defined at 2015. The baseline data will be utilized for comparison to proposed scenarios under a future task.

2.3 Subject Area

The Town of Newmarket is located in seacoast New Hampshire and includes 9,080 acres in land area. Land use in the Town is divided as follows: 40% forested; 20% residential; 12% wetland; 11% water; 7% agriculture; 3% outdoor (i.e., parks, cemeteries, etc); 2% transportation, commercial, services, and institutional, communications and utilities; and ≤less 1% of industrial, barren, transitional, industrial and commercial complexes, vacant, and mixed use developments (Figure 1).

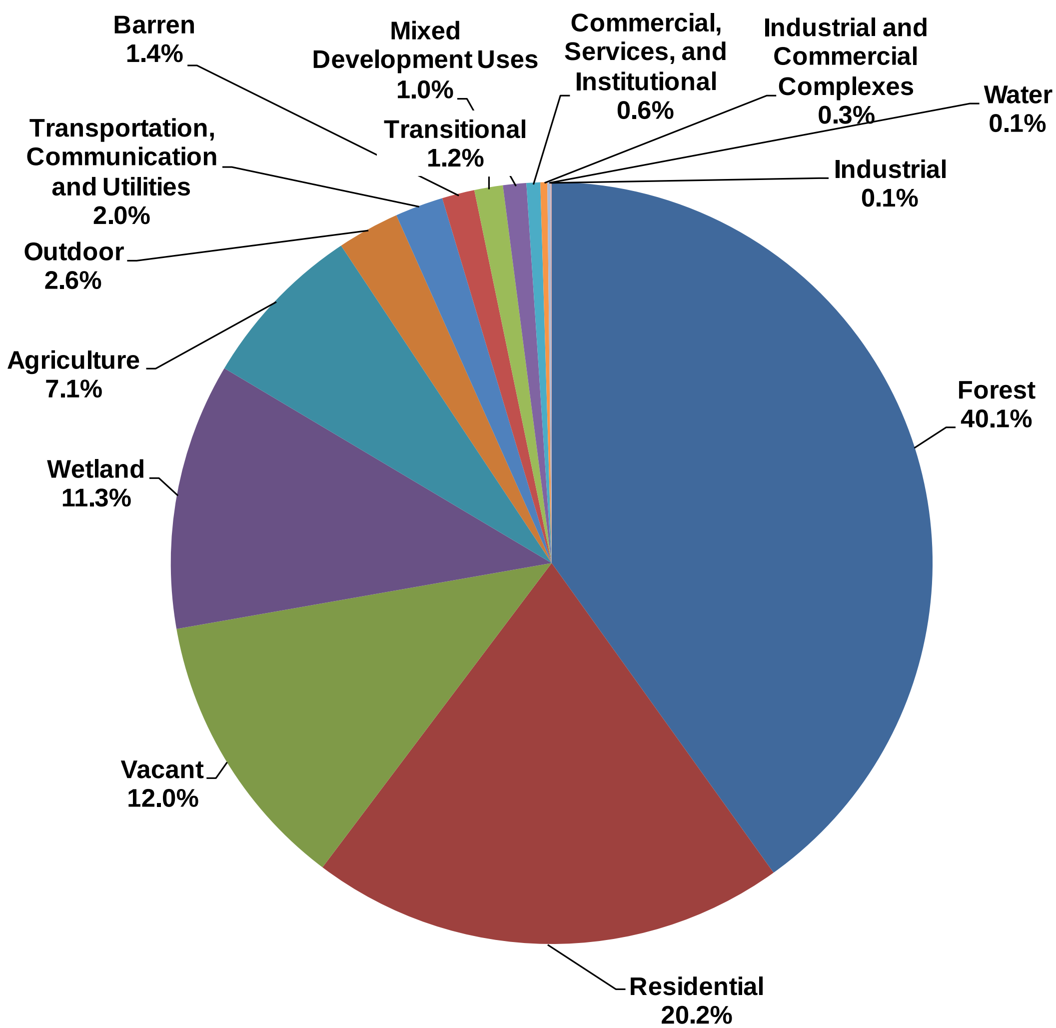


Figure 1: Town of Newmarket Land Use

Based on 2015 impervious area data from the New Hampshire Geographic Information Clearinghouse (GRANIT), 6.4% of the Town is impervious (579 acres of impervious cover out of 9,080 total acres). Of the estimated 579 impervious acres, approximately 58% is residential; 26% transportation (i.e., roads), communications and utilities; and 6% represents commercial, services, and institutional. Each of the remaining land use categories makes up 10% of the impervious area. Refer to Figure 2 for a summary of impervious area by land use.

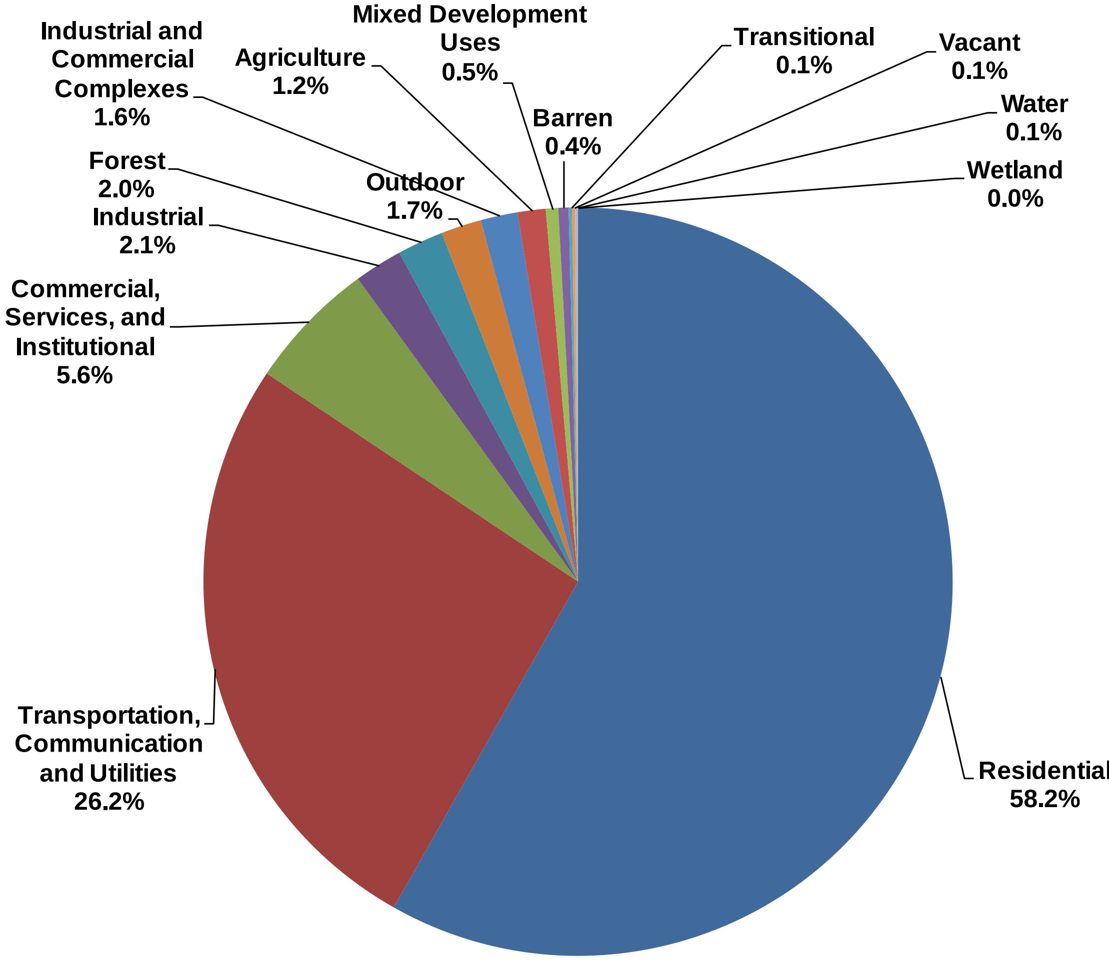


Figure 2: Town of Newmarket Impervious Area.

3.0 STORMWATER LOAD

The purpose of the stormwater model is to use PLERs to calculate an annual pollutant load from the land uses within the Town. The model uses the methodology developed by EPA (2017), which uses a hydrologic response units (HRUs) approach. PLERs from EPA (2017) were used to calculate both an initial and delivered annual baseline load. The initial load, or unattenuated load, represents available pollutant load on the land surface. Following a rain event, a portion of the initial load is transported via stormwater from the land surface. When stormwater is transported over pervious or natural surfaces, attenuation or uptake may occur. To account for attenuation, a delivery factor, of 0.87, is multiplied by the initial load to calculate a delivered load. The delivered load represents the actual pollutant load that would be expected to reach a receiving water body following a storm event.

3.1 Hydrologic Response Units (HRUs)

A HRU is a unique combination of land use, hydrologic group soil category (A-D), and impervious cover (e.g., residential pervious land underlain by hydrologic soil groups A, or residential land use underlain by D soils with impervious cover). Table 1 presents the area of each HRU within the Town. To quantify the area of each HRU within the watershed, the following geospatial data layers were used:

- 2015 Land Use Data, prepared by Strafford Regional Planning Commission (SRPC);
- USDA/NRCS SSURGO-Certified Soils; and
- 2015 Impervious Cover, provided by New Hampshire GRANIT.

Hydrologic soil groups are defined by the following characteristics (NRCS, 2007):

- *Group A soils* – have low runoff potential when thoroughly wet. Soils typically have less than 10 percent clay and more than 90 percent sand or gravel. The saturated hydraulic conductivity of the soil layers typically exceeds 5.67 inches per hour.
- *Group B soils* – have moderately low runoff potential when thoroughly wet. Soils typically have between 10 and 20 percent clay and 50 to 90 percent sand and have loamy sand or sandy loam textures. The saturated hydraulic conductivity of the soil layers typically ranges from 1.42 to 5.67 inches per hour.
- *Group C soils* – have moderately high runoff potential when thoroughly wet. Soils typically have between 20 and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, silty clay, or sandy clay textures. The saturated hydraulic conductivity of the soil layers typically ranges from 0.14 to 1.42 inches per hour.
- *Group D soils* – have high runoff potential when thoroughly wet. Soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. The saturated hydraulic conductivity of the soil layers is less than or equal to 0.14 inches per hour.

HRU characteristics are summarized in Table 1. Within the Town, Group B soils are most common (42% of pervious area), followed by Group C soils (41% of pervious area). The most prevalent HRU is forested underlain by C soils and B soils (both 18% of total area). When assessing only the developed portion of the watershed, the most common HRU is residential pervious land use underlain by B soils (10% of total area).

Table 1: Area of Hydrologic Response Units within the Town of Newmarket.

Land Use Type	Pervious Areas				Total Impervious Area (ac)	Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)			
DEVELOPED SOURCES							
Agriculture	35	200	391	11	6	4	**648**
Commercial, Services, and Institutional	5	7	3	0	33	6	**53**
Industrial and Commercial Complexes	24	3	0	0	10	53	**90**
Industrial	1	1	0	0	13	11	**27**
Mixed Development Uses	0	0	0	0	3	1	**5**
Outdoor	37	76	106	6	10	5	**240**
Residential	162	886	352	15	337	80	**1,832**
Transportation, Communications, and Utilities	2	16	13	2	151	4	**186**
TOTAL DEVELOPED SOURCES	**265**	**1,189**	**864**	**34**	**564**	**163**	**3,079**
UNDEVELOPED SOURCES							
Barren	12	62	20	12	3	18	**125**
Forest	194	1,606	1,642	151	11	38	**3,641**
Transitional	5	49	37	4	1	13	**110**
Vacant	1	2	8	0	1	0	**12**
Water	0	6	15	30	0	976	**1,027**
Wetland	11	121	378	561	1	14	**1,086**
TOTAL UNDEVELOPED SOURCES	**223**	**1,846**	**2,101**	**757**	**16**	**1060**	**6,001**
TOTAL	**488**	**3,035**	**2,966**	**791**	**579**	**1222**	**9,081**

3.1.1 Impervious Surface Disconnection

Impervious surface disconnection allows for some runoff volume and pollutant load generated on impervious surfaces to infiltrate as it passes overland onto down-gradient pervious surfaces. Impervious cover that is not directly connected to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) results in a reduced stormwater pollutant load due to attenuation and infiltration as runoff moves across pervious surfaces. To account for this decrease in pollutant load, we used the Sutherland equations (EPA, 2014) to estimate the area of directly connected impervious area (DCIA) based on total impervious area for each land use type in Newmarket (Table 2). EPA provides guidance on the use of the Sutherland equations for prediction of the level of DCIA specific to each type of developed land use.

Table 2: Equations Used to Calculate Directly Connected Impervious Cover (DCIA).

Land Use Category	Sutherland Equation for DCIA (EPA, 2014)
Commercial/Services/Institutional Industrial Industrial and Commercial Complexes Mixed Use Developments Outdoor Residential (medium density) Transportation/Communications/Utilities Vacant	DCIA = 0.1(TIA)^1.5
Agriculture Barren Forest Transitional	DCIA = 0.01(TIA)^2

As part of this modeling exercise, we recalculated the HRUs factoring in DCIA; the revised calculations are provided in Table 3. As one would expect, pervious areas increase and impervious area decreases as DCIA is transferred from the impervious to pervious category. When the Sutherland equations are used for the Town, the directly connected impervious cover decreases from 579 acres (6.4% of total area) to 168 acres (1.9% of total area); which is consistent with the fact that much of the Town, outside of downtown has country drainage (uncurbed),and is therefore considered to be disconnected.

Table 3: Area of Hydrologic Response Units with Directly Connected Impervious Cover (DCIA) within the Town.

Land Use Type	PERVIOUS (including Disconnected IA)				DCIA				Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)		
DEVELOPED SOURCES										
Agriculture	35	204	393	11	0	0	0	0	4	**648**
Commercial, Services, and Institutional	8	12	4	0	3	5	1	0	19	**53**
Industrial and Commercial Complexes	1	2	1	0	0	2	0	0	21	**27**
Industrial	25	4	0	0	0	0	0	0	60	**90**
Mixed Development Uses	0	0	0	0	0	0	0	0	5	**5**
Outdoor	39	78	109	6	0	0	0	0	7	**240**
Residential	198	1,059	408	17	4	14	3	0	129	**1,832**
Transportation, Communications and Utilities	3	32	23	3	15	60	21	2	26	**186**
Vacant	1	2	8	0	0	0	0	0	1	**12**
Total Developed Sources	**311**	**1,394**	**947**	**37**	**22**	**81**	**26**	**2**	**271**	**3,091**
UNDEVELOED SOURCES										
Barren	12	63	20	12	0	0	0	0	18	**125**
Forest	195	1,611	1,646	151	0	0	0	0	38	**3,641**
Transitional	5	49	37	4	0	0	0	0	14	**110**
Water	0	6	15	30	0	0	0	0	976	**1,027**
Wetland	11	122	379	561	0	0	0	0	14	**1,086**
Total Undeveloped Sources	**223**	**1,851**	**2,097**	**757**	**0**	**0**	**0**	**0**	**1,060**	**5,989**
TOTAL	**534**	**3,245**	**3,044**	**795**	**22**	**81**	**26**	**2**	**1,332**	**9,080**

3.2 Initial (Unattenuated) Stormwater Load

To quantify the initial (unattenuated) annual stormwater pollutant load washed from the land surface, the HRU land area is multiplied by a PLER. The PLERs for total nitrogen (Table 4) were developed by EPA under the NH 2017 Final MS4 Permit (EPA, 2017).

Table 4. Nitrogen Pollutant Load Export Rates (EPA, 2017)

Land Use Category	N Pollutant Load Export Rate (lb/ac/yr)				
	Directly Connected Impervious Area (DCIA)	Pervious Cover			
		HSG A	HSG B	HSG C	HSG D
Commercial and Industrial	15	0.3	1.2	2.4	3.6
Residential	14.1	0.3	1.2	2.4	3.6
Highway	10.5	0.3	1.2	2.4	3.6
Forest	11.3	0.5	0.5	0.5	0.5
Open Land	11.3	0.3	1.2	2.4	3.6
Agriculture	11.3	0.3	1.2	2.4	3.6
Wetland*		0.5	0.5	0.5	0.5

**Assumed to be the same as forest*

Table 5 presents the total nitrogen unattenuated stormwater pollutant load by land use for the Town. Stormwater runoff from land uses within the Town generates approximately 8,820 pounds (4.4 tons) of total nitrogen per year. The developed portion of the watershed contributes approximately 71% of the annual unattenuated total nitrogen load, with residential land use contributing the greatest pollutant load, followed by transportation, communications and utilities, and agricultural.

