FINAL REPORT

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LONG ISLAND SOUND BMP TRACKING TOOL

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Acknowledgements and Project Team

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Long Island Sound Study
A Partnership to Restore and Protect the Sound

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Executive Summary

The Long Island Sound TMDL (NYSDEC & CTDEP, 2000) has a phased implementation plan, which includes commitments to reevaluate nitrogen reduction targets periodically and prepare revised TMDLs accordingly. Since the initial TMDL was drafted, several studies have recommended developing an NPS N tracking system. Phase I of that effort reviewed available tracking tools (WaterVision, 2014), and recommended developing the tracking tool in Phase II. In 2019, NEIWPCC contracted with the Center for Watershed Protection (CWP) and the University of Connecticut (UConn) Center for Landuse Education and Research (CLEAR) to compete Phase II – Part 1, with Phase II – Part 2 focusing on developing and testing the Long Island Sound BMP Tracking Tool (LISBTT).

This project (Phase II – Part 1) focused on developing a sound technical basis for LISBTT, and testing and applying a prototype proof of concept spreadsheet tool (the Tool). The technical support for the Tool was summarized in two memos, which served as the technical underpinning to develop the Tool. The purpose of the Tool is to serve as a proof of concept for crediting BMPs within the LIS watershed and was tested using two sets of publicly available data. Throughout the project period, the project team was advised and assisted by a Technical Advisory Committee (TAC) who provided valuable assistance and oversight.

The technical memos developed as a part of this project included the Baseline Memo and the BMP Crediting Memo. The Baseline Memo summarized decisions regarding the baseline year (2016), land cover layer (National Land Cover Database; NLCD, 2016), analysis scale (HUC 12) and a set of loading rates for NLCD land cover types. The BMP Crediting Memo summarized a recommended list of BMPs, including practices implemented in both urban and agricultural settings, as well as Onsite Sewage Disposal Systems (OSDSs). The methods used were derived primarily from methods used regionally in New England, with methods from the Chesapeake Bay CAST Model when no regional method was available.

The Tool incorporated the assumptions in the two technical memos and was tested using two datasets: 1) A database of bioswales from New Haven Connecticut and 2) MS4 data submitted to CT DEEP by East Lyme, CT. While it was possible to account for BMPs implemented in each data set, some assumptions were necessary to quantify benefits using the Tool. In particular, not all data sets included drainage area information for BMPs. Further, none of the datasets reflected all of the practices implemented within the defined drainage area. This pilot suggested that, in order to make the LISBTT tool effective, some mechanism will be needed to ensure that: 1) sufficient data are collected about BMP design and implementation to make them trackable and 2) some legal or other mechanism (such as the NPDES MS4 permit) is used to ensure that new practices are entered.

Over the course of the project, some concerns arose over decisions that were incorporated into the initial memos. While some concerns related to incorporating recent research from the North Shore of Long Island, and were easily resolved, some issues remained with regard to consistency with the original 2000 LIS TMDL:

- The Base Year was decided to coincide with recently updated MS4 permits (2017) which, as well as the most recent NLCD land cover layer, but concerns were raised regarding how this year could be reconciled with the original (2000) base year. In fact, the original TMDL was developed using a 1992 land cover layer.

- The NLCD Land Cover layer and boundaries do not align with the scale and detail of the original TMDL, in that the TMDL uses a broader land classification (only three categories) and identifies Terrestrial Management Zones that do not align exactly with the borders of the HUC 12 watersheds and were not available in a digital format during the project period.
- The loading rates developed for this project were different than those used in the original TMDL, and instead reflected consistency with other regional tracking tools as well as recent LIS modeling and monitoring results and studies.

While the Tool incorporated some minor modifications to allow users to select an alternative set of loading rates consistent with the TMDL, the original land cover layer was not available, and could not be directly compared to available more recent land cover. Since the TAC had approved the 2016 base year, this year was used in the Tool, largely due to challenges related to the data quality of the original land cover layer. It is important to note that the Tool has not undergone regulatory review by the appropriate regulatory agencies. Due to this, the tool should not be used to document progress toward meeting the TMDL or suggest any further management decisions at this stage. Rather, the goal was to serve as a proof of concept and to identify data gaps for tracking BMP implementation.

