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Oyster River Integrated Watershed Plan for Nitrogen Load Reductions

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Executive Summary

The Town of Durham and the University of New Hampshire (UNH), as Project Partners, seek to develop a more cost-effective and sustainable means to meet future permitting compliance needs and improve water quality in the Oyster River watershed through an Integrated Permitting approach. This proposed approach, consistent with the U.S Environmental Protection Agency's (EPA) Integrated Planning and Permitting Policy (IP3)[1], would balance future upgrades to Durham's wastewater treatment facility (WWTF) with nonpoint and point source stormwater control measures in an effort to reduce existing and future nitrogen loads to the Oyster River estuary as well as achieve other water quality objectives.

Both Durham and UNH share in the use and the operating costs of Durham's WWTF, which discharges to the tidal portion of the Oyster River that leads to Great Bay Estuary. The WWTF is operating under an administratively continued discharge permit that expired in December 2004. In anticipation of the next permit renewal, the Project Partners are concerned with potentially being required to meet a "Limit of Technology" effluent limit of 3 mg/L for total nitrogen that EPA has imposed on other communities in recent permits. The facility currently maintains a relatively low effluent concentration for total nitrogen compared to other WWTF's in the Seacoast region. The Draft Facility Plan indicates that to meet a seasonal average effluent limit of 3 mg/L, a carbon supplement such as ethanol or methanol may be needed to stimulate sufficient biological activity, especially in the cooler temperature months. The use of a carbon supplement will not only result in much higher capital and operational costs but would pose serious public health and safety concerns with respect to the storage and transport of a volatile compound. It could also contribute to higher greenhouse gas emissions. As described herein, a balanced approach of using nonpoint source (NPS) control measures in combination with a modest WWTF upgrade as part of an Integrated Permit could achieve similar if not greater nitrogen load reductions in a more cost-effective and sustainable manner than achieving a total nitrogen effluent limit of 3 mg/L. The added costs and increased public safety concerns associated with the potential use of a carbon supplement could be avoided.

Both the Town and UNH are also subject to EPA's MS4 Stormwater General Permit having adjacent regulated urbanized areas that also drain to the Oyster River estuary. The 2003 MS4 General Permit has expired and is expected to be renewed in the next six to twelve months. It is anticipated that the renewed MS4 permit will also require reductions of existing nitrogen loads as well as other stormwater related pollutants given language included in the NH DRAFT MS4 General Permit released in 2013. Given the overlapping requirements between the two permit programs (i.e., wastewater and MS4), the Town and UNH believe an Integrated Permit approach would result in greater economic and environmental benefits and eliminate duplication of efforts. This approach also aligns with the Town's and UNH's close working relationship and shared use of the WWTF as well as other stormwater and drinking water infrastructure.

This report presents the results of several recent planning and data collection efforts initiated by the Project Partners to provide the technical basis for an Integrated Permitting approach. These efforts include a watershed based modeling effort to estimate existing nitrogen loads from nonpoint sources, initial baseline water quality monitoring at select locations within the watershed, an evaluation of potential management measures for nitrogen load reduction and the development of a Draft Nitrogen Control Plan to identify and prioritize effective management measures for future nitrogen load reductions within the watershed. This report also provides

[1] June 2012, EPA Memo: Integrated Municipal Stormwater and Wastewater Planning Approach Framework

recommendations for next steps to advance this permitting approach as pending federal permits for Durham's WWTF and the NH MS4 Stormwater General Permit are renewed in the foreseeable future.

Both EPA and the New Hampshire Department of Environmental Services (NHDES) have initially endorsed Durham's and UNH's proposed Integrated Permit approach and have suggested that it be pursued further for a variety of practical and environmental reasons. EPA-Region 1 representatives, however, have indicated that due to limited flexibility contained in the Clean Water Act (CWA), they may be required to include a Limit of Technology (LOT) effluent limit of 3 mg/L in a NPDES permit regardless of whether other alternative NPS and stormwater control measures may be equally or even more effective in reducing nitrogen loads. Having to meet this LOT requirement will substantially raise future compliance costs and minimize the incentive to pursue other innovative and cost-effective measures. Although there appears to be no precedent for an Integrated Permit in Region 1, numerous case studies in other EPA regions have initiated Integrated Permits where NPS control measures have been used in lieu of advanced wastewater treatment. EPA suggested that the proposed integrated approach could be done through an Administrative Order on Consent (AOC) similar to those issued to Newmarket and Exeter. Although AOC's allow additional time to operate in a non-compliance mode to address more stringent permit requirements, they do not necessarily allow for the integration of overlapping permit requirements nor offer the flexibility to identify the best combination of measures to achieve the water quality objectives in the most cost-efficient manner.

The AOC's issued to Newmarket and Exeter allow these communities to operate "out of compliance" for up to 10 years as long as they meet a number of conditions including meeting an interim seasonal effluent limit of 8 mg/l for total nitrogen within 5 years, developing a watershed based allocation of nonpoint source nitrogen loads and developing a Nitrogen Control Plan by 2017 to identify specific non-point source and stormwater point source control measures that would be used within their respective towns to reduce existing nitrogen loads. In addition, the communities must develop a tracking and accounting procedure to document, quantify and annually report progress on nitrogen load reduction activities. By 2023, both Towns are required to submit an Engineering Report to describe their progress in reducing existing nitrogen loads, provide an update on nitrogen levels in receiving waters and a potential justification as to why additional WWTF upgrades are not necessary to meet an effluent of 3 mg/L for total nitrogen given recent success in reducing nitrogen loads and nitrogen levels in receiving waters based on ongoing water quality monitoring data. These Towns are also subject to the MS4 Stormwater permit, which would have to be addressed separately or in addition to the nonpoint source requirements included in the AOC.

The potential "non-compliance" or permit "violation" status associated with an AOC is also contrary to Durham's and UNH's recent efforts to address nonpoint sources and in improving its WWTF. Durham already has a relatively low seasonal average effluent concentration for nitrogen at its WWTF and both the Town and UNH have taken a number of proactive steps to reduce pollutant loads from impervious cover. The Town was one of the first communities in the region to update its local stormwater regulations for both new and redevelopment. More importantly, the use of NPS controls as part of an Integrated Permit approach would result in additional water quality benefits to upstream water bodies in the Oyster River watershed as well as the estuary for potentially far less cost. Improvements to the WWTF would only result in water quality benefits to the estuary. The use of NPS control measures would reduce other pollutants and would likely engage other watershed stakeholders as NPS control measures are implemented and provide a model template for others to follow in implementing innovative source control measures in other parts of the watershed, thus, resulting in greater nitrogen load reductions.

Durham and UNH wish to continue to discuss the benefits of an Integrated Permit approach with EPA and DES and work towards to developing a permit approach that addresses the water quality objectives in a more cost-effective manner while at the same time potentially achieve greater environmental benefits to result in a more positive triple bottom-line outcome of enhanced financial, environmental and social benefits.

The watershed assessment component of this planning phase was based on an established nitrogen loading model originally developed for the Buzzards Bay project in Massachusetts and more recently modified by the NHDES to develop average annual nitrogen load estimates from nonpoint sources that are within the larger Great Bay watershed. This model was refined even further as part of this effort in consultation with regional and local experts involved with nitrogen research. The model indicates that nonpoint sources in the Oyster River watershed contribute an average annual nitrogen load of approximately 73,440 pounds (36.7 tons), which is very similar to the average annual load estimate calculated from existing water quality data collected in the Oyster River. Approximately 80 percent of the estimated load is attributed to four major land use categories or human activities including the use of lawn fertilizer, agricultural fertilizer (including manure), stormwater runoff from impervious surfaces and nitrogen released from septic systems with each source contributed nearly equal amounts or nearly 20 percent of the total annual load. Almost half (47 percent) of the estimated annual watershed load or approximately 17.3 tons is associated with sources located within the Town of Durham and UNH's Campus area. Excluding the atmospheric load that falls directly on natural vegetation and surface water bodies which are considered to be "unmanageable", the annual nitrogen load attributed to sources located within Durham and UNH Campus that are manageable was estimated to be approximately 14 tons (~10 tons for Durham and ~4 tons for UNH).

A Draft Nitrogen Control Plan was developed to estimate the potential nitrogen load reductions that may be achieved through various NPS control measures using the model results and estimated removal efficiencies for a variety of management measures. The estimated removal efficiencies were based primarily on the Implementation documents developed for the Chesapeake Bay Watershed TMDL. The measures included in the Draft Control Plan were estimated to reduce annual nitrogen loads by approximately 0.5 to 2.0 tons/year depending on the type and number of control strategies and BMPs used, the geographical extent and duration of the implementation period. To achieve the high end of the estimated load reduction range would require 3 acres of oyster bed restoration, which accounted for nearly half of the estimated nitrogen removal and appears to be one of the most cost-effective measures. Oyster bed restoration, however, would not improve water quality conditions in the upper portions of the watershed. A nitrogen load reduction of 2.0 tons would more than compensate for the estimated additional load differential if the wastewater treatment plant was upgraded to meet a seasonal average effluent limit of 5 mg/L instead of 3 mg/L, based on current discharge rates. Preliminary cost estimates indicate that achieving this nitrogen load reduction target through NPS control measures instead of upgrading the WWTF to meet an effluent limit of 3 mg/L could result in annual savings of between $200,000 and $300,000 depending on the selected control strategies and as much as $3 to $4 million in savings over 20 years based on the estimated Life-Cycle costs.

Future discussions with the EPA and NHDES will be needed to reach consensus of the estimated removal credits for the various NPS control measures included in the Draft Control Plan and to further advance the proposed integrated permit framework and language as part of an Integrated Permitting approach. Completion of this process may depend on the timing of when the pending MS4 Stormwater General Permit for New Hampshire is finalized.

1.0 Introduction

1.1 Report Organization

This report presents findings of several recent planning and monitoring studies that were conducted to develop the technical framework for an Integrated Planning and Permitting approach in Durham, New Hampshire. The primary focus of these studies was to inventory and quantify the nitrogen loads contributed from various nonpoint sources (NPS) within the Oyster River watershed and identify the best combination of management measures that could be used to reduce these estimated nitrogen loads delivered to the Oyster River estuary and larger Great Bay estuary. These nonpoint sources evaluated include septic systems, chemical fertilizers used on lawns, managed turf and agricultural fields, pet and livestock waste and stormwater runoff from impervious surfaces. The findings of these studies are contained in this report and organized in the following manner:

- Chapter 2.0 describes Durham's Wastewater Treatment Facility and the considerations for treatment upgrades to reduce nitrogen loads.
- Chapter 3.0 summarizes recent water quality monitoring data collected in the Oyster River watershed used to help describe baseline conditions and validate the model estimates.
- Chapter 4.0 describes the watershed modeling approach used to estimate the nonpoint source loads.
- Chapter 5.0 outlines various management measures identified to reduce nitrogen loads from nonpoint sources as well as nitrogen harvesting techniques. The estimated load reductions associated with these measures were based on literature data generated primarily by the Chesapeake Bay Watershed Program.
- Chapter 6.0 describes considerations in developing a tracking and accounting procedure that will help to track existing activities and source contributions and future actions that lead to nitrogen load reductions.
- Chapter 7.0 provides recommendations to further advance the Integrated Planning and Permitting approach in the future.
- Chapter 8.0 summarizes various state and federal funding assistance programs that could be utilized to help fund the implementation of various aspects of the proposed Integrated Permit.

1.2 Existing Durham/UNH Permit Status and Regulatory Drivers

Both the Town of Durham and the University of New Hampshire (UNH) share in the use and the costs of operating Durham's Wastewater Treatment Facility (WWTF), which discharges to the tidal portion of the Oyster River that leads to the Great Bay Estuary. Durham, like many other communities in the Great Bay region, has been operating under an administratively continued permit for this facility since it expired in 2004. The facility has a permitted discharge rate of 2.5 million gallons per day (MGD) but currently has an average annual discharge flow of approximately 1.0 MGD with about two-thirds of the volume coming from UNH. EPA has delayed issuing a new wastewater discharge permit for the Durham facility to allow time to further develop an Integrated Permit approach. Based on recent permits issued for other nearby Towns, the next wastewater discharge permit will most likely contain a more stringent, "Limit of Technology" effluent limit of 3 mg/L for total nitrogen. The facility currently maintains a rolling 7-month average effluent concentration that is below 8 mg/L for total nitrogen, which is considerably lower than most if not all the other wastewater treatment facilities in the Great Bay region.

Both the Town and UNH are also subject to the requirements of EPA's MS4 Stormwater General Permit. This permit expired in 2008 and is expected to be renewed in the near future and perhaps by end of 2014. The DRAFT 2013

MS4 Stormwater Permit contains new provisions requiring communities to develop Water Quality Response Plans (WQRPs) for stormwater outfalls that discharge to impaired water bodies. The entire Great Bay and all of its tributaries are currently listed as impaired based on NHDES' 2012 303(d) list due to several indicators that suggest declining water quality conditions (e.g., low dissolved oxygen, increased abundance of phytoplankton and rooted macro-algae, declining eelgrass habitat) and these declines may be linked to excessive nitrogen inputs although this is still being studied by NHDES and has not been firmly established. College Brook, Pettee Brook and Beards Creek are also listed as impaired due to elevated bacteria and chloride levels. The WQ Response Plans would need to identify measures that would be used to reduce current pollutant loads from stormwater discharges located within the regulated urbanized area and are contributing to these impaired waters. Since Durham and UNH are located in the same watershed and already share in the costs of maintaining the WWTF as well as other infrastructure, this presents an even more compelling reason to develop an Integrated Permit to address the potential overlapping requirements for nitrogen load reductions between the pending MS4 permit and NPDES discharge permits. This more holistic approach, which involves an assessment of all NPS sources within Durham's and UNH's jurisdiction and not just the MS4 regulated areas is expected to be much more cost-effective and result in greater load reductions than what would otherwise be achieved under the MS4 Program.

Recent NPDES wastewater permits issued for the Towns of Newmarket and Exeter requires their WWTF's to meet a seasonal average effluent limit of 3 mg/L for total nitrogen or the current "Limit of Technology." The Limit of Technology represents the lowest limit that can reasonably be expected given current technology. Since this permit condition could not be readily met, both communities entered into Administrative Orders of Consent (AOC) with EPA that outline a series of interim steps and milestones that leads to an alternative compliance path and possibly not having to meet the LOT requirement. These interim steps focus on reducing existing nitrogen loads through a combination of wastewater upgrades and nonpoint source control measures targeting nitrogen. The communities agreed to meet an interim average seasonal effluent limit of 8 mg/L for nitrogen within five (5) years and develop a Nitrogen Control Plan, complete with implementation schedule that outlines various measures that would be used to reduce nitrogen loads from nonpoint sources. By 2023, the communities will need to submit an Engineering Evaluation to justify why an effluent limit of 3 mg/L is not warranted given successful implementation of various NPS control measures identified in their Nitrogen Control Plan and nitrogen levels in ambient waters are trending lower as shown by future water quality monitoring data.

The Town and UNH are concerned with the significantly higher incremental costs involved with meeting an effluent limit of 3 mg/L TN as well as the public health and safety issues related to the transport and onsite storage of methanol or ethanol which may be needed as a supplemental carbon source to stimulate the biological activity required to achieve 3 mg/L, especially in cooler months. The transport and storage of methanol or ethanol, which are commonly used as carbon supplements, pose serious worker safety concerns as they are highly volatile and potentially explosive. These compounds also pose environmental concerns as methanol can contribute to greenhouse gases. The reliance on added chemicals is not considered economical or environmentally sustainable and is not consistent with EPA's sustainability concepts promoted in its Integrated Planning and Permitting Policy.

1.3 Durham / UNH's Proposed Integrated Planning and Permitting Approach

As part of an Integrated Planning and Permitting process, Durham and UNH propose a balanced approach of using a combination of nonpoint source control measures and WWTF treatment upgrades to identify the most cost-effective and sustainable measures to reduce nitrogen loads to the Oyster River and Great Bay estuaries. To this end, the Partners propose to optimize the WWTF treatment process to achieve a "Sustainable Limit of Technology" that provides the greatest nitrogen reduction without using a carbon supplement and, at the same time, identify the most feasible and effective nonpoint source control measure as described in the proposed Draft Nitrogen Control Plan (Section 5 of this Report). This Plan will need to be refined and finalized with additional stakeholder input and based on results of water quality data currently being collected. This balanced approach would be designed to meet the pending permit requirements of both the wastewater discharge permit and the MS4 Stormwater Permits in the future. As described in this Report, Durham and UNH have funded several studies to generate the technical basis in support of an Integrated Permit Approach.

The primary principles of Durham's/UNH's proposed Integrated Planning and Permit Approach include:

Collaboration: Build on current research and monitoring efforts being done in the Great Bay region to make the most efficient use of available resources and technical expertise and achieve nitrogen reductions in a more holistic and watershed-based approach.

Cost-Effectiveness: Identify best combination of cost-effective solutions aimed at stormwater management and nonpoint source control.

Sustainability: Achieve water quality objectives with the least amount of structural modifications, maintenance and additional operational costs using innovative green technology.

The study results described herein will need to be discussed further with regulatory agency personnel in order to define future permit conditions as part of an Integrated Permit approach and reach consensus on the various nitrogen removal credits for the NPS control measures included in the Draft Nitrogen Control Plan. In is anticipated these agency discussions would occur prior to the final MS4 Stormwater Permit being released (tentatively scheduled for fall 2014) and prior to the pending renewal of the WWTF Permit. Since Durham is already achieving an annual average effluent limit of 8 mg/L or better (in summer months) for total nitrogen, the renewal Durham's WWTF permit is not likely imminent but could occur in the next year or two.

Identifying funding sources to assist in the future implementation NPS control measures is also a priority of the Project Partners. Potential state and federal funding assistance programs are described herein.

1.4 Examples of NPS Controls Used to Offset Wastewater Treatment

EPA has supported for over a decade the concept of using nonpoint source controls as means to restore impaired waters and attainment of water quality standards as part of its Water Quality Trading (WQT) Policy[2]. EPA believes a trading program can be a cost-effective strategy to achieve pollutant load reductions on a watershed-scale and/or between different sources and to meet a specified load limit that was established as part of Total Maximum Daily Load (TMDL) study. A primary benefit of a WQT Program is that it promotes innovation and can expand the assessment of potential management measures to involve pollutant sources that would typically be evaluated because they are not regulated. Most notably, this includes agriculture uses, which can contribute to water quality impairments in many watersheds. A WQT program can provide a framework where farmers or other stakeholders can monetarily benefit by using specific treatment measures and/or enhance operations to achieve pollutant reduction credits.

EPA's guidance document states that, "Allowing a facility to meet an established Water Quality Based Effluent Limit (WQBEL) through trading does not necessarily constitute a less stringent effluent limitation if the facility is still

[2] EPA Water Quality Trading Toolkit for Permit Writers, updated in 2009, EPA-833-R-07-004.

responsible for the same level of pollutant reduction. In that case, trading merely offers the discharger an additional means of achieving that limitation and must not result in a net increase in the pollutant discharged to the water body or in a localized impairment. Similarly, allowing a facility to meet a WQBEL through trading does not necessarily constitute a revised effluent limit under section 303(d) (4) (A) if a facility is still responsible for the same level of pollution reduction." A pre-TMDL trade must not cause or contribute to further impairments of the water body according to the 301(b)(1)(C) of the Clean Water Act.

Across the country, there are a number of case study examples where nonpoint source control measures are used in lieu of more advanced and costly wastewater treatment requirements as part of a nutrient trading and permitting framework. One relevant example involves the phosphorus loading trading plan implemented by Alpine Cheese Company (ACC) in Ohio for the Sugar Creek Watershed. Following the development of a phosphorus TMDL, the state environmental protection agency (Ohio EPA) imposed more stringent phosphorus effluent limitations for the ACC wastewater treatment facility. Recognizing the much greater costs and challenges to meet this new effluent limit, the ACC proposed a watershed-wide nutrient trading plan that involved working with local farmers and other nonpoint source landowners to implement Best Management Practices to reduce existing phosphorus loads. The nutrient trading plan became integral component of the new NPDES wastewater permit. Varying nutrient reduction credit ratios were included to account for differing effects of BMP types and source locations on load reductions within the watershed and the plan included various contingencies for additional BMP measures if initial targeted measures were not fully adopted. A comprehensive water quality monitoring program was also included. The entire watershed trading program was developed in cooperation with the Ohio State University and was managed by the local soil and water conservation district.

A similar watershed based approach was also adopted in Minnesota as a result of the Southern Minnesota Beet Sugar Cooperative (SMBSC) wanting to build its own wastewater treatment plant, but due to an existing waste load allocation (WLA), additional phosphorus loads could not be increased on the Lower Minnesota River. As a result, the SMBSC had to completely offset its proposed phosphorus discharge through negotiated contracts with over two hundred member farmers to install BMPs (e.g., cover crops, conservation tillage, etc.) to reduce their existing phosphorus loads.

In Oregon, Clean Water Services (CWS), a utility that operates four (4) wastewater treatment facilities on the Tualatin River, developed a Temperature Management Plan to alleviate elevated temperature effects from their wastewater discharges. Rather than installing expensive chillers or refrigeration units for each outfall, CWS developed a watershed based plan to reduce thermal impacts from solar radiation through riparian shading and stream corridor plantings. The plan established a long term strategy to offset the entire wastewater thermal load over a twenty year period. Through this planning effort, the Oregon Dept. of Environmental Quality was able to integrate the NPDES Permits covering all four facilities and MS4 stormwater requirements into one watershed based Integrated Permit (See Fact Sheets in Appendix A).

2.0 Existing Wastewater Treatment Facility

2.1 Existing Treatment Operations

The Durham Wastewater Treatment Facility (WWTF) serves both the Town and the University of New Hampshire. Durham's total population is estimated to be 14,638 according to the 2010 Census, which includes the Town's permanent residential population and the on-campus and in-town students attending University of New Hampshire (UNH). Approximately 80 percent of this population is currently served by the wastewater collection and treatment system. The Town of Durham operates and maintains the wastewater treatment facility (WWTF), three pumping stations and over 17 miles of sanitary sewers. There is approximately another 9 miles of sanitary sewer associated with the UNH campus area that leads to the WWTF. The WWTF is located off of Route 4 and discharges to the estuary portion of the Oyster River below the head of tide dam. A more complete description of the WWTF infrastructure and treatment works are contained in the 2012 Draft Facilities Plan prepared by Wright-Pierce.