3.3 Delivered (Attenuated) Stormwater Load

When precipitation falls on the land surface, natural attenuation of nitrogen occurs as water travels across pervious surfaces and vegetated buffers, through streams and natural waterways. Attenuation is caused by particulate settling, filtering, and biological uptake. By accounting for natural attenuation, the pollutant load that ultimately arrives at the receiving water (the delivered load) can be estimated. As part of the GBNNPSS, approximately 87% of nitrogen traveling in stormwater through surface water pathways will be transported from its origin to the receiving waters, and 13% is attenuated along the way (Trowbridge et al., 2014). The delivered stormwater load is presented in Table 5.

Approximately 7,673 pounds (3.8 tons) per year of nitrogen is delivered in stormwater to the receiving waters in the Town of Newmarket. Of the delivered stormwater nitrogen load, approximately 29% is from natural or undeveloped sources (i.e., barren, forested, transitional, water, and wetlands). The remaining 71% is from developed sources with the largest load from residential development, which is 45% of the total developed load. Transportation and agricultural land uses contribute approximately 21% and 20% of the total developed load, respectively.

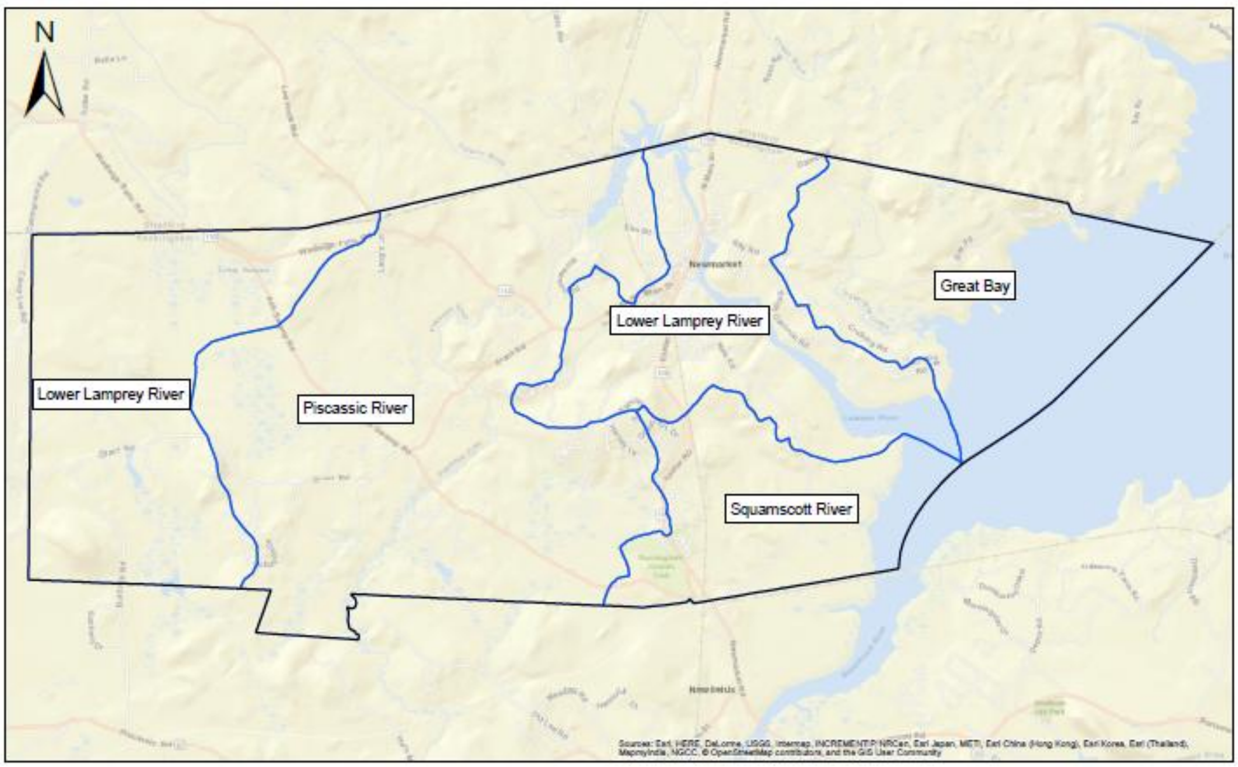
Table 5: Total Nitrogen Stormwater Pollutant Load by Land Use for Town.

Land Use Type	UNATTENUATED N LOAD (LBS/YR)						ATTENUATED N LOAD (LBS/YR)					
	HSG A	HSG B	HSG C	HSG D	DCIA	TOTAL	HSG A	HSG B	HSG C	HSG D	DCIA	TOTAL
DEVELOPED LAND												
Agriculture	11	245	943	41	0	**1,240**	9	213	821	35	0	**1,079**
Commercial, Services, and Institutional	2	15	10	1	267	**295**	2	13	9	1	232	**256**
Industrial	0	2	2	0	77	**81**	0	2	2	0	67	**71**
Industrial and Commercial Complexes	8	5	0	0	13	**26**	7	4	0	0	12	**23**
Mixed Development Uses	0	0	0	0	31	**31**	0	0	0	0	27	**27**
Outdoor	12	94	263	21	12	**402**	10	82	229	18	11	**349**
Residential	59	1270	979	62	465	**2,835**	52	1105	851	54	404	**2,467**
Transportation, Communications, and Utilities	1	39	55	10	1,226	**1,331**	1	34	48	9	1,067	**1,158**
Vacant	0	2	20	0	2	**24**	0	2	17	0	2	**21**
TOTAL DEVELOPED LAND LOAD:						**6,265**						**5,450**
UNDEVELOPED LAND												
Barren	4	76	48	41	1	**170**	3	66	42	36	1	**148**
Forest	98	806	823	76	0	**1,802**	85	701	716	66	0	**1,567**
Transitional	3	25	19	2	0	**48**	2	21	16	2	0	**42**
Water	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Wetland	5	61	189	280	0	**536**	5	53	165	244	0	**466**
TOTAL UNDEVELOPED LAND LOAD:						**2,555**						**2,223**
TOTAL INITIAL LOAD:						**8,820**						**7,673**

4.0 SUBWATERSHED SUMMARY

The Town was subdivided based on USGS hydrologic unit code (HUC) 12 into four subwatersheds in order to gain a better understanding of the relative contribution of each contributing drainage area to the overall nitrogen load. The subwatersheds are shown in Figure 3 and include: Lower Lamprey River, Piscassic River, Squamscott River, and Great Bay. Tables showing the area of HRUs and the area of HRUs with DCIA for each subwatershed are provided in Attachment B. The subwatersheds are delineated with the Town as its boundary and therefore, do not represent the contributing load from the areas outside of the Town.

Table 6 provides the total, unattenuated (initial) nitrogen stormwater pollutant load by land use for each subwatershed. To quantify the unattenuated annual stormwater pollutant load, the HRU land area was multiplied by the PLERs for total nitrogen developed by EPA (2017). In addition, Table 7 shows the total unattenuated load for each subwatershed, as well as the percentage each subwatershed contributes towards the total unattenuated load in the Town.



*Notes:

1) Piscassic River is contributory to the Lamprey River watershed
2) Lower Lamprey River is contributory to the Lamprey River watershed.
3) Squamscott River is contributory to the Exeter River watershed.

Figure 3. Subwatersheds in Newmarket*

Table 6 provides the total delivered nitrogen stormwater pollutant load by land use for each subwatershed. As noted above, the GBNNPSS was used to estimate that approximately 87% of nitrogen traveling in stormwater through surface water pathways will be delivered from its origin to the receiving waters (Trowbridge et al., 2014). Table 6 also shows the total delivered stormwater load for each subwatershed, as well as the percentage each sub-watershed contributes towards the total delivered load in the Town.

Figure 4 illustrates the relative contribution that each subwatershed has to the overall nitrogen load (unattenuated or delivered). The Lamprey River (Lower Lamprey River subwatershed and Piscassic River subwatershed) receives 79% of the stormwater nitrogen load from the Town. The Exeter River (Squamscott subwatershed) receives 10% and 8% discharges directly to Great Bay.

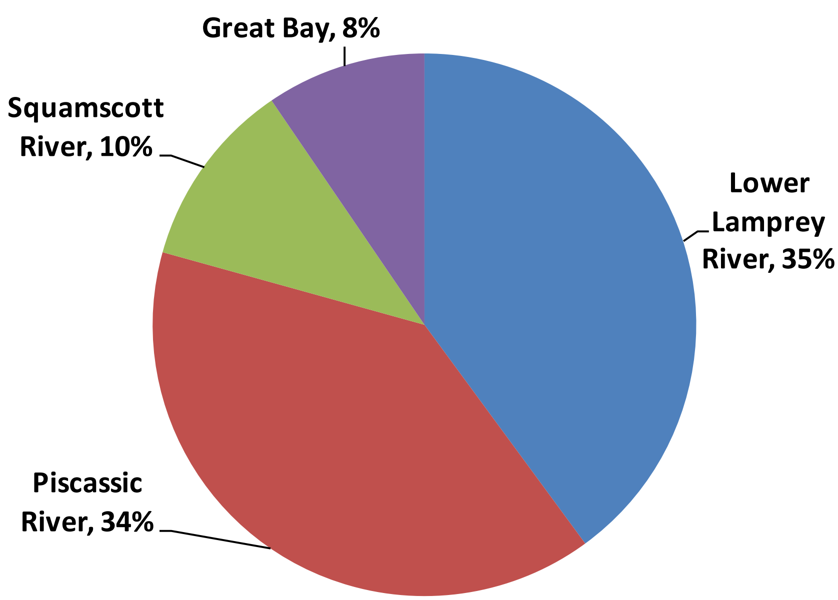


Figure 4: Relative contribution of delivered nitrogen by subwatersheds in the Town.

Table 6: Total Nitrogen Stormwater Pollutant Load by Land Use for Each Subwatershed.

Land Use Type	Unattenuated Load (lbs/yr)					Attenuated Load (lbs/yr)				
	Lower Lamprey River	Piscassic River	Squamscott River	Great Bay	TOTAL	Lower Lamprey River	Piscassic River	Squamscott River	Great Bay	TOTAL
DEVELOPED LAND										
Agriculture	360	512	294	74	**1,240**	313	445	256	64	**1,079**
Commercial, Services, and Institutional	213	48	33	0	**295**	185	42	29	0	**256**
Industrial	32	0	50	0	**81**	27	0	43	0	**71**
Industrial and Commercial Complexes	24	2	0	0	**26**	21	2	0	0	**23**
Mixed Development Uses	26	5	0	0	**31**	22	4	0	0	**27**
Outdoor	114	63	140	85	**402**	99	55	122	74	**349**
Residential	1,266	1,217	146	206	**2,835**	1,102	1,059	127	179	**2,467**
Transportation, Communications, and Utilities	565	561	85	120	**1,331**	492	488	74	104	**1,158**
Vacant	13	9	2	0	**24**	11	8	2	0	**21**
SUBTOTAL	**2,613**	**2,416**	**750**	**485**	**6,265**	**2,273**	**2,102**	**653**	**422**	**5,450**
UNDEVELOPED LAND										
Barren	57	36	4	73	**170**	50	31	3	63	**148**
Forest	652	775	175	200	**1,802**	567	675	152	174	**1,567**
Transitional	22	10	1	15	**48**	19	9	1	13	**42**
Water	0	0	0	0	**0**	0	0	0	0	**0**
Wetland	178	236	56	66	**536**	155	205	49	58	**466**
SUBTOTAL	**908**	**1,058**	**235**	**354**	**2,555**	**790**	**920**	**205**	**308**	**2,223**
TOTAL LOAD	**3,521**	**3,474**	**986**	**839**	**8,820**	**3,064**	**3,022**	**858**	**730**	**7,673**
Percent of Stormwater Total Load	**40%**	**39%**	**11%**	**10%**		**35%**	**34%**	**10%**	**8%**	

5.0 GROUNDWATER NITROGEN LOAD

The amount of the initial nitrogen load deposited on the pervious land surface that makes its way to groundwater is quantified as the "groundwater non-septic system load." Nitrogen that leaches from septic systems is quantified as the "groundwater septic system load." The nitrogen load estimation methodology and the estimated total nitrogen loads for groundwater (both unattenuated and delivered) are described in the following sections.

5.1 Initial (Unattenuated) Groundwater Nitrogen Load

5.1.1 Septic System Load

The estimated annual nitrogen load derived from the use of septic systems is based on estimates from GBNNPSS. The estimated direct load to the receiving water from septic systems is based on the distance of the septic system to the receiving water body. GBNNPSS quantifies population and associated septic systems within 200 meters of a 5th order stream and the number of systems located beyond that distance. Scientific literature suggests that systems within 200 meters of a 5th order stream or estuary assessment unit contribute a greater proportion of nitrogen to the Great Bay Estuary than those septic systems located outside of 200 meters (NHDES, 2014).

Table 7 presents the unattenuated nitrogen load estimates for septic systems from the GBNNPSS for the Town as a whole and for each subwatershed (refer to Figure 3 for a map of the subwatersheds). Septic systems within the Town contribute approximately 24,761 pounds of total nitrogen per year, 93% of which is from septic systems located more than 200 meters from a 5th order stream, and 7% is from septic systems located less than 200 meters from a 5th order stream. Compared to the other subwatersheds, the Piscassic River subwatershed contributes the most of the unattenuated groundwater septic system initial load (almost 49%). The total unattenuated groundwater load from septic systems to the Lamprey River, which includes both the Piscassic and Lower Lamprey subwatersheds is approximately 21,300 pounds (86% of the total load).

Table 7: Groundwater Septic System Unattenuated Total Nitrogen Load by Town and by Subwatershed.

	Septic Systems Initial (unattenuated) Load (lbs N/yr)			% of Town Total
	INSIDE 200 M	OUTSIDE 200 M	Total	
Town of Newmarket	1,661	23,100	24,761	
Estimated No. of Systems	72	993	1,065	
Subwatershed:				
Piscassic River	0	12,127	12,127	49%
Lower Lamprey River	1,204	7,973	9,177	37%
Great Bay	335	1,545	1,879	8%
Squamscott River	122	1,456	1,578	6%

5.1.2 Non-Septic System Load

The annual unattenuated load to groundwater from non-septic system sources (i.e., infiltration) is estimated by subtracting the stormwater and groundwater septic load from the total source load deposited on the surface, as estimated in the GBNNPSS. The GBNNPSS used the Nitrogen Load Model (Valiela, et al., 1997) to quantify nitrogen inputs from atmospheric deposition, chemical fertilizers, septic systems and groundwater and calculate the total source load. To estimate the unattenuated groundwater load from non-septic system sources, the stormwater load (8,820 pounds) and septic system load (24,761 pounds) were subtracted from total source load (101,841 pounds) (Table 8).

Table 8: Calculation of Groundwater Non-Septic Unattenuated Total Nitrogen Load.

	Initial (unattenuated) Load (lbs N/yr)						
	Total Source Load		**Stormwater**		**Groundwater Septic**		**Groundwater Non-Septic**
Town of Newmarket	101,841	-	8,820	-	24,761	=	**68,260**
Subwatershed:							
Piscassic River	39,879	-	3,521	-	12,127	=	**24,278**
Lower Lamprey River	37,342	-	3,474	-	9,177	=	**24,643**
Great Bay	12,700	-	986	-	1,879	=	**9,982**
Squamscott River	11,920	-	839	-	1,578	=	**9,357**

5.2 Delivered Groundwater Load

The delivered load from septic systems was multiplied by a delivery factor to account for natural attenuation of nitrogen within the groundwater pathway (Trowbridge et.al, 2014). For septic systems located within 200 meters of a 5th order stream, a delivery factor of 60% was applied. For septic systems located more than 200 meters from a 5th order stream, a delivery factor of 26% was applied.

The nitrogen load delivered to the receiving water from non-septic sources originates from deposition on the ground surface in rainfall that infiltrates. This is different from surface runoff, which ultimately makes its way through the soil layers and into a groundwater aquifer. To estimate the amount of total nitrogen that is not "lost" during this transport pathway through the soil layers to an aquifer, a delivery factor is applied. Based on the GBNNPSS, a range of groundwater delivery factor for non-septic system groundwater are available depending on nitrogen input source and land use type (9 to 15%). A delivery factor of 15%, the most conservative value, was applied in order to estimate the delivered groundwater load from the aquifer to the receiving waters.