Based on the results and experiences of this project, it is recommended that Phase II – Part 2 focus on developing a web-based tool to be implemented in Connecticut and states in the Upper Watershed, including New Hampshire, Vermont and Massachusetts:

1) Revisit the issue of the baseline year and land cover layer, with input from the TAC to select an appropriate year and approach.
2) Implement the Tool in additional pilot communities.
3) Conduct a land use change analysis from the selected (see #1 above) base conditions to current conditions in pilot basins.
4) Evaluate the costs and resources of implementing the Tool throughout the LIS watershed
5) Convert the Tool to a readily-shareable (potentially web-based) format (LISBTT)
6) Work directly with CT DEEP to integrate the Tool into the MS4 reporting process.

Contents

Figures

Tables

1 Project Background and Approach

1.1 Project Background

Hypoxia, or low dissolved oxygen caused primarily by excess nitrogen (N) loading, has been identified as the issue of greatest concern for water quality in Long Island Sound (LIS). In 2000, a total maximum daily load (TMDL) was developed for LIS that assigns a 10% reduction to nonpoint source (NPS) N from urban/suburban and agricultural land uses (NYSDEC & CTDEP, 2000). The TMDL has a phased implementation plan, which includes commitments to reevaluate nitrogen reduction targets periodically and prepare revised TMDLs accordingly.

In 2012, the Long Island Sound Study (LISS) Management Committee and the five watershed states approved a framework for the assessment of the TMDL known as the Enhanced Implementation Plan (LISS, 2012). One component of that plan was an assessment of the adequacy of current stormwater and NPS N control efforts in achieving the 2000 LIS TMDL. The assessment found that although the number, diversity, and coverage of nitrogen control programs have increased since 1990, little quantitative data and information are available to measure the effectiveness of these NPS programs in reducing total nitrogen loading to the Sound (NEIWPCC, 2014). The watershed itself has also undergone significant development since 1990. The assessment concluded that it is uncertain how the increase in N management strategies combined with changes in land use have affected progress towards the 10% reduction requirement and recommended further investigation into the effectiveness of NPS practices implemented in the basin (NEIWPCC, 2014). As a result, the Comprehensive Conservation and Management Plan (LISS, 2015) and the most recent update to the implementation actions (LISS, 2021) include development of an NPS N tracking system as key actions.

NEIWPCC and LISS have since begun a multi-phase effort to develop and implement a feasible tracking system that will allow for quantitative TMDL evaluations of the attainment of stormwater and NPS N load reductions, as required by the TMDL. Phase I, completed in 2014, was a review of existing NPS tracking systems for application to LIS. The WaterVision (2014) report "An Evaluation of Nonpoint Source Pollution Control Measure Tracking Systems for Long Island Sound" recommended adaption of the Chesapeake Assessment and Scenario Tool (CAST) framework to LIS as the basis for the NPS tracking system. NEIWPCC contracted with the Center for Watershed Protection (CWP) and the University of Connecticut (UConn) Center for Landuse Education and Research (CLEAR) to develop and pilot an NPS tracking tool. This project used a slightly different approach from what was recommended by the WaterVision (2014) report, by integrating a combination of crediting techniques used in the CAST model along with techniques derived from other northeastern regional methods such as the best management practice (BMP) pollutant removal curves developed by the University of New Hampshire, which are integrated into several ongoing tracking or accounting tools used in New England such as the Lake Champlain BMP Accounting and Tracking Tool (LC BATT) and the US EPA's OptiTool (Tetra Tech, 2015).

1.2 Project Approach and Goals

While the ultimate goal of Phase II is to develop an integrated tool for the five-state LIS watershed, the purpose of this project (Phase II – Part 1) was more targeted, with a focus on understanding current data limitations and identifying specific needs for developing an integrated tracking tool in the future. The project included six overall tasks, including:

1) Assembling and Working with a Technical Advisory Committee (TAC) to provide oversight throughout the project.
2) Developing a “Baseline Memo” that selects a baseline year for evaluating BMP benefits and quantifies loading rates for land covers in LIS watershed.
3) Selecting BMPs and methods for calculating N Credits for this group of BMPs
4) Developing a spreadsheet tool that integrates the Baseline and Crediting approaches
5) Piloting the tool in three locations, and
6) Recommending an approach for developing an integrated tracking tool based on the lessons learned in this project.