The WWTF's current average daily discharge rate is approximately 1.0 million gallons per day (MGD) but is considerably lower during the summer months when UNH is not in session. During summer months, the average daily discharge rate is closer to 0.5 MGD or nearly half the average annual daily discharge rate (Wright-Pierce 2012). The National Pollutant Discharge Elimination System (NPDES) Permit issued by EPA for the facility, which expired in 2004, allows for average daily discharge rate of up to 2.5 MGD. Since 2004, the facility has been operating under an administratively continued permit and EPA is likely to renew the permit in the next year or two. EPA has indicated that the next permit is likely to contain a stringent effluent limit of 3 mg/l for nitrogen that would be based on a 7-month rolling average discharge concentration from April to October. An effluent limit of 3 mg/L is essentially considered the "Limit of Technology" or the lowest level that can be reasonably expected given current technology. This effluent limit has been included in the recent NPDES Permits issued to the Towns of Exeter and Newmarket.

As part of the Draft Facilities Plan, an evaluation was conducted to identify the treatment configurations and upgrades that would needed to meet potential future effluent limits (Wright-Pierce, 2012). Due to facility upgrades completed in 2005, the WWTF currently maintains a 7-month seasonal rolling average nitrogen effluent limit that is below 8 mg/L, which is much lower than most, if not all, other facilities in the Seacoast Region. To achieve a total nitrogen limit of either 3 or 5 mg/L, at the current and/or design flows and loads, the installation of a 4-Stage Bardenpho nutrient removal system was recommended. The Draft Facilities Plan suggests that with reasonably certainty an effluent limit of 5 mg/L could be met using this process, however, it was unclear whether an effluent limit of 3 mg/L could be achieved without requiring the use of a carbon supplement such as methanol to stimulate biological activity, especially during the cooler months. The report states that a "Biological Aeration Filter" (BAF) may be needed to meet the lower 3 mg/l effluent limit. To gain a better understanding of the potential treatment needs beyond the 4-stage Bardenpho process, Wright-Pierce recommended that a two-year, pilot study being conducted to optimize the treatment process without the use of supplemental chemicals or the aeration filter.

2.2 Pilot "Optimization" Study

Consistent with the Draft Facilities Plan recommendations, Durham and UNH have initiated a small scale pilot study using the proposed 4-stage Bardenpho treatment process to gain a better sense of the operational aspects and potential effectiveness of the proposed treatment upgrade to enhance nitrogen removal. This study will start in the summer of 2014 and extend through the summer of 2016. To complete the study, the existing four aeration tanks at the treatment plant will be reconfigured into a two-train 4-stage Bardenpho configuration. The study results will help to determine whether a seasonal nitrogen effluent limit of less than 5 mg/L can be feasibly achieved without the use of supplemental carbon, and to further assess how increased flow in the future might affect nitrogen loads. Plant operators will also gain operational experience and operational data that will be used to confirm the future process/technology selection and final design criteria for a full-scale treatment process.

2.3 Preliminary Cost Estimates and Estimated Nitrogen Load Reductions for Possible WWTF Upgrades to Meet and Effluent Limit of 5 or 3 mg/L

Table 2-1 presents preliminary cost estimates included in the Draft Facilities Plan that show the relative difference in the potential construction and maintenance costs involved with upgrading the WWTF to meet a 5 mg/L effluent limit instead of a 3 mg/L effluent limit. These cost estimates only pertain to the infrastructure needs for nitrogen control and do not include other facility upgrades that may be needed to address flow capacity and other physical improvements. The treatment needs and related costs are subject to change depending on the results of the pilot study. These cost estimates are based on 2012 dollars and do not reflect any future escalation due to inflation.

Based on this preliminary cost analysis, the added costs to meet an effluent limit of 3 mg/L instead of 5 mg/L is estimated to be approximately $650,000 per year. This includes approximately $325,000 in annual O&M costs and approximately $330,000 in added debt service for capital costs amortized over a 20 year period. Based on a present value comparison of Life Cycle costs over 20-year period, the difference in the two treatment levels could result in $9.4 million in added costs (Wright-Pierce 2012).

Table 2.1: Estimated Costs for WWTF Upgrades to Achieve an Effluent Limit of 5 and 3 mg/L

Process Configuration		Annual (O&M) Cost[1]	Capital Cost[1]	Annualized Capital Cost	Total Annual Cost	Life Cycle Cost Estimate[2]
4-stage Bardenpho (6 Aeration Tanks:	5 mg/L	$ 362,000	$ 8.7 M	$ 612,140	$ 971,140	$13.8 M
Same as above plus Biological Filter:	3 mg/L	$ 688,000	$ 13.4 M	$ 942,840	$1,680,340	$23.2 M
Difference		$ 326,000	$ 4.7 M	$ 330,700	$656,700	$9.4 M

Notes: [1]Facility upgrade cost estimates as presented by Wright-Pierce in the July 2012 Draft Wastewater Facilities Plan (Table 6-8 on page 6-34). The capital and annual O&M costs are presented in 2012 dollars. [2]Life Cycle costs are based on 20 yr. life cycle with an interest rate of 3.5 percent.

Table 2-2 presents the relative difference in the estimated nitrogen load reductions that would occur if the WWTF was upgraded to meet a 7-month seasonal average effluent limit of 5 or 3 mg/l as compared to the existing average seasonal discharge concentration of 8 mg/L at the current average daily discharge rate of 1.0 MGD.

Table 2.2: Estimated Difference in Annual Nitrogen Loads with Effluent Limits of 5 and 3 mg/L

Average Seasonal Effluent Limit	Conc. Difference (mg/L)	Conversion Factor	Daily Nitrogen Load (lbs/day)	Total N Load (7 month period)
5 mg/L	3 mg/L	8.34	25.0	5,254 lbs
3 mg/L	5 mg/L	8.34	41.7	8,757 lbs
Difference	2 mg/L	--	16.7	3,503 lbs

Notes: Load reductions are based on an equation, lbs/day = flow (mgd) x conc. (mg/L) x conv. Factor provided by Wright-Pierce 2012. Since the effluent limits are anticipated to be on 7-month rolling average the load reductions were only calculated for 7 month period, however, additional nitrogen reductions may occur for the rest of the year to a lesser extent. This analysis intended to provide a relative difference.

Based on this comparison of the expected load reductions for different WWTF upgrades, an additional 3,500 lbs/yr or 1.8 tons of nitrogen can be expected to be removed if the WWTF was upgraded to meet an effluent limit of 3 mg/L instead of 5 mg/L. As discussed in Section 5.0, it is anticipated that 3,500 lbs of nitrogen per year could be reduced more cost effectively using nonpoint source control measures within the watershed.

3.0 Review of Existing Water Quality Data

This section summarizes existing water quality data previously collected in the Oyster River watershed. Nearly all of the existing water quality data was generated from discrete grab samples collected at various locations by multiple organizations. Although grab sampling data can be highly valuable in assessing historical trends, it does not provide a complete assessment on how precipitation events might affect nitrogen concentrations and related loads in local streams. As part of the proposed Integrated Planning effort, the Town and UNH funded the Water Systems Analysis Group (WSAG) of the Natural Resources Department to conduct additional sampling using continuously recording nitrate sensors and data soundes to help provide a better understanding of how nitrogen concentrations and loads change spatially and over time as a result of precipitation events and seasonal influences. This data was also intended to help support the watershed modeling effort. In 2013, nitrate sensor data was collected was from late April to early December at several locations, however, estimates of nitrogen flux could not be fully established due to incomplete stage-discharge curve data at select locations. In 2014, an additional data is being collected to fill the flow data gaps and collect additional nitrogen concentration data. The results of this effort are anticipated to be available at the end of 2014.

3.1 Status of Great Bay & Local Water Resources in Oyster River Watershed

In 2009, NHDES established a draft water quality criterion 0.3 mg/L for nitrogen in tidal waters in order to fully support the designated uses of the Great Bay. NHDES had concluded that observations of increased algae growth, lower dissolved oxygen levels, reduced water clarity and light transparency, and greater macro-algae abundance were due to excessive nitrogen loading from point and nonpoint sources as these declining water quality conditions are often symptoms of nutrient enrichment. Shortly thereafter, NHDES listed the Great Bay Estuary and many of its sub-estuaries including the Oyster River estuary as impaired. More recently, in response to a legal challenge, a panel of national experts conducted a peer review of the data used to support this criteria and concluded that the available scientific data was not sufficient to clearly link nitrogen as the principal cause for the declining water conditions in the Great Bay. It is unclear at this time, how and whether the peer review results will affect EPA's requirements in future permit renewals and whether NHDES will develop new criteria for nitrogen or other pollutants that may be contributing to declining water quality.

3.2 Existing Water Quality Data in the Watershed

Existing water quality data has been collected by several volunteer and academic research groups at various locations, frequency and time periods. The primary groups collecting water quality data include the Water Quality Testing Committee of the Oyster River Watershed Association (ORWA), UNH's Water Systems Analysis Group, UNH's Water Resource Research Center (WRRC) and the Piscataqua Region Estuaries Partnership (PREP).
NHDES (PREP) Monthly Sampling Data in the Oyster River Collected at the Head of Tide.

The Piscataqua Region Estuary Partnership (PREP) collected monthly samples in the Oyster River main stem just upstream of the Mill Pond Dam (head-of-tide dam) along Route 108 between the years 2009 and 2011(DES Environmental Management System). Over this time period, over forty-three (43) samples were collected and analyzed for total dissolved nitrogen (TDN).

Table 3.1: Estimated Nitrogen Loads Based on NH PREP Monthly Data from 2008 to 2011

Watershed Location	Estimated Drainage Area (ac)	Median Annual Flow (cfs)[1]	Mean Total Dissolved N Conc. (mg/L)	Estimated Total Dissolved Nitrogen tons/yr	Estimated Total Nitrogen tons/yr	Percent of Total N Load
Oyster River at Mill Pond Dam	12,830	32.1	0.39	17.3	20.88	56%
Tidal Estuary Downstream of Dam	6,830	17.2	0.43	13.5	16.31	44%
Total Watershed	19,860	49.3	--	20.8	37.19	

Notes: [1]Median annual flow is based on the recorded annual flow during the 2008 to 2011 sampling period at the USGS Oyster River gauging station and not the entire historical record. The flow during this period was generally higher than the historical average flow over the long term records.

Oyster River Watershed Association Volunteer River Assessment (VRAP) Data

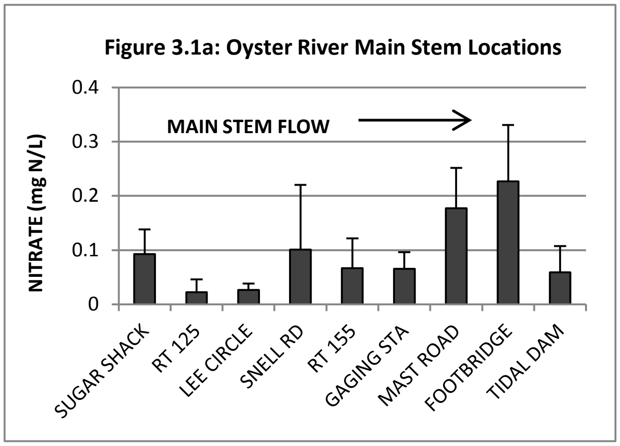
The Oyster River Watershed Association (ORWA) has been collecting water quality data since 2001 as part of the NHDES Volunteer River Assessment Program (VRAP). The group has collected data from over twenty different sites along the main stem and tributaries mostly within the freshwater portion but several sites are on tributaries that drain to the tidal portion namely Reservoir Brook, Beards Creek and Johnson Creek. The data is collected on a monthly basis during the growing season months, mainly April through October. The primary data routinely collected consists of field measurements of physical parameters including pH, temperature, dissolved oxygen, turbidity and specific conductance. During specific years, specifically 2001, 2002 and 2005 to 2010 that vary somewhat by location, water quality samples were collected for laboratory analysis of specific ions including chloride, sodium, phosphorus in phosphate, nitrogen in nitrate, ammonium, and dissolved organic nitrogen (DON), and total dissolved nitrogen (TDN). The chemical analyses were done by the New Hampshire Water Resources Research Center (NH WRRC) laboratory at the University of New Hampshire.

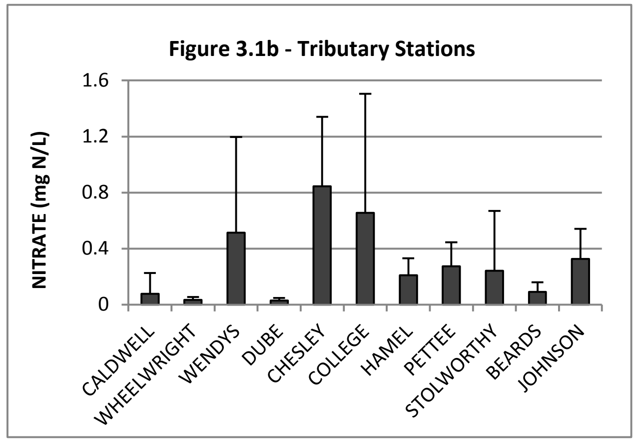
The ORWA Water Quality Committee recently completed a report summarizing all of their data collected between years 2001 through 2011 (Colbert, et. al, 2014). The following provides a brief summary of the data focusing on the various forms of nitrogen that analyzed at each of the stations. The graphs below were excerpted from the ORWA report using bar graphs which show the historical average concentration for each parameter at each sampling station as represented by the top of the bar the with on standard deviation shown by the added “whisker” above the bar. Refer to the full report for a more detailed discussion of the data analysis and sample location maps.

Nitrate- N

Figures 3.2a and 3.2b compare the historical mean nitrate concentrations for the Oyster River main stem stations and tributary stations, respectively. The concentrations in the main stem, in general, are considerably lower than those measured in the tributary stations. Most of the main stations had historical means below < 0.1 mg/L except for somewhat higher levels at the Mast Road (Route 155A) and the Footbridge Station below the UNH drinking water reservoir. Nitrate-N levels measured at three tributary sites including Wendy’s, College, and Chesley Brooks had historical mean values generally above 0.4 mg/L and peak concentrations above 1.0 mg/L. Chesley Brook had the highest mean value and College Brook had standard deviation. The higher levels would appear to be indicative of nearby nitrogen source contributions. For Chesley Brook, the likely sources would be related to either agricultural sources or septic systems or both.

Figure 3.1 a & b: Observed Mean Nitrate-N Concentrations (mg/L) for Oyster River Stations



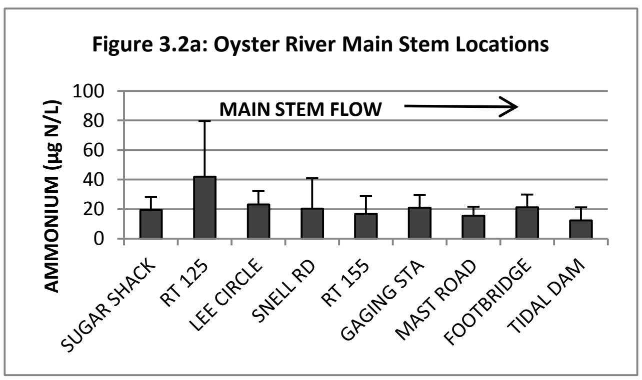


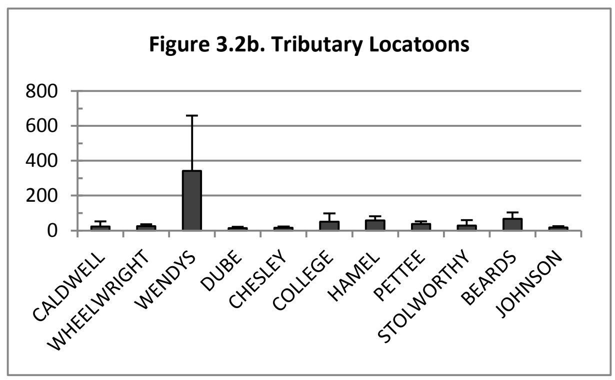
Source: Oyster River Watershed Association; Water Quality of Oyster River, 2001-2011, February 2014, www.oysterriver.org

Ammonia-N

Nitrogen in the form of ammonium (NH_4^+) is generally the least stable in the environment is readily oxidized and converted nitrate and nitrogen oxide gas. Thus, it is typically measured at much lower concentrations than other nitrogen forms unless samples are collected in close proximity to the source (Dubrovsky et al. 2010). The ammonia-N concentrations measured at Oyster River main stem sites were very low and did not vary much except at the Route 125 station (just south of Lee Traffic Circle). Since the historical mean was based on a small sample set (n=6) collected at this location, the average could be skewed by one unusually high value could have been an anomaly.

Figure 3.2 a & b: Observed Mean Ammonia-N Concentrations for Oyster River & Tributary Stations





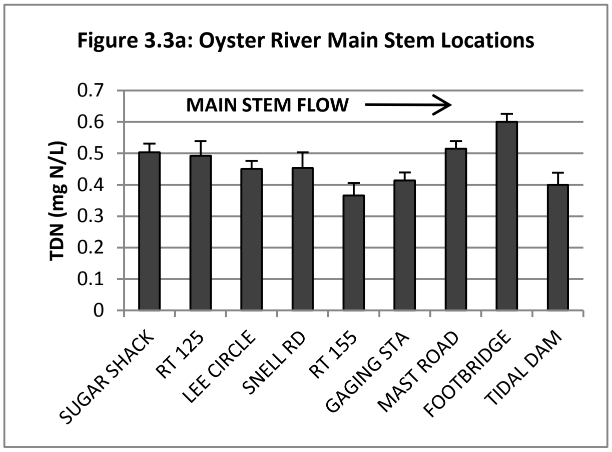
Source: Oyster River Watershed Association; Water Quality of Oyster River, 2001-2011, February 2014, www.oysterriver.org

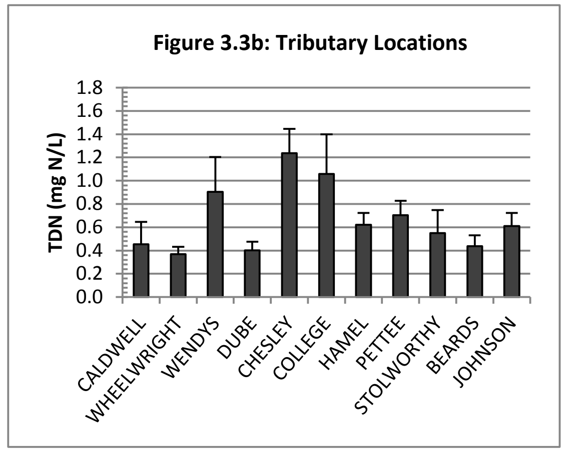
The considerably higher mean ammonia concentrations measured at the Wendy's Brook station, however, relative to the other stations also suggest there is a potential human or animal waste related source nearby.

Total Dissolved Nitrogen (TDN)

The reported mean total dissolved nitrogen (TDN) for sites along the Oyster River main stem generally ranged from 0.35 to 0.5 mg/L with the higher range values (0.5 to 0.6 mg/L) measured at the Mast Road and Footbridge sites. TDN levels appear to drop back down downstream near the Tidal Dam where the historical mean was about 0.4 mg/L. A similar pattern occurs with the nitrate-N levels shown above. The downstream decline may suggest some denitrification may be occurring in the impoundment behind the Mill Pond dam. Similar to the nitrate levels, Wendy's, Chesley and College Brook had higher mean total dissolved nitrogen levels relative to other tributaries.

Figure 3.3 a & b: Observed Mean Dissolved Nitrogen Conc. for Oyster River & Tributary Stations





Source: Oyster River Watershed Association; Water Quality of Oyster River, 2001-2011, February 2014, www.oysterriver.org

Bacteria

Bacteria samples were also analyzed, specifically *E. coli* bacteria, at most of the same twenty (20) main stem and tributary locations. The minimum number of samples collected per station ten (10) but 60 percent of the stations had more than forty (40) samples collected. Samples were generally taken between 6 and 11 am using sterilized bottles and stored on ice for delivery to the DES laboratory in Concord NH for analysis prior to noon of the day samples were taken.

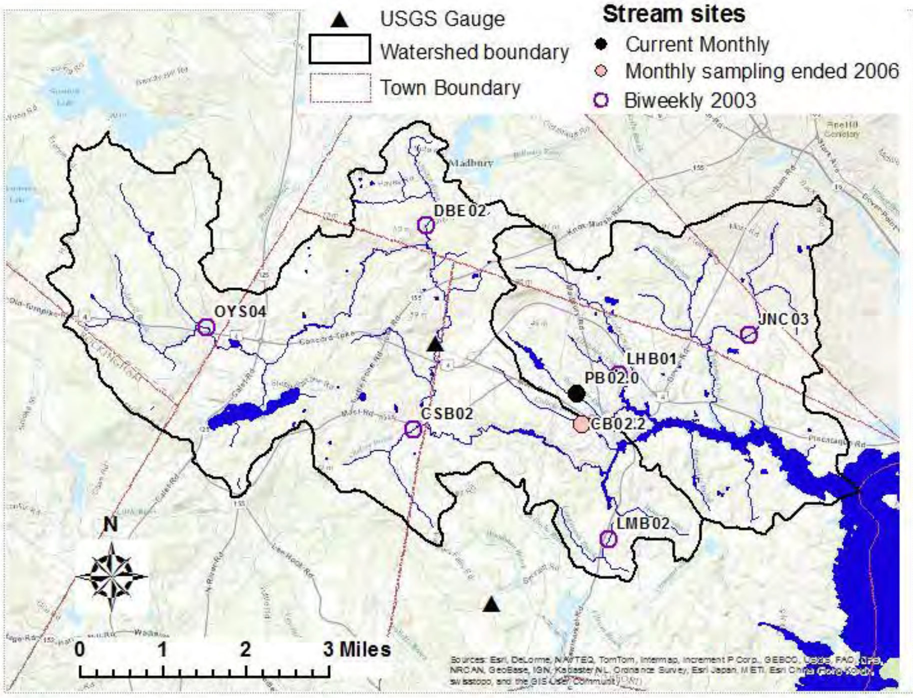
To meet state water quality standard for Class B waters, E. coli levels should remain below 406 counts/100 ml. All sites had at least 6 percent of observations above Class B standards (> 406 cts/100 ml) and seven of nine main stem sites reported at least one value > 1,000 cts/100 ml. While none of the main stem sites show chronically elevated *E. coli* levels, three sites located between Routes 155 and 155A (Mast Road) over a river length of about 2.5 miles near the Lee-Durham town line, had more than 10 percent of the samples with levels above 1,000 cts/100 ml. It is unclear why this section of river would have higher bacterial levels compared to other main stem sections.