Refer to Table 9 for a summary of the delivered groundwater load for the Town and for each subwatershed. The total delivered groundwater nitrogen load is estimated to be 17,182 pounds per year. Of that total, 39% originates in the Piscassic River subwatershed, 38% originates in the Lower Lamprey River subwatershed, for a combined 77% to the Lamprey River. The Great Bay subwatershed contributes 12% and the Squamscott subwatershed 11%, of the delivered nitrogen load.

Table 9: Groundwater Delivered Total Nitrogen Load.

	Delivered Groundwater Nitrogen Load (lbs/yr)				% of Town Total
	Non-Septic	Septic System (inside 200 m)	Septic System (outside 200 m)	Total Load	
Delivery Factor	*15%*	*60%*	*26%*	--	
Town of Newmarket	10,239	997	5,946	**17,182**	
Subwatershed:					
Piscassic River	3,642	0	3,122	**6,763**	39%
Lower Lamprey River	3,696	723	2,052	**6,471**	38%
Great Bay	1,497	201	398	**2,096**	12%
Squamscott River	1,404	73	375	**1,851**	11%

6.0 WASTEWATER TREATMENT FACILITY NITROGEN LOAD

The Newmarket WWTF was issued a stringent seasonal total nitrogen (TN) NPDES discharge limit of <3 mg/L, effective annually from April 1 through October 31. The Town negotiated an Administrative Order on Consent (AOC) with the EPA and was issued an interim seasonal TN limit of 8 mg/L. Based on these regulatory requirements, the Town began construction of a WWTF upgrade to meet the interim TN limits (< 8 mg/L) and provide the flexibility to meet potential future TN limits (<3 mg/L) with minor process upgrades if the effluent requirements deemed necessary in the future. The Town reached substantial completion of the WWTF upgrades in July 2017. Based on the AOC, the Town is required to comply with the interim TN limit of <8 mg/L beginning July 31, 2018.

The baseline nitrogen loading from the Newmarket WWTF is 61,000 lb/year (30.5 tons/year), as determined by NHDES in the Draft Analysis of Nitrogen Loading Reductions for Wastewater Treatment Facilities and Non-Point Sources in the Great Bay Estuary Watershed (NHDES, 2010). The value is based on WWTF effluent data collected from 2003 to 2008.

Table 10. Baseline Effluent WWTF Nitrogen Load

Pre-WWTF Upgrade (2003 – 2008)	Effluent Total Nitrogen	
	(lb/d)	(lb/yr)
Daily Average	167	61,000

7.0 BASELINE TOTAL NITROGEN LOAD ESTIMATES

For the baseline assessment, the total nitrogen unattenuated (initial) load from the Town is estimated at 162,841 pounds (81.4 tons) per year (Figure 5). Of the total baseline unattenuated load, approximately 42% is from groundwater non-septic (68,260 lbs TN/yr) followed by 38% (61,000 lbs TN/year) is from the wastewater treatment facility, 15% (24,761 lbs TN/year) from groundwater due to septic systems, 5% (8,820 lbs TN/year) from stormwater.

For the baseline assessment, the total nitrogen delivered load from the Town is estimated at 85,855 pounds (42.9 tons) per year (Figure 6). Of the total baseline delivered load, approximately 71% (61,000 lbs TN/year) is from the wastewater treatment facility followed by 12% (10,239 lbs N/year) from groundwater non-septic, 9% (7,673 lbs TN/year) from stormwater, and 8% (6,943 lbs TN/year) from groundwater due to septic systems.

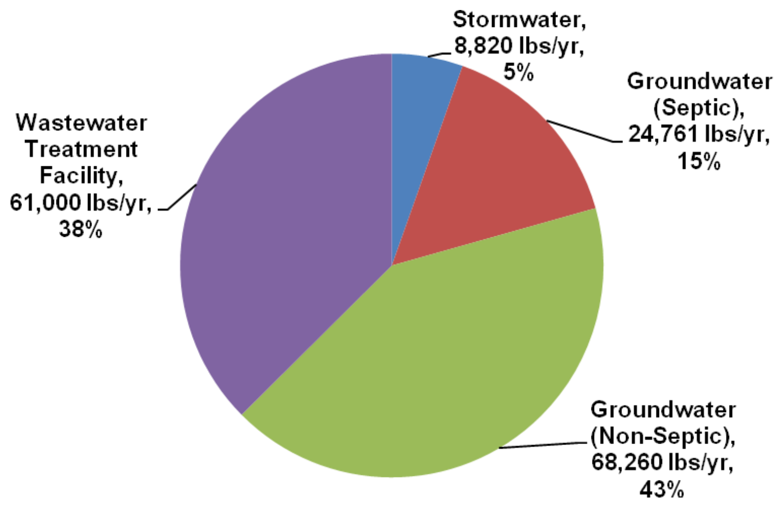


Figure 5. Baseline Unattenuated Total Nitrogen Load from Town

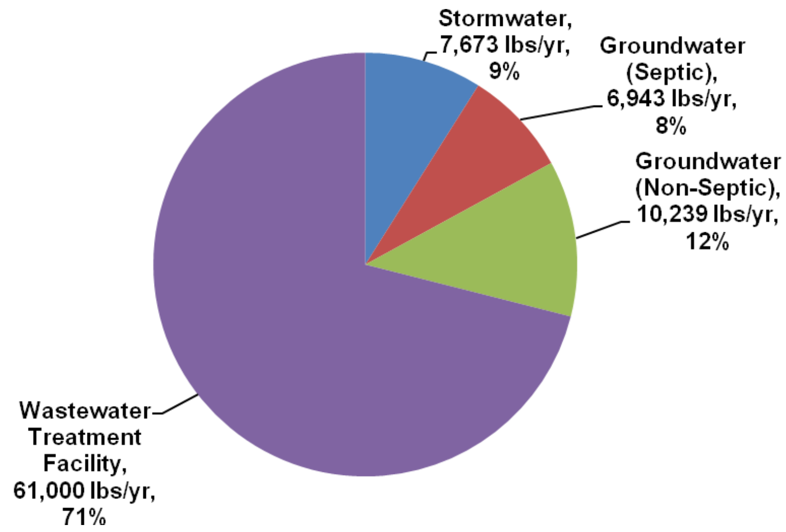


Figure 6. Baseline Delivered Total Nitrogen Load from Town

8.0 PRISTINE LOAD

To best understand the impacts that development has on the receiving water quality from the Town, estimates of the pristine stormwater load, prior to development, have been calculated. These estimates do not represent thresholds or targets for the Town to achieve when considering future reductions to improve water quality. The pristine condition is meant to demonstrate that environment naturally produces nitrogen and that future reduction thresholds should not be aimed at zero total nitrogen. To estimate this load, all developed land (all land uses other than forested, water and wetlands) were converted back to undeveloped land. It is understood that over time, wetlands were filled to create developable land and that forested areas were harvested to create buildable lots. All of the developed areas, including impervious cover areas, are underlain by a hydrologic soil group (i.e., A, B, C or D). It was assumed that this underlying soil group is consistent with what existed in a pristine condition. Based on these assumptions, all developed land uses were converted to a forest or wetland area, in each of the underlying hydrologic soil groups. Table 11 presents the land area within the watershed under the pristine condition.

Table 11. Pristine Land Area in Town

Land Use Type	Area (acres)					TOTAL AREA (AC)
	A soil	B soil	C soil	D soil	Water	
Forest / Wetland	556	3,320	3,055	767	356	**8,053**
Water	0	6	15	30	976	**1,027**
TOTAL	**556**	**3,326**	**3,070**	**797**	**1,332**	**9,080**

To quantify the pristine stormwater load for total nitrogen, each of the hydrologic response units (HRU) land areas from Table 11 were multiplied by the PLERs to quantify the unattenuated pollutant load. Table 12 presents the unattenuated stormwater total nitrogen load for the Town. The estimated load of 3,849 pounds per year is approximately 4,971 pounds less than or 44% of the developed stormwater load in 2015. The unattenuated stormwater load is multiplied by the delivery factor (0.87) to calculate the attenuated stormwater load equal to 3,349 pounds of total nitrogen per year (Table 13).

Table 12. Town Pristine Stormwater Unattenuated Total Nitrogen Load (lbs/yr)

Land Use Type	UNATTENUATED STORMWATER TOTAL NITROGEN LOAD (LBS N/YEAR)				TOTAL LOAD (LBS N/YR)
	A soil	B soil	C soil	D soil	
Forest / Wetland	278	1,660	1,527	384	3,849
Water	0	0	0	0	0
TOTAL	**278**	**1,660**	**1,527**	**384**	**3,849**

Table 13. Town Pristine Stormwater Attenuated Total Nitrogen Load (lbs/yr)

Land Use Type	ATTENUATED STORMWATER TOTAL NITROGEN LOAD (LBS N/YEAR)				TOTAL LOAD (LBS N/YR)
	A soil	B soil	C soil	D soil	
Forest / Wetland	242	1,444	1,329	334	3,849
Water	0	0	0	0	0
TOTAL	**242**	**1,444**	**1,329**	**334**	**3,349**

9.0 FUTURE NITROGEN LOAD

The Town of Newmarket completed a water and sewer build-out analysis in 2017 (Wright-Pierce, 2017). The goal of the study was to determine whether the Town had adequate water supply and wastewater treatment plant capacity to accommodate future community growth. The study completed a build-out analysis for a twenty-year planning period, to 2037. The analysis also looked at a full (saturation) build-out based on the Town's current zoning and based on the potential future zoning. This analysis was used to predict the future nitrogen load from the Town to the receiving water bodies. It was assumed that all human waste from future growth within the water and sewer district would be serviced by the WWTF and outside of the district by septic systems.

9.1 Stormwater Load

To determine the future land use changes in 2037, the estimated buildable area within the Town by planning zone (Table 14) and population projections (Table 15) were used (Wright-Pierce, 2017). A permitted future use was assigned to each zone based on the Town's Zoning Code which also correlates to a nitrogen PLER. The buildable acres represent area within and outside of the water and sewer district and areas that may already have a dwelling or be developed in the Town. Buildable area excludes wetlands, water and conservation land as documented by Wright-Pierce (2017). For each of the zones, the 2015 land use area was calculated to determine the developable land uses (i.e., forest, barren, vacant and transitional) where future development, or land use conversion, may occur.

The projected population in 2037 (Wright-Pierce, 2017) for Newmarket is 10,480 persons. Based on the 2015 US Census, the 2015 population in Newmarket was 8,907 persons with approximately 4,025 households, which equates to 2.2 persons per household. Based on these projections, an additional 1,573 persons or 715 households are anticipated in Newmarket in 2037. To determine the area of residential land that would need to be developed to accommodate this growth, the undeveloped area within the residential zones (R1, R2, R3, and R4) was used (Table 15). Of the 3,991 acres of residential buildable area (Table 14 and 15), 1,952 are within the barren, forest, transitional and vacant land uses. Using the minimum lot size and the maximum number of lots the future residential developable acres is approximately 1,306 acres.

Table 14. Saturated Buildable Area in Town

ZONE	PERMITTED FUTURE USE	BUILDABLE AREA (ACRES)
B1	Commercial, Services, and Institutional	**147**
B2	Commercial, Services, and Institutional	**291**
B3	Commercial, Services, and Institutional	**229**
M1	Mixed Development Uses	**6**
M2	Mixed Development Uses	**42**
M-2A	Mixed Development Uses	**19**
M3	Mixed Development Uses	**73**
M4	Mixed Development Uses	**115**
R1	Residential	**3207**
R2	Residential	**665**
R3	Residential	**111**
R4	Residential	**8**
	TOTAL	**4912**

Table 15. Future Residential Developable Area by Zone

Zone	Available Buildable Area (Acres)	Developed Area* (Acres)	% Buildable Area	Minimum Lot Size (Acres)	No. of Lots**	Future Residential Developable Area (Acres)
R1	3,207	1,726	88%	2	632	1,265
R2	665	206	11%	0.5	75	38
R3	111	19	1%	0.5	7	3
R4	8	1	0%	0.25	1	0
TOTAL	**3,991**	**1,952**			**715**	**1,306**

**Barren, Forest, Transitional and Vacant Land Uses*
***Calculated as maximum number of households (715) multiplied by % Undeveloped Area*

For the future developable areas within each of the planning zones, the developable land uses (i.e., barren, forest, vacant and transitional) were converted to the permitted use for the 2037 future nitrogen load calculations. Pervious area was converted to impervious and pervious area in the future land use/permitted use category (Table 14), by using a percent impervious by land use as established by the Soil Conservation Service (SCS, 1986) (Table 16).

Table 16. Percent Impervious by Permitted Use

Land Use / Permitted Use	Zone	Percent Impervious (SCS, 1986)
Commercial, Services, and Institutional / Mixed Development Uses	B1-B3; M1-M4	85%
Residential, ¼ acre lot	R4	38%
Residential, ½ acre lot	R2 and R3	25%
Residential, 2 acre lot	R1	12%

Table 17 presents the 2015 baseline area in Town by land use compared to the 2037 area. Commercial, services and institutional would see a 669% increase or conversion of 355 acres. Mixed use development would see a 1,645% increase or conversion of 82 acres. Residential would see a 71% increase or conversion of approximately 1,300 acres.

Table 17. Land Use Area in 2037 Compared to 2015

LAND USE	2015 AREA (ACRES)	2037 AREA (ACRES)	% CHANGE
Agriculture	648	648	0%
Barren	125	73	-42%
Commercial, Services, and Institutional	53	408	669%
Forest	3641	2007	-45%
Industrial	86	86	0%
Industrial and Commercial Complexes	30	30	0%
Mixed Developed Uses	5	87	1,645%
Outdoor and Other Urban and Built-up Land	240	240	0%
Residential	1832	3131	71%
Transitional	110	66	-40%
Transportation, Communication, and Utilities	186	186	0%
Vacant	12	7	-46%
Water	1027	1027	0%
Wetlands	1086	1086	0%

.

Table 18 presents the future unattenuted and attenuated total nitrogen load from stormwater for the future in 2037. The future stormwater load represents an untreated load where no stormwater best management controls are implemented to manage the changes in land use. When compared to the baseline (2015) condition, future unmanaged land use changes would result in an increase in the stormwater load of 5,492 pounds per year.

Table 18. Future Stormwater Total Nitrogen Load

Land Use Type	UNATTENUATED N LOAD (LBS/YR)						ATTENUATED N LOAD (LBS/YR)					
	HSG A	HSG B	HSG C	HSG D	DCIA	TOTAL	HSG A	HSG B	HSG C	HSG D	DCIA	TOTAL
DEVELOPED LAND												
Agriculture	11	245	950	41	0	**1,246**	9	213	826	35	0	**1,084**
Commercial, Services, and Institutional	10	70	151	60	3,568	**3,858**	8	61	131	52	3,104	**3,357**
Industrial	1	2	50	0	68	**122**	1	2	44	0	59	**106**
Industrial and Commercial Complexes	7	5	137	0	9	**158**	6	4	120	0	7	**138**
Mixed Development Uses	0	27	15	2	861	**905**	0	23	13	1	749	**787**
Outdoor	12	94	278	21	1	**406**	10	82	242	18	1	**353**
Residential	76	1957	2,805	143	458	**5,440**	66	1703	2,440	124	399	**4,733**
Transportation, Communications, and Utilities	1	42	79	10	1,164	**1,296**	1	37	68	9	1,013	**1,128**
Vacant	0	1	11	0	0	**13**	0	1	10	0	0	**11**
TOTAL DEVELOPED LAND LOAD:						**13,444**						**11,696**
UNDEVELOPED LAND												
Barren	2	41	41	33	0	**117**	2	36	36	28	0	**102**
Forest	38	441	464	55	0	**998**	33	384	403	48	0	**868**
Transitional	2	16	13	2	0	**33**	1	14	12	2	0	**29**
Water	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Wetland	5	61	194	280	0	**541**	5	53	169	244	0	**471**
TOTAL UNDEVELOPED LAND LOAD:						**1,689**						**1,469**
TOTAL INITIAL LOAD:						**15,133**						**13,165**

9.2 Septic System Load

Based on the projected population and buildable land outside of the water and sewer district, the number of additional septic systems and their associated load were estimated (Table 19). Approximately 37% of the buildable land is outside water and sewer district which would require septic. Of this area, approximately 4% is within 200 meters of an estuary assessment unit. Based on these factors, approximately 12 new septic systems would be installed within 200 meters of the estuary and 253 new septic systems outside the 200 meter buffer. These systems would result in an additional delivered nitrogen load of 1,692 pounds of nitrogen per year.