The key outcomes of the project were:

1) A simple tool that integrates assumptions and practices recommended by the TAC.
2) A better understanding of what kind of data is currently available, and how that might need to be modified to consistently track progress.
3) Identifying some other issues that need to be resolved in the future, such as consistency with both the original TMDL and the Long Island Sound Nitrogen Reduction Strategy, and consistency with other tracking tools and ongoing modeling and monitoring efforts in LIS.
4) Agreement and support of member states on how best to work together in Phase II – Part 2.

1.3 TAC Membership and Roles

The TAC provided oversight throughout the project, and particularly in reviewing methods for developing the Baseline Memo and the BMP Crediting techniques that were used to develop the Tool. TAC membership included representatives from the U.S. Environmental Protection Agency (US EPA), the U.S. Geological Survey (USGS), UCONN, state agencies and one nonprofit organization (Table 1). The TAC provided specific technical comments and also provided valuable insight into some of the legal and logistical challenges heading forward with the tracking tool to be developed in Phase II – Part 2. The TAC process included four meetings over the course of the project (Table 2).

Table 1. TAC Members

TAC Member	Organization
Emily Bird	VT DEC
Michael Dietz	UCONN
Richard Friesner	NEIWPCC (Project Officer)
Michele Golden	NYS DEC
John Mullaney	USGS
Leah O'Neill	US EPA
Paul Stacey	Footprints on the Water
Kelly Streich	CT DEEP
Nicole Tachiki	US EPA
Koon Tang	NYS DEC
Mark Tedesco	US EPA
Sue Van Patten	NYS DEC
Bessie Wright	US EPA

Table 2. TAC Meetings

Meeting Date	Goals
October 15, 2019	Kick off the process and solicit input for completing the Baseline Memo
November 26, 2019	Go over the Baseline Memo and identify BMPs for the Crediting portion.
February 24, 2020	Review the BMP Crediting Memo and evaluate next steps
February 1, 2021	Demonstrate the spreadsheet tool and discuss remaining issues

1.4 Caveats and Terminology

Throughout this report, there is reference to “The Tool” and “LISBTT.” LISBTT refers to a web-based tracking system that will be developed as a part of Phase II – Part 2, which is anticipated to begin in the Fall of 2021. The Tool refers to the proof-of-concept spreadsheet tool that was developed as a part of this project (Phase II – Part 1). Although the Tool was developed in concert with the TAC and serves as an initial framework for the LISBTT tool, it important to note that the Tool has not undergone regulatory review and, consequently, is not intended to be used to document progress toward meeting the TMDL.

1.5 Outline of This Report

The remaining Sections of this report summarize findings and products of this project:

- Section 2 summarizes Baseline Loading, including sources for loading factors, the base year, and delivery factors.
- Section 3 describes the methods used to quantify selected BMPs as part of the Tool.
- Section 4 describes three pilot studies conducted using the Tool.
- Section 5 summarizes lessons learned as a part of this project and describes steps needed to LISBTT.

2 Loading Rates

This section summarizes key decisions made to represent baseline conditions for the Tool. For most programs that assess TMDL implementation progress, the baseline typically aligns with the date of the monitoring and/or land cover data used in the TMDL since this represents the conditions under which the receiving water was determined to be impaired. BMPs implemented after this baseline can then be tracked and accounted for to measure progress towards the required load reductions. This section summarizes how land cover and baseline conditions are represented in the Tool, and also discusses issues raised in developing the loading rates and baseline conditions that need to be addressed in Phase II – Part 2, which has been approved by the LISS Management Committee. When these areas of disagreement are noted, they are typically presented as “Alternative Considerations” rather than “Recommendations.” Key elements considered in establishing the baseline include the following:

1) Land Cover Data
2) Watershed Boundaries
3) Baseline Year
4) Nitrogen Loading Rates, and
5) Delivery Factors/Attenuation Rates

2.1 Land Cover Data

Recommendation Implemented: 2016 NLCD Land Cover Data

For baseline loading estimates, the project team selected the 2016 National Land Cover Dataset (NLCD). The decision to use this dataset was approved at the project kickoff meeting, including representatives from CT DEEP, NYS DEC, US EPA and NEIWPCC, in August of 2019, and by the TAC in October of 2019. NLCD is 30-meter pixel land cover based on imagery from the LandSat series of satellites. Although UCONN CLEAR produces a comparable product for Connecticut that is also based on LandSat, the NLCD was chosen for two main reasons. First, as a national dataset it can be used throughout the LIS watershed, to include Massachusetts, Vermont, New York and New Hampshire.[1] Second, as a product of a federal consortium it is reasonable to assume that data will continue to be produced in subsequent years, whereas the CLEAR land cover is dependent upon grant funding and therefore updates are impossible to guarantee.