Two tributary sites, Wendy's Brook and College Brook, reported having consistently higher bacteria levels. In College Brook, sixty-five percent of the samples collected did not meet Class B standards and 40 percent had levels above 1,000 cts/100 ml. For Wendy's Brook, sampled approximately ¼ mile below the Lee Traffic Circle, more than 90 percent of samples exceeded the Class B standard, and 75 percent of the samples exceeded 1,000 cts/100 ml. The elevated *E. coli* counts in Wendy's Brook, coupled with the higher levels of nitrogen found at this site, especially in the form of ammonia, suggest that there is a fairly direct and chronic contamination source that is most likely related to faulty septic tank since there are no centralized sewer collection systems in this area.

3.3 UNH Water Resources Research Center

The UNH Water Resources Research Center (WRRC) under the direction of Dr. William McDowell and Michelle Daley has also collected baseline nitrogen data at multiple locations throughout the watershed as part of a variety of projects with varying objectives. This data was recently compiled and presented in Draft Interim Report entitled Nitrogen Assessment for the Oyster River Watershed prepared by Michelle Daley, December 2013. The principal sampling locations are shown in Figure 3.4 below.

Figure 3.4: UNH WRRC Sample Sites for Various Tributary Streams and Oyster River Main Stem



The following provides a summary of the WRRC's sampling data, including estimated flow-weighted mean concentrations for various forms or nitrogen and estimated nitrogen loads for sampling locations in key tributary streams as well as a headwater location in the Oyster River (OYS-04). It should be noted that the sampling time period and sampling frequency vary somewhat for the various stations as presented in Table 3.2. The data was derived entirely from grab samples.

Table 3.2: Sampling Information for Stations in the Oyster River Watershed by the UNH WRRC

Stream	Station ID	Start Date	End Date	Sampling Frequency	Drainage Area km^2	Drainage Area acres
College Brook	CB02.2	5/17/2000	9/22/2006	Monthly	2.028	501
Chesley Brook	CSB02	8/18/2001	8/15/2009	Bi-weekly 2003 with a few additional ORWA samples[1]	3.979	983
Dube Brook	DBE02	6/29/2002	8/15/2009	Bi-weekly 2003 with a few additional ORWA samples[1]	3.417	844
Johnson Creek	JNC03	8/18/2001	8/12/2009	Bi-weekly 2003 with a few additional ORWA samples[1]	5.414	1338
Littlehale Brook	LHB01	1/14/2003	12/19/2003	Bi-weekly 2003	0.907	224
Long Marsh Brook	LMB02	3/3/2003	12/19/2003	Bi-weekly 2003	1.271	314
Oyster R-headwaters	OYS04	1/14/2003	12/19/2003	Bi-weekly 2003	11.747	2903
Pettee Brook	PB02.0	5/17/2000	9/30/2009	Monthly	2.542	628

Notes: [1]Grab sampling data supplemented with ORWA VRAP data. All data compiled and provided by UNH WRRC personnel.

Table 3.3 presents a summary of the estimated flow-weighted mean (FWM) concentrations (mg/L) for various nitrogen forms for each of the stations. The flow-weighted concentrations were based on the average daily discharge recorded on the day of sampling at the Oyster River gauging station. The dissolved inorganic nitrogen

(DIN) concentrations are comprised of nitrate-N and ammonia concentrations and are generally considered to be urbanization and greater human activity. Streams with the higher TDN concentrations (i.e., > 0.4 mg/L) generally had much higher nitrate concentrations and lower dissolved organic nitrogen (DON) concentrations. Streams with relatively low TDN concentrations, including Dube Brook, Long Marsh Brook and the Oyster River headwaters generally had higher DON concentrations and lower DIN concentrations. These streams represent the less developed sub-watersheds in the larger watershed.

Table 3.3: Flow-Weighted Mean Concentrations[1] For Streams in the Oyster River Watershed

Stream	Nitrate-N (NO_3) mg/L	Ammonium (NH_4) mg/L	Dissolved Inorganic Nitrogen (DIN) mg/L	Dissolved Organic Nitrogen (DON) mg/L	Total Dissolved Nitrogen (TDN) mg/L
College Brook	0.85	0.05	0.90	0.16	1.04
Chesley Brook	0.46	0.03	0.48	0.28	0.76
Dube Brook	0.05	0.02	0.07	0.30	0.37
Johnson Creek	0.31	0.03	0.34	0.30	0.63
Littlehale Brook	0.29	0.04	0.33	0.14	0.47
Long Marsh Brook	0.07	0.03	0.10	0.25	0.35
Oyster R- headwaters	0.05	0.04	0.09	0.20	0.29
Pettee Brook	0.40	0.08	0.48	0.23	0.68

Notes: [1]Flow–weighted mean concentrations were calculated using the average daily flow rate measured at the Oyster River gauging station on the day of sampling. Source: UNH WRRC Draft Interim Report on the Nitrogen Assessment for Oyster River Watershed, Dec 24th, 2013.

Table 3.4 presents estimated total dissolved nitrogen and total nitrogen load estimates (lbs/ac/yr) based on UNH's WRRC sampling data collected in each of the subwatersheds. The load estimates were calculated by multiplying the flow-weighted mean concentrations by the median average annual runoff volume as measured by the Oyster River gage station and then area adjusted for each drainage area.

Table 3.4: Estimated Nitrogen Loads (lbs/ac/yr) at Each Station based on the Sampling Data

Stream	DON (lbs/ac/yr)	DIN (lbs/ac/yr)	Total Dissolved Nitrogen (lbs/ac/yr)	Total Nitrogen (lbs/ac/yr)
College Brook	0.890	4.879	5.769	6.75
Chesley Brook	1.523	2.618	4.141	4.84
Dube Brook	1.633	0.374	2.007	2.35
Johnson Creek	1.622	1.844	3.465	4.05
Littlehale Brook	0.772	1.797	2.569	3.00
Long Marsh Brook	1.360	0.564	1.924	2.25
Oyster R- headwaters	1.113	0.469	1.583	1.85
Pettee Brook	1.256	2.629	3.885	4.35

Notes: Total Dissolved N loads were calculated by multiplying the flow weighted mean concentration by the median average annual runoff volume (24 inches) based on gaging station data recorded between years 2000 and 2009. Total nitrogen loads are calculated based on TN to TDN ratio of 1.17 based on UNH WRRC data observed in Lamprey River watershed

In summary, the historical data collected by UNH WRRC personnel show a wide range of total DIN and DON concentrations in the Oyster River watershed. Higher DIN concentrations are more prevalent in the more developed or urbanized subwatersheds. College Brook has the highest estimated total nitrogen yield at approximately 6.75 pounds per acre followed by Chesley Brook, Pettee Brook and Johnson Creek which have estimated yields generally between 4.0 to 5.0 pounds per year based on the monitoring data. In minimally developed watersheds such as in the Oyster River headwaters, Dube Brook and Long Marsh Brook, the expected total nitrogen yield is closer to 2.0 lbs/ac/yr. This estimated yield data is used to compare to the model results of estimated nitrogen loads discussed in Section 4.5 of this report.

3.4 UNH Water Systems Analysis Group

To support the current Integrated Planning and Permitting approach, the UNH Water Systems Analysis Group (WSAG) is collecting additional baseline nitrogen data at key locations within the watershed. The key difference in this sampling effort is the use of continuous data loggers equipped with nitrate-N sensors to gain a better understanding of the potential temporal and seasonal fluctuations of nitrate concentrations and how these fluctuations may affect annual nitrogen yields in key watersheds. The continuous data is supplemented with periodic grab sampling to obtain more detailed information on the various forms of nitrogen and the potential correlation with surrogate parameters. The sampling was initiated in early summer of 2013 continued through November 2013 and is anticipated to be restarted in April 2014.

A Draft Summary Report prepared in December 2013 (WSAG 2013) revealed some preliminary findings but also had various data gaps, especially with respect to flow rating curves at each sampling station. These data gaps will be addressed with additional flow data anticipated to be collected in 2014. This additional flow data and chemistry data will help to develop more conclusive findings. The continuous nitrate sensor data has shown that there can be both an initial flushing and dilution effect on nitrate concentrations during storm events. The dilution effect appears to initially lower nitrate concentrations below that typically observed during base flow conditions and also occurs for a longer period of the storm relative to the flushing effect. This might suggest that the net effect of wet-weather periods could result in lower flow weighted mean concentrations than that observed if just based on dry-weather grab sampling data. This could have a significant impact on estimating annual nitrogen loads. Another initial finding suggests that base flow and the period of peak flow during storm events are both lower in flashy or urbanized streams compared to that measured at stream gauges in larger streams. Using local flow measurements in flashier streams instead of extrapolating from gauging data may result in lower annual nitrogen load estimates. These preliminary findings will need to be evaluated further based on additional data being collected in 2014.

3.5 General Summary of Findings in Review of Existing Water Quality Data

The following represent some general findings or interpretations of the existing water quality data:

1. Sampling within the Oyster River main stem indicates relatively low nitrogen concentrations observed in the upstream headwater portions of the watershed and concentrations tend to increase in the middle sections between Route 155 and 155A near the Lee/Durham town line and then decrease again near the Mill Pond dam. The downstream decline may be due to denitrification processes occurring in the Mill Pond.

2. Several tributaries tend to have relatively higher total dissolved nitrogen concentrations and as a result higher estimated loads including College, Chesley and Reservoir (Pettee) Brook compared to other streams.

3. Streams with higher TDN concentrations also tended to have elevated bacterial levels relative to other streams potentially collaborating a nitrogen source related to animal or human waste.

4. Streams with more urbanized or developed watersheds tend to have higher total dissolved nitrogen concentrations.

5. The continuous monitoring nitrogen and flow data currently being collected by the WSAG group will help to either refine or validate current nitrogen load estimates in select streams. This data is expected be available by end of 2014.

4.0 Modeling of Nonpoint Sources in the Oyster River Watershed

4.1 Introduction

In order to identify effective management measures to reduce pollutant loads, it is essential to develop a detailed understanding of the relative pollutant contributions from the various nonpoint sources throughout the watershed. This is typically accomplished through a combination of model simulation and analysis of monitoring data. There is a wide variety of models available that use various methods to simulate the fate and the transport of pollutant source inputs and exports within natural environment. Model selection can depend on a wide range of factors including model complexity, data needs, development time, source types and desired outcomes. Regardless of model used, the model estimates should be reasonably close to measured data in order to have confidence in the model results.

For this study, a modified version of the Nitrogen Loading Model (NLM) was used. The NLM model was previously used by New Hampshire Department of Environmental Services (DES) as part of their Great Bay Nitrogen Nonpoint Source Study (GBNNPSS). For the larger Great Bay, DES concluded that the model had a margin of error or level of accuracy of +/-13 percent based on a comparison of model load estimates with measured data in seven major watersheds draining to the Great Bay. DES stated that the model was most appropriate for large watersheds and model accuracy would likely decline when used in smaller watersheds. Additional information on DES' model assumptions and results for the Great Bay region can be found in the DES GBNNPSS Reports released in June 2014.

A principal advantage of the NLM model is that it generates annual nitrogen load estimates for each of the principal nitrogen sources (i.e. atmospheric deposition, chemical fertilizer, animal waste and human waste) within each land use type. For example, for residential areas, nitrogen contributions are tracked by specific sources within this land use such as septic systems, lawn fertilizer, pet waste and impervious surface rather than combining the inputs from each of these sources into a single export coefficient to represent the entire land use area, which is typically done in many models. This level of detail in model output allows for greater flexibility in identifying specific management measures that will affect each contributing source rather than just a broad land use type.

As described in more detail below, the Project Team modified several model components, utilized higher resolution data and revised key assumptions with the assistance of a Technical Advisory Committee (TAC) comprised of UNH researchers, DES personnel and a local agricultural specialist with the Natural Resources Conservation Service. These changes improved the model functionality and the model estimates for the various sources. On a watershed and sub-watershed basis, the model estimates were reasonably close to the calculated nitrogen load estimates derived by others using measured data. This comparison is described in more detail in Section 2.5.

4.2 Watershed Description

The Oyster River watershed comprises approximately 31 square miles or 19,660 acres of area with two-thirds of the watershed draining to a point above the head of tide dam (Mill Pond Dam) and the other third draining directly to tidal estuary portion that leads to the Great Bay (Figure 4.1). The principal headwaters originate in Barrington along the Route 4 corridor west of the Lee Traffic Circle and the main stem flows east and southeast through Madbury, Lee and then Durham before emptying into the Great Bay near the entrance to Little Bay. Its overall length is approximately 17 miles with 14.1 miles above the head of tide dam (Mill Pond Dam) and 2.9 miles that consists of tidal estuary from Durham to the Great Bay. The Oyster River represents the smallest of seven major tributaries that drain into the Great Bay estuary.

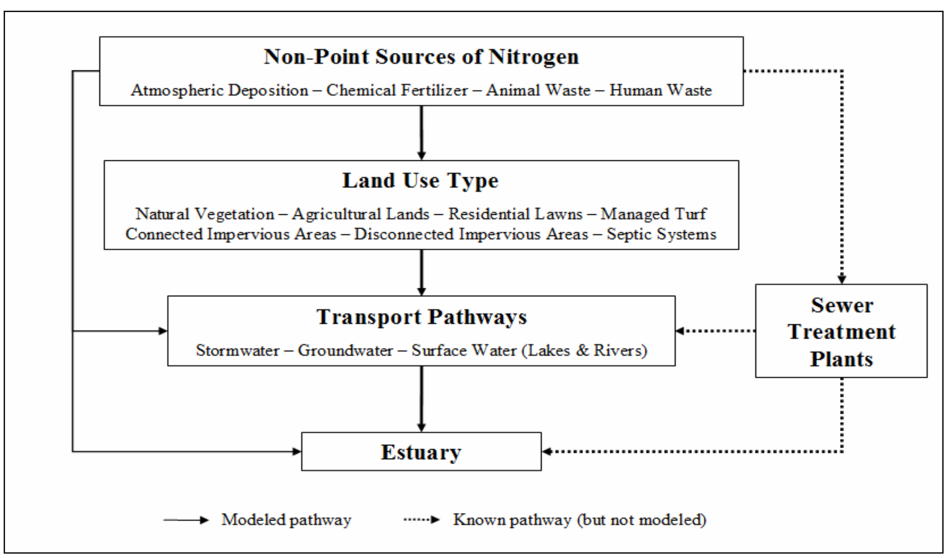
The watershed contains portions of six communities with Durham comprising the highest percentage of land area at 38 percent, followed by Lee (24%), Madbury (17%), Barrington (15%), Dover (5%) and Nottingham (2%). The University's main campus area is also located within the watershed along with a large portion of its agricultural operations and fields. Nearly three-quarters (73 percent) of the watershed is undeveloped or is natural vegetated state with various local pockets of densely developed residential and/or commercial areas. Much of the more densely developed areas center around the Durham downtown area and the UNH main campus as well as commercially developed areas near the Lee Traffic Circle along Route 4. Durham's downtown area has seen a recent spike in redevelopment activity consisting of a mixed use of residential and commercial space.

4.3 Model Background

The Nitrogen Loading Model (NLM) was originally developed by Valiela et al. (1997) to estimate nonpoint source nitrogen loads to the Waquoit Bay in the Cape Cod region. The model has since been used to conduct similar nonpoint source evaluations for other embayments including the Waquoit Bay, in Massachusetts (Valiela et al., 2000), Barnegat Bay in New Jersey (Bowen et al., 2007) and in seventy-four (74) small embayments in southern New England (Latimer and Charpentier, 2010). In these studies, the model was used to develop source load estimates on a watershed basis that were ultimately used to identify and select management measures to achieve nitrogen load reductions from the major sources.

Figure 4.2 illustrates the nitrogen load estimation processes included in the NLM model accounting for the primary nitrogen source inputs, the effects of land use types and transport pathways that ultimately affect the amount of nitrogen that is delivered to estuary. There are four major sources of nitrogen including atmospheric deposition, chemical fertilizers, animal waste and human waste discharged through septic systems. How much nitrogen is generated and ultimately delivered to an estuary largely depends on the land use types, amount of development and human activity within the watershed. Atmospheric deposition is a major contributor of nitrogen and can be delivered directly to the estuary or indirectly through groundwater or stormwater flow from major land uses and sources. The NLM model does not include loads from wastewater treatment facilities (WWTF) but is included in the diagram to reflect the significance of WWTF contributions to the total nitrogen load relative to nonpoint sources.

Figure 4.2: Schematic of the Nitrogen Loading Model Inputs and Processes



Source: DES Great Bay Nitrogen Non-Point Source Study. Draft Public Review Copy, May 16, 2013. R-WD-13-

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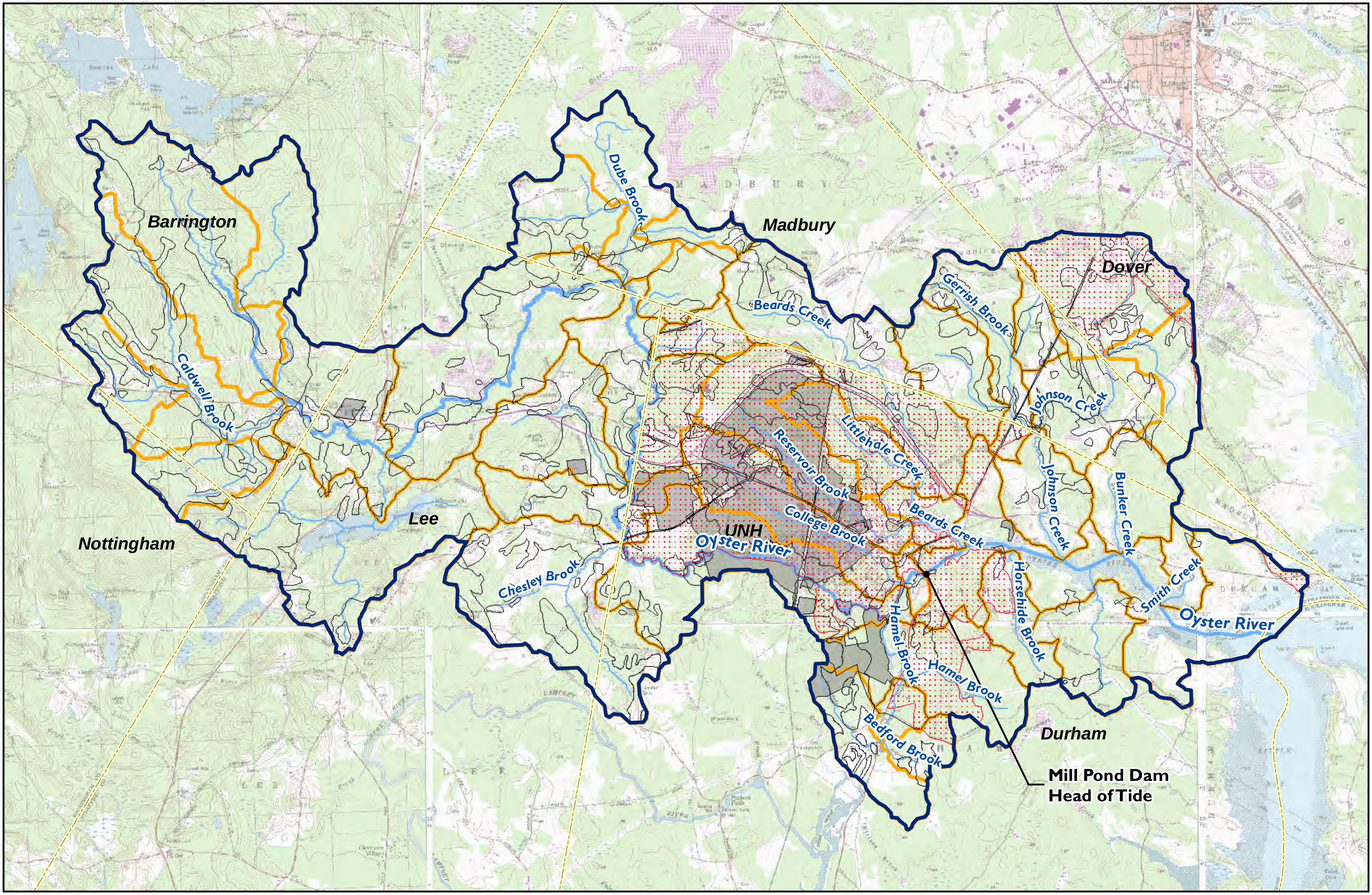

Legend

- Analysis Unit Unit (n=240)
- UNH Property Boundary
- MS4 Area
- Oyster River
- Tributary to Oyster River
- Watershed Boundary
- Subwatershed Boundary
- Municipal Boundary

0 5,500 11,000 Feet

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Figure 4.1
Map of Analysis Units within the Oyster River Watershed
Oyster River Watershed
Durham, New Hampshire

4.4 Initial Model Inputs and Assumptions

Table 4.1 summarizes the major source inputs and land use types used in the model to develop nitrogen load estimates for each analysis unit. The project team used available 2010 high-resolution, land use data along with geo-processing tools in ArcGIS to calculate the land use areas and source inputs for each analysis unit. The primary analysis units included the towns, UNH campus area, subwatershed areas and regulated MS4 areas within the overall Oyster River watershed.