Table 19. Future Septic System Load

	INSIDE 200 M	OUTSIDE 200 M	Total
Future Estimated No. of Systems	12	253	265
Future Additional Unattenuated Load (lbs N/yr)	269	5,889	6,158
Future Additional Attenuated Load (lbs N/yr)	161	1,531	1,692
Baseline Attenuated Load (lbs N/yr)	997	5,946	6,943
TOTAL FUTURE SEPTIC SYSTEM LOAD (LBS N/YR)	**1,158**	**7,477**	**8,635**

9.3 Wastewater Treatment Facility Load

To determine the WWTF's level of nitrogen load both the post-upgrade and future effluent TN loads was calculated. Using average effluent daily flow the data for 2015 – 2017, the post-WWTF upgrade effluent TN loading was calculated using the AOC concentration limit (8 mg/L). To calculate the future point source nitrogen load from the WWTF, the NPDES permit effluent TN concentration (3.0 mg/L) was used as the future limit with the 20-year projected average daily flow (0.75 MGD) from the Wastewater System Build-out Study (Wright-Pierce, 2017). The projected 20-year annual average flow represents a 52% increase from the 2015 – 2017 average daily flow of 0.49 MGD. Table 20 provides a summary of the current and future WWTF effluent TN allocations based on the AOC and NPDES permit.

Table 20. Post-Upgrade and Future WWTF Effluent Total Nitrogen

	Effluent Flow	Effluent Total Nitrogen		
	(MGD)	(mg/L)	(lb/d)	(lb/yr)
Post-Upgrade (2017)	0.49	8.0	32.7	11,957
Future (2037)	0.75	3.0	18.8	6,862

The future annual average flows are entirely dependent on build-out projections and are subject to changes resulting from zoning revisions, industrial and commercial development, and overall population trends. While the 2017 Wastewater System Build-out Study also discusses a worst case full-build-out flow, the Town would most likely limit growth from this degree of saturation in order to maintain flows within the current permit limit of 0.85 MGD.

10.0 CONCLUSIONS

- For the baseline assessment, the total nitrogen delivered load from the Town is estimated at 85,855 pounds (42.9 tons) per year. Of the total baseline delivered load, approximately 71% (61,000 lbs TN/year) is from the wastewater treatment facility followed by 12% (10,239 lbs N/year) from groundwater non-septic 9% (7,673 lbsTN/year) from stormwater, and 8% (6,943 lbs TN/year) from groundwater due to septic systems.
- In 2037, future land use changes and population growth would result in an annual increase of approximately 5,500 pounds of total nitrogen delivered to the receiving waters from the stormwater pathway if left unmanaged. An additional 1,700 pounds of total nitrogen would be added annually from septic systems. However, due to upgrades at the WWTF load, the WWTF load will decrease by 54,138 pounds per year.

11.0 REFERENCES

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NRCS. 2007. *National Engineering Handbook, Part 630, Chapter 7 – Hydrologic Soil Groups*. Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). May.

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ATTACHMENT A

WASTEWATER MEMORANDUM

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

TO:	Renee Bourdeau	**DATE:**	2/21/2018 3/2/2018 (REV 1) 3/13/2018 (REV 2)
FROM:	Chelsea Dean, Neil Cheseldine	**PROJECT NO.:**	13994A
SUBJECT:	Newmarket, NH – Nitrogen Control Plan and Lamprey River Water Quality Monitoring Program Baseline and Future WWTF Total Nitrogen Effluent Loads		

The purpose of this memorandum is to define both the current baseline and future effluent nitrogen loads being discharged from the Town of Newmarket's WWTF.

BACKGROUND

The Newmarket WWTF has been identified by EPA as a major point source of nitrogen into the Great Bay Watershed. As a result, the WWTF was issued a stringent seasonal total nitrogen (TN) NPDES discharge limit of < 3 mg/L, effective annually from April 1 through October 31. The Town negotiated an Administrative Order on Consent (AOC) with the EPA and was issued an interim seasonal TN limit of 8 mg/L. Based on these regulatory requirements, the Town began construction of a WWTF upgrade to meet the interim TN limits (< 8 mg/L) and provide the flexibility to meet potential future TN limits (< 3 mg/L) with minor process upgrades if the effluent requirements return in the future. The Town reached substantial completion of the WWTF upgrades in July 2017. Based on the AOC, the Town is required to comply with the interim TN limit of < 8 mg/L beginning July 31, 2018.

BASELINE NITROGEN DATA

As discussed, the WWTF underwent a process upgrade in July 2017 from a process that did minimal TN removal, to a process which completes a significant amount of TN removal. As a result, the nitrogen loads have been presented based on pre- and post- WWTF upgrade data sets. The pre-upgrade nitrogen loading from the Newmarket WWTF is 61,000 lb/year (30.5 tons/year), as determined by NHDES in the Analysis of Nitrogen Loading Reductions for Wastewater

Treatment Facilities and Non-Point Sources in the Great Bay Estuary Watershed (NHDES, Draft December 2010). This value is based on WWTF effluent data collected from 2003 to 2008. To develop baseline post-upgrade nitrogen loads from the WWTF, data were analyzed from the Town's Monthly Operating Reports from August 2017 – December 2017.

Table 1 presents the pre-upgrade and post-upgrade effluent flows and nitrogen loading. Based on the TN data post-upgrade, the WWTF has seen a 90% reduction (150 lb/day) of the effluent total nitrogen load from the pre-upgrade period (2003 through 2008) to the post-upgrade period (August 2017 through December 2017).

It should be noted that the average daily effluent flow for the period of 2015 – 2017 data (pre-and-post-upgrade) is 0.49 MGD. This average daily effluent flow compares favorably to the annual average influent flow of 0.48 MGD (2008 – 2016) calculated as part of the 20-year Water and Sewer Buildout Study (Wright-Pierce, July 2017).

TABLE 1
BASELINE EFFLUENT WWTF NITROGEN LOAD

	Effluent Flow[1]	Effluent Total Nitrogen		
	(MGD)	(mg/L)	(lb/d)	(lb/year)
Pre-WWTF Upgrade (2003 – 2008)				
Daily Average	---	---	167	61,000
Post-WWTF Upgrade (August 2017 – December 2017)[2]				
Daily Average	0.34	5.86	17.0 [3]	6,205

Notes:

1. Effluent flow data was measured using the Facility's parshall flume. However, internal recycle flows may slightly misrepresent pre-upgrade flows and bias effluent flows to be high than actual effluent flows.
2. Post-upgrade dataset is small (8 TN samples) and should be re-evaluated constantly as additional WWTF TN data becomes available.
3. Post-WWTF upgrade effluent total nitrogen loading (lb/d) is calculated using the average of the daily loading values, instead of a calculation using the average flow and concentration presented in this table.

The interim TN limit (8 mg/L) and the 2015 – 2017 average daily flow (0.49 MGD) are used to estimate the post-WWTF upgrade point source nitrogen loading attributed to the WWTF. Review of the post-upgrade data as well as discussions with the operations staff indicate that the Town has been consistently capable of treating TN to concentrations < 7 mg/L.

To help determine the WWTF's level of nitrogen load reduction necessary to remedy the water quality concerns in the Great Bay watershed, both the current and future effluent TN loads must be developed. Using average effluent daily flow the data for 2015 – 2017, the post-WWTF upgrade effluent TN loading was calculated using the AOC concentration limit (8 mg/L). To calculate the future point source nitrogen load from the WWTF, the NPDES permit effluent TN concentration (3.0 mg/L) is used as the future limit with the 20-year projected average daily flow (0.75 MGD) from the Wastewater System Build-out Study (Wright-Pierce, July 2017). The projected 20-year annual average flow represents a 52% increase from the 2015 – 2017 average daily flow of 0.49

MGD. **Table 2** provides a summary of the current and future WWTF effluent TN allocations based on the AOC and NPDES permit.

TABLE 2
CURRENT AND FUTURE EFFLUENT NITROGEN ALLOCATION

	Effluent Flow	Effluent Total Nitrogen		
	(MGD)	(mg/L)	(lb/d)	(lb/year)
Post-Upgrade (2017)	0.49	8.0	32.7	11,957
Future (2037)	0.75	3.0	18.8	6,862

It should be noted that the future annual average flows are entirely dependent on buildout projections and are subject to changes resulting from zoning revisions, industrial and commercial development, and overall population trends. While the 2017 Wastewater System Build-out Study also discusses a worst case full-buildout flow, the Town would most likely limit growth from this degree of saturation in order to maintain flows within the current permit limit of 0.85 MGD.

ATTACHMENT B

STORMWATER SUMMARY TABLES BY SUBWATERSHED

Table 1a: Area of Hydrologic Response Units within the Lower Lamprey River Subwatershed.

Land Use Type	Pervious Areas				Total Impervious Area (ac)	Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)			
DEVELOPED SOURCES							
Agriculture	22	85	96	5	2	3	**213**
Commercial, Services, and Institutional	2	3	1	0	24	5	**35**
Industrial and Commercial Complexes	0	1	0	0	3	0	**4**
Industrial	18	3	0	0	10	27	**57**
Mixed Development Uses	0	0	0	0	3	1	**3**
Outdoor	8	19	31	3	2	3	**66**
Residential	61	326	165	4	165	52	**772**
Transportation, Communications, and Utilities	0	9	7	1	67	2	**86**
Vacant	0	1	4	0	0	0	**6**
Total Developed Sources	**111**	**448**	**303**	**13**	**276**	**93**	**1,244**
UNDEVELOPED SOURCES							
Barren	3	18	7	5	2	8	**42**
Forest	104	479	668	49	4	23	**1,327**
Transitional	2	14	26	2	1	12	**56**
Water	0	1	4	0	0	0	**6**
Wetland	0	3	6	6	0	157	**172**
Total Undeveloped Sources	3	11	166	175	0	8	**363**
TOTAL	**112**	**526**	**876**	**237**	**7**	**208**	**1,967**

Table 1b: Unattenuated Total Nitrogen Stormwater Pollutant Load by Land Use for the Lower Lamprey River Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	7	104	230	19	0	**360**
Commercial, Services, and Institutional	1	7	4	0	200	**213**
Industrial	0	2	2	0	28	**32**
Industrial and Commercial Complexes	6	5	0	0	13	**24**
Mixed Development Uses	0	0	0	0	26	**26**
Outdoor	2	24	76	12	0	**114**
Residential	23	479	461	15	289	**1,266**
Transportation, Communications, and Utilities	0	21	31	7	506	**565**
Vacant	0	2	9	0	2	**13**
TOTAL DEVELOPED LAND LOAD:						**2,613**
UNDEVELOPED LAND						
Barren	1	23	16	17	0	**57**
Forest	52	240	334	25	0	**652**
Transitional	1	7	13	1	0	**22**
Water	0	0	0	0	0	**0**
Wetland	1	6	83	87	0	**178**
TOTAL UNDEVELOPED LAND LOAD:						**908**
TOTAL LOAD:						**3,521**

Table 1c: Stormwater Delivered Total Nitrogen Load for the Lower Lamprey River Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	6	91	200	16	0	**313**
Commercial, Services, and Institutional	1	6	4	0	174	**185**
Industrial	0	2	1	0	24	**27**
Industrial and Commercial Complexes	5	4	0	0	12	**21**
Mixed Development Uses	0	0	0	0	22	**22**
Outdoor	2	20	66	10	0	**99**
Residential	20	417	401	13	251	**1,102**
Transportation, Communications, and Utilities	0	19	27	6	440	**492**
Vacant	0	2	8	0	1	**11**
					TOTAL DEVELOPED LAND LOAD:	**2,273**
UNDEVELOPED LAND						
Barren	1	20	14	15	0	**50**
Forest	45	209	291	21	0	**567**
Transitional	1	6	11	1	0	**19**
Water	0	0	0	0	0	**0**
Wetland	1	5	72	76	0	**155**
					TOTAL UNDEVELOPED LAND LOAD:	**790**
					TOTAL LOAD:	**3,064**

Table 2a: Area of Hydrologic Response Units within the Piscassic River Subwatershed.

Land Use Type	Pervious Areas				Total Impervious Area (ac)	Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)			
DEVELOPED SOURCES							
Agriculture	12	46	179	5	4	1	**246**
Commercial, Services, and Institutional	0	2	1	0	5	0	**9**
Industrial and Commercial Complexes	0	0	0	0	0	1	**2**
Industrial	6	0	0	0	0	26	**32**
Mixed Development Uses	0	0	0	0	1	1	**1**
Outdoor	15	12	16	0	3	0	**47**
Residential	89	408	150	11	138	26	**822**
Transportation, Communications, and Utilities	0	2	2	0	59	1	**64**
Vacant	0	0	3	0	0	0	**4**
Total Developed Sources	**122**	**471**	**351**	**16**	**209**	**58**	**1,228**
UNDEVELOPED SOURCES							
Barren	8	16	2	3	0	6	**35**
Forest	79	675	731	61	4	14	**1565**
Transitional	3	11	7	0	0	1	**21**
Water	0	1	7	2	0	23	**33**
Wetland	3	74	151	244	0	1	**473**
Total Undeveloped Sources	**93**	**775**	**899**	**310**	**5**	**45**	**2,127**
TOTAL	**215**	**1,246**	**1,246**	**326**	**214**	**103**	**3,351**

Table 2b: Unattenuated Total Nitrogen Stormwater Pollutant Load by Land Use for the Piscassic River Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	4	58	433	17	0	**512**
Commercial, Services, and Institutional	0	5	5	1	38	**48**
Industrial	0	0	0	0	0	**0**
Industrial and Commercial Complexes	2	0	0	0	0	**2**
Mixed Development Uses	0	0	0	0	5	**5**
Outdoor	5	16	40	2	1	**63**
Residential	32	580	413	45	147	**1,217**
Transportation, Communications, and Utilities	0	6	8	2	544	**561**
Vacant	0	0	9	0	0	**9**
					TOTAL DEVELOPED LAND LOAD:	**2,416**
UNDEVELOPED LAND						
Barren	2	19	6	9	0	**36**
Forest	40	338	367	31	0	**775**
Transitional	2	5	3	0	0	**10**
Water	0	0	0	0	0	**0**
Wetland	1	37	76	122	0	**236**
					TOTAL UNDEVELOPED LAND LOAD:	**1,058**
					TOTAL LOAD:	**3,474**

Table 2c: Stormwater Delivered Total Nitrogen Load for the Piscassic River Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	3	50	377	15	0	**445**
Commercial, Services, and Institutional	0	4	4	0	33	**42**
Industrial	0	0	0	0	0	**0**
Industrial and Commercial Complexes	2	0	0	0	0	**2**
Mixed Development Uses	0	0	0	0	4	**4**
Outdoor	4	14	35	2	0	**55**
Residential	28	505	359	39	128	**1,059**
Transportation, Communications, and Utilities	0	5	7	2	474	**488**
Vacant	0	0	7	0	0	**8**
					TOTAL DEVELOPED LAND LOAD:	**2,102**
UNDEVELOPED LAND						
Barren	2	16	5	8	0	**31**
Forest	35	294	319	27	0	**675**
Transitional	1	5	3	0	0	**9**
Water	0	0	0	0	0	**0**
Wetland	1	32	66	106	0	**205**
					TOTAL UNDEVELOPED LAND LOAD:	**920**
					TOTAL LOAD:	**3,022**

Table 3a: Area of Hydrologic Response Units within the Squamscott River Subwatershed.

Land Use Type	Pervious Areas				Total Impervious Area (ac)	Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)			
DEVELOPED SOURCES							
Agriculture	2	57	92	1	0	0	**152**
Commercial, Services, and Institutional	3	1	0	0	4	0	**8**
Industrial and Commercial Complexes	1	0	0	0	10	10	**20**
Industrial	0	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	0	**0**
Outdoor	14	29	32	2	5	1	**83**
Residential	12	70	10	1	17	1	**110**
Transportation, Communications, and Utilities	1	5	4	0	12	0	**23**
Vacant	1	0	1	0	0	0	**1**
Total Developed Sources	**33**	**162**	**139**	**3**	**49**	**12**	**398**
UNDEVELOPED SOURCES							
Barren	1	0	1	0	0	0	**2**
Forest	11	168	151	19	0	0	**349**
Transitional	0	1	1	0	0	0	**2**
Water	0	1	0	1	0	114	**116**
Wetland	5	21	36	50	0	5	**116**
Total Undeveloped Sources	**17**	**191**	**189**	**70**	**1**	**119**	**586**
TOTAL	**49**	**353**	**328**	**73**	**50**	**131**	**983**

Table 3b: Unattenuated Total Nitrogen Stormwater Pollutant Load by Land Use for the Squamscott River Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	0	69	222	3	0	**294**
Commercial, Services, and Institutional	1	3	1	0	29	**33**
Industrial	0	0	0	0	49	**50**
Industrial and Commercial Complexes	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	**0**
Outdoor	4	34	84	6	11	**140**
Residential	4	97	27	2	15	**146**
Transportation, Communications, and Utilities	1	10	15	0	59	**85**
Vacant	0	0	2	0	0	**2**
					TOTAL DEVELOPED LAND LOAD:	**750**
UNDEVELOPED LAND						
Barren	0	0	3	0	0	**4**
Forest	6	84	76	9	0	**175**
Transitional	0	1	1	0	0	**1**
Water	0	0	0	0	0	**0**
Wetland	3	10	18	25	0	**56**
					TOTAL UNDEVELOPED LAND LOAD:	**235**
					TOTAL LOAD:	**986**

Table 3c: Stormwater Delivered Total Nitrogen Load for the Squamscott River Subwatershed.