NLCD is coordinated through the 10-member MultiResolution Land Characteristics Consortium (MRLC), a two decades-long interagency federal government collaboration to provide digital land cover information for the Nation. This summer, the USGS released a new generation of NLCD products named NLCD 2016 for the conterminous U.S. NLCD 2016 contains 28 different land cover products characterizing land cover and land cover change across 7 epochs from 2001-2016, in addition to data on urban imperviousness, urban imperviousness change, tree canopy and tree canopy change. NLCD 2016 now offers land cover for years 2001, 2003, 2006, 2008, 2011, 2013, 2016, and impervious surface for 2001, 2006, 2011, and 2016.

Although all 28 land cover categories were not used in the Tool, this granularity of cover types allow for the most accurate use of loadings estimates available for the LIS watershed area. In addition, 2016 is

[1] A very small portion of the watershed is in Quebec Provence, Canada and is not included in the Tool.

the most recent year available for NLCD and is close to the 2017 initiation of the new Connecticut General Stormwater (MS4) Permit, which requires significant measures to reduce NPS through disconnections of impervious cover and other measures. Figure 1 includes screen captures from the NLCD 2016 online viewer.

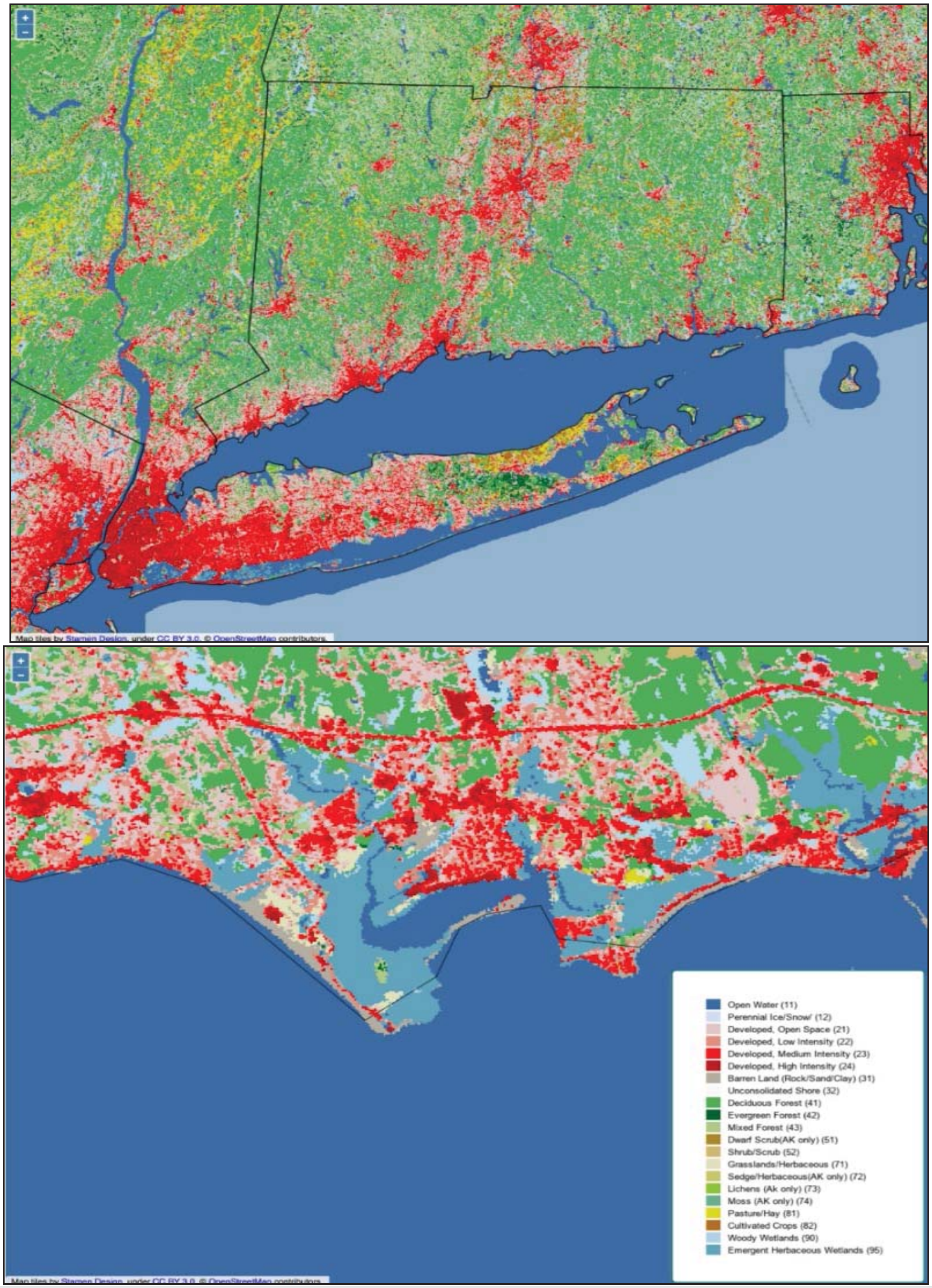


Figure 1. Screen captures from the NLCD 2016 online viewer.

Top: NLCD data for the LIS region. Bottom: detail of portion of CT coastline, showing NLCD categories.

Alternative Consideration: Reproduce TMDL Land Cover Data

As the project progressed, some members of the TAC expressed concern that the Tool, should align with the original land cover assumptions of the TMDL. There are some underlying concerns regarding the quality and resolution of the original data, which were produced in 1992 for the Connecticut portion (Civco, 1992); that reference described the land cover dataset as an initial effort at developing a statewide land cover set from remotely sensed data. Further, the land cover categories are not directly comparable to more recent datasets (e.g., NLCD). Data from Long Island were from a planning document rather than digital land cover. At the same time, there may be some value in accounting for changes in land cover between the baseline year and the present. Decisions about how to relate load reductions and decisions about how to be consistent with this baseline will be considered in Phase II – Part 2.