Model scripts were developed within the ArcGIS program to automate and preserve the geospatial and mathematical equations used to manipulate existing datasets to produce the required input data for the model. The resulting GIS processed, model input data was then imported into Excel spreadsheets that contained source load rates, pathway partitioning coefficients and delivery factors. VHB developed additional model scripts within the spreadsheet using Visual Basic for Applications (VBA) to perform the loading calculations while preserving the analysis unit base information (jurisdiction, sub-watershed, regulated MS4 areas) land use, source and pathway. These raw results were then summarized by each of the primary categories to help define the loads within the overall watershed. Additional information on model data inputs, modifications and assumptions can be found in Appendix D of this Report.

Table 4.1: Listing of Nitrogen Sources and Land Use Types Used in the Oyster River NLM Model

Source / Land Use Inputs	Sub-Unit
Lawn	Residential Lawns UNH Lawns
Agriculture	Corn, Apples, Hay, UNH Corn & Hay fields Fertilized with Manure, Other Agricultural fields (not fertilized)
No. of Septic Systems	Septic systems within 200 meters of the tidal estuary
	Septic systems outside 200 meter buffer but still in the direct drainage area of the tidal estuary Septic systems outside of 200 meter buffer and outside of the direct drainage area of the tidal buffer area
Natural Vegetation Area	Natural Vegetation Area UNH Grasslands (grassy areas that are not fertilized)
Impervious Cover	Connected Impervious Cover Disconnected Impervious Cover- Medium Density Residential Disconnected Impervious Cover- High Density Residential Disconnected Impervious Cover- UNH Campus Disconnected Impervious Cover- Commercial
Open Water Area	Estuary, Lakes and Ponds
Managed Turf	Golf Courses Athletic Fields UNH Athletic Fields Parks /School Recreational Fields
Animals	No. of Cows, Horses and Dogs

Table 4.2 summarizes the local and regional data sources to refine and quantify watershed conditions and sources to estimate nitrogen inputs.

Table 4.2: Local Data Sources Used to Quantify Land Uses & Nitrogen Sources in the Watershed

Model Input	Description of Available Data Source (s)
General Land Use Areas	2010 Community Technical Assistance Program (CTAP) data - digitized land use areas (Strafford Regional Planning Commission) and UNH campus mapping
Impervious Cover Area	2010 high-resolution (1-meter) GIS impervious cover data layer for Durham, Lee, Madbury and UNH Campus. IC data for other watershed Towns was based on the 2010 30-meter resolution GIS data.
Directly Connected vs. Disconnected Impervious Cover Areas	Durham and UNH storm drain mapping data to estimate directly connected and disconnected impervious surfaces in Durham area.
Sub-watershed Boundaries	NHDES Geologic Survey watershed boundaries included in the Piscataqua Region Stressed Basin Mapping data plus elevation data included in LIDAR for key tributaries in Durham/UNH area including College, Reservoir & Littlehale Brooks.
Septic System Counts	Based on digitized buildings located outside the mapped sewered area to determine the number of septic systems in the watershed/sub-watersheds and number of homes within or outside of 200 meters of the tidal estuary.
Stormwater / Groundwater Partitioning Pathway Coefficient for Disconnected IC & Vegetated areas	Use pathway partitioning coefficients based on land cover and hydrologic soil group and varying groups of disconnected impervious cover.
Impervious Cover Nitrogen load Rate	Impervious cover load rate included in the 2013 DRAFT NH MS4 Stormwater permit: Appendix H: Attachment 1.
Lawn Area	Actual lawn area within Durham was delineated based on high-resolution land use data, impervious cover mapping, and LiDAR data. UNH Campus Lawn area was based on UNH Campus base maps.
Percentage of Lawn Area assumed to be treated with Fertilizer	UNH Survey Center: Resident Survey on Fertilizer Use and Practices, Nov. 2013.
Agricultural Fields Assumed to be Treated with Fertilizer	Local knowledge and input provided by NRCS Local Agricultural Specialist

4.4.1 Model Revisions Based on TAC Input

Following an initial modeling analysis, the project team established a Technical Advisory Committee (TAC) to evaluate the representativeness of the input data, assumptions and subsequent model results. The TAC was comprised of UNH researchers and DES personnel who are principally involved with nitrogen research as well as a representative from the Natural Resource Conservation Service (NRCS) who had local knowledge of the agricultural practices and fertilizer usage in the watershed. The modeling approach and assumptions were discussed in three separate TAC meetings held in October and November of 2013.

Based on TAC input, data inputs and assumptions were revised to better reflect local conditions and the potential effect of these source/land use types within the watershed. One major change involved revising the stormwater/ groundwater partitioning coefficients using mapped soils data to better reflect the effect of soil type on rainfall/ runoff partitioning for disconnected impervious areas and vegetated surfaces. The default model used a uniform partitioning coefficient that assumed 12 percent of the applied or deposited nitrogen on all vegetated land use cover types and disconnected impervious areas traveled via stormwater and the other remaining 88 percent infiltrated to the groundwater. This approach did not account for effects of different soil types and levels of imperviousness on the stormwater/groundwater relationship and, thus, resulting in relatively low nitrogen load estimates from impervious cover areas, which accounted for only 6 percent of the overall watershed load initially.

In addition, based on input from a local NRCS agricultural specialist, the amount of existing hay fields initially assumed to be fertilized was reduced from an initial estimate of 50 percent of the field area to 25 percent of the identified field area (D. Wright, personal communication, Jan. 2014). In NHDES's most recent GBNNPS model report (released June 16, 2014), NHDES reduced the amount of hay field assumed to be fertilized to 10 percent of the total hay field area. In the end, the project team decided not to revise the model assumptions further as the potential net effect of revising this assumption is likely to account for less than 3 percent of the overall nitrogen load estimate and, more importantly, management measures recommended in Section 5 of this report intentionally did not target agricultural sources on private lands and only focused on UNH's agricultural operations.

In conjunction with this project, the UNH Survey Center conducted a random telephone survey of Durham residents in the fall 2013. Based on the results of this survey, the amount of residential lawn area initially assumed to be treated with fertilizer was reduced from 64 to 45 percent to better reflect current lawn fertilizer practices by Durham residents (see Survey Summary Report in Appendix B).

Researchers at the UNH Stormwater Center suggested that the initial nitrogen load rate for impervious surfaces appeared too low resulting in lower load estimates compared to that has been observed in sampling data from parking lots. The initial model values were based on measured regional atmospheric deposition rates and did not fully account for other potential localized sources such as vehicle emissions, tire byproducts, sediment accumulation and perhaps stormwater run-on from adjacent vegetated surfaces. It was suggested that intensity of use and daily vehicle traffic volumes were major factors affecting nitrogen levels in parking lot and roadway runoff based on the results of recent studies expressed in the literature and specifically a USGS study conducted for MassDOT where roadway runoff was sampled from varying roadways (Smith and Granato, 2010). In the end, the model load rate for impervious cover was increased to 14.1 lbs/ac/year from 7.0 lbs/ac/yr. The higher load rate is consistent with the suggested load rate included in the 2013 Draft MS4 Stormwater General Permit for New Hampshire (Appendix H; Attachment 1). This higher initial load rate was used for all impervious surface types and did not distinguish between impervious surfaces associated with roof tops, roadways and parking lots.

The following lists the principal changes to the model assumptions:

1. The percentage of hay field acres assumed to be fertilized was reduced from 50 percent to 25 percent of the total hay field area in the watershed based on information provided by NRCS.
2. The surface water/groundwater pathway partitioning coefficients were revised for vegetated, pervious areas including lawns, agricultural fields, natural vegetation and disconnected impervious cover based on soil type and estimated imperviousness.
3. As described above, the annual nitrogen deposition rates on impervious cover surfaces were essentially doubled to reflect the higher nitrogen loads that haven reported in recent sampling studies from various impervious surfaces and be consistent with the suggested the nitrogen areal load estimate included in the 2013 Draft MS4 Genera Permit for impervious cover.
4. The amount of residential lawn area assumed to be treated with chemical fertilizer was reduced from 64 to 45 percent of the lawn area based on results of a recent residential survey.

4.5 Modeling Results

The Oyster River watershed model estimates of nitrogen loads from nonpoint sources are summarized below. The results are presented by jurisdiction, land use and source type which are key factors to be considered in selecting future management measures and their potential effectiveness. The estimated loads are also presented by sub-watershed area to allow comparison to measured data and prioritization of potential "hot spot" analysis.

4.5.1 Estimated Loads by Jurisdictional Boundary

The model setup and framework allows for comparisons of estimated average annual nitrogen loads associated with various jurisdictions including the Town of Durham and UNH Campus area. Table 4.4 presents the estimated nitrogen loads for each community in the watershed and a breakdown of the estimated load originating from within regulated MS4 areas within the watershed. The total watershed load associated with nonpoint sources is estimated to be 73,440 pounds (36.7 tons) per year. This estimated load compares favorably with the estimated load based on measured water quality data presented in Section 4.5 and discussed further below.

Sources located within the Town of Durham and UNH campus area are estimated to contribute approximately 35,000 pounds or 17.5 tons of nitrogen representing 47 percent of the total estimated nonpoint source nitrogen load for the Oyster River Watershed. Nonpoint sources located within Madbury and Lee are estimated to contribute approximately 16 and 23 percent of the total estimated watershed load, respectively. Durham's and UNH's estimated share of the delivered nitrogen load is higher than their corresponding percentage of the total watershed area mainly due to the higher density of sources within the urbanized areas of campus and downtown areas as well as due to the UNH's agricultural facilities.

Table 4.3: Model Load Estimates for Each Jurisdictional Area within the Watershed

	Estimated Delivered Nitrogen Load		Percent of Estimated Load from an	Portion of Watershed Area	
Town	(lb/yr)	(%)	MS4 Area*	Area (ac)	Percent
Durham	26,500	36%	44%	6,220	32%
UNH Main Campus Durham	8,500	11%	97%	1,360	7%
Lee	14,420	20%		4,590	23%
Madbury	9,830	13%		3,160	16%
Barrington	7,410	10%		2,890	15%
Dover	4,610	6%	65%	880	4%
Nottingham	1,330	2%		320	2%
Newington	90	0%		10	0%
NHDOT w/in MS4 area	740	1%	100%	190	1%
Total	73,440			19,660	

4.5.2 Estimated Loads by Land Use and Source Type

Table 4.4 and Figure 4.2 present the estimated nitrogen loads by source type for Durham, UNH and the Oyster River Watershed. Table 4.4 also includes a breakdown of initial source load estimates for each source compared to the estimated delivered load to Oyster River Estuary.

The model results suggest that atmospheric deposition (including that from impervious cover), chemical fertilizer, and septic systems contribute approximately 40, 28 and 20 percent of the overall watershed load, respectively. Another 12 percent is estimated to be due to animal waste including dogs, cows and horses (including UNH liquid manure fertilizer). Overall, approximately 26 percent of the total nitrogen estimated introduced into the watershed is estimated watershed to be delivered to the estuary. This is similar to that reported by Daley et al., 2010, in the nearby Lamprey River watershed where approximately 24 percent of the total nitrogen estimated to enter into the watershed was estimated to be delivered to the downstream estuary and the remaining 76 percent was considered attenuated in the watershed based on measured data. These results were based on sampling data collected in a suburban-type sub-watershed with approximately 10 percent impervious cover.

For sources associated with the Town of Durham (excluding UNH), fertilizer use on lawns and agricultural fields represents 30 percent (8,020 pounds) of the estimated nitrogen load. Another 18 percent of the Town's estimated total nitrogen load is from septic systems. Atmospheric deposition represents the largest source accounting for approximately 44 percent of the estimated load. This is mainly due to the large amounts of connected impervious surfaces (i.e. closed drainage system) which allows for efficient delivery and partly because of the relatively larger surface water area associated with the tidal estuary located within the Town limits. All of the atmospheric nitrogen that falls directly on surface water areas is assumed to be delivered directly without any attenuation. A more detailed discussion of the estimated source loads by land use and land cover areas is provided below.

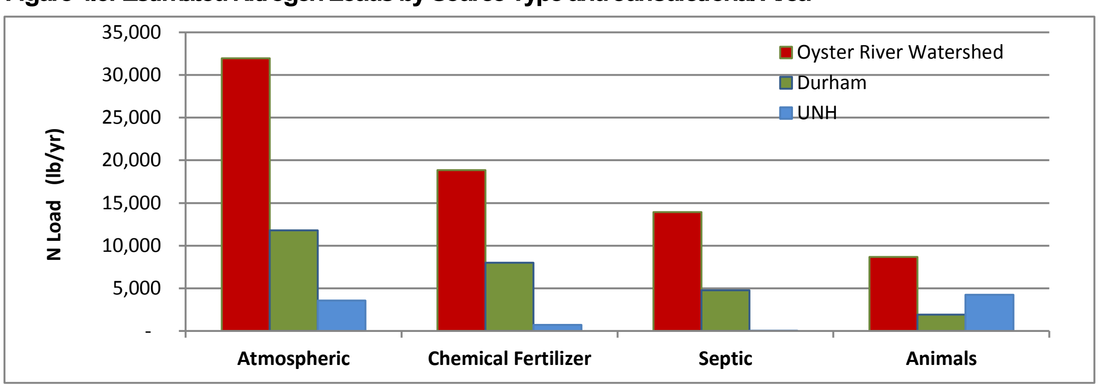
The estimated load associated with UNH was primarily derived from the land application of liquid manure, which represents 50 percent of the estimated total load and atmospheric deposition which comprised approximately 42 percent of the estimated UNH load mainly due to the amount of impervious surfaces.

Table 4.4: Model Load Estimates by Source in the Oyster River Watershed, Durham and UNH Campus

	Oyster River Watershed				Percent of Initial Source Input	Durham		UNH	
Source	Initial Source Inputs (pounds)	(%)	Delivered Load (pounds)	(%)	Delivered (%)	Delivered Load (pounds)	(%)	Delivered Load (pounds)	(%)
Atmospheric	114,620	40%	31,950	44	28%	11,780	44%	3,570	42%
Chemical	80,630	28%	18,860	26	23%	8,020	30%	710	8%
Septic	56,690	20%	13,950	19	25%	4,760	18%	30	0%
Animals	33,950	12%	8,670	12	26%	1,910	7%	4,260	50%
Total	285,890	--	73,440	--	26%	26,480	--	8,570	--

Note: The atmospheric load includes the higher load rate used on impervious cover surfaces to account for local sources in addition to the regional wet and dry deposition.

Figure 4.3: Estimated Nitrogen Loads by Source Type and Jurisdictional Area



Notes: The estimated atmospheric load includes the higher localized contributions to impervious surfaces in addition to the regional wet and dry deposition. The animal waste load includes UNH's land application of manure to its agricultural fields.

4.5.3 Estimated Loads by Source and Land Use

Table 4.5 and Figure 4.3 present a breakdown of model load estimates by source input and land use type for the overall watershed and for the Durham and UNH area. For the overall watershed, lawn fertilizer, impervious cover, septic systems, and agricultural fertilizer contribute nearly equal amounts of nitrogen and combined make up 80 percent of the overall load. Natural vegetation is estimated to contribute 16 percent of the overall load even though it comprises nearly 73 percent of the watershed area. On an aerial basis, the estimated natural vegetation delivered load rate is approximately 0.9 lbs/ac/yr compared to approximately 8.6 and 10.1 lbs/ac/yr for agricultural and impervious cover areas, respectively.

The distribution of estimated loads for Durham is similar to that for the overall watershed. Approximately 80 percent of the overall load is related to lawn fertilizer, impervious cover, septic systems and agricultural fertilizer. Lawn fertilizer accounts for highest portion of the estimated nitrogen load totaling 6,000 lbs/yr (3 tons/yr). The total lawn area in Durham is estimated to 540 acres or approximately 9 percent of Durham's total area, which results in an estimated delivered load rate of approximately 11.1 lbs/ac/yr.

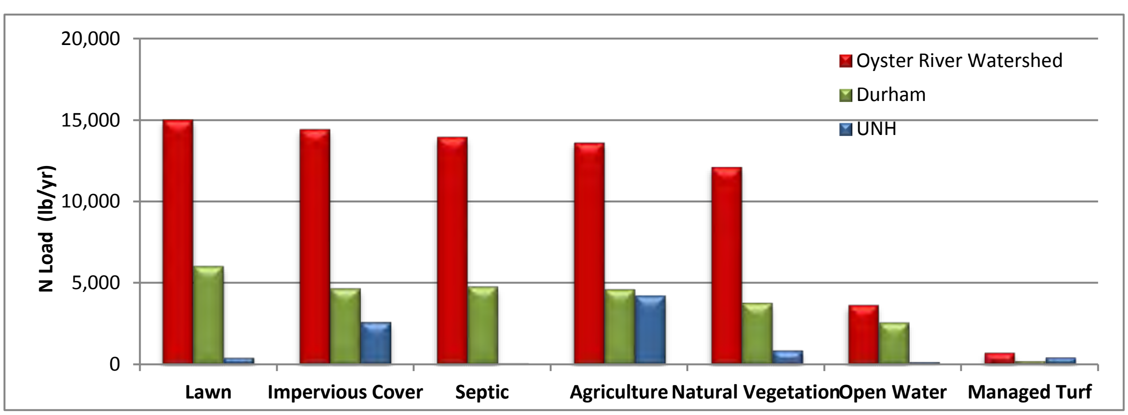
The model results indicate that nearly half (49%) of UNH's estimated overall nitrogen load is attributed to its agricultural operations and is primarily linked to the manure applications associated with their dairy and horse barn operations. Impervious cover also represents a significant portion of UNH's estimated load (30%) while estimated loads from fertilizer use on campus lawns and athletic fields are estimated to contribute approximately 10 percent of UNH's estimated total load.

Table 4.5: Nitrogen Load Estimates by Land Use/Source for the Watershed, Durham & UNH

Land Use/ Source Input	Oyster River Watershed				Durham				UNH			
	Load (lbs/yr)	Load (%)	Area (ac)	Area (%)	Load (lbs/yr)	Load (%)	Area (ac)	Area (%)	Load (lbs/yr)	Load (%)	Area (ac)	Area (%)
Lawn	15,020	20%	1,470	7%	6,000	23%	540	9%	390	5%	50	4%
Impervious	14,420	20%	1,540	8%	4,640	18%	480	8%	2,580	30%	220	16%
Septic	13,950	19%	na	na	4,760	18%	na	na	30	0%	na	na
Agriculture	13,590	19%	1,570	8%	4,570	17%	620	10%	4,180	49%	140	10%
Natural	12,100	16%	14,300	73%	3,750	14%	4,070	65%	850	10%	940	68%
Open Water	3,640	5%	740	4%	2,560	10%	500	8%	140	2%	30	2%
Managed	710	1%	30	0.2%	200	0.8%	10	0.2%	400	5%	10	0.7%
Total	73,440		19,660		26,480		6,220		8,570		1,39	

Notes: [1]Managed turf primarily consists of athletic fields and golf courses or driving ranges.

Figure 4.4: Estimated Nitrogen loads by Land Use/Source in the OR Watershed, Durham and UNH



4.5.4 Estimated Loads by Delivery Pathway

Table 4.6 provides a breakdown of the estimated loads delivered by each major transport pathway for sources attributed to Durham, UNH and the Oyster River watershed based on model assumptions. For the overall watershed, the model predicted approximately 46 percent of the estimated load is delivered by stormwater runoff. For UNH, this estimate increased to approximately 63 percent of UNH's total estimated nitrogen load from all sources. Thus, stormwater treatment BMPs both in terms of impervious cover and perhaps agricultural operations should be part of any future load reduction strategies on the UNH campus. Approximately a third (32%) of the non-septic related load for the watershed is estimated to be delivered via groundwater flow. The estimated septic load that was assumed to travel entirely by groundwater flow accounts for 19 percent of the total watershed load.

Table 4.6: Estimated Nitrogen Loads by Pathway for Watershed Area, Durham and UNH Campus

	Oyster River Watershed Load		Durham Load		UNH Load	
Pathway Type	**(lbs/year)**	**(%)**	**(lbs/year)**	**(%)**	**(lb/year)**	**(%)**
Groundwater: non-Septic	23,360	32%	7,570	29%	3,140	37%
Groundwater: Septic	13,950	19%	4,760	18%	30	0%
Stormwater	33,900	46%	12,010	45%	5,390	63%
Direct	2,230	3%	2,140	8%	-	0%
Total	73,440		26,480		8,570	

Table 4.7 presents a breakdown of the estimated nitrogen loads for each source/land use conveyed by stormwater. Impervious surfaces located in Durham and on UNH campus are estimated to contribute over 7,000 pounds (3.75 tons) of nitrogen to the downstream estuary via stormwater runoff. This will need to be a priority for future management strategies geared toward treating and reducing stormwater conveyed nitrogen loads from impervious cover. Approximately 23 percent of Durham's stormwater conveyed nitrogen load is associated with lawns in Durham while 34 percent of the stormwater conveyed nitrogen derived from UNH was related to agricultural.

Table 4.7: Estimated Stormwater Delivered Nitrogen Loads by Source or Land Use Input

Land Use /	Durham Load		UNH Load	
Source Input	**(lbs/year)**	**(%)**	**(lbs/year)**	**(%)**
Impervious Cover	4,490	37%	2,560	47%
Lawn	2,820	23%	180	3%
Agriculture	2,100	17%	1,850	34%
Natural Vegetation	2,080	17%	460	9%
Open Water	420	3%	140	3%
Managed Turf	100	1%	200	4%
Total	12,010		5,390	

4.5.5 Estimated Loads by Sub-Watershed Area

Table 4.8 presents estimated average annual nitrogen loads (total and lbs/acre/yr) for each major tributary. Figure 4.4 presents sub-watershed areas for the major tributaries in the watershed. For the overall watershed, the average annual nitrogen load per acre was estimated to be 3.7 lbs/ac/yr and ranged from a low of 2.7 lbs/ac/yr in Dube Brook to a high of 8.0 lbs/ac/yr for College Brook in Durham. These estimated loads are similar to those developed using measured sampling data collected in various sub-watersheds as shown in Table 4.10 in next section.