Land Use Type	N Load Pervious Areas A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)	DCIA (lbs/yr)	TOTALS (lbs/yr)
DEVELOPED LAND						
Agriculture	0	60	193	3	0	**256**
Commercial, Services, and Institutional	1	3	1	0	25	**29**
Industrial	0	0	0	0	43	**43**
Industrial and Commercial Complexes	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	**0**
Outdoor	4	30	73	5	10	**122**
Residential	4	85	24	2	13	**127**
Transportation, Communications, and Utilities	1	9	13	0	52	**74**
Vacant	0	0	2	0	0	**2**
TOTAL DEVELOPED LAND LOAD:						**653**
UNDEVELOPED LAND						
Barren	0	0	3	0	0	**3**
Forest	5	73	66	8	0	**152**
Transitional	0	0	0	0	0	**1**
Water	0	0	0	0	0	**0**
Wetland	2	9	15	22	0	**49**
TOTAL UNDEVELOPED LAND LOAD:						**205**
TOTAL LOAD:						**858**

Table 4a: Area of Hydrologic Response Units within the Great Bay Subwatershed.

Land Use Type	Pervious Areas				Total Impervious Area (ac)	Water (ac)	Total (ac)
	A Soil (ac)	B Soil (ac)	C Soil (ac)	D Soil (ac)			
DEVELOPED SOURCES							
Agriculture	0	11	24	0	0	0	**36**
Commercial, Services, and Institutional	0	0	0	0	0	0	**0**
Industrial and Commercial Complexes	0	0	0	0	0	0	**0**
Industrial	0	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	0	**0**
Outdoor	0	17	26	0	0	0	**44**
Residential	0	82	28	0	18	0	**128**
Transportation, Communications, and Utilities	0	0	0	0	12	0	**13**
Vacant	0	0	0	0	0	0	**0**
Total Developed Sources	**0**	**111**	**79**	**1**	**31**	**0**	**221**
UNDEVELOPED SOURCES							
Barren	0	29	10	4	0	3	**46**
Forest	0	284	92	22	2	0	**400**
Transitional	0	24	4	2	0	0	**30**
Water	0	1	2	21	0	683	**707**
Wetland	0	16	25	92	0	0	**133**
Total Undeveloped Sources	**0**	**353**	**133**	**140**	**2**	**687**	**1,316**
TOTAL	**0**	**464**	**211**	**141**	**33**	**687**	**1,537**

Table 4b: Unattenuated Total Nitrogen Stormwater Pollutant Load by Land Use for the Great Bay Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	0	14	59	1	0	**74**
Commercial, Services, and Institutional	0	0	0	0	0	**0**
Industrial	0	0	0	0	0	**0**
Industrial and Commercial Complexes	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	**0**
Outdoor	0	20	63	1	0	**85**
Residential	0	114	78	0	14	**206**
Transportation, Communications, and Utilities	0	1	1	1	117	**120**
Vacant	0	0	0	0	0	**0**
					TOTAL DEVELOPED LAND LOAD:	**485**
UNDEVELOPED LAND						
Barren	0	34	23	15	0	**73**
Forest	0	143	46	11	0	**200**
Transitional	0	12	2	1	0	**15**
Water	0	0	0	0	0	**0**
Wetland	0	8	13	46	0	**66**
					TOTAL UNDEVELOPED LAND LOAD:	**354**
					TOTAL LOAD:	**839**

Table 4c: Stormwater Delivered Total Nitrogen Load for the Great Bay Subwatershed.

Land Use Type	N Load Pervious Areas				DCIA (lbs/yr)	TOTALS (lbs/yr)
	A soil (lbs/yr)	B soil (lbs/yr)	C soil (lbs/yr)	D soil (lbs/yr)		
DEVELOPED LAND						
Agriculture	0	12	51	1	0	**64**
Commercial, Services, and Institutional	0	0	0	0	0	**0**
Industrial	0	0	0	0	0	**0**
Industrial and Commercial Complexes	0	0	0	0	0	**0**
Mixed Development Uses	0	0	0	0	0	**0**
Outdoor	0	18	55	1	0	**74**
Residential	0	99	68	0	12	**179**
Transportation, Communications, and Utilities	0	1	1	1	102	**104**
Vacant	0	0	0	0	0	**0**
					TOTAL DEVELOPED LAND LOAD:	**422**
UNDEVELOPED LAND						
Barren	0	30	20	13	0	**63**
Forest	0	124	40	9	0	**174**
Transitional	0	10	2	1	0	**13**
Water	0	0	0	0	0	**0**
Wetland	0	7	11	40	0	**58**
					TOTAL UNDEVELOPED LAND LOAD:	**308**
					TOTAL LOAD:	**730**

ATTACHMENT B:

WWTF Nitrogen Control Measures Memorandum

WRIGHT-PIERCE
Engineering a Better Environment

MEMORANDUM

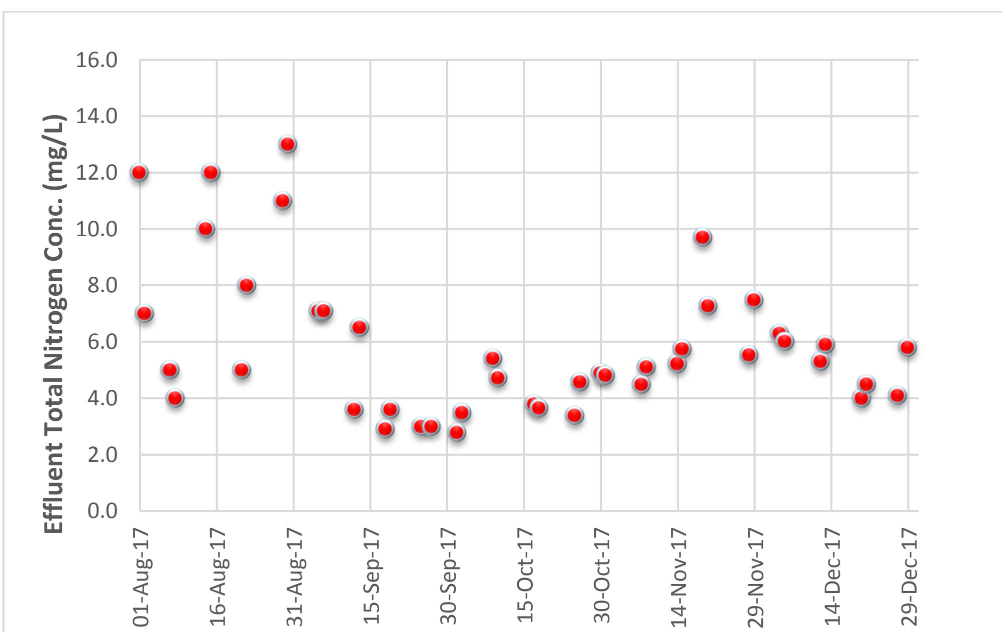
TO:	Sean Greig	**DATE:**	4/13/2018
FROM:	Michael Curry, P.E. Neil Cheseldine, P.E.	**PROJECT NO.:**	13994A
SUBJECT:	Newmarket, NH – Nitrogen Control Plan and Lamprey River Water Quality Monitoring Program WWTF Nitrogen Control Measures		

The purpose of this memorandum is to identify and evaluate WWTF treatment process modifications to further reduce point source nitrogen loading from the WWTF.

BACKGROUND

The Newmarket WWTF was upgraded in July 2017 to a 4-Stage Bardenpho process preceded by Primary Clarifiers. The process was designed to achieve an effluent TN limit of less than 8 mg/L, potentially less than 5 mg/L at annual average design flows (0.85-MGD) without supplemental carbon. Actual WWTF effluent total nitrogen (TN) concentrations for the first five months of treatment data are depicted below in **Figure 1**.

FIGURE 1
NEWMARKET, NH WWTF EFFLUENT TOTAL NITROGEN CONCENTRATIONS



After approximately 1.5 months of operation, the Town operators had tuned in the biological process to achieve consistent effluent TN levels < 8 mg/L, with over 50% of the effluent TN samples since September 1st resulting in concentration of < 5 mg/L. High effluent TN concentrations prior to September 1st were attributed to biological process start-up disruptions and are not included in the data presented in **Table 1**.

TABLE 1
WWTF EFFLUENT TN CONCENTRATIONS

Criteria	**TN Conc. (mg/L)**	**TN Load (lbs/day)**
Average	5.02	14.9
Maximum	9.70	32.2
Minimum	2.78	6.10
95th Percentile (mg/L)	7.34	26.7

Note: Data analysis includes data from 9/1/17 through 12/31/17. Data prior to this timeframe is not considered to be representative of normal operation.

Discussions with the Town indicate that they continue to improve TN treatment and have produced effluent TN values consistently < 5 mg/L from January 2018 through March 2018. There have been several instances of effluent TN values < 3 mg/L, without supplemental carbon addition. It should be noted that these treatment results occurred at influent flowrates of approximately 0.4 MGD, roughly 50% of design flow. As influent flow rates to the WWTF increase, TN treatment capabilities may also vary.

NITROGEN TREATMENT OPTIMIZATION

Current Process Optimization

The existing 4-Stage Bardenpho process contains the following process control features:

- Four independent dissolved oxygen (D.O.) sensors in the oxic zone to monitor dissolved oxygen levels and subsequently control air flow requirements
- Four independent air control valves in the oxic zones to modulate air flow requirements based on an automatic D.O. control loops

- Oxidation Reduction Potential (ORP) probes in the anoxic zones to monitor internal recycle rate effects
- Hybrid screw blowers with variable frequency drives to control air supply

These process features allow the Town to control the treatment process for TN treatment. Since coming online in July 2017, the Town has steadily improved process operation and improved TN treatment. Effluent TN results during the winter of 2018 have been consistently < 5 mg/L, with March 2018 TN results as low as 1.9 mg/L. These results indicate that the Town has optimized the existing 4-Stage Bardenpho process for the current influent wastewater conditions. As a result, no additional testing protocols or monitoring regimens are recommended to improve process operation at the existing flows and loads. The Town should continue to monitor general process variables (D.O., temperature, sludge retention time, sludge volume index) as influent flow and characteristics change.

Process Enhancement Alternatives

The WWTF has been capable of consistently producing effluent TN results < 8 mg/L, and more recently, < 5 mg/L using the existing process configuration and at the current flow and loading conditions. Current wastewater flow and loading conditions are approximately 50% of the average design day flow for the WWTF, which may, at least in part, contribute to the current TN treatment performance. TN treatment can be limited by the following factors, which can affect the ability for the WWTF to consistently achieve effluent TN concentrations lower than 5 mg/L throughout the year:

I. Post Anoxic Denitrification Rates: The post-anoxic zone acts as a final denitrification step in the 4-Stage Bardenpho process. Because there is minimal available carbon in this zone, the denitrification zone can be carbon-limited without addition of an external, supplemental carbon source. Supplemental carbon is discussed later in this section.

II. Effluent Total Suspended Solids: Effluent TSS consists of cellular and inert material which can consist of +/- 10% TN by weight. Using the average effluent TSS from the WWTF of 6 mg/L, effluent TSS may contribute +/- 0.6 mg/L of TN to the effluent. In general, effluent

TSS concentrations are limited to concentrations of 5 mg/L or higher based on settling limitations of the mixed liquor suspended solids. The TN associated with effluent TSS may only be achieved by removing TSS using some type of filtration technology. Effluent filtration technologies are discussed later in this section.

III. Soluble *Nonbiodegradable* TN: This fraction of TN cannot be removed from the wastewater stream using standard treatment practices (i.e., supplemental carbon, effluent filters) and can range from 1-2 mg/L of effluent TN, depending on the wastewater characteristics.

Supplemental Carbon Addition

The use of an external, supplemental carbon source for denitrification is generally necessary at WWTFs where effluent TN limits are less than 6-8 mg/L. As previously discussed, the Town has more recently been able to achieve TN treatment to < 5 mg/L (at current flows) without a supplemental carbon source. However, the addition of supplemental carbon may help the Town further remove TN to levels consistently below 3.5 mg/L throughout the year. Supplemental carbon may also be used in the future to supplement TN treatment as the Town grows and wastewater flows increase. To evaluate how the TN treatment is impacted by using supplemental carbon, the Town could complete a pilot supplemental carbon study. A pilot study would allow the Town to evaluate the effectiveness of supplemental carbon on TN treatment and to help gain a better understanding of the operational factors involved with the addition process.

Several different types of supplemental carbon sources are available including methanol, ethanol, acetate, and proprietary glycerin-based products (MicroC©). For the purposes of the pilot study, a glycerin-based product, such as MicroC©, is recommended, due to its non-hazardous characteristics and flexibility for temporary (pilot program) installation. Based on the current WWTF influent flow rates, the process would require between 8 to 15 gallons of supplemental carbon per day. For a supplemental pilot study, the following equipment is recommended (estimated costs in parentheses):

1. Temporary equipment structure to be sited adjacent to the Aeration Tank No.1
2. Supplemental carbon tote, 265-gallons ($5.75 per gallon for low volume orders)

3. NEMA 4X chemical feed pump with temporary piping to the front end of the post-anoxic zone 1E

The Newmarket WWTF has two independent aeration trains which allows the Town to do a side-by-side comparison of the effects of the pilot supplemental carbon program. The following general procedure has been developed to help evaluate the effectiveness of supplemental carbon addition:

<u>Aeration Train 1:</u>

1. For a period of two weeks, take samples (twice per week) of the MLSS from Zone F and conduct a settleometer test.
2. Decant the settleometer after a maximum of 60-minutes of settling and test the decant for nitrogen species (ammonia, TKN, nitrate/nitrite).
3. After two weeks of baseline sampling to collect effluent nitrogen data, begin dosing Zone 1 E with supplemental carbon. The Town should begin dosing at a rate of 8-gallons per day, controlled by the pace of the effluent flow meter.
4. For the next two weeks, take samples (2/week) of the MLSS from Zone F and conduct a settleometer test followed by a test of the decant for all nitrogen species listed above.
5. If effluent nitrate results are > 0.5 mg/L, increase the supplemental carbon dose slowly (+25%) and start the procedure over to evaluate results.

<u>Aeration Train 2:</u>

1. Conduct steps 1-2 from Aeration Train 1 and compare samples to establish a baseline effluent nitrogen species values (listed above) from each aeration train.
2. During supplemental carbon dosing of Aeration Train No. 1, take samples (2/week) of the MLSS from Zone F and conduct a settleometer test, followed by nitrogen species sampling of the decant. Nitrate results can be compared to Aeration Train No. 1 to determine the effectiveness of supplemental carbon.

For cost comparison purposes in nitrogen control planning, the capital and annual operation and maintenance costs for supplemental carbon system addition are presented below in **Table 2**.

These estimates are planning level system cost estimates based on the infrastructure required for a non-hazardous supplemental carbon system. Based on observed TN treatment results at the WWTF and modeled TN reduction using supplemental carbon, this system is estimated to provide TN treatment down to 3.5 mg/L. Using the current average annual flow estimates of 0.45 MGD, this additional removal would result in approximately 2,060 additional pounds of TN removed annually.

TABLE 2
SUPPLEMENTAL CARBON SYSTEM COSTS

ITEM	COST
Construction Costs	$230,000
Technical Services (Engineering)	$50,000
Estimated Capital Cost	$280,000
Annual Operation & Maintenance Costs[1]	$21,000
SYSTEM LIFE CYCLE COSTS[2]	$810,000
ANNUAL COST/LB ADD'L TN REMOVED	$19.75

Notes:
1. O&M costs include chemical and electricity costs, but do not account for additional labor requirements.
2. Net present worth calculated assuming a 20-year loan term, 2.5% annual interest rate, and 1% annual O&M cost inflation.