2.2 Watershed Boundaries

The Tool allows the user to account for BMPs from any part of the LIS watershed within the United States, expanding beyond the original "Lower LIS" watershed in the original TMDL, which included only the portion of the LIS watershed in New York and Connecticut. Land Cover and location information are aggregated at the HUC 12 scale and are expanded to include portions of the LIS watershed in Massachusetts, New Hampshire and Vermont (Figure 2). These watersheds differ from the original TMDL, and therefore the results from this assessment cannot be truly compared to the TMDL.

Figure 2. LIS Watershed Boundaries.

2.3 Baseline Year

Selected Option for the Tool: 2016 Baseline Year

The NEIWPCC request for proposals (RFP) for this project suggested a baseline year of 2017. This year coincides with the issuance of Connecticut's MS4 General Permit, which requires permittees to report Impervious Cover Disconnection beginning in Year 4 of the permit. Although Connecticut's permit allowed permittees to report on BMPs installed as far back as 2012, other considerations for selecting the baseline date include the availability of land cover data, and the years for which reliable BMP data can reasonably be obtained. 2016 was chosen as the baseline year to coincide with the 2016 NLCD land cover layer. The 2016 year was recommended and approved at the at the project kickoff meeting, including representatives from CT DEEP, NYS DEC, US EPA and NEIWPCC, in August of 2019, and by the TAC in October of 2019.

Alternative Consideration: 2000 Baseline Year

Some TAC members expressed concern that changing the baseline year from the original 2000 baseline could create challenges in tracking progress against the original TMDL. To track progress of meeting the TMDL reductions, the original baseline data would be used in an analysis to assess the progress toward meeting the TMDL goals. The Tool does not reproduce 2000 baseline conditions, as described in Section 2.2. This decision was largely practical and relate to the quality and scale of the original land cover data, the inability to gather reliable information about practices implemented since the start of the TMDL, and the scale of the original TMDL, which assigned loads at a much larger scale than the HUC 12 or Town scale proposed in the Tool. This issue will be addressed and resolved in Phase II – Part 2.