Not surprisingly, the more urbanized watersheds such as College Brook and Reservoir Brook produced higher aerial loads. However, similar or even higher aerial loads (e.g. > 5.0 lbs/ac/yr) were estimated for less developed areas such as the Chesley Brook, Smith Creek and the direct drainage to the tidal estuary. These higher loads are largely due to relatively greater amounts of agricultural fields and septic systems in these areas.

Table 4.8: Estimated Nitrogen Loads on Aerial Basis for Each Sub-Watershed Area

Watershed	Average Annual Delivered Load (lbs)	Area (acres)	Average Annual Areal N Load (lbs/ac/yr)
Beards Creek	4,790	1,094	4.4
Beaudette Brook	930	332	2.8
Bedford Brook	530	126	4.2
Bunker Creek	1,270	347	3.7
Caldwell Brook	4,290	1,332	3.2
Chesley Brook	3,710	1,035	3.6
College Brook	4,200	526	8.0
Dube Brook	2,420	905	2.7
Gerrish Brook	2,690	759	3.5
Hamel Brook	2,480	628	3.9
Horsehide Brook	860	260	3.3
Hoyt Pond	580	153	3.8
Johnson Creek	7,160	1,709	4.2
Little hale Creek	940	295	3.2
Long marsh Brook	270	98	2.8
Oyster River	20,980	6,655	3.2
Oyster River Tidal	7,300	1,403	5.2
Reservoir Brook	2,800	666	4.2
Smith Creek	740	122	6.0
Wheelwright Pond	4,500	1,216	3.7
Total	73,440	19,660	3.7

4.6 Comparison of Load Estimates to Existing Water Quality Data

Table 4.9 provides a comparison of the model estimates (first row) to load estimates (lbs/ac/yr) derived from measured data as reported by the UNH Water Resources Research Center (WRRC), which includes data collected in nearby watersheds (Daley et al., 2010). The WRRC data suggests that forested cover and percent imperviousness have considerable influence on the amount of delivered nitrogen load. The data collected in the main stem of the Lamprey River had the lowest estimated average annual load of 2.2 lbs/ac/year given its relatively low percentage of impervious cover. Wednesday Hill and Moonlight Brooks both having higher percent imperviousness and less forested cover also had higher estimated average annual loads ranging from 4.3 to 5.0 lbs/ac/yr, respectively. The modeled estimated load for the Oyster River falls somewhere in between at 3.7 lbs/ac/year, which appears commensurate with the estimated percent forested cover and percent imperviousness compared to the other watersheds. This comparison to load estimated derived from measured data suggest that the model produced load estimates that are reasonably close and representative of measured data.

Table 4.9: Comparison of Oyster River NLM Loads to Load Estimates Derived from Measured Data

Watershed	Estimated % Forested Cover	Estimated % Impervious	Source Load (lbs/ac/yr)	Delivered Load (lbs/ac/yr)	Percent Delivered
Oyster River NLM	68 %	9.3%	16.3	3.7	24%
Lamprey River	80 %	< 5%	11.8	2.2	19%
Wednesday Hill Brook[1]	60 %	12 - 15 %	17.8	4.3	24%
Moonlight Brook[1]	< 50 %	30 - 40 %	12.5[2]	5.0	40%

Notes: [1]Load estimates are based on data presented in Nitrogen Assessment for the Lamprey River Watershed (Daley et. al. 2010).
[2]This watershed is primarily sewered, which may explain relatively lower source load input value.

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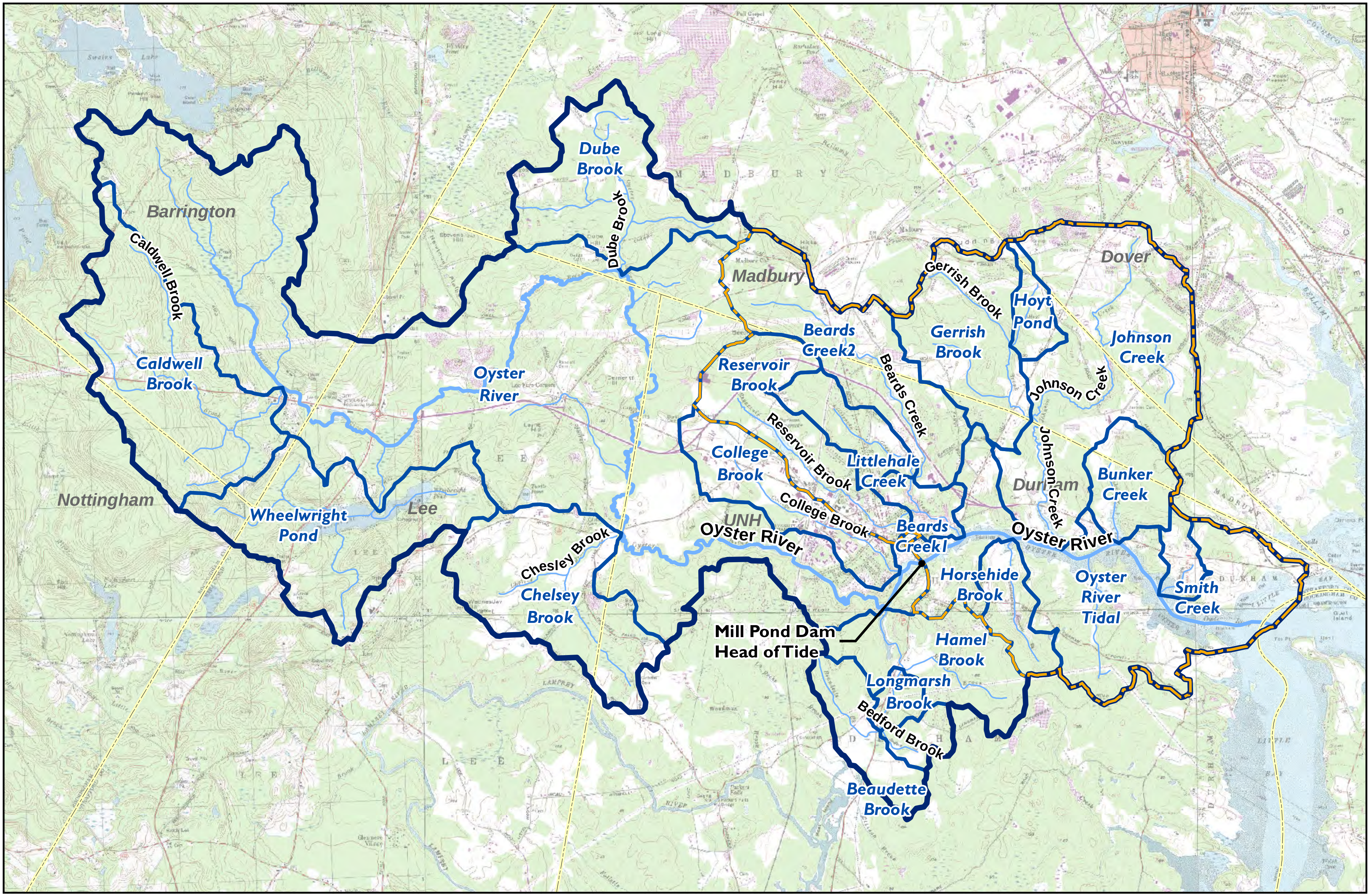

Legend

- Oyster River
- Tributary to Oyster River
- Watershed Boundary
- Subwatershed Boundary
- EstuaryDrainage
- Municipal Boundary

0 5,500 11,000 Feet

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Figure 4.4
Map of Major Tributary Subwatershed Areas
Oyster River Watershed
Durham, New Hampshire

Table 4.10 presents model estimates of average annual nitrogen loads for specific tributary streams located in the Oyster River watershed in comparison to reported measured load estimates developed by UNH WRRC (Daley et. al., 2013). The reported measured load estimates developed by UNH were derived by multiplying flow-weighted mean concentrations for each stream by the median annual flow rate as measured at the USGS stream flow gauging station on the Oyster River with the area adjusted flow rate based on the ratio of tributary watershed to the gauge station watershed area. Depending on the sampling location, the drainage area used to derive the measured load estimate may be different than that used in the model. Long Marsh Brook had the largest difference where the model drainage area was 55 percent larger than that estimated by the UNH WRRC relative to its sample location.

Table 4.10: Comparison of Model Output to Measured Nitrogen Load Estimates Using Sampling Data Collected in Eight Streams

Tributary	VHB Model Load Estimates (lbs/ac/yr)	UNH WWRC Measured Load Estimates (lbs/ac/yr)	% Difference from Measured Data	
			Drainage Area	Total N Load
Oyster R headwaters	2.6	1.9	100%	142%
Dube Brook	2.8	2.3	100%	121%
Chesley Brook	3.6	4.8	105%	75%
College Brook	7.1	6.7	100%	106%
Reservoir Brook	3.4	4.5	100%	74%
Little Hale	2.9	3.0	121%	97%
Long marsh Brook	3.1	2.2	155%	139%
Johnson Creek	4.9	4.3	82%	115%
		Average	108%	108%

4.7 Implications of Modeling Results for Nonpoint Source Control Measures

The relatively close comparison of model load estimates to load estimates derived from measured data suggests that the model performed reasonably well in estimating the nonpoint source loads on a watershed scale. On a sub-watershed scale, other site specific factors begin to introduce greater variability with respect to the local influences affecting nitrogen inputs and delivery on sub-watershed scale. Also, the sampling data itself and the associated measured load estimates are subject to considerable variability with respect to the methods used and varying conditions under which the data were collected. Given the initial comparisons discussed above, it appears the model may underestimate loads in some watersheds and overestimated in others. As more water quality and flow data is collected in the future, comparisons of modeled estimates to measured data should be revisited to identify areas or conditions where the model more accurately reflects measured data and other areas where the model does not adequately reflect measured data.

The model estimates are considered sufficient to evaluate the relative contributions from the various sources and political jurisdictions and to prioritize and identify potential management measures that could be used to reduce existing nitrogen loads from nonpoint sources within the watershed. A more detailed analysis of various nonpoint source control measures and their potential effect on load reductions is presented in the next section of this report. Based on model results, the estimated annual delivered nitrogen load associated with potentially “manageable” sources and land use activities within Durham’s and UNH’s jurisdiction consists of approximately 27,800 lbs (14 tons). The “manageable” nonpoint source loads pertain to the source loads associated with human activities and land uses and exclude the atmospheric source loads to natural vegetation and open water areas. Durham’s portion of the total estimated annual nitrogen load from “manageable” sources consists of approximately 20,200 lbs/yr (~10 tons) while UNH’s portion consists of approximately 7,600 lbs/yr (~3.8 tons). For Durham, the estimated nonpoint source loads are equally distributed amongst lawn fertilizer use, agricultural fertilizer use, impervious cover and septic systems and, thus, potential management measures should be identified for each of these sources to evaluate their feasibility and potential cost-effectiveness of reducing nitrogen loads. For UNH, the principal sources/land uses include impervious cover and agricultural operations and, thus, these should be a major focus in evaluating future management alternatives.

5.0 Draft Nitrogen Control Plan for Nonpoint Sources

As discussed previously, most of the nonpoint source nitrogen load originates from four principal sources or land use activities including lawn fertilizer, agricultural fertilizer, septic systems and impervious cover. Identifying cost-effective measures to reduce source contributions from each of these sources or land uses will be essential to developing an effective implementation plan that will maximize future load reductions for the least amount of cost. Both nonstructural and structural measures will be considered. Nonstructural measures include activities such as education programs targeted toward source control by eliminating and promoting more efficient use of nitrogen inputs. Structural stormwater treatment measures tend to rely on treatment mechanisms to capture and treat pollutants generated onsite from impervious surfaces and other land cover areas. Structural measures tend to have considerably higher cost per pound (lb) of nitrogen reduced than nonstructural control measures (See Appendix E). Structural measures, however, also have the added benefit of capturing and reducing other pollutants such as suspended sediment and total phosphorus, which are common stormwater pollutants from impervious surfaces.

The measures discussed herein focus principally on nonpoint sources that are within the geographic limits of the Town of Durham and UNH's main campus and include sources and land areas/activities that are outside the regulated MS4 areas. It is anticipated that the Nitrogen Control Program as outlined in this Draft Plan will be refined in the future following review by Durham and UNH staff, town officials, watershed residents and discussions with agency personnel. In addition, in developing an Integrated Permit, a target load reduction will likely need to be established as a permit condition and milestones are to be needed for each of the various implementation measures identified. The various metrics to measure success are suggested for each of the implementation measure, as described herein.

Given that a target load reduction for nitrogen has not been formally established, this Plan does not explicitly define the level of effort and/or extent of the measures that need to be implemented. However, preliminarily, this Plan outlines the type and extent of the recommended measures that could be used to ultimately achieve a nitrogen load reduction approximately 3,500 pounds (lbs) or 1.8 tons, which is the equivalent load difference if the WWTF was to meet a seasonal effluent limit of 5 mg/l instead of 3 mg/L.

It is also expected that the measures included herein would also address the pending overlapping permit requirements that are likely to be included in the MS4 Stormwater Permit to address impaired waters. An Integrated Permit approach, would enable the Partners to prioritize use of limited resources to achieve multiple water quality objectives in a more cost-effective and sustainable manner focusing principally on reducing nitrogen loading first and addressing other water quality impairments in sequence in the overall compliance schedule. As such, the Partners would like to continue to have a dialogue with EPA and DES and explore their possibilities of developing an Integrated Planning and Permitting (IPP) Approach.

5.1 Existing Measures and Programs

Both Durham and UNH have implemented various measures in recent years to reduce nutrients as well as other pollutant loads. In the last three years, Durham has installed several stormwater BMPs including a rain garden at the High School, an enhanced bioretention system in the Tedeschi parking lot and a gravel wetland off of Oyster River Road. All totaled these BMPs treat approximately 6 to 8 acres of impervious area. The Town has also updated its stormwater management regulations as part of their site plan and subdivision regulations that require new commercial and redevelopment proposals to use Low Impact Development (LID) measures and provide stormwater treatment. In the past, the UNH Stormwater Center has worked with the UNH Facilities Program to retrofit several parking areas and walkways with porous asphalt or concrete. UNH Facilities have recently committed to cost-sharing agreement to install several bioretention systems to treat one of its largest parking lots (7.6 acres) on campus. UNH has also converted a portion of its shuttle bus fleet to operate on natural gas which results in cleaner emissions and less nitrogen oxide. The Town, just in the last three years, has invested over $600,000 to preserve nearly 300 acres of land, some of which had a proposed subdivision plan in place and would have resulted in numerous new house lots. These combined results of these efforts have already begun to produce water quality benefits and have set the stage for expanded efforts as port of this plan.

5.2 Evaluation of Management Strategies for Nonpoint Source Control

The evaluation of potential management measures that could be used for additional nonpoint source control was based on a culmination of several interim project products, review of relevant research and consultations with local specialists and research scientists. Project activities and interim products completed to date include:

- Initial Project Integration Planning Strategy Plan, May 2013
- Durham/Oyster River Nitrogen Management Alternatives Memo June 17, 2013
- DRAFT Technical Modeling Report, August 2013
- Durham Lawn Care Attitude Survey Results dated November 2013
- Interviews with Public Works, University and Planning Staff over Fall 2013
- Cost Effectiveness Literature Review Memo, October 22, 2013
- Draft Technical Memo of Management Alternatives Analysis to Achieve Future NPS Nitrogen Load Reductions, December 20, 2013

5.3 Overview of the Screening Analysis to Identify Management Measure

The estimated potential effectiveness and costs to implement each measure was primarily based on relevant research findings that have been reported for similar efforts conducted in other parts of the country and mostly research conducted in the Chesapeake Bay watershed. For purposes of this analysis, capital costs were defined as either one time program costs or structural improvement costs while annual costs were anticipated re-occurring costs for administration and management and operations and maintenance to sustain program measures.

For each of the identified potential management measures presented below, the following elements are provided:

- Model Estimates of Existing Nitrogen Loads by Source/ Land Use
- Listing of Major Program Components
- Program Activity Details
- Summary of the Research Findings
- Estimated Potential Nitrogen Load Reduction
- Staff Responsibilities and Needs
- Anticipated Timeline
- Anticipated Measures of Success
- Estimated Program Costs including Annual and Capital Costs

5.4 Potential Development of a "Bay Friendly" Lawn Fertilizer Program

As shown in Table 5.1 below, based on model assumptions, approximately 6,100 pound (lbs) per year of nitrogen was estimated to be contributed to the Oyster River estuary from lawn fertilizer usage in Durham and on the UNH Campus. Another 1,700 lbs of nitrogen was estimated to be contributed to the Great Bay estuary from fertilizer used on lawns in Durham but outside the Oyster River watershed. Durham has approximately 540 and 180 acres of lawn area within and outside the Oyster River watershed, respectively. The area outside of the Oyster River watershed is mainly located in the adjacent Lamprey River watershed.

Table 5.1: Estimated Nitrogen Loads Associated with Lawn Fertilizer Use in Durham & UNH

Jurisdiction	Location		Estimated Area (Acres)	Estimated Delivered Nitrogen Load[1] (lbs/yr)
Durham	Within Oyster Riv. Watershed	Residential Lawn	540	5,300
		School Athletic Fields	8	150
	Outside Oyster Riv. Watershed[2]	Residential Lawn Area	180	1,700
UNH	Within Oyster Riv. Watershed	Main Campus Lawn	43	290
		Athletic Field Complex	11	380
		Totals	**785**	**7,820**

Notes: [1]Model estimates of delivered load accounts for fertilizer inputs only and excludes atmospheric and pet waste that falls on lawn areas. The nitrogen inputs for the Durham lawn area was based on an application rate of 2.0 lbs N/1000 sf/yr and 45 percent of the lawn area assumed to be treated based on the 2013 UNH survey of residents. UNH application rates were based on actual reported usage in 2012 and 2013. [2]Lawn area that is located in the Lamprey River watershed or direct watershed to the Great Bay

Relevant Research Findings

The Chesapeake Bay Program (CBP) developed in Urban Nutrient Management Program that could result in an estimated nitrogen removal efficiency ranging from 5 to 17% with the overall effectiveness depending 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. (This is already included in Durham regulations)
- Employ lawn practices to increase soil porosity and infiltration capability, especially along portions of the lawn that convey or treat stormwater runoff.

The New England Interstate Water Pollution Control Commission (NEIWPCC) has also developed a new Turf Management Program geared toward educating homeowners and professionals with a principle focus on Right Time, Right Amount, Right Place, Right Product & Right Equipment as well as many of the core principles outlined above (NEIWPCC, 2013).

Possible Major Education and Outreach Program Components

Fertilizer management is perhaps best addressed through a well-orchestrated, homeowner education program focusing on best practices to enhance nutrient uptake and minimize excessive and/or inefficient usage. To enhance effectiveness, hiring a Social Marketing expert may be highly valuable to conduct targeted focus groups or surveys with homeowners to better understand the data gaps and potential barriers for proper lawn maintenance. From this information, a more focused and effective education and messaging program can be developed to improve homeowner understanding on the best practices and importance of "environmentally friendly" lawn maintenance.

The potential components of a Lawn Fertilizer Management Program may include:

- Comprehensive Public Education and Outreach Campaign
- Voluntary Landscaper Training / Certification Program
- Municipal/ UNH Facility Applicator Trainings

Rather than passive distribution of education materials, public education involving direct engagement through a series of workshops and hands-on training sessions with home owners and/or businesses would be anticipated. Partnering with UNH Cooperative Extension, PREP and the Natural Resources Outreach Coalition (NROC) would be viable options to help engage and supplement training assistance. The education program could be supplemented with a certification program for local commercial fertilizer applicators to identity those willing to commit to a set of mutually-agreed upon performance standards.

Initial Startup Activity

Initiating a comprehensive Lawn Fertilizer Public Outreach Program would require that the Partners appropriate funds to establish a Program budget and develop a Request for Proposal to contract out the program development with an experienced social marketing/public education specialist as part of a multi-faceted social marketing plan.

Implementation Activity

The implementation of a detailed lawn fertilizer public education and marketing campaign may include the use of focus groups to conduct message testing and analyze behavior barriers and resident perceptions to better inform an educational approach. The specialist would develop outreach materials, a program manual and separate training modules for residents, lawn care professional and municipal/university employees. Homeowners and commercial applicators from other communities in the Oyster River watershed could participate in the program.

Follow-Up Activity

Conduct a follow-up resident survey using the UNH Survey Center or similar means to assess program effectiveness.

Estimated Load Reductions

The Chesapeake Bay Urban Nutrient Management Program established removal credits of 5 to 17 percent for implementing a "Bay Friendly" Public Education Program with the ultimate success dependent upon the number of outreach events, homeowner participation and follow-up measures to assess effectiveness of the Program. Since lawn fertilizer appears to be a major nitrogen source in Durham, it is anticipated that interest in a lawn care education program will be high as the residents are generally well-engaged, educated and aware of the environmental issues surrounding the Great Bay.

As such, it seems reasonable to assume that a 15 percent load reduction is feasible consistent with the reported range by the Chesapeake Bay Program. With a total estimated nitrogen load of approximately 7,000 lbs/yr associated with lawn fertilizer use on all of the Durham lawn area (includes lawn area inside and outside of watershed), a 15 percent reduction credit would result in a **nitrogen load reduction of approximately 1,050 lbs/yr**.

Additional nitrogen load reductions could be achieved from best practices used on managed turf areas as these areas are managed differently from homeowner lawn areas and may involve different management activities targeted towards for school athletic fields or on UNH athletic fields. The estimated lawn fertilizer reduction does not include additional load reductions that could result from homeowners in other watershed communities participating in the Program and engaging in better lawn fertilizer usage practices.

Staff Responsibilities/ Needs

This program is require some additional staff time to assist in program management and administration, oversight of any regulation changes, consulting with residents and landscapers as well as assisting in the promotion and tracking of certification trainings, outreach materials and participation levels. Coordination with school facilities personnel and homeowner associations in key neighborhoods will also be important. The estimated amount of time needed may be equivalent to a 0.5 full-time staff person and could involve a new position as a Nonpoint Source/ Stormwater Management Program Coordination with the other 50% of the Coordinator's time possibly involved with administering and managing other components of the NPS Program.