Using the annualized net present worth value of the supplemental carbon system, additional TN removal using supplemental carbon results in a cost of approximately $19.75/lb of additional TN removed.

Tertiary Treatment (Filtration)

In order to consistently achieve the NPDES permit effluent TN discharge limit of 3 mg/L, non-biologically active filter or biologically active filter would likely be required. It should be noted that the ability to achieve a seasonal (April through October) average effluent TN concentration less than 3.0 mg/L is predicated on the site-specific solids removal performance of the secondary treatment system. As such, while the facilities have recently achieved less than 3.0 mg/L with only secondary treatment, process modeling has indicated that a tertiary treatment step would likely be required (i.e., filtration device) to meet the NPDES permit effluent TN discharge limit of 3.0 mg/L. There are two main types of tertiary filtration processes for consideration; (1) biologically active filters and (2) non-biologically active filters. The type of filter required is determined by the level of treatment that occurs upstream of the filters.

A biologically active filter (also referred to as a BAF or "Denitrification Filter") is a generic term for solids separation/filtration process that also includes bacteria attached to the filtration media. These filters will remove solids as well as convert nitrate to nitrogen gas for further nitrogen removal. These filters are typically capable of reducing the effluent nitrogen of nitrified wastewater to 3.0 mg/L.

The second type of filter (a non-biologically active filter) removes solids and does not provide any biological treatment. A modest 0.5 mg/L nitrogen reduction is expected with this treatment system. In general, these filters are significantly less complicated and less expensive to construct and operate than biologically active filters, but have limited nitrogen removal capacity. These filters must be paired with an upstream biological process that fully nitrifies and denitrifies.

While a non-biologically active filter may help to remove the portion of TN associated with effluent TSS, the most effective and reliable technology to achieve a limit of less than 3 mg/L is a BAF. This is one of a suite of technologies that is considered the current "limit of technology". Due to wide variations of influent flows and loads, there is always a risk of not achieving an effluent TN of less than 3 mg/L with either filter technology. However, this risk is greater with a non-biologically active filter.

For nitrogen control planning cost comparison purposes, the capital and annual operation and maintenance costs for a biologically active filter are presented below in **Table 3**. The current WWTF system has been designed to hydraulically and spatially accommodate a BAF after the secondary clarifiers. Based on TN treatment modeling for the WWTF, a BAF is estimated to provide TN treatment from 3.5 mg/L (estimated modeled conditions with supplemental carbon addition), to less than 3 mg/L after the BAF. Using the current average annual flow estimates of

0.45 MGD, this additional 0.5 mg/L removal would result in approximately 685 additional pounds of TN annually removed by the BAF system.

TABLE 3
BIOLOGICAL ACTIVE FILTER COSTS

ITEM	COST
Construction Costs	$3,260,000
Technical Services (Engineering)	$650,000
Estimated Capital Cost	$3,910,000
Annual Operation & Maintenance Costs[1]	$18,000
SYSTEM LIFE CYCLE COST[2]	$5,330,000
ANNUAL COST/LB ADD'L TN REMOVED	$388

Notes:

1. O&M costs include chemical and electricity costs, but do not account for additional labor requirements.
2. Net present worth calculated assuming a 20-year loan term, 2.5% annual interest rate, and 1% annual O&M cost inflation.

Using the annualized net present worth value of the BAF system, additional TN removal using the biological active filter results in a cost of approximately $388/lb of additional TN removed after supplemental carbon treatment.

ATTACHMENT C:

Preliminary Nitrogen Control Measures Memorandum

Horsley Witten Group
Sustainable Environmental Solutions
113 R2 Water Street • Exeter, NH • 03833
603-658-1660 • horsleywitten.com

MEMORANDUM

To: Sean Greig, Town of Newmarket

From: Renee L. Bourdeau, Project Manager, Horsley Witten Group

Date: June 13, 2018, Revised July 11, 2018 and September 23, 2018

Re: Nitrogen Control Plan – Preliminary Nitrogen Control Measures

cc: Neil Cheseldine and Chelsea Dean, Wright-Pierce

1.0 PURPOSE

The purpose of this memorandum is to summarize the preliminary nitrogen control measures which will be used to develop planning-level cost estimates and rate of implementation for three non-point source nitrogen control alternatives. These alternatives include reducing nitrogen non-point source levels:

1) Level 1 implementation of non-point source controls;
2) Level 1 implementation of non-point source controls with an additional annual investment of approximately $75,000; and
3) equivalent to the removal if the wastewater treatment facility (WWTF) were upgraded to achieve a 3-mg/L effluent concentration at current flows (4,250 pounds of nitrogen).

2.0 NON-POINT SOURCE LOAD REDUCTION STRATEGIES

There are a variety of feasible non-point source load reduction strategies that Newmarket can consider to reduce the Town's baseline non-point source delivered nitrogen load (24,855 lbs per year) to receiving waters. These strategies are described below.

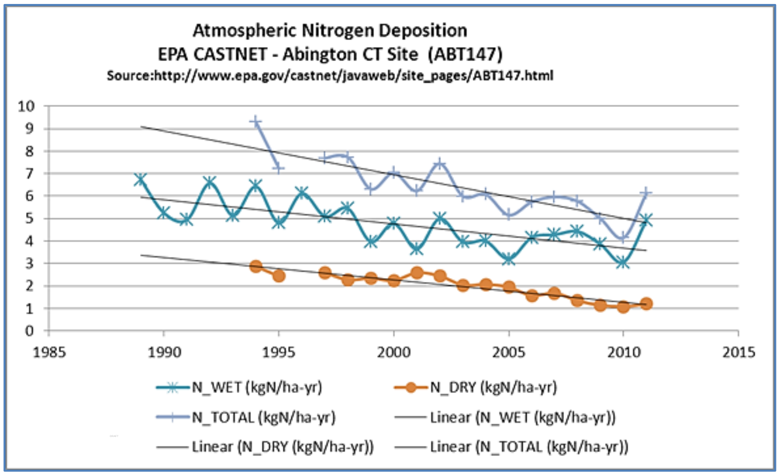
2.1 Non-Structural Load Reduction Strategies

2.1.1 Atmospheric Deposition

Atmospheric sources of nitrogen are a non-negligible portion of the total nitrogen load and has historically been treated as a static value based on published values representative of the late 1990s; however, there is a growing body of data which indicates that atmospheric nitrogen deposition is decreasing, especially since the late 1990s when the Clean Air Act and Clean Air Act Amendments were promulgated (Wright-Pierce, 2017). In particular:

- The Long Island Sound TMDL Report (CTDEP, 2000) included an 18% reduction in atmospheric nitrogen deposition as a part of the required reductions. The CTDEP Long Island Sound Study Work Group is currently re-evaluating the TMDL and expects that atmospheric nitrogen deposition has been reduced more than the 18% value.

- A paper entitled "Historical Changes in Atmospheric Deposition to Cape Cod", (Bowen, Valiela, 2001) analyzed atmospheric nitrogen deposition trends for the 20th century. The conclusions presented in the paper indicate that there was an upward trend through the 20th century; that the data was very variable; and that the upward trend through the 20th century seems to slow down or even reverse in the last decade.
- The NHDES "Great Bay Non-Point Source Study" (Trowbridge, et.al., 2014) summarizes the basis for the NHDES nitrogen loading model for the Great Bay Estuary. Appendix A of the report summarizes data regarding wet deposition rates, dry deposition rates, NOx emissions estimates and NOx emissions projections through 2020. Referencing EPA estimates, NHDES cites that NOx emissions are expected to decrease by 65% from 2001 to 2020.
- The EPA CASTNET (Clean Air Status and Trends Network) program is a long-term environmental monitoring program. Data collected from selected sites around the country are posted on their website (www.epa.gov/castnet). Data for wet deposition, dry deposition and total deposition for their site in Abington, CT (which is the closest site) indicate clear trends towards reduced atmospheric nitrogen deposition (see inset figure). Reductions in total deposition from the late 1990s to 2012 at this site are approximately 20%.



By documenting the reductions in atmospheric sources of nitrogen over the planning period, the scope and cost of implementing non-point source controls will be reduced. For planning purposes, we have assumed an expected 18% reduction in the nitrogen load from atmospheric deposition, which is applied to all land uses in the Town. To verify these observations, the Town could request that a local agency (i.e., UNH, PREP) establish a local atmospheric deposition monitoring station for the benefit of all Great Bay communities. Estimated total nitrogen reductions in atmospheric deposition come at no cost to the Town.

2.1.2 Agriculture Nutrient Management Program

Nitrogen is one of the most important crop inputs; yet, it is also one of the most complex. It is susceptible to environmental losses, and its effectiveness is impacted by soil types and weather. Feasible and widely used agricultural best management practices (BMPs) include the use of slow release fertilizer and the use of cover crops.

UNH Cooperative Extension recommends that at least 15% of the fertilizer be of a reduced water solubility to be considered a slow release fertilizer. This reduced water solubility allows for the gradual release and uptake of nitrogen and phosphorous which in turn reduces excess nutrient wash off.

Cover crops are another valuable management practice available for protecting water quality, especially groundwater quality. Cover crops reduce soil erosion by protecting the soil surface from raindrop impact, increasing water infiltration, trapping and securing crop residues, improving soil aggregate stability and providing a network of roots which protect soil from flowing water (USDA, 2013).

The Chesapeake Bay Program (CBP) established nitrogen removal efficiency credits of up to 40% for farmers that adopt agricultural fertilizer best management practices primarily through enhanced and comprehensive nutrient management plans. The enhanced nutrient management plans involve a number of agronomic practices and land/crop treatment measures. Further, the 2010 Maryland TMDL Plan listed specific nitrogen removal credits for the following agriculture best practices:

- Nutrient Management Plan Compliance: 3 pounds per acre reduction
- Precision Agriculture: 2 pounds per acre reduction
- Cover Crops: 5.8 pounds per acre reduction
- Conservation Tillage: 4.6 pounds per acre reduction
- Streamside Buffer: 17.1 pounds per acre reduction

The proposed measures outlined in the CBP to reduce nitrogen loads in existing agricultural operations consist of:

- Enhancing Nutrient Management Plans (application timing, rate and agronomic utilization)
- Increased Use of Land Treatment Measures (cover crops, conservation tillage, vegetated stream buffers)
- Possible Use of Structural Nutrient Management (structural BMPs for treatment removal, additional storage, anaerobic digesters and/or offsite transport systems)

A potential program for Newmarket could focus on the development and implementation of enhanced nutrient management plans including increased use of land treatment measures and possible structural nutrient management measures for agricultural activities in collaboration with United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and UNH Cooperative Extension. We can assume that implementation of a program such as this could achieve, at a minimum, a potential reduction of 15% from the agricultural load. This is consistent with assumptions made in the Oyster River Watershed Integrated Plan (VHB, 2014), developed for Durham, NH.

According to the Town two (2) farms are regulated under NRCS within the Town boundaries and therefore a program like this may not be worth the staff and financial investment. If the Town decided in the future to implement such a program, it would require an estimated additional 0.1 full time staff (FTE) to assist in the program management and administration, oversight of any regulation changes, and consultation with farmers and NRCS staff (Table 1). The cost per farm to develop a management plan is estimated to be approximately $5,000. The total cost for implementation of a nutrient reduction management plan for an average farm in the Northeast was estimated at $9,307 per year, based on data provided in NRCS, 2003. This is equivalent to $12,000 per year per farm in 2018 dollars (an assumed additional 30% was added to account for inflation to 2018 dollars).

Table 1. Agriculture Nutrient Management Program Estimated Costs

Program Measure	Estimated Annual Cost	Estimated One Time Capital Cost
Development of Comprehensive Plans		$5,000
Farm Program Implementation	$12,000	
Annual Administration of Program (0.1 FTE)	$7,500	
Total	**$19,500**	**$5,000**
20-Year Life-cycle Cost*		**$436,000**

** Life-cycle Cost calculated assuming 20-year loan term, 2.5% annual interest rate, and 1% annual O&M inflation*

2.1.3 Residential Fertilizer Program

The Town of Newmarket currently does not have an ordinance specific to restrictions of fertilizer use on residential properties. The Chesapeake Bay Program developed an Urban Nutrient Management Program targeted at reducing pollutant loads from residential lawns (Schueler and Lane, 2014). The program estimates that it could achieve a nitrogen removal efficiency ranging from 6% for low risk lawns to 20% for high risk lawns and a blended efficiency of 9%. High risk lawns have one or more of the following characteristics:

- Owners are currently over-fertilizing beyond state or Cooperative Extension recommendations
- Soils are phosphorus-saturated soils as determined by soil analysis
- Newly established turf
- Steep slopes (greater than 15%)
- 5% or more of the soil is exposed soil for managed turf, or more than 15% of the soil is exposed for unmanaged turf
- Water table within 3 feet of soil surface
- Over-irrigated lawns
- Soils are shallow, compacted or have low water holding capacity
- High use areas
- Sandy soils, or soils with infiltration rates greater than 2 inches per hour

- Within 300 feet of a stream, river, or Bay
- Located on karst terrain
- Active construction sites

The overall effectiveness of the program is dependent on the number and extent of core elements promoted and adopted by homeowners and lawn care professionals as a result of a comprehensive and multi-faceted Public Education and Outreach Program. The core elements of CBP's Urban Nutrient Management Program include the following:

- Maintain dense vegetative cover to reduce runoff, prevent erosion, and retain nutrients.
- Choose not to fertilize, or adopt a reduce rate/monitor approach or a small fertilizer dose approach.
- Retain clippings and mulched leaves on yard and keep them out of streets & storm drains.
- Do not apply fertilizers before spring green up or after grass becomes dormant.
- Maximize use of slow-release N fertilizer during the active growing season.
- Set mower height at 3 inches or taller.
- Immediately sweep off any fertilizer that falls on a paved surface.
- Restrict fertilizer usage within 25 feet of a water feature and require this zone as meadow, grass buffer, or a forested buffer.
- Employ lawn practices to increase soil porosity and infiltration capability, especially along portions of the lawn that convey or treat stormwater runoff.

For the Town, an assumed load reduction of 9% is being applied, which represents a blend of low and high risk lawns. Since a lawn fertilizer program is not currently underway, it is anticipated that participation would be low to moderate as the residents become engaged and aware of the environmental issues.

Implementation of a successful program would require additional staff time of approximately 0.5 FTE to assist in the program management and administration, oversight of any regulation changes, consultation with residents and landscapers, and assistance with the promotion and tracking of certification trainings, outreach and participation levels. Coordination with homeowner associations in key neighborhoods will also be important. Staffing needs for this program could potentially be met through a new staff position that could also provide 0.5 FTE for administering and managing other components of a Non-Point Source Program.

Full implementation of this program is anticipated to take several years and perhaps as much as five years to fully implement. Depending on the results after the fifth year, additional measures may need to be considered. The level of effort required to sustain the program beyond the five years will depend on the initial resident response and the level of involvement / interaction with other program partners.

The estimated program costs, including one-time capital costs, staff time and other annual costs, are outlined in Table 2.

Table 2. Residential Fertilizer Program Estimated Costs

Program Measure	Estimated Annual Cost*	Estimated One Time Capital Cost
Develop Outreach Plan and Materials		$25,000
Staff (0.5 FTE)	$37,000	
Personnel Training/Certification	$5,000	
Assessment Survey		$25,000
Total	**$42,000**	**$50,000**
20-Year Life-cycle Cost**		**$278,000**

**Annual costs are only assumed for 5-years*
***Life-cycle Cost calculated assuming 20-year loan term, 2.5% annual interest rate, and 1% annual O&M inflation*

2.1.4 Enhanced Street/ Pavement Cleaning Program

The Town currently conducts street sweeping and pavement cleaning approximately twice per year. The estimated program costs are outlined in Table 3. These costs include a one-time investment to develop the program, an estimated cost to replace an existing high-efficiency regenerative air-vacuum sweeper every ten-years, and the annual cost to maintain the program. Maintenance of the program includes staff time to operate the sweeper and equipment operation and maintenance including fuel and sweeper brushes. These costs are based on local data provided by the Town. Implementation of a street/pavement cleaning program using a high-efficiency regenerative air-vacuum sweeper twice per year, would result in a 2% reduction in initial load from directly connected impervious surfaces.