2.4 Nitrogen Loading Rates

Selected Option for the Tool: Literature Survey Loading Rates

The default nitrogen loading rates were derived from a literature survey conducted as a part of this project (Table 3). The loading rates for urban land are derived from the assumptions and calculations in the Opti-Tool (US EPA Region 1, 2016). The project team reviewed several options for N loading rates, including other modeling tools, the initial loading rates included in the 2000 TMDL, other modeling studies, and available monitoring data. The method selected was informed by input from the initial TAC meeting held on October 15, 2019. This section summarizes the considerations in selecting N loading rates, and the sources reviewed as a part of the selection process. The nitrogen loading rates were not peer reviewed by any outside entities as part of a larger comment period, such as is done in a TMDL process, and therefore should not be considered in any regulatory or management decisions.

Alternative Option: TMDL Loading Rates

Another issue related to the concern over consistency with the TMDL is that the loading rates derived as a part of the literature survey are different than those in the TMDL in two ways: 1) The literature values are aggregated to more specific land cover categories for developed land and 2) The literature values tend to be lower than the values in the TMDL on average. One possible explanation for this discrepancy is that the TMDL loading rates were developed by calibrating two loads from single watersheds with uniform land cover and it is possible that watersheds in the forest category, for instance, also included other land covers. Further, the loads in the Tool are based on stormwater loads, and another discrepancy could have been the load from groundwater or unaccounted-for point sources. The Tool currently incorporates the TMDL loading rates as an alternative option, but a consistent set of loading rates will be recommended in Phase II- Part 2.

Table 3. Recommended N Loading Rates for NLCD Land Covers: Watershed Scale

<table>
<tr><th>NLCD Land Cover Categories</th><th>Literature Survey Loading Rates (kg/ha/yr)</th><th>TMDL Loading Rates (kg/ha/yr)</th></tr>
<tr><td>24: Developed High Intensity</td><td>15.3</td><td rowspan="4">13.4</td></tr>
<tr><td>21: Developed, Open Space</td><td>2.3</td></tr>
<tr><td>22: Developed, Low Intensity</td><td>4.9</td></tr>
<tr><td>23: Developed, Medium Intensity</td><td>9.2</td></tr>
<tr><td>31: Barren Land
41-43: Forest, 51,52: Shrub/Scrub
71-74: Herbaceous, 90,95: Wetlands</td><td>0.7</td><td>4.3</td></tr>
<tr><td>81: Pasture/ Hay</td><td>2.4</td><td rowspan="2">7.6</td></tr>
<tr><td>82: Cultivated Crops</td><td>6.7</td></tr>
</table>

2.5 Overall Approach and Key Considerations for Deriving N Loading Rates

The project team selected N loading rates to be consistent with the project goals, and the available data. Overall guidelines for the Tool and consideration for selection of the N loading rates included the following:

1) Data should be derived from studies conducted in or relevant to the LIS Basin.
2) Loading rates should be scientifically justified and accepted by the regulatory community to be consistent with TMDL implementation.
3) The Tool should be very simple, with a focus on being precise (i.e., consistent) over behaving as a verified model (i.e., accurate).
4) The Tool will focus on nonpoint sources, and primarily those found in stormwater runoff, so the loading rates should be from *stormwater* but the Tool will account for some elements of groundwater loading as described in Section 3.
5) The loading rates need to be translated readily to the land cover categories included in the 2016 NLCD Land Cover layer.
6) An understanding that, the Tool would be implemented in select pilot communities, and could be adapted based on the results at those locations.

Taking these considerations into account, the team considered sources that identified general annual loading rates for broad land use categories and were able to separate the loads from stormflow versus baseflow.

2.6 Resources Reviewed

The loading rates identified in the initial TMDL are included in (Table 4). An alternative to these loads was also derived because: 1) more recent data were available to characterize the watershed; and 2) the land cover categories may be too broad for planning at the scale of a town or small HUC 12. Although there was not unanimous agreement on this point, it was thought that, with the land cover summarized in these categories, changes in the character of land within a development category would not be reflected in the Tool. For example, there would be no distinction between residential and commercial development.