Anticipated Timeline

It is anticipated that it will take several years and perhaps as much as five years to fully implement this program. Depending on the results of the survey 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 partners such as Piscataqua Region Estuaries Partnership (PREP) personnel, UNH Cooperative Extension and Natural Resources Outreach Coalition.

Measures of Success

Successful implementation could be measured through documenting completion of various milestones of the education and marketing campaign for Durham residents and professional staff over the course of several years. This measure would include recording and tracking of landscaper participation in the certification program as well as homeowner and stakeholder participation in workshops or other planned events. A follow-up resident survey would be used to measure Behavior Change (i.e., % of residents using less fertilizer) to compare with 2013 survey.

Estimated Program Costs

Table 5.2 presents approximate preliminary opinion costs for the major program components. The annual costs include estimated staff time and other reoccurring costs that would need to be budgeted each year. For activities anticipated to occur once over the course of the implementation period were categorized as one time capital costs that could be financed through a comprehensive capital improvement bond rather than an operating budget.

Table 5.2: Estimated Annual and Capital Costs for Potential Lawn Fertilizer Education Program

	Program Activity or Measure	Sequence	Annual Costs	One Time Capital Costs
New Program Costs	Hire Social Marketing Specialist to Develop Outreach Social Marketing Plan and Implementation Materials	Startup	--	$85,000
	Annual Administration and Management Costs: [1] (assume estimated 0.5 FTE needed) – multiple years	ongoing	$45,000	--
	Facility Personnel Training / Certification	ongoing	$5,000	--
	Implementation of follow-up Assessment Survey	Follow-up	--	$25,000
			$50,000	$110,000
		Total Annualized Costs[2]	**$57,800[2]**	

Notes: [1]Includes Durham staff time at estimated 0.5 FTE for management and administration of the program, ordinance education, neighborhood outreach programs, lawn care technical support, certification trainings and staff time associated with trainings, maintenance of media campaign materials, tracking and reporting, mileage, supplies, equipment and postage.

[2] Annualized costs includes estimated one-time, capital costs amortized over 20 years at 3.5% interest plus recurring annual costs.

5.5 Potential Management Strategies for Agriculture in Durham and UNH

Table 5.3 provides a summary of model estimates of delivered nitrogen loads associated with agriculture fertilizer use in the Town of Durham and on UNH agriculture fields based on a number of model assumptions and data inputs as discussed in Section 4.0 of this Report. It is important to note that although private agricultural land areas were included in the model source assessment, for purposes of this study, the management measures discussed below specifically target the estimated source contributions from UNH agricultural operations and not private land areas.

Table 5.3: Estimated Delivered Nitrogen Loads from Agricultural Fertilizer Use in Durham and UNH

Jurisdiction	Crop Type/ Source	Estimated Area (Acres)	Estimated Delivered Nitrogen Load[1] (lbs/yr)
Durham	Varies: 85% of the Ag land categorized as hay fields	608	3,160
UNH	Fertilizer[1] applied to Corn	44	2,250
	Fertilizer[1] applied to Hay Fields	100	1,840
	UNH Subtotal	144	4,090
	Totals	**752**	**7,250**

Note: [1]UNH Farm Operations fertilizes primarily through manure applications and minor supplemental amounts of chemical fertilizer.

Relevant Research Findings

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 can involve a number of agronomic practices and land/crop treatment measures. As an example, Maryland's Nutrient Management Manual provides detailed nutrient application guidelines for various crops, environmental risk assessment tools, animal manure and waste management, and applicable laws and regulations.

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

Possible Program Components

The proposed measures 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)

The potential program would focus on enhancing nutrient management plans for agricultural activities associated with UNH's agricultural operations in collaboration with USDA-NRCS and/or UNH Cooperative Extension. NRCS could also be consulted to assess opportunities to identify best management practices on private lands but this was not factored into this analysis at this time.

Possible Program Details & Assumptions

***Initial Startup Activity*:** UNH in conjunction with the New Hampshire Agriculture Experiment Station (NHAES) would assess how the existing Nutrient Management Plan (NMP) might be enhanced for greater nutrient management based on best practices guidance developed locally and in other regions.

***Implementation Period*:** Over the course of several years, various nutrient management plan recommendations would be implemented which could include additional soil testing, modified application rates and timing, off farm transport of excess nutrients, land treatment conservation measures including additional cover crop, enhancing field buffers and improved drainage control, precision agriculture investments and recordkeeping. The estimated program costs assume that no major capital investment for infrastructure would be required.

***Additional Program Activity*:** Collaborate with USDA-NRCS on nutrient accounting and tracking of existing nutrient control management actions for UNH and potentially for other Oyster River watershed private farms.

Estimated Load Reductions

With an estimated 40 percent removal credit established by the Chesapeake Bay Program (CBP) for developing comprehensive nutrient management plans, it seems reasonable to assume that, at a minimum, potential load reductions of 15 to 20 percent could be achieved through similar enhanced nitrogen management planning focusing primarily on UNH agricultural facilities for implementation as described herein.

A 15 to 20 percent reduction applied to just UNH's agricultural operations within the Oyster River watershed would result in a load reduction of approximately 600 to 800 lbs/year given an estimated annual delivered nitrogen load of approximately 4,090 lbs/year. Additional load reductions may be possible for UNH fields outside of the watershed.

Using Maryland's land treatment BMP credits as an alternative means to estimate potential load reductions, the use of a winter cover crop alone could result in as much of 5.0 lbs/ac reduction. Over an estimated 144 acres of fields, this would result in a load reduction of approximately 720 lbs/yr, which is roughly 18 percent of the total estimated model load. The ultimate removal efficiency that might be applied will depend on the various existing management practices that are currently deployed by UNH's agriculture operations and the feasibility of adopting additional measures. These factors would need to be assessed as part of any proposed efforts to develop a CNMP.

Additional load reductions could be gained through use of nutrient management and land treatment systems on private farm lands or on other UNH agricultural fields located outside of the Oyster River watershed. These activities and potential reductions could be tracked as measures are completed and in future plan updates.

Staff Responsibilities/ Needs

It is anticipated that UNH Facilities personnel would assist in providing administrative support for reporting and documentation and perhaps funding. NHAES could assist in specialist procurement, precision agriculture research, program development, recordkeeping and reporting. No new staff positions are anticipated but ongoing management of the CNMP will need to be done by NHAES staff and was assumed as part of administration costs.

Measures of Success

Potential load reductions would be measured through to be developed nutrient removal credits for new implementation activities and enhanced land treatment practices in the most sensitive areas.

Estimated Program Costs

Table 5.4 provides preliminary cost estimates for various measures that could be included to enhance the Nutrient Management Plan for the UNH Agricultural facilities. The cost estimates are largely based on the cost data included in the "Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plan", NRCS 2003. Given the report date, the estimated program costs were increased by 30% to account for 2014 dollars.

The estimated capital costs include an estimated contractual cost to enlist the services of agricultural specialists during the initial part of the program and estimated funds for various land treatment measures including winter cover seeding, conservation tillage, buffer plantings, etc. as well as funds to implement precision agricultural techniques based on average costs presented in the NRCS document.

Table 5.4: Estimated Annual & Capital Costs for Potential Nutrient Management Program for UNH

	Program Activity or Measure	Sequence	Annual costs	One Time or Capital Costs
New Program Costs	Develop Comprehensive Nutrient Management Plan[1]	startup	--	$65,000
	Implement various Land Treatment Measures[2]	Implement	--	$200,000
	Research/ Implement Precision Agricultural Techniques[3]	Implement		$45,000
	Annual Administration and Management Costs: [4]	Implement	$30,000	--
	Allowance for Added Offsite Transport/ Disposal (if needed)	Implement	$30,000	--
		Totals	$60,000	$310,000
		Total Annualized Cost[5]	**$81,800**	

Notes:[1] Includes estimated costs for contracted services from local agronomist or other agricultural specialist to assist with plan development.
[2]Land treatment measures could include cover cropping, conservation tillage, increased buffer establishment, drainage improvements, etc.
[3]Precision agricultural relates to the use of innovative technology, mapping and automated equipment to optimize fertilizer application timing to achieve maximize crop uptake and minimize offsite loss of nutrients.
[4] Includes estimated costs to assist in management of nutrient control plan, supplies, testing, precision agriculture research administration, coordination across university facilities and staff, inspections, and recordkeeping. Various grant funding programs and cost-sharing could potentially reduce the planning and/ or implementation costs.
[5]Annualized costs represent the estimated one-time capital costs amortized over 20 years at 3.5% interest plus recurring annual costs.

5.6 Potential Management Strategies for Impervious Cover Areas in Durham and UNH

Table 5.5 provides a summary breakdown of the various types of impervious cover and the model estimates of annual nitrogen loads for these impervious cover areas located in Durham and UNH. It is important to note that for modeling purposes, the same initial nitrogen loading rate was used for all impervious cover types but, in reality, parking lots and roadways are likely to have a higher loading potential than rooftops due to the added local vehicle exhaust emissions as well as the potential for runoff and accumulation of organic matter and/or fertilizer overspray from adjacent areas. Thus, higher load reductions may be gained for treatment of parking lots and roads as opposed to rooftops. This will need to be considered in finalizing the nutrient removal credits for future tracking and accounting protocols for impervious cover.

Table 5.5: Model Estimates of Delivered Nitrogen Loads for Impervious Cover in Durham and UNH

Jurisdiction	Impervious Cover Type	Estimated Area (Acres)	Estimated Delivered Nitrogen Load[1] (lbs/yr)
UNH	Parking Lots	51	615
	Roads/Driveways	28	305
	Rooftop Area	44	440
	Walkways	23	260
	UNH Subtotal	156	1,620
Durham	Municipally-Owned Parking	9	105
	Municipal Roads	21	245
	Private Commercial Parking Lots	43	510
	Residential Rooftops & Driveways	306	2,830
	Durham Subtotal	386	3,680
Totals		**532**	**5,300**

Notes: [1]The estimated delivered loads relate to these specific areas that are most likely to be considered for management and/or treatment and may not include other miscellaneous impervious cover areas.

Relevant Research Findings

Measures most often used to reduce nitrogen loads from existing impervious cover fall into three (3) main categories including:

- Source Control (i.e., street sweeping, catch basin cleaning).
- Rooftop and Pavement Disconnection.
- Stormwater BMP Retrofits.

Relative costs and effectiveness of these measures vary considerably. Most of these same measures are also required by EPA's Draft MS4 Stormwater Permit for impervious cover within designated urbanized areas. In addition to street sweeping and catch basin cleaning activities, both Durham and UNH have recently installed stormwater BMPs in various locations to provide enhanced water quality treatment for impervious cover.

Source Control Measures

Attachment 2 of Appendix F included in EPA's 2013 Draft NH MS4 Stormwater General Permit provided estimated removal efficiencies for phosphorus based on relevant research findings. For our analysis, similar removal efficiencies were used to estimate potential nitrogen load reductions for street sweeping and catch basin cleaning.

Impervious Cover Disconnection

Disconnection of impervious surfaces can involve a variety of measures ranging from simple redirection of rooftop downspouts to allow collected runoff to spread across pervious area to more engineered practices designed to store and infiltrate a target water quality volume. Nitrogen loads delivered to downstream water bodies is generally much lower when traveling in groundwater due to greater attenuation and denitrification losses along the shallow interflow/riverine interface as compared to the stormwater pathway.

Based on a 2013 Chesapeake Bay Network report, Virginia had established nutrient reduction credits of 25 to 50 percent for rooftop disconnection (Schueler and Lane, 2013a). The lower end of the range was targeted towards simple, rooftop disconnection on Hydrologic Group C or D soils while the higher end range was considered appropriate for simple disconnection on A or B soils or the use of engineered BMPs designed to reduce runoff volumes through groundwater infiltration. To be conservative, load reduction resulting from potential impervious cover disconnection efforts in the UNH and Durham area are anticipated to be at the lower end of the reported removal efficiencies and, thus, a range of 15 to 35 percent was used to estimate future load reductions.

Stormwater BMP Treatment Retrofits

Higher removal efficiencies have been reported for engineered, stormwater BMPs designed to treat stormwater runoff through extended detention, filtering or vegetative uptake. Research conducted by the UNH Stormwater Center for various stormwater BMPs represents some of the most recent and locally applicable data. Reported removal efficiencies for nitrogen typically range from 45 to 75 percent with the low end range applicable for a typical rain garden or extended detention basin while the higher end values would be applicable for BMPs that support a subsurface anaerobic environment to promote denitrification such as gravel wetlands or an enhanced bioretention basin, similar to that installed in the Tedeschi parking lot in downtown Durham.

Proposed Major Program Components

Durham's current sweeping program consists of twice-weekly mechanical broom sweeping from April to December for the major roads and municipal parking areas in the downtown area (estimated 30 acres of impervious area). Sweeping is also done during spring cleanup for most of the remaining town roadways. Based on the phosphorus removal credits for sweeping included in the 2013 Draft MS4 permit, a nitrogen removal credit of 6 percent was assumed to result, similar to the phosphorus credit, for the twice weekly mechanical broom sweeping that Durham DPW conducts in the downtown area for nine months out of the year.

UNH currently sweeps the main university roads and parking areas twice a year during early spring and summer clean up. We have assumed a low and high range removal efficiency of 0.5 and 1.0 percent for these areas. Catch basin cleaning reduces the nutrient load fraction associated with sediment and debris captured from impervious areas. Durham and UNH both clean catch basins in the same areas designated for sweeping. Our load reduction estimates provided below assume a removal efficiency of 2 percent for this activity for both Durham and UNH.

Another potential source control measure may include converting diesel fueled buses or other large fleet vehicles to natural gas fueled vehicles to lower the nitrogen oxide emissions in vehicle exhaust. Researchers at the UNH Stormwater Center have reported measuring lower nitrogen levels in runoff samples collected from a UNH parking lot after a large portion of the UNH campus bus fleet was converted to natural gas vehicles (J. Houle, pers comm. January 2014). However, establishing potential nitrogen reduction credits associated with this activity would be difficult due to limited data currently available and, thus, this potential option was not evaluated in this analysis.

Impervious Cover Disconnection

Impervious cover disconnection measures are often targeted towards roof-top disconnection for commercial and residential buildings and driveways. Local regulations and site plan design review activity should promote rooftop disconnection for commercial redevelopment and new development, to the extent feasible. Homeowners can also be encouraged to use low-cost and low-tech measures such as rain barrels and simple downspout redirection to pervious areas as part of a future public education and outreach campaign. This effort could be rolled into the same education program established for lawn fertilizer. Emphasis should be placed on the higher density residential areas in Durham that are considered directly connected to the storm drain system and contain an estimated 50 to 75 acres of the impervious area. The Town of Durham has provided discounted rain barrels to residents in the past for roof top disconnection.

For directly connected impervious area (i.e. drain directly to a closed drain system), the anticipated low and high removal efficiency was estimated to be 15 to 35 percent. For all other impervious areas not directly draining to the storm water drain system, the assumed removal efficiency was estimated to be 10 to 20 percent. The amount of area that was estimated to be disconnected on annual basis was 0.5 acres each for UNH and Durham.

Stormwater BMP Treatment Retrofits

Reported removal efficiencies for structural Best Management Practices (BMPs) designed to capture and treat stormwater runoff from impervious surfaces generally range between 45 and 75 percent for nitrogen with the higher efficiencies applicable to BMPs that promote denitrification such as gravel wetlands and enhanced bio-retention systems that maintain an anaerobic environment (UNH Stormwater 2012 Biennial Report). These BMPs are typically sized to treat between 0.5 to 2.0 acres of impervious area depending on the available area. There can be a wide range in the potential design and installation costs can from $5,000 to over $100,000 per acre treated, depending on site constraints. For purposes of this analysis, an average annual cost of $30,000 per acre treated was used to develop planning level cost estimates for design and installation of new BMPs. Annual operation and maintenance costs are typically in the order of 2 to 5 percent of the installation costs. In addition, it was assumed that both UNH and the Town of Durham could construct enough BMPs to treat as much as 2.5 acres of existing impervious area each year, on average, for a total of 5 acres per year.

An additional 1 to 2 acres per year is assumed to be treated by new BMPs constructed by developers as part of private commercial redevelopment projects. Durham's recently revised stormwater management regulations require redevelopment proposals to include Low Impact Development (LID) measures to reduce their effective impervious area and provide water quality treatment for at least 50 percent of the total impervious area.

Estimated Load Reductions

Tables 5.6 and 5.7 summarize the estimated load reductions for proposed measures targeting different impervious cover areas associated with the UNH Main campus and the Town of Durham, respectively, based on the model load estimates, relevant research findings and assumptions, as discussed in previous section.

Table 5.6: Estimated Nitrogen Load Reductions for Measures Targeting UNH Impervious Cover

Targeted Area	Measure	Estimated Area Treated Annually (ac)	Estimated Annual Load		Estimated Removal Efficiency	Estimated Annual Load Reduction After 5 Years (lbs/yr)	
			Lbs/ac	Lbs/yr		Low	High
UNH Parking/ Roads	Street Sweeping	80	11.5	920	0.5 – 1.0 %	4[1]	9[1]
	Catch basin Cleaning				2.0 %	18[1]	18[1]
	Stormwater BMP Retrofits	2.5	11.5	30	45 – 75 %	15 (75)[2]	22 (110)[2]
UNH Building Roof Area	Downspout Disconnection	0.5	11.5	6	15 – 35 %	1 (5)[2]	2 (10)[2]
					UNH Total	**110[3]**	**150[3]**

Notes: [1] Sweeping and catch basin cleaning were not included in the total load reduction estimate since these are existing practices.
[2]Values in parenthesis represent the cumulative load reduction estimate after five years of activity as new IC areas are treated each year.
[3] Future load reductions will depend on the type, location and treatment efficiency associated with the actual measures implemented.

Table 5.7: Estimated Nitrogen Load Reductions for Measures Targeting Durham Impervious Cover

Targeted Area	Measure	Estimated Area Treated Annually (ac)	Estimated Annual Delivered Load (lbs/yr)		Estimated Removal Efficiency	Estimated Annual Load Reduction After 5 Years (lbs)	
			Lbs/ac	Lbs/yr		Low	High
Durham Parking / Roads	Street Sweeping	30 ac	11.5	350	6.0%	21[1]	21[1]
	Catch basin cleaning				2.0%	7[1]	7[1]
Municipal Roads/Parking	Stormwater BMP Retrofits	2.5 ac	12.0	30	45 -75 %	15 (75)[2]	24 (110)[2]
Commercial Redevelopment		2 ac	12.0	24	45 -75 %	12 (60)[2]	18 (90)[2]
Durham Residential Roof and Driveway	Homeowner Green Infrastructure	0.5 ac Connected IC	11.5	6	15-35 %	1 (5)[2]	2 (10)[2]
		0.5 ac Disconnected	8.6	4.3	15-35 %	0.7 (3.5)[2]	1.5 (7.5)[2]
					Durham Total	**140[3]**	**220[3]**

Notes: [1]Street sweeping and catch basin cleaning were not included in the total load reduction estimate since these are existing practices.
[2]Values in parenthesis represent the cumulative load reduction estimate over five years of activity.
[3] Future load reductions will depend on the type, location and treatment efficiency associated with the actual measures implemented.

Table 5.8 provides preliminary annual cost estimates for various impervious cover related measures. For initial cost estimating purposes, it was assumed that the proposed program would be implemented over a minimum of five years but could be longer depending on multiple factors. The average annual nitrogen load reduction after a 5 year implementation period to treat both Durham and UNH impervious cover areas is expected to range between 250 and 370 pounds (lbs) per year. The projections depend somewhat on the amount of commercial redevelopment that occurs over time and how much is subject to the enhanced treatment requirements included in Durham's updated stormwater regulations as well as the amount of homeowner activity in disconnecting rooftop areas. Stormwater treatment measures targeting impervious cover areas would also result in other water quality benefits by reducing loads of other key pollutants such as total suspended solids and total phosphorus. The 2013 Draft MS4 Permit included proposed language requiring regulated entities to identify existing impervious areas for future BMP retrofits to reduce existing pollutant loads.

Staff Responsibilities/ Needs

New staff responsibilities would likely include coordination and management of the stormwater BMP implementation program for both UNH and the Town and would likely include the following activities:

1. Review of designs for BMPs and redevelopment projects.
2. Inspection of BMP installation and post-construction activity.
3. Inventorying and identifying important areas for retrofit BMPs.
4. Tracking O&M activities for BMPs.
5. Grant funding applications and reporting

On a preliminary basis, this program is estimated to require a 0.25 FTE to coordinate these activities on an annual basis for both the Town and UNH.

Measures of Success

The measurement of success would involve tracking the actual number and type of stormwater BMPs installed for treating and/or disconnecting existing impervious cover areas over time. Structural measures are easier to track and account for the potential removal credits than nonstructural measures as their removal efficiencies have been well researched. As part of a future tracking and accounting procedure, nitrogen load reduction credits will need to be established for each BMP type which then can be applied to the estimated area to be treated.

Table 5.8: Estimated Annual and Capital Costs for Potential Measures Targeting Impervious Cover

	Program Activity or Measure	Jurisdiction	Annual Costs	One Time or Capital Costs
Existing Activity	Existing Street Sweeping Costs[1]	Durham	$40,000[1]	--
		UNH	$10,000[1]	--
	Catch Basin Cleaning[1]	Durham	$45,000[1]	--
		UNH	$40,000[1]	--
New Program Costs	Annual Administration and Management Costs[2]**:** (staff cost is based on estimated 0.25 FTE needed)	Both	$30,000	--
	Residential Rooftop Disconnection (Rain Barrel funding assist, education material)	Durham	$5,000	--
	Design and Installation of New Stormwater BMPs to treat Impervious Cover (5 ac/yr treated x $30K/acre = $150k/yr)[3]	Both	--	$750,000
	UNH Rooftop Disconnection Retrofits ($20,000/yr to implement minor modifications for rooftop downspouts	UNH	--	$100,000
		Totals	$35,000	$850,000
		Total Estimated Annualized Cost[4]	**$94,800**	

Notes: [1]Existing sweeping and catch basin cleaning costs are not included as they are existing practices and not new program costs.
[2]New program activity assumes staff administration of the program (shared across UNH and Durham) requiring 0.25 FTE staff time to review designs, bid/consultant coordination, BMP tracking, recordkeeping, post- construction BMP inspections & maintenance).
[3] Estimated capital costs include engineering, permitting and construction costs over five years of implementation. Various grant funding programs could potentially reduce the design & construction costs by 50 percent or more depending on match requirements.
[4] Annualized costs represent estimated one-time, capital costs amortized over 20 years at 3.5% interest plus recurring annual costs.