Table 3. Enhanced Street/ Pavement Cleaning Program Estimated Cost

Program Measure	Estimated Annual Cost	Estimated One-Time Capital Cost
Develop Program		$5,000
Regenerative Sweeper (replaced every 10 years)		$375,000*
Sweeper Maintenance	$13,000	
Sweeper Operation (1 FTE)	$75,000	
Total	**$88,000**	**$380,000**
20-Year Life-Cycle Cost**		**$2,801,000**

**Represents the cost to purchase one regenerative sweeper*
*** Life-cycle Cost calculated assuming 20-year loan term, 2.5% annual interest rate, and 1% annual O&M inflation*

2.1.5 Infrastructure Operations and Maintenance Program

Currently the Town owns and operates a vacuum truck and cleans catch basins twice per year in the spring and fall. The estimated program costs are outlined in Table 4. These costs include a one-time investment to develop the program and the annual cost to implement the program. These costs also include the cost to purchase a new vacuum truck, which is a shared cost (1/3 of total cost) with the water and sewer departments. These costs are based on data from the Town. Through implementation of this program, the Town would achieve a 6% (NH MS4 Permit, 2017) reduction in the initial nitrogen load from all directly connected impervious cover.

Table 4. Infrastructure Operation and Maintenance Program Estimated Cost

Program Measure	Estimated Annual Cost	Estimated One Time Capital Cost
Develop Program		$5,000
Vacuum Truck*		$110,000
Vacuum Truck Maintenance	$3,000	
Vacuum Truck Operation (0.1 FTE)	$7,500	
Total	**$10,500**	**$115,000**
20-Year Life-Cycle Cost**		**$377,000**

**Represents one third the cost to purchase a new vacuum truck*
*** Life-cycle Cost calculated assuming 20-year loan term, 2.5% annual interest rate, and 1% annual O&M inflation*

2.1.6 Enhanced Organic Waste and Leaf Litter Collection Program

The Town currently removes leaves from publically owned parcels in Town including town buildings, parks, roads and cemeteries and disposes of them at the Town's transfer station. The cost to implement the program is covered under the Town's current efforts for enhanced street sweeping. Through implementation of this program, the Town would receive a 5% reduction in the initial nitrogen load from all directly connected impervious cover.

2.2 Structural Load Reduction Strategies

2.2.1 Advanced Onsite Septic Systems

Traditional septic systems do not remove nitrogen from wastewater. Advanced systems are similar to traditional septic systems, but have an added component that reduces nitrogen 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 O&M 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.

An advanced treatment system refers to a system that includes a septic tank, an aeration system, and a recirculation system in the septic tank. Some systems may also have an additional component for advanced denitrification. Alternative treatment components can be added to a conventional system, often between the septic tank and the drainfield, to provide advanced treatment of nitrogen (Figure 1).

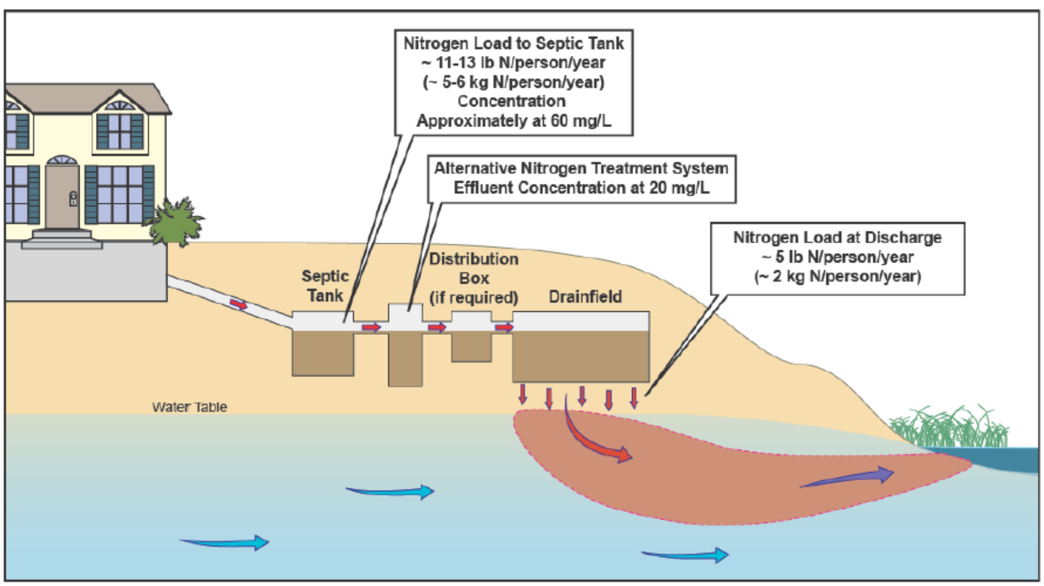


Figure 1. Advanced Onsite System with Nitrogen Treatment (Source: EPA, 2013)

A typical human contributes approximately 10.6 pounds of nitrogen in wastewater to the drain field each year (Trowbridge, et. al., 2014). According to the 2010 US Census, an average household in Newmarket is made up of approximately 2.2 persons, which would result in approximately 23 pounds of nitrogen per year entering an average septic system drain field. The nitrogen load delivered to a receiving waterbody from a septic system drain field (the 'delivered load') depends on the distance of the system to that receiving waterbody. According to Trowbridge, et. al. (2014), a septic system drain field within 200 meters of a receiving waterbody would deliver approximately 60% of the initial load, whereas a septic system drain field outside 200 meters would deliver approximately 25.7% of the initial load.

Implementation of an advanced onsite system removes approximately 7 pounds of nitrogen per person per year to the drain field (66% reduction in initial load) (EPA, 2013). Therefore, approximately 8.6 pounds of nitrogen per year would enter an advanced onsite treatment drain field. Table 5 presents the estimated initial and delivered load for both traditional and advanced onsite treatment systems in Newmarket.

Table 5. Initial and Delivered Load by Onsite System Type

System Distance from Waterbody	No. of Systems	Traditional System		Advanced System	
		Initial Load (lbs N/yr)	Delivered Load (lbs N/yr)	Initial Load (lbs N/yr)	Delivered Load (lbs N/yr)
Within 200 meters	71.3	23.1	15.2	8.6	5.2
Greater than 200 meters	992.3	23.2	6.6	8.6	2.2

The average capital cost per household to install a traditional septic system is estimated to be between $5,000 and $6,000 (EPA, 2013); to be conservative, we have used a value of $10,000 in this analysis. The average advanced onsite treatment system, which includes a septic tank, an aeration system, and an anoxic environment separate from the septic tank, is approximately $10,000 to $15,000. In our analysis, we used a conservative estimate of $20,000 per system for installation, with an annual operation and maintenance cost of $500 per system. These costs assume a new system is being installed and represents an average system with ideal subsurface conditions to treat onsite wastewater. The 20-year life-cycle cost is approximately $37,000 per system.

2.2.2 Sewer Extensions

The Twenty-Year Water and Wastewater System Build-Out Study for the Town of Newmarket (Wright-Pierce, 2017) explored locations in Town that are currently serviced by septic systems that could be served by the wastewater treatment plant through sewer extensions. Sewer extensions would result in the wastewater load being diverted from a non-point source (groundwater) to a point source (wastewater treatment plant) discharge. The Town identified three locations where sewers may be extended that could result in the disconnection of on-site septic systems. These locations, the number of systems which could be connected, cost and load reduction are summarized in Table 6.

The conversion of an onsite septic system to a sewer connection for an average residence in Newmarket would result in 3.63 lbs N/year delivered to the receiving water or an estimated 76% and 45% reduction in delivered load to the receiving water, for septic systems inside or outside 200 meters of a stream, respectively. The cost to connect a single home to sewer was assumed to be $40,000 per household (Wright-Pierce, 2015). The annual operation and maintenance is assumed to be equivalent to an annual sewer bill which is estimated to be 90 units per household at a rate of $10.50 plus an annual fee of $24, or $969. The 20-year life-cycle cost to connect a household to the sewer system is approximately $72,000.

As presented in Table 6, Birch Drive would be the most cost-effective location to extend sewer with regards to removing nitrogen load, at a cost of approximately $500 per pound per year.

Table 6. Possible Sewer Extension Locations and Load Reductions

Metric		**Birch Drive**	**Industrial Park**	**Wadleigh Falls Road**
No. of Parcels	Inside 200 Meters	17	0	0
	Outside 200 meters	18	15	48
	TOTAL	**35**	**15**	**48**
Baseline Delivered Load to Groundwater (lbs N/Yr)	Inside 200 Meters	258	0	0
	Outside 200 meters	119	99	317
	TOTAL	**377**	**99**	**317**
Delivered Load to WWTF (lbs N/Yr)	Inside 200 Meters	62	0	0
	Outside 200 meters	65	54	174
	TOTAL	**127**	**54**	**174**
Delivered Load Removed (lbs N/Yr)	Inside 200 Meters	197	0	0
	Outside 200 meters	53	45	143
	TOTAL	**250**	**45**	**143**
20-Year Life-cycle Cost		**$ 2,517,000**	**$1,079,000**	**$3,451,000**
Annual $ Per LB N Removed		**$ 500**	**$ 1,210**	**$ 1,210**

2.2.3 Stormwater Best Management Practices

In accordance with the Town's ordinances, the Town must implement and enforce regulations which require the use of structural stormwater BMPs optimized for the reduction of nitrogen in both new development and redevelopment. The Town is also making efforts to retrofit existing impervious areas with structural stormwater BMPs, when properties are being redeveloped. A range of structural stormwater BMPs that provide varying degrees of nitrogen load reduction based on the practice type, the underlying soil type (i.e., rate of soil infiltration) and the capture depth of the BMP (i.e., the size of the practice compared to the drainage capture area are presented in Table 7 below. Infiltration practices (i.e., trenches, basins, rain gardens and bioretention) are suitable for soils capable of infiltrating a minimum of 0.17 inches per hour which is characteristic of soils with a hydrologic soil group (HSG) of A or B. Therefore, in areas of Town with underlying soils in HSG A and B, infiltration BMPs will be most suitable when optimizing for nitrogen. For areas of Town with underlying soils in HSG C and D, gravel wetlands or enhanced biofiltration systems with internal storage reservoirs will be most suitable when optimizing for nitrogen removal.

Table 7. Range of Cumulative Nitrogen Load Reduction for Structural Stormwater BMPs (Source: 2017 NH MS4 Permit)

Stormwater Structural BMP Practice	Range of Cumulative Nitrogen Load Reduction*
Infiltration Trench	56% - 100%
Surface Infiltration Practices (i.e., basins, rain gardens and bioretention)	52% - 100%
Bio-filtration Practice	9% - 40%
Gravel Wetland System	22% - 79%
Enhanced Bio-filtration with Internal Storage Reservoir (ISR)	22% - 79%
Sand Filter	9% - 40%
Porous Pavement;	76% - 79%
Wet Pond or wet detention basin;	9% - 40%
Dry Pond or detention basin; and	1% - 23%
Dry Water Quality Grass Swale with Detention.	1% - 23%

**Range based on underlying soil infiltration rate and/or BMP capacity*

Using a literature review together with best professional engineering judgment estimates for the cost to implement structural stormwater BMPs in Newmarket are provided in Table 8. These costs include both construction and pre-construction costs (i.e., design and permitting) (which typically range from 10 to 40 percent of the BMP construction cost) by impervious acre treated. Since structural BMPs will be selected based on their nitrogen load reduction capability (Table 7), the average cost per impervious acre treated for infiltration practices and wetland/enhanced biofiltration were averaged. These costs are also presented in Table 8.

Table 8. Planning Level Unit Cost for Structural Stormwater Best Management Practices[1] (UMCES, 2011)

ROW ID	Structural Stormwater BMP	Initial Costs Per Impervious Acre Treated		
		Pre-Construction Costs[2]	Construction Costs[3]	Total Initial Costs
A	Wet Ponds	$ 21,333	$ 42,665	$ 63,998
B	Dry Extended Detention Ponds	$ 22,500	$ 45,000	$ 67,500
C	Infiltration Practices w/o Sand, Veg.	$ 16,700	$ 41,750	$ 58,450
D	Infiltration Practices w/ Sand, Veg.	$ 17,500	$ 43,750	$ 61,250
E	Filtering Practices (above ground)	$ 14,000	$ 35,000	$ 49,000
F	Filtering Practices (below ground)	$ 16,000	$ 40,000	$ 56,000
G	Bioretention	$ 9,375	$ 37,500	$ 46,875
H	Vegetated Open Channels	$ 4,000	$ 20,000	$ 24,000
I	Bioswale	$ 12,000	$ 30,000	$ 42,000
	Rounded Average Cost – Infiltration Practices (Rows C, D, and G)	**$15,000**	**$41,000**	**$56,000**
	Rounded Average Cost –Enhanced Bio (Rows E and F)	**$15,000**	**$38,000**	**$53,000**

Notes:

1. All costs are expressed per acre of impervious area treated, not per acre of BMP. Initial costs are assumed to take place in year T=0; annual costs are incurred from year T= 1 through year T= 20.
2. Includes cost of site discovery, surveying, design, planning, permitting, etc. which, for various BMPs tend to range from 10% to 40% of BMP construction costs.
3. Includes capital, labor, material and overhead costs, but not land costs, and associated implementation.

Since a portion of the developed load that could be treated by structural stormwater practices may come from pervious area, a cost per pervious acre treated needs to be estimated. Pervious areas when compared to impervious areas, produce a reduced volume of runoff and pollutant load, therefore, the cost per pervious acre treated is expected to be less than and impervious acre. To determine the cost reduction of a pervious acre compared to an impervious acre, the ratio of pervious load (82%) from the Town to the impervious load (18%) was compared. Based on this ratio, the capital cost per impervious acre was discounted by 78% to derive a pervious capital cost per acre, which is approximately $12,000 for infiltration practices and $12,000 for enhanced biofiltration practices (Table 9). It is also assumed that the annual operation and maintenance would be approximately 3% of the total capital cost of the BMP.

Table 9. Structural Stormwater BMP Cost by Land Surface Type and Soil Group

Land Surface Type by Hydrologic Soil Group	Developed Area (acres)	Unattenuated Pollutant Load (lbs N / Year)	Average PLER (lbs N/ ac/ yr)	BMP Type	BMP Removal Efficiency*	One-Time Capital Cost ($/ac)	Annual O&M Cost	20-Year Life-cycle Cost**
Pervious HSG A	311	93	0.3	Surface Infiltration	0.92	$ 12,000	$ 360	$ 23,000
DCIA HSG A	22	257	11.8		0.92	$ 56,000	$ 1,680	$ 108,000
Pervious HSG B	1,394	1,672	1.2		0.905	$ 12,000	$ 360	$ 23,000
DCIA HSG B	81	926	11.5		0.905	$ 56,000	$ 1,680	$ 108,000
Pervious HSG C	947	2,272	2.4	Enhanced bio-filtration	0.525	$ 12,000	$ 360	$ 23,000
DCIA HSG C	26	294	11.2		0.525	$ 53,000	$ 1,590	$ 102,000
Pervious HSG D	37	135	3.6		0.525	$ 12,000	$ 360	$ 23,000
DCIA HSG D	2	23	10.9		0.525	$ 53,000	$ 1,590	$ 102,000
TOTAL	**2,820**	**5,673**						

**BMP Removal Efficiency optimized for nitrogen, per MS4 permit*
*** Life-cycle Cost calculated assuming 20-year loan term, 2.5% annual interest rate, and 1% annual O&M inflation*

The structural stormwater BMPs, nitrogen load reduction capability and cost will be used in a range of alternatives to determine the level of reduction the Town could achieve through implementation of these controls.

3.0 NUTRIENT REDUCTION ALTERNATIVES

With guidance from the Town, HW evaluated a range of alternatives with varying nutrient reduction goals. For each strategy, we also evaluated the level of implementation and developed a planning-level cost to implement the strategy. The nutrient reduction strategies discussed above were compared and ranked to determine the most cost effective practice based on the cost per pound of nitrogen removed. The comparison of each of the strategies is summarized in Attachment A and the ranking summarized in Table 10.

Table 10. Ranking of NPS Reduction Strategies by Cost per Pound Removed

NPS REDUCTION STRATEGY	20-YR LIFE-CYCLE COST PER LB N REMOVED
Residential Fertilizer Program	$ 75
Agricultural Program	$ 135
Septic System (within 200m of Waterbody)	$ 185
Infrastructure Maintenance Program	$ 350
Septic System (outside 200m of Waterbody)	$ 420
Birch Drive Sewer Extension	$ 500
Surface Infiltration BMP Treating One Impervious Acre	$ 520
Surface Enhanced Biofiltration BMP Treating One Impervious Acre	$ 850
Surface Infiltration BMP Treating One Pervious Acre	$ 850
Wadleigh Falls Road Sewer Extension	$ 1,210
Industrial Park Sewer Extension	$ 1,210
Surface Enhanced Biofiltration BMP Treating One Pervious Acre	$ 1,475
Enhanced Street/ Pavement Cleaning Program & Organic Waste and Leaf Litter Collection Program	$ 2,235

The most cost effective strategy at reducing nitrogen is a residential fertilizer program. Based on discussions with the Town, while cost effective, the following practices were determined to be infeasible from a political or regulatory perspective in the next five years: agricultural program and septic system retrofits, therefore these strategies were excluded from alternatives 1 and 2 below.