5.7 Potential Management Strategies for Existing Septic Systems in Durham

The following provides a summary of the estimated delivered nitrogen load associated with septic systems located in the Town of Durham and the potential load reduction measures that could be used to reduce future loading. Approximately 4,760 pounds of nitrogen or 18 percent of Durham's total annual nonpoint source nitrogen load is estimated to be contributed from approximately 650 septic systems that were estimated to be located in Durham and in the Oyster River watershed. This estimated load is nearly same as the annual load estimated for impervious cover and lawn fertilizer. Conventional septic systems provide limited treatment for nitrogen, except for some minor ammonia volatilization and captured organic nitrogen in the septic tank. Most of the organic nitrogen contained in the septic tank is converted to nitrates, which pass through the leaching system to the underlying groundwater. As much as 75 percent of the nitrogen released from septic systems originates as urine (EPA, 2013).

Consistent with DES' Great Bay Nitrogen Nonpoint Source Study (public draft, May 2013), systems located within 650 feet (200 meters) of the tidal estuary were assumed to deliver 60 percent of the nitrogen released from septic systems to the estuary due to the limited opportunity for attenuation along a shorter travel distance. Systems located outside the 200 meter buffer or in the upper watershed (above tidal dam) were estimated to deliver between 23 and 25 percent of the nitrogen to the estuary, respectively. The initial per capita nitrogen loading rate to each septic system was assumed to be 10.6 lbs/year resulting in approximately 6.4 to 2.5 lbs/person/yr estimated to be delivered to the estuary, depending on system location within the watershed.

Table 5.9 summarizes the estimated number of septic systems located within the tidal buffer and those located elsewhere in Durham and the Oyster River watershed and their associated estimated nitrogen loads based on the model.   Approximately 75 septic units identified as being located within 200 meters of the estuary are estimated to contribute nearly a third of the overall load or approximately 1,204 lbs/year or 16 lbs per system, while the remaining 575 systems located outside the 200 meter buffer are estimated to contribute 3,551 lbs annually or approximately 6.2 lbs per unit, on average. The higher delivery ratio assumed for systems within the 200 meter buffer has a major influence in the overall load. For comparison, the Chesapeake Bay Program (CBP) Watershed Model assumed that all systems in the watershed delivered 40 percent of the nitrogen to the estuary, which resulted in an estimated delivery rate of 3.6 lbs per person or approximately 9 lbs per system, on average, assuming 2.5 persons per household (EPA 2010).

Table 5.9: Estimated Delivered Nitrogen Loads from Septic Systems in the Oyster River Watershed

	# Units[1]	N load (lbs/yr)	Lbs/ unit
Durham Tidal Buffer (200 m)	75	1,204	16
Durham Outside Tidal Buffer	575	3,551	6.2
Subtotal	650	4,755	

Relevant Research Findings

Strategies available to reduce nitrogen loading from septic systems may include education programs to encourage homeowners to increase system maintenance and operations (i.e., pumping), providing funding assistance to help replace existing systems with systems with updated design standards or advanced treatment and increasing inspection requirements to detect poorly functioning or failing systems and extending sewer lines to connect existing homes to the wastewater collection system. Capturing waste through the installation of composting toilets or urine separating toilets as part of a urine diversion program represent other complimentary programs. Implementing these strategies can be done either through a voluntary program with financial incentives or through regulatory approaches where increased maintenance or replacement is required depending on certain conditions.
Other states such as Massachusetts and Rhode Island have passed legislation requiring increased inspections in critical areas and/or at specific times such as the during real estate transfers to identify poorly functioning or failing systems. Durham's Shoreland Protection Ordinance currently requires the Code Enforcement Officer/Health Inspector to inspect any existing septic system that does not conform to the required setback (e.g., 125 feet for Oyster River, Lamprey River and tidal waters and 75 feet for any perennial stream) as part of a real estate transfer. If deemed in adequate, the system must be replaced prior to completion of the real estate transfer. This local regulation could be evaluated to include larger setback for tidal areas or include other priority areas based on known soil conditions, system age or risk factors.

The potential nitrogen removal credit for these strategies range from 5 percent for increased septic tank pumping (according to CBP Septic Mgt Program) to as high as 88 percent for sewer extensions based on the difference in the typical nitrogen concentration of 40 mg/L in septic effluent to that (5 mg/L) anticipated at the WWTF. Advanced treatment technologies for onsite septic systems are reported to achieve 25% to 50% reductions for systems using recirculated aeration systems or denitrifying processes, respectively (DES Draft NPS Assessment Plan, 2013). The overall capital and operating and maintenance costs for these various treatment technologies vary considerably.

According to the CBP's Model Septic Management Program, advanced treatment technologies in the form of recirculating aeration tanks or denitrifying systems could reduce the nitrogen load from septic systems by 49 and 74 percent, respectively. The additional cost to include a recirculating aeration system is estimated to range between

$4,000 and $10,000 and from $10,000 to $15,000 for a denitrifying system, depending on system size and other site specific factors (EPA 2010).

Potential Program Considerations

Measures or strategies to reduce septic system loading are likely to rely on voluntary homeowner participation, with the exception of requirements already codified in state or local regulations (e.g., shoreland setbacks and inspections). Homeowner participation could be encouraged through a dedicated fund to provide financial assistance septic system upgrades and use of advanced treatment. This fund could initially be established through the Capital Improvement Program and potentially replenished or sustained through inspection fees or a nominal flat fee assessed to all households serviced by septic systems similar to the sewer fees since the responsibility of maintaining the Great Bay and the Oyster River estuary (public resources) extends beyond sewer rate payers. This program could extend to all homeowners in Town and not just those in the Oyster River watershed

If a fund was established to assist homeowners with system upgrades, it would worthwhile to develop a Septic System Management Plan to help identify areas of Town where septic systems may pose a greater risk to the downstream water bodies due to various site specific conditions and/or other system related factors. These factors include distance to the water body, age and design of the system, household density, replacement history, high ground water tables, steep slopes, water quality indicators, and presence of marine clays to name a few. This assessment would help to prioritize and target specific areas where there may be greater potential for higher loads due to poorly functioning systems. This would allow the Town to achieve a better return on investment and would help to better track and account for potential load reductions.

Estimated Load Reductions

Table 5.10 summarizes the estimated load reductions expected for the various management measures proposed for improved septic management measures. Certain activities such as developing a septic system management plan or developing a better tracking and accounting system are not expected to directly result in load reductions but will provide useful information for prioritizing resource investment and activities going forward as well as assist in measuring success and compliance with proposed permit commitments.

Table 5.10: Estimated Load Reductions for Recommended Measures Related to Septic Systems

Treatment Measure	Target Area	Estimated Participation Level[1]	Estimated Annual Load	Estimated Removal Efficiency	Estimated Annual Load Reduction After 5 Years (lbs/yr)	
			Lbs/yr	%	Low	High
Public Education and Outreach to Increase Septic Pumping	Tidal shoreland	50%	600	5%[2]	30	30
	Watershed-wide	25%	800	5%[2]	45	45
Funding Assistance for Voluntary System Upgrades	Tidal shoreland	2 unit/yr	32	50- 75%[2]	16 (32)[3]	24 (120)[3]
	Watershed-wide	2 units/yr	12	50-75%[2]	6 (30)[3]	8 (40)[3]
Septic Mgt Plan	Town-Wide	100%	Na	na[2]	na	na
Tracking Septic Inspections	Designated Shoreland Area	Varies	Na	na[2]	na	na
					140[3]	230[3]

Notes: [1]Estimated percentage of homeowners that would pump their systems or replace their systems as result of public education was based on best professional judgment. [2]Estimated removal credit for septic pumping was assumed to be 5%, while advanced treatment and denitrifying systems are reported to provide 50 and 75 % removal, respectively.
[3]Values in parenthesis represent cumulative 5 year totals based on the additional units upgraded each year.
[4]The estimated load reduction associated with sewer extensions was not included in the analysis as there is substantial uncertainty as to where and when this might occur and the associated costs. This would likely occur more on a twenty year time frame.

Measures of Success

Potential measures of success would likely include monitoring and tracking the participation levels and activities completed as part of a public education and outreach campaign. The number of septic systems upgraded with advanced treatment will likely depend on available funding assistance provided to homeowners. Tracking of system upgrades and inspections will require coordination between code enforcement and NHDES Subsurface Bureau.

Estimated Program Costs

Table 5.11 presents the estimated annual and capital costs related to implementing the septic system program.

Table 5.11: Estimated Annual and Capital Costs for Potential Measures Targeting Septic Systems

	Program Activity or Measure	Sequence	Annual Costs	One Time or Capital costs
New Program Costs	Develop a Public Education and Outreach Campaign to Increase Homeowner System Pumping & Maintenance	Startup	--	$20,000[1]
	Develop a Septic System Management Plan	Startup	--	$50,000
	Establish a Revolving Fund to Assist Homeowners with System Upgrades and installing Advanced Treatment	implement	$50,000	--
	Annual Administration and Management Costs [2] (assume estimated 0.25 FTE needed)	implement	$30,000	--
	Research Feasibility of Pilot Urine Diversion Program	startup	--	$15,000
			$80,000	$85,000
	Total Estimated Annualized Cost[3]		**$86,000**	

Notes: [1]The estimated costs for the public education component assumes some overlap with the lawn fertilizer education program.
[2]The estimated administration and management costs include some staff time to coordinate and manage the program.
[3]Annualized costs include amortized estimated one-time capital costs over a 20 year period at 3.5% interest plus recurring annual costs.

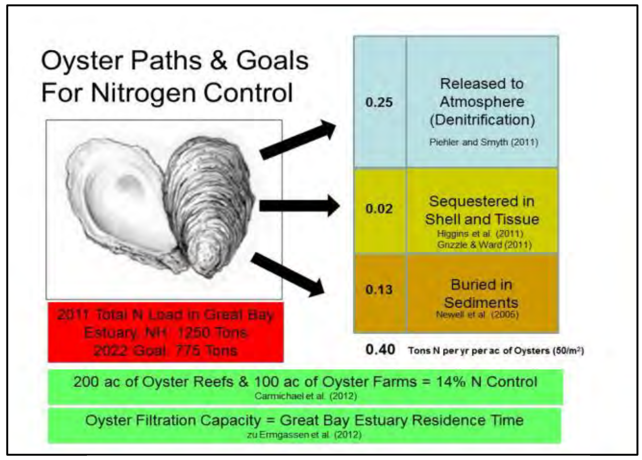
5.8 Urine Segregation or Diversion

Urine segregation or diversion is another recent developing practice that has gained considerable attention as a low-cost alternative. Urine collection can be done through urine separating toilets in combination with or as an alternative to septic system upgrades as well as a stand-alone program that targets a particular user group or facility(s) that would otherwise direct wastewater to the wastewater treatment facility. Urine is estimated to contain 80% of the nitrogen found in sanitary wastewater and, therefore, urine segregation could be highly effective in reducing of nitrogen loads in wastewater (Hazen & Sawyer, 2009). Because of its nitrogen content, it can be also be a valuable resource as an agricultural fertilizer.

In collaboration with the UNH Engineering Department, Durham DPW has launched a pilot project by constructing a small, towable urine collection facility (referred to as “Pee-Wagon”) that can be used as temporary public rest room for students. The initial cost to construct this facility was under $1,000. Although the current facility is only capable of collecting several gallons of urine at a time, a few local farmers have expressed interest in using the collected urine for fertilizer. Future expansion of this program through homeowner participation and additional facilities could result in a meaningful reduction and reuse of nitrogen that would otherwise be sent to the wastewater facility.

5.9 Oyster Bed Restoration

Oyster reefs provide a number of important ecological benefits to the Great Bay ecosystem, including nutrient removal through denitrification and sequestration in tissues of reef organisms. The Virginia Institute of Marine Science considered oyster restoration as a BMP in the Lynnhaven River for the Chesapeake Bay TMDL, and found that denitrification at oyster reef sites could remove up to 240 lbs N/acre/year, while sequestration could remove up to 7,000 lbs N/acre/year depending on oyster density (Sisson *et al* 2011). Nutrient removal via oyster reefs in the Choptank River revealed a potential to remove 540 lbs/acre/year and sequestration of 871 lbs/acre/year for oyster densities of more than 100 oysters per square meter (Kellogg *et al* 2013). Factors that affect nitrogen assimilation include intensity of planting, ecological effects, and available space (Carmichael *et al*. 2012). The TNC has indicated that a restored one acre of oyster reef can remove approximately 0.4 tons of nitrogen on an annual basis.



Effects of Oyster Bed Restoration on Nitrogen
Source: The Nature Conservancy, 2013.

However, the oyster population in the Great Bay has declined significantly over the past century due to overharvesting, pollution, and disease. The Oyster Conservationist Program organized by the Nature Conservancy and University of New Hampshire are constructed oyster reefs using hard surfaces such as oyster shells on which hatchery-raised larval oysters can grow.

Existing Programs

According to Ray Konisky at The Nature Conservancy (TNC), the Oyster River has proven to be a viable and successful area for oyster growth, with an existing total restoration footprint of at least two acres. The Oyster River once included over 20 acres of oyster shellfish beds. Oyster bed restoration can improve fish habitats and the overall clarity of water both of which are critical components to restoring the estuary and water quality.

The program's restoration methods include planting shells on firm channel bottom using primarily surf-clam shell (*Spisula solidissima*) from a seafood processor. One method used for spreading shell was a spud barge that deployed shell from feed bags attached to a crane, which covered 20-60 percent of the targeted area. Constructed shell reefs ranged from 0.2 acres to 3 acres with shell spreads of 100-200 cubic yards, yielding natural oyster recruitment ranging from 6,000 to at least 140,000 spat. Restoration efforts in parts of Great Bay have been concentrated in areas closed to harvest near municipal wastewater flows in order to maximize filtration benefits.

Potential Program Components

The sequential steps involved with restoring Oyster Reefs include:

- Identifying ideal sites for restoration
- Obtaining seed source and shell substrate for placement
- Permitting
- Installation
- Post-Construction Monitoring

Proposed Program Details and Assumptions

Implementation: Initiate restoration activities with TNC and UNH Oyster restoration partners. This process would include providing funding for restoration of 3 acres of reef over 5 years. The funding would support planning (i.e. identification of most viable Oyster River locations), permitting, shell acquisition and placement, spat seeding and post-construction monitoring and management.

Estimated Load Reductions

The TNC reports an average annual nitrogen load reduction of 0.4 tons (800 lbs/yr) per acre of oyster reef restored. The actual number of acres of oyster bed restored will depend on site feasibility, agency approval of credits and available funding. Nitrogen reduction occurs as a result of assimilation, sequestration and denitrification processes.

Staff Responsibilities/ Needs

Durham and UNH staff provides administrative support and funding. TNC provides restoration planning, permitting, installation, post-construction monitoring, recordkeeping and reporting. No new staff positions are anticipated. Estimated Program Costs for Oyster Bed Restoration

Based on information provided by the Nature Conservancy's Oyster Bed Restoration specialist, the typical cost to develop and maintain an acre of oyster bed is approximately $85,000. This cost includes planning, permitting and actual construction costs. An additional cost of up to $10,000 was included to fund start-up coordination and administration staff time. An annual maintenance cost of $3,000 per year was included.

Table 5.12: Estimated Annual and Capital Costs for Potential Oyster Bed Restoration

	Program Activity or Measure	Sequence	Annual Costs	One Time or Capital Costs
New Program Costs	Initial Administration and Management Costs; includes contract development between town and oyster restoration partners, oyster reef planning)	Startup	--	$10,000[1]
	Implementation Costs: (assuming 3.0 acres of restoration at ~$85,000 per acre)	Implementation	--	$260,000
	Annual Operation & Maintenance Cost	Ongoing	$3,000[2]	
			$3,000	$270,000
	Total Estimated Annualized Costs[3]		**$22,000**	

Notes: [1]The estimated start-up costs covers some staff time and legal assistance time for coordination and assistance with permit acquisition.
[2]It was assumed that there would be some nominal costs in the administration of monitoring and maintaining viability of the oyster beds.
[3]Annualized costs include amortized capital or one-time cost over 20 years at 3.5% interest plus recurring annual costs.

5.10 Preliminary Cost Estimates for the Possible Nitrogen Control Program

Table 5.13 provides preliminary cost estimates and estimated load reductions for the various nitrogen control program options discussed herein. The preliminary cost estimates include annual operational/maintenance costs and capital costs related to construction or other one-time costs that are amortized over 20 years. It is anticipated that it may take as much as five years to fully implement this Program, which could result in an annual nitrogen load reduction of just over 4,600 pounds or 2.3 tons based on the assumed removal efficiencies and level of implementation for each measure. Approximately half or 2,400 pounds of the estimated load reduction is related to 3 acres of proposed oyster bed restoration. Oyster bed restoration appears to be relatively cost effective but how much oyster bed restoration that can be feasibly done will depend on site suitability in the Oyster River and the acquisition of appropriate permits. Oyster bed restoration is also reliant on the viability and survivability of the oysters, which can be prone to occasional disease and other survivability factors. It also does not provide water quality benefits for waters in the upper reaches of the watershed.

Public education efforts promoting more efficient use of lawn and agriculture fertilizer appear to be very cost-effective as compared to impervious cover and septic system management measures. However, impervious cover measures would result in other pollutant load reductions such as total suspended solids and total phosphorus and are likely to be required by the pending MS4 stormwater permit. On a case by case basis, septic system upgrades could prove to be more cost-effective especially for poorly performing or failed systems near water bodies.

Table 5.13: Preliminary Cost Estimates for Possible Nonpoint Source Control Program in Durham & UNH

NPS Program	Estimated Annual Load Reduction[1] (lbs N/yr)	Annual (O&M) Cost[1]	Capital Cost[2]	Annualized Capital Cost[3]	Total Annual Cost	Total Cost per LB of Nitrogen[4]
Lawn Fertilizer Program	1,050	$ 50,000	$ 110,000	$ 8,000	$ 58,000	$ 280
UNH Ag Nutrient Mngmt	720	$ 60,000	$ 310,000	$ 21,800	$ 81,800	$ 570
Impervious Cover Program	250	$ 35,000	$ 850,000	$ 60,000	$ 95,000	$ 1,900
Septic System Program	230	$ 80,000	$ 85,000	$ 6,000	$ 86,000	$ 1,870
Oyster Bed Restoration (3	2,400	$ 3,000	$ 270,000	$ 19,000	$ 22,000	$ 50
Water Quality Monitoring		$ 80,000	$ 40,000	$ 3,000	$ 83,000	---
Total	**4,650**	**$ 308,000**	**$1,665,000**	**$117,800**	**$425,800**	**$ 460**

Notes: [1]Estimated load reductions represent annual load reductions after five years of implementation.
[2]Estimated annual costs include capital costs amortized over 20 years at 3.5% interest rate plus recurring annual costs.
[3]Oyster Bed restoration costs are estimated to be approximately $94,000 per acre based on information from TNC.
[4]The total cost per pound was based on the total 5-yr implementation cost (annual cost x 5) divided by total annual load reduction after 5 years

Comparing preliminary cost estimates for the NPS control program to the planning level cost estimates for the WWTF upgrade to meet a limit of 3 mg/L (Section 2.3), indicates that achieving a nitrogen load reduction of approximately 2.0 tons, which is roughly equivalent to the difference in the annual nitrogen load with an effluent limit of 5 mg/L instead of 3 mg/L, could be done much more-cost effectively with NPS control measures than upgrading the WWTF to 3 mg/L. The added annual costs to upgrade the WWTF to meet an effluent limit of 3 mg/L instead of 5 mg/L was estimated to be approximately $650,000 over 20 years. The estimated cost to implement the NPS control program is approximately $425,800 per year over five years resulting in a potential annual savings of approximately $225,000 per year and even more when compared to the 20-year Life Cycle costs. Some additional maintenance costs are anticipated beyond the initial 5 year period to sustain the NPS Program but these are likely to be much less than the estimated annual O&M costs of $325,000 to maintain the 3 mg/L limit. In addition, the NPS program would result in additional water quality benefits by enhancing upstream waters and resulting in other pollutant load reductions that would not occur with the WWTF upgrade. The Lawn Fertilizer Outreach Program, enhanced Nutrient Management Measures for UNH Agriculture and 3 acres of Oyster Bed Restoration could potentially be done for less than $200,000 per year and result in close to 2.0 tons in annual nitrogen load reduction.

6.0 Tracking and Accounting for Future Nitrogen Control Program

6.1 Overview of Tracking and Accounting for Regulatory Compliance

The development of a tracking and accounting system will be an essential component of an Integrated Permit as well as complying the pending MS4 Stormwater General Permit. Tracking and accounting essentially involves establishing an inventory of existing types and quantities of pollutant sources, monitoring and documenting changes in these sources due to changes in operations and/or as a result of future development and then quantifying the effects of these changes or any management measures used to reduce existing pollutant loads. The basic premise behind the new regulatory trend is that it allows regulated entities, stakeholders and EPA to better monitor progress towards restoring impaired waters and achieving water quality objectives.

The 2013 Draft MS4 Stormwater Permit included a provision requiring regulated entities to track and account changes in impervious cover and any activities related to "disconnecting" impervious cover through future stormwater BMPs. The Exeter and Newmarket AOC's also include a requirement to track and account impervious cover changes as well as other activities that might affect nitrogen loads associated with nonpoint sources and wastewater treatment.

In addition to meeting compliance needs, a tracking and accounting tool could serve to provide or enhance other useful functions such as budget planning, tracking expenditure and personnel hours and other reporting and administrative functions. The following lists other important functions that could be provided:

- Budget Estimating and Scheduling Work Flow and Operations and Maintenance Needs
- Inventory and Asset Management
- Future Planning and Goal Setting
- Provide Residents & Stakeholders with Updates on Program Services and Accomplishments
- Periodic or Annual Reporting for other Needs and Services

6.2 Relevant Activities for Tracking and Accounting

Table 6.1 provides a listing of some of the relevant activities that would likely need to be tracked and the various sources and methods that could be used to compile data. Certain aspects on these activities are currently being documented in some manner at the Town and state level. For example, at the Town level, street sweeping, catch basin cleaning, approvals of new septic systems or upgrades, new development approvals and related impervious cover changes, changes in agricultural operations and stormwater BMP installations, are some activities that are currently being recorded by various municipal personnel. Other information is likely to be contained in application materials and plans submitted by developers in pursuit of approvals from the Planning Department, Conservation Commission, Code Enforcer and/or DPW. This data is recorded to some degree in data base systems used by each Department and is likely stored and shared on the Town server. At the state level, other information related to new development may be available related to approvals of new or septic system upgrades, wetland permits, shoreland permits and Alteration of Terrain permits, of which some details are provided by DES' OneStop web database.

A key step going forward involves developing a centralized data base where this information from a variety of sources can be compiled and processed to generate specific details on the quantifiable effect on nitrogen loads.

Initially, it will be essential to review current data recording practices and coordinate with the various Town and UNH Departments and outside agencies to identify how the data is recorded for operational activities and as part of application and approval processes and identify how the data collection process can be enhanced and allow for a more automated record-keeping. Detailed checklists can be created /modified to specify data needs to allow quantification of changes in new or modified sources and the frequency and extent of management activities and/or structural practices and their effect on existing nutrient loads.

Through this initial coordination, the framework for a centralized tracking and accounting system can be developed that allows for more consistent methods of data compilation and recordkeeping that will later support processes to quantify changes in pollutant loads. As discussed in Section 6.4 below, the level of complexity used to develop the proposed tracking system can range from a simple, single-user, Excel spreadsheet to a more advanced web-based program that allows multiple user access and greater automation processes to help in data compilation and quantification steps and reduce the amount of staff time needed for data entry and report generation.

Table 6.1: Potential List of Activities and Measures and Related Data Sources for Nitrogen Tracking

	Potential Data Sources														
Principal Activity/Change	Durham DPW	UNH Facilities	GIS Mapping Data	New Development	Planning Board	Conservation Comm.	Code Enforcement	Local Contractors	UNH Coop Extension	Real Estate Sales	NRCS Consultation	Watershed Advisory	Retail Store Sales	DES One Stop Wetland Applications	DES Septic System Approvals
Impervious Cover															
Street Sweeping	x	x													
Catch basin cleaning	x	x													
New Impervious Cover	x	x	x	x	x					x					
Decreased Impervious Cover	x	x	x	x	x	x	x			x					
Disconnection of Impervious Cover	x	x		x	x	x									
Stormwater Treatment BMPs	x	x		x	x	x									
Adoption of New Regulations	x	x			x		x								
Lawn/Turf Fertilizer Use															
New / Reduced Fertilizer Lawn Area	x	x	x	x	x	x			x						
Public Education Events/Attendance	x	x				x			x			x			
Training /Certifications	x	x				x			x			x			
Re-plantings or Lawn conversions	x	x	x	x	x	x	x		x	x	x	x		x	
Retail Sales of Fertilizer													x		
Agriculture Fertilizer User															
Inventory of Ag Fields using Fertilizer	x	x	x	x	x	x			x		x				
Manure Applications		x					x		x		x				
Nutrient Management Plans Updates		x							x		x				
Field Buffer widths	x	x	x						x						
Land Use Convers./Property Transfer			x	x	x	x			x	x	x				
Septic System Upgrades															
In-kind Replacements							x	x		x					x
New Systems				x	x		x	x		x					x
System Upgrades using Advanced Tech							x	x		x					x
Evidence of Poor functioning/ Seeps			x				x	x		x					
Septic Tank Pumping	x							x							
Other															
Illicit Discharge Detections	x	x						x							
Land Conservation		x	x	x	x	x					x				
Urine Diversion Collection Activity	x														

6.3 An Evaluation of other Tracking and Accounting System Developments

There are few examples where tracking and accounting tools have currently been developed, especially in the Northeast region. The Chesapeake Bay Watershed and Tampa Bay Estuary Programs are perhaps two of the best examples where tracking and accounting procedures have been developed. The program development in these examples occurred over many years, required extensive funding and stakeholder collaboration and represent relatively high end, web-based protocols and GIS mapping programs geared toward large scale, multi-county or state-wide evaluations. The level of complexity involved with these applications and programs are likely to be greater than what is needed for Durham and UNH but many of the basic concepts and functional capabilities are likely to be useful in a more-scaled down application. There are a number of options and considerations to be assessed in the systems development in terms of the desired level of convenience, data processing automation and the level of details to be included in the report generation. The relative advantages and disadvantages of these options are described further in Section 4.4 below.

In June 2014, NHDES had hosted a tracking and accounting workshop to initiate a collaborative effort amongst several Seacoast towns, mainly Durham, Exeter and Newmarket to help develop a universal tool or approach that each community could use to address this pending tracking and accounting requirement and more specifically to comply with the AOC requirements for Exeter and Newmarket. Durham and UNH should participate in this collaborative effort for program development over the ensuring months. The 2013 Draft MS4 Stormwater Permit also contains recommended calculation methods to account for load reductions related to impervious cover.

The Long Island Sound (LIS) Program recently released a Phase I Report summarizing examples of various tracking and accounting tool used in the Northeast region and elsewhere in the country (NEIWPCC 2014). The LIS Phase I Study identified the following core elements are critical for future tracking and accounting:

- Ability to compile a diverse set of data and details for various control measures into a common framework.
- Ability to track and quantify the effects of a wide variety of control measures including nonstructural, educational and regulatory measures.
- Ability to locate, categorize and rank control measures by geographic location.
- Ability to compute nitrogen load reduction credits in a defensible manner for each type of control measure.

Developing a program that has the capacity to extract, import and populate data both electronically and through automation processes could prove to be much more cost-effective than relying on frequent manual data entry and should be an important consideration for program development. Geo-referencing BMP locations and other activities is also a valuable function to enable users to locate and evaluate load reduction measures on a watershed basis within the larger Oyster River watershed. Although building this functionality into the application can generally result in greater upfront costs for program development, it would likely result in substantial time and cost savings over the long run by minimizing the data collection and entry, data management and report generation.

6.4 Various Options for a Tracking and Accounting Procedure

A tracking and accounting process involve two major aspects. The first aspect focuses on identifying how relevant activities are currently being recorded and reported in terms of new impervious surfaces, street sweeping, catch basin cleaning, septic system inspections and upgrades, fertilizer usage on municipal land, etc. This will require a series of meetings or workshops with Durham and UNH personnel to discuss and evaluate how current practices could be improved and what functional capabilities would be useful in making their jobs easier in tracking and reporting these activities as part of a nitrogen tracking and accounting tool. It is important to fully understand current recordkeeping practices amongst the various departments and outside agencies prior initiating the program development to make sure specific needs and preferences are addressed.

The second aspect or phase would focus on developing the actual tracking and accounting system which could range in complexity from a modified, Excel spreadsheet or Access database template where relevant data would be entered manually by one principal user to a more customized, web-based program that allows for multiple user access through a login/password system and includes custom program scripts that enables more automated data entry and can extract data other electronic data sources. A custom built program could allow greater functional capability for data management and report generation and possibly enable GIS map viewing, automated load calculations and the ability to evaluate the relative effects of different implementation scenarios and alternatives.

Two areas that are likely to require the greatest effort include establishing appropriate units of measure for each tracking activity, especially for nonstructural or management measures, and secondly, establishing acceptable nitrogen removal credits for each measurable unit of activity. The latter will likely rely heavily on the removal credit system developed in the Chesapeake Bay watershed or elsewhere and will require multiple discussions with regulatory personnel to gain consensus and agreement on removal credits. Once the credits are determined the actual load reduction credits can be calculated through an automated process built into the tracking and accounting tool. This added functional capability would save time in the subsequent reporting efforts.

The following provides summary of the advantages and disadvantages of two primary options and description the various potential capabilities and levels of complexities based on information provided by VHB's and W&C's IT professionals experienced in developing custom spreadsheet tools and web-based programs and applications.

Option A: Excel Online Spreadsheet

The most basic option would involve modifying an Excel spreadsheet to include data entry placeholders for the various tracking activities for each municipal and UNH department responsible for recording such activities. Using Microsoft's online functionality, the spreadsheet could be accessed by multiple users through the Town's and UNH's computer servers. This approach would rely heavily on manual data entry to populate data placeholders for specific data needs for each program/activity. The spreadsheet would include imbedded formulas to calculate changes in annual loading for each activity. It is envisioned that the spreadsheet would be developed with separate modules or tabs for each major municipal department or program. A system would need to be developed to coordinate the data entry details and sequence amongst the approved users to minimize the number of versions and changes.

The primary advantages of Option A include:

- Less development time and upfront cost
- Less potential training needs depending on familiarity with Excel spreadsheets
- Program can be easily modified and adjusted based on changing needs

The primary disadvantages of Option A include:

- Limited accessibility to potential users outside of municipal staff
- Limited functionality to customize data entry formats
- Not as user friendly as other customized web-based formats
- Minimal report creation capabilities
- Minimal support for mapping component

Preliminary estimates for program development costs for Option A are expected to range between $15,000 and $25,000 with the level of effort to depend greatly on the amount of coordination required upfront with the various departments to assess existing data collection and recording processes and the amount of time involved with establishing the removal credits with the regulatory agencies. The upfront coordination to assess status of existing data, data collection and reporting needs is likely to comprise as much of half the estimated effort.

Option B: Custom Web-Based Application

The other option would be to develop a more customized web-based application that would include a more user-friendly data entry interface to include some automated methods to make data entry easier. As custom built product could be designed with data entry formats that resemble an online survey with a series of key questions to incorporate specific data inputs that would populate the data spreadsheet. Specific drop down menus could be incorporated to ease data entry on specific activities and include automatic reminders to notify users when changes have been made or data entry needs. It is anticipated that the program would have multiple modules segmented by the major sources and various control measure types (i.e., structural vs. nonstructural). The program could also integrate with GIS and GPS mapping tools and reporting generating processes to address other municipal reporting needs such as budget planning or work order reminders.

The primary advantages of Option B include:

- Allows for custom user-friendly interface
- Increased functional capabilities
- Allows multi-user access over the web based via login/password system
- Potential for built-in reporting functions
- Enables integration with mapping component add-on

The principal disadvantages of Option B include:

- Greater upfront program development costs
- Longer development time and increased need for ongoing support
- Future modifications/updates may require outside technical assistance

Depending on the various functional capabilities and level of customization for different data entry and reporting needs, the upfront program development costs are expected to be in the range of $25,000 to $35,000 which could be completed in phases. The integration of a map viewer component would push the potential upfront costs closer to the higher end of the estimated cost range, which could be phased in at a later date.

7.0 Recommendations to Advance the Integrated Permitting Process

The following provides a list of recommendations to help advance the Integrated Permit process with the resource agencies and address future compliance needs with respect to reducing nitrogen loads to the Great Bay.

Program / Activity
A. Agency Consultation and Draft Integrated Permit Language
A.1 Given peer review results on draft nutrient criteria, schedule a meeting with NHDES to get an update on nutrient criteria development and the Great Bay water quality conditions.
A.2 Given recent EPA personnel changes, schedule a meeting with EPA Region 1 to discuss feasibility of an Integrated Permit and continue to engage EPA headquarter personnel into discussions.
A.3 Continue to develop Draft Integrated Permit language that outlines the Town's and UNH's goals and commitments to leverage flexibility and promote sequencing of compliance activities.
A.4 Assess how the Town and UNH could coordinate on MS4 Permit Compliance activities and eliminate duplicative and overlapping activities to address the pending MS4 Permit requirements.
B. Model Assessment and Implementation Plan
B.1 Review pending update of the 2013 WSAG Water Quality Report with revised flow estimates and additional data being collected in 2014 findings for comparison to model findings.
B.2 Initiate discussions with Town and UNH personnel to assess feasibility and potential effort required to implement measures included in Draft Nitrogen Control Plan and identify budget needs for next five years and the potential alternatives, roles and responsibilities.
B.3 Consult with UNH Stormwater Center to consider a feasibility analysis to identify and prioritize stormwater BMPs locations for impervious cover to optimize future nutrient load reductions.
C. Preparation for MS4 Permit Compliance
C.1 Review 2013 Draft MS4 Permit and pending Massachusetts Draft Permit to conduct budget planning and identify potential staffing requirements and means to collaborate in meeting new compliance tasks.
C.3 Identify Town-owned and University owned impervious cover that is currently untreated and treated using the existing impervious cover data (See Rec B.3 above).
D. Tracking and Accounting Protocols
D.1 Appropriate funding to develop initial tracking and accounting tool and collaborate with other towns to develop a uniform process to track and account future NPS load reductions.
D.2 Meet with town and university personnel to discuss how existing recordkeeping of nitrogen related activities could be enhanced to develop a future tracking and accounting system.
D.3 Participate in the pending NHDES collaborative approach to develop a universal tracking and accounting procedure.
E. Asset Management and Data Collection
E.1 Use summer intern to review existing Town storm drain mapping and compare to UNH mapping data to identify data gaps and steps needed to achieve consistency with system mapping and attribute data.
E.2 Allocate budget to conduct a town-wide septic system inventory to identify priority areas for future management and evaluate regulatory options for increased inspections & maintenance.
F. Public Information and Engagement
F.1 Update project web site to host recent project information, Draft Report and wq data.
F.2 Schedule next public informational meeting to invite watershed residents to provide update on preliminary findings on modeling, water quality data, Draft Nitrogen Control Plan.
F.3 Provide project updates to other Town departments and committees & other watershed officials
G. Pursue Future Grant Funding
G.1 Consult with NRCS personnel about potential funding assistance for UNH Ag Program and local farmers to implement additional measures to improve water quality.

8.0 Potential Grant Funding Programs

As indicated in Section 5.0, implementation of the various nonpoint source controls to reduce nutrient loads will require substantial investment on the part of the Project Partners as well as other stakeholders. There are a number of state and federal funding programs that could help in reducing the implementation cost burden. These programs vary widely in their objectives, amount of available funding, application process, matching requirements, recipient eligibility and the types of projects targeted for funding. Other potential grant funding may be available through non-profit organizations and charitable foundations but these programs typically target funding toward other non-profits, volunteer groups or individuals rather than municipal government or state institutions, with some exceptions. The Durham Public Works Department has been successful in securing grant funding for various recent projects primarily through the NHDES 319 Program and the Clean Water Revolving Loan Fund to assist in stormwater BMP installations.

Table 8.1 provides a summary of the major governmental funding programs that are typically available in this region. NHDES' Section 319 grant funding program is perhaps one of the most popular grant funding programs in the state. The Funds are specifically targeted toward funding measures that will help improve water quality in water bodies deemed to be impaired. Grants are typically in the order of $40,000 to $125,000 for eligible projects, depending on the type of and complexity of the project. The program is highly competitive and requires a 40% match from the applicant, a portion of which can in-kind services and the rest cash. A general pre-requirement of this program, is that there be quantitative assessment (typically involving a Watershed Management Plan) that provides a relative assessment of the source contributions and potential allocation or target reduction needed to meet water quality standards. This assessment helps to ensure that funds are being used on the most effective measures that will improve water quality. Projects eligible for funding under this program would include stormwater BMP design and installation, green infrastructure and other treatment measures, public education and outreach programs, regulation review and updates and use of natural vegetation for water quality treatment. The UNH Stormwater Center in partnership with UNH Facilities has recently been awarded a 319 grant to install stormwater BMP retrofits in the A-lot parking lot.

Another viable but perhaps less known state grant funding program consists of the Aquatic Resources Mitigation (ARM) Fund. This program funds are primarily directed toward wetland restoration projects, but also fund land conservation projects via purchase or conservation easements as well as stream channel and shoreland buffer restorations projects. There is no required match, however, some financial or in-kind commitment improves the chances of being selected for funding. The available funding depends on the number of projects that paid in-lieu fees within each identified HUC-12 watershed and the number of requests for funding in any given year. Typically, grant awards range between $50,000 to $150,000, depending on the project and the restoration potential. Eligible projects considered for funding program include wetland restoration, acquiring land conservation easements especially along stream and shoreland, restoration of tile-drained areas as well as channel restoration and stream buffer plantings.

At the federal level, the USDA Natural Resources Conservation Service (NRCS) has several funding assistance programs dedicated toward implementing measures to improve water quality. The Conservation Innovation Program (CIG) is most applicable since both the Town and UNH would be eligible whereas most other programs are targeted to local farmers. This Program provides grants of $25k to $75K to help adopt innovative solutions to nutrient management and promote conservation practices to improve water quality. It does not support research efforts. There is generally an annual Request for Projects issued in the spring with an online application through the federal grants web site. Identifying appropriate projects and use of these funds for implementation purposes should be discussed with NRCS personnel in preparation for next fiscal year. The Oyster River watershed is identified as a priority watershed.

Table 8.1: Summary of Existing State and Federal Grant Funding Programs for Implementation Funding Assistance

	Funding Source	Approx. $$ Available	Match Requirement	Application Deadline	Eligible Recipients	Program Goal/ Targeted Projects	Potential Projects	Contact Information
1	NH Clean Water Revolving Loan Fund	$50,000 - $150,000	low interest loan	No deadline posting yet for FY2015	Towns, Utility Districts	Stormwater improvements and system assessment/ planning	In FY13, Durham used partial grant/loan to acquire excavator/ rain gardens	Daniel Fenno, SRF Program Manager (603) 271-3448 daniel.fenno@des.nh.gov
2	NHDES 319 Funds for Impaired Waters - Planning & Implementation	FY2015 $0.5 Mil: Typical awards $50,000 - $125,000	40%	Deadline for Pre-App not set yet – usually by August	Towns, watershed groups, landowners	Stormwater BMP design /construction, public education outreach campaigns, other remedial and treatment measures	Current UNH A-Lot Stormwater BMP/ Expansion of Urine Diversion	Sally Soule- NHDES (603) 559-1517 sally.soule@des.nh.gov
3	NHDES Aquatic Resource Mitigation (ARM) Fund	$150,000 for FY2014	no min match but local commitment increases award probability	April	Towns, watershed groups, landowners	Wetland restoration efforts as well as land conservation, stream channel or buffer restoration (increasing vegetation buffer along stream corridors is a primary objective)	Easements or plantings to enhance stream vegetation buffer/ restore tile drain areas no longer in agricultural production	Lori Summer Mitigation Coordinator (603) 271-4059 lori.sommer@des.nh.gov
3	DES Env-Wq 2000 Coastal Program Grant	$20,000 - $50,000	No	No set deadline	Towns, nonprofit groups, regional planning	Public Education & Outreach, Training & other Efforts that Address a Broader Audience in the Seacoast	Collaborative Training via Southeast Watershed Alliance	Catherine Coletti, coordinator (603) 559-0024 catherine.coletti@des.nh .gov
4	NOAA Coastal Nonpoint Source Program	Varies	No	Usually Summer	Low to Mod	Primarily directed toward technical exchange and education programs for communities and watershed groups in coastal areas to improve water quality.	In Mass, one project worked to improve local stormwater regulations.	Allison Castellan NOAA Coastal Programs allison.castellan@noaa.gov (301) 713-3155 x125
5	NRCS – Conservation Innovation Program(CIG) under Environmental Quality Incentives Program (EQIP)	In FY14, $150,000 in NH: low $25,000 High $75,000	1:1 half of match can be in-kind services	May 2014	Farmers, Towns, State Higher Educ. Institutions	Help adopt and promote innovative solutions to solve agricultural issues with respect to water quality and nutrient management	Improve nutrient mgt via cover crops, conservation tilling, filter strips, terraces, and in some cases, edge-of-field water quality monitoring	Brandon Smith, Assist. State Conservationist (603) 868-7581 x111

	Funding Source	Approx. $$ Available	Match Requirement	Application Deadline	Eligible Recipients	Program Goal/ Targeted Projects	Potential Projects	Contact Information
6	EPA Integrated Permit Technical Assistance	$65K in tech assistance	none	LOI due June 27,2014	Municipalities & other Regulated Entities	Targeted toward Communities or other Entities seeking to develop an Integrated Permit	Planning Assessments to evaluate opportunities to eliminate overlapping permit requirements and/or use nonpoint source control measures to offset WWTF upgrades	Kevin Weiss IP_Tech_Assistance@epa.gov
7	EPA Five Star – Urban Waters Restoration Program	FY2014 $25,000 to $50,000	1:1	RFP generally late Fall	Cities, Towns, Educational Institutions	Funding targeted toward urban stream restoration efforts as well as public information and education efforts	Green Infrastructure, Sustainability Favors Strong Educational Component	Lindsay Vacek Coordinator, Eastern Partnership Office
8	Water Environment Research Foundation (WERF) - Sustainable Integrated Water Management (SIWM)	$100,000- one time solicitation	na	Submittal period closed	Varies	Assist cities and towns to move toward sustainable management and integrate wastewater, stormwater, drinking water, and source water, as well as other infrastructure (energy, transportation, parks, etc)	Assist in the development of case studies or real world examples of resource integration and sustainable management	Amit Pramarink Senior Program Manager (571)-384-2101
9	National Fish and Wildlife Foundation: Environmental Solutions for Communities, Partnership with Wells Fargo Bank 5 yr Initiative thru 2017.	FY14 $3 mil Median Award $40,000 High $100k Low $25k	1:1	Annual RFP		Varies. Grant funds used to support priority projects in states and communities where Wells Fargo operates.	Promoting sustainable agriculture, green infrastructure, restoring or natural habitat and encouraging broad citizen participation for implementation.	Carrie.Clingan@nfwf.org 202-857-0166 http://www.nfwf.org/

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Appendices

A: EPA Water Quality Trading Policy Guidance and Case Study Fact Sheets

B: Durham Resident Survey Results on Fertilizer Usage

C: Draft Interim Water Quality Monitoring Reports (UNH WRRC and WSAG)

D: Input Data & Assumptions Used In Oyster River Watershed Assessment Model

E: Management Measures Screening Analysis Memo