3.1 Alternative 1: Level 1 Non-point Source Implementation

Alternative 1 represents the level of nitrogen non-point source strategy implementation and associated cost for operations the Town is currently conducting. The requirements have been extrapolated out for 20-years, for comparison purposes to the other alternatives, with the assumption that the requirements would not become more stringent over time. The Town currently implements an organic waste and leaf litter collection program, infrastructure maintenance program and an enhanced street/pavement cleaning program. The Town also evaluates Town owned properties and infrastructure for their potential to be retrofit with BMPs to mitigate impervious area. We assumed that 1 acre of impervious cover would be treated per year. This alternative also assumes that there would be reductions in atmospheric deposition over the 20-year implementation period.

This alternative could serve as the anticipated minimum estimated cost to the Town for implementation of strategies to provide nitrogen reduction from non-point sources. The level of implementation, estimated nitrogen load reduction and a planning-level cost to implement this alternative are presented in Table 11.

This alternative removes an estimated 1,545 pounds of nitrogen from the total non-point source delivered load to the receiving water for an estimated 20-year life-cycle cost of $4,794,000, $241,000 annually or $940 per pound of nitrogen removed[1]. This represents a 6% reduction in the total non-point source delivered load (24,855 lbs).

[1] Load reduction from atmospheric deposition not included in calculation for cost per pound of nitrogen removed

Table 11. Alternative 1

		A	B	C	D	E	F	G	H	I	J	K	L	M
Reduction Strategies	**Primary Target Pathway**	**Available Acreage**	**Baseline Initial Load (LBS N/ YR)**	**Estimated N Reduction from Strategy**	**Baseline Initial Load Removed (LBS N/ YR)**	**Baseline Initial Load Remaining (LBS N/ YR)**	**Baseline Delivered Load (LBS N/ YR)**	**Delivered Load Remaining (LBS N/ YR)**	**Delivered Load Removed (LBS N/ YR)**	**One-Time Capital Cost**	**Annual O&M Cost**	**Total 20-Year Life-Cycle Cost**	**Equivalent Annual Cost**	**Estimated Annual $/LBS N Removed**
Calculation					**(B x C)**	**(B - D)**	**(B x 0.87)**	**(E x 0.87)**	**(F - G)**				**(K ÷ 20 YRS)**	**(L ÷ H)**
Atmospheric Deposition	Stormwater	9,080	8,228	18%	1,481	6,747	7,158	5,870	1,289	$ -	$ -	$ -	$ -	$ -
Infrastructure Maintenance Program	Stormwater	98	1,030	6%	62	968	896	842	54	$ 115,000	$ 10,500	$ 377,000	$ 19,000	$ 353
Organic Waste and Leaf Litter Collection Program	Stormwater	98	1,030	5%	52	979	896	851	45	$ 760,000	$ 88,000	$ 2,801,000	$ 141,000	$ 2,248
Enhanced Street/ Pavement Cleaning Program	Stormwater	98	1,030	2%	21	1,009	896	878	18					
Stormwater Structural BMPs	Stormwater	2,820	5,673	2.8%	161	5,512	4,936	4,796	140	$ 840,000	$ 25,200	$ 1,616,000	$ 81,000	$ 600
TOTAL					**1,776**				**1,545**	**$ 1,715,000**	**$ 123,700**	**$ 4,794,000**	**$ 241,000**	**$ 940**

3.2 Alternative 2: Level 1 Implementation with Additional Investment

Alternative 2 represents the level of nitrogen non-point source strategy implementation under Alternative 1 plus an additional annual investment of approximately $75,000. The level of implementation by strategy, estimated nitrogen load reduction and a planning-level cost to implement this alternative is presented in Table 12.

For Alternative 2, we assumed that the Town would implement all non-structural programmatic strategies as described in Alternative 1 with the addition of the residential lawn fertilizer program and treating an additional 14.8 acres of directly connected impervious cover with stormwater structural BMPs.

This alternative removes an estimated 1,875 pounds of nitrogen from the delivered load to the receiving water for an estimated 20-year life-cycle cost of $6,245,000, $314,000 annually or $578 per pound of nitrogen removed[1]. This alternative would cost the Town an additional $73,000 per year, when compared to Alternative 1. The load reduction results in a 7% reduction in the total baseline non-point source delivered load (24,855 lbs).

[1] Load reduction from atmospheric deposition not included in calculation for cost per pound of nitrogen removed

Table 12. Alternative 2

Reduction Strategies	Primary Target Pathway	Available Acreage	Baseline Initial Load (LBS N/ YR)	Estimated N Reduction from Strategy	Baseline Initial Load Removed (LBS N/ YR)	Baseline Initial Load Remaining (LBS N/ YR)	Baseline Delivered Load (LBS N/ YR)	Delivered Load Remaining (LBS N/ YR)	Delivered Load Removed (LBS N/ YR)	One-Time Capital Cost	Annual O&M Cost	Total 20-Year Life-Cycle Cost	Equivalent Annual Cost	Estimated Annual $/LBS N Removed
		A	B	C	D	E	F	G	H	I	J	K	L	M
Calculation					**(B x C)**	**(B - D)**	**(B x 0.87)**	**(E x 0.87)**	**(F - G)**				**(K ÷ 20 YRS)**	**(L ÷ H)**
Atmospheric Deposition	Stormwater	9,080	8,228	18%	1,481	6,747	7,158	5,870	1,289	$ -	$ -	$ -	$ -	$ -
Infrastructure Maintenance Program	Stormwater	98	1,030	6%	62	968	896	842	54	$ 115,000	$ 10,500	$ 377,000	$ 19,000	$ 360
Organic Waste and Leaf Litter Collection Program	Stormwater	98	1,030	5%	52	979	896	851	45	$ 760,000	$ 88,000	$ 2,801,000	$ 141,000	$ 2,250
Enhanced Street/ Pavement Cleaning Program	Stormwater	98	1,030	2%	21	1,009	896	878	18					
Stormwater Structural BMPs	Stormwater	2,820	5,673	5%	277	5,396	4,936	4,695	241	$ 1,450,000	$ 43,500	$ 2,789,000	$ 140,000	$ 590
Residential Fertilizer Program	Stormwater	1,682	2,371	9%	213	2,158	2,063	1,877	186	$ 50,000	$ 2,100	$ 278,000	$ 14,000	$ 80
TOTAL									**1,832**	**$ 2,375,000**	**$ 144,100**	**$ 6,245,000**	**$ 314,000**	**$ 578**

3.3 Alternative 3: Nitrogen Load Reduction Equivalent to Final Permit Limit (3.0 mg/L)

Alternative 3 is the implementation of a combination of nitrogen reduction strategies to achieve a reduction of 4,250 pounds per year, which is the equivalent amount of nitrogen that would be removed by providing tertiary treatment at the WWTF to achieve a 3-mg/L effluent concentration. The level of implementation strategy and planning-level cost to implement these strategies to meet the 4,250 pounds is presented in Table 13.

For Alternative 3, we assumed that the Town would implement all non-structural programmatic strategies as described in Alternative 1 with the addition of the residential lawn fertilizer program, treating an additional 88 acres of directly connected impervious cover with stormwater structural BMPs, extending sewer service to the Birch Drive development and upgrading 26% or 278 septic systems to advanced systems.

This alternative removes an estimated 4,250 pounds of nitrogen from the total non-point source delivered load to the receiving water for an estimated 20-year life-cycle cost of $27,142,000, $1,359,000 annually or $459 per pound of nitrogen removed[1]. This alternative would cost the Town an additional $1,118,000 and $1,045,000 per year when compared to Alternative 1 and 2, respectively. The load reduction results in a 17% reduction in the baseline non-point source delivered load (24,855 lbs).

[1] Load reduction from atmospheric deposition not included in calculation for cost per pound of nitrogen removed

Table 13. Alternative 3

Reduction Strategies	Primary Target Pathway	A	B	C	D	E	F	G	H	I	J	K	L	M
		Available Acreage	Baseline Initial Load (LBS N/ YR)	Estimated N Reduction from Strategy	Baseline Initial Load Removed (LBS N/ YR)	Baseline Initial Load Remaining (LBS N/ YR)	Baseline Delivered Load (LBS N/ YR)	Delivered Load Remaining (LBS N/ YR)	Delivered Load Removed (LBS N/ YR)	One-Time Capital Cost	Annual O&M Cost	Total 20-Year FV Cost	Equivalent Annual Cost	Estimated Annual $/LBS N Removed
Calculation					**(B x C)**	**(B - D)**	**(B x 0.87)**	**(E x 0.87)**	**(F - G)**				**(K ÷ 20 YRS)**	**(L ÷ H)**
Atmospheric Deposition	Stormwater	9,080	8,228	18%	1,481	6,747	7,158	5,870	1,289	$ -	$ -	$ -	$ -	$ -
Infrastructure Maintenance Program	Stormwater	98	1,030	6%	62	968	896	842	54	$ 115,000	$ 10,500	$ 377,000	$ 19,000	$ 360
Organic Waste and Leaf Litter Collection Program	Stormwater	98	1,030	5%	52	979	896	851	45	$ 760,000	$ 88,000	$ 2,801,000	$ 141,000	$ 2,250
Enhanced Street/ Pavement Cleaning Program	Stormwater	98	1,030	2%	21	1,009	896	878	18					
Stormwater Structural BMPs	Stormwater	2,820	5,673	19%	1,072	4,602	4,936	4,003	932	$ 5,760,000	$ 172,800	$ 11,077,000	$ 554,000	$ 600
Residential Fertilizer Program	Stormwater	1,682	2,371	9%	213	2,158	2,063	1,877	186	$ 50,000	$ 2,100	$ 278,000	$ 14,000	$ 80
Birch Drive Sewer Extension	Groundwater			66%	-	-	377	127	250	$ 1,400,000	$ 34,000	$ 2,517,000	$ 126,000	$ 510
Septic System Upgrades	Groundwater			21%	-	-	6,932	5,454	1,478	$ 5,566,000	$ 139,150	$ 10,092,000	$ 505,000	$ 350
TOTAL									**4,251**	**$ 13,651,000**	**$ 446,550**	**$ 27,142,000**	**$ 1,359,000**	**$ 459**

4.0 SUMMARY

For comparison purposes, Table 14 presents the three alternatives and their associated cost and load reduction. Alternative 3 represents the most cost-effective alternative to implement with regards to the "estimated annual dollars per pound of nitrogen removed" metric ($460) with Alternative 1 being the least cost-effective based on $940 per pound of nitrogen removed. Alternative 3 has the greatest non-point source load reduction; however, would be the most expensive for the Town to implement.

Table 11. Cost and Load Reduction by Alternative

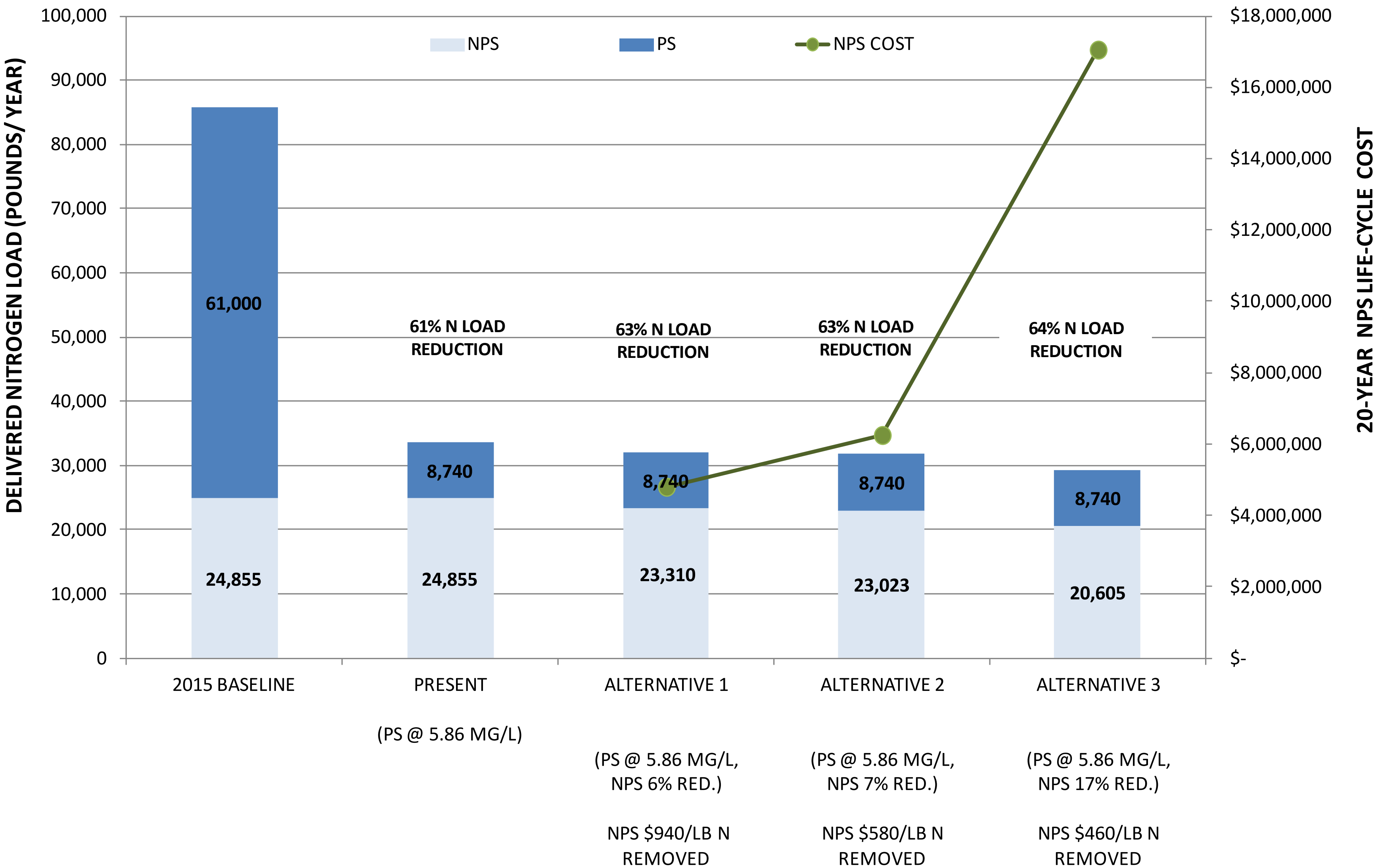
Alternative	Total 20-Year Life-Cycle Cost	Equivalent Annual Cost	Delivered Load Removed (lbs N/year)	Percent of Total NPS Delivered Load Removed[1]	Estimated Annual $ / lbs N Removed[2]
1	$ 4,794,000	$ 241,000	1,545	6%	$ 940
2	$ 6,245,000	$ 314,000	1,832	7%	$ 580
3	$ 27,142,000	$ 1,359,000	4,251	17%	$ 460

1. *Includes both stormwater and groundwater load (24,855 pounds N per year)*
2. *Does not include load removed from atmospheric deposition.*

For comparison purposes, the three alternatives and the baseline load are presented in Figure 1. Figure 1 demonstrates the significant strides that the Town is taking in reducing their total nitrogen load to the Lamprey River through operation of the WWTF with an effluent concentration of 5.86 mg/L, which is equivalent to 8,740 pounds per year or a reduction of 86% of the total point source load. Implementation of the requirements Alternative 1 provides a reduction of 6% of the non-point source load. Combined, Alternative 1 and upgrades to the WWTF account for an overall reduction of 63% of the total delivered load to the receiving water.

When compared to the two additional alternatives (2 and 3), the amount of additional nitrogen being removed when compared to the total baseline load (point and non-point source) is nominal; however, the incremental costs are significant over 20-years. Therefore, the Town should consider allowing time and investing in monitoring to determine if their current investments, through implementation of the current upgrade and implementation of the Alternative 1 results in a water quality improvement before investing further dollars in significant watershed improvements or upgrades at the WWTF.

FIGURE 1. NITROGEN REDUCTION SCENARIOS



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