Table 4. Loading Rates from the LIS TMDL (NYS DEC and CT DEEP, 2000; Appendix A)

Land Cover	Loading Rate (kg/ha/yr)
Forest	4.3
Agriculture	7.6
Urban	13.4

The project team reviewed several resources in two primary categories (Table 5): 1) Models and Modeling Studies and 2) Monitoring Studies. Memoranda developed as a part of the “Establishing Nitrogen Endpoints for Three Long Island Sound Groupings” project (Tetra Tech, 2018) were used to identify data sources. Although a wealth of monitoring data is available, the data could not easily be related to land cover to develop unit loading rates, unless land cover variables were considered at a very coarse scale. Consequently, the chosen approach relied on models that allowed for a clear isolation of the surface runoff component of nitrogen loading.

Table 5. Modeling and Monitoring Resources Consulted

Model or Reference	**Description**	**Utility for the Tool**
Nitrogen Loading Model (Applied to LIS embayments by Vaudrey et al. https://vaudrey.lab.uconn.edu/embayment-n-load/). Original Model Source: Valiela et al., 2004.	The model was used in LIS Embayments to evaluate nitrogen loads. Identifies contributors including deposition, fertilizer and others.	The NLM relies on input data including fertilizer application rates and atmospheric deposition. Without more detailed data regarding fertilizer application, it was unclear how to extract land cover-based loading rates from this study.
SPARROW Model (Moore et al., 2011)	Reviews application of the SPARROW model in the Northeast, and an appendix describes the model coefficients in detail.	The regression equation described does include factors for different land sources, but sources for agricultural lands include manure and fertilizer sources, which are not easily summarized at the scale of the LIS watershed.
Watershed Treatment Model (Fuss and O'Neill, 2013; Original Model Source: Caraco, 2013)	Describes the use of the WTM model in the Rooster Watershed in Connecticut.	This model uses unit loads to estimate non-urban loading rates and calculates urban loading rates based on urban runoff concentrations. The model is not calibrated with data specific to the LIS.
Opti-Tool (Tetra Tech, 2015)	Draft memo identifying loading rates for loading rate in the Region 1 Opti-Tool. Opti-Tool is a planning level tool to strategically select stormwater BMPs.	The urban loading rates in the Tool are a good option for reflecting loads from surface runoff in the LIS but need some assumptions (described below) to develop unit loads.
AV GWLF (Georgas et al., 2009)	Application of the GWLF model in 64 subwatersheds within the LIS Basin. The paper summarized unit loading by land use categories.	Study summarizes unit loads (kg/ha/yr) for direct runoff.
AVGWLF (Evans, 2008)	Application of GWLF in the Connecticut River.	Used to evaluate how attenuation was modeled in this effort.
Mullaney and Schwartz, 2013; Mullaney 2016	LOADEST program used to estimate annual loads from continuous modeling. Regression equations used to predict loads at ungauged sites.	Good estimate of annual loads, but the regression equations were not easily converted to simple unit loading estimates.

2.7 Deriving Urban Nitrogen Loading Rates

The assumptions in the Opti-Tool model were used to estimate N loading rates for the urban land uses are presented in Table 3. They are based on a 2015 memo which includes loading rates for both Directly Connected Impervious Area (DCIA) and pervious land cover types (Tetra Tech, 2015). The project team used a combination of loads for “Developed Pervious” and “Developed Impervious” for each land use category (Table 6) to develop composite loading rates (Table 7), as described below. As a simplification, collective loading rates at the watershed scale based solely on land cover rely on using a single loading rate for urban pervious land. It is envisioned that, as BMPs are entered into the Tool, more detailed information may be available at the site scale, so that the Hydrologic Soil Group (HSG) will also be incorporated.

Table 6. Loading Rates for Land Cover Categories (derived from Tetra Tech, 2015)

Land Cover Category	Loading Rate (kg/ha/yr)
Commercial/Industrial/Institutional Directly Connected Impervious Cover (DCIA)	16.9
Residential DCIA	15.8
Developed Pervious[1]	2.0
Developed Pervious: HSGA	0.3
Developed Pervious: HSG B	1.3
Developed Pervious: HSG C	2.7
Developed Pervious: HSG C/D	3.4
Developed Pervious: HSG D	4.1
[1]: Estimate is an average of pervious loading for all soil groups.	

To determine the loading rates for urban categories presented in Table 3, the following steps are taken:

a. Estimate the impervious cover as the average of the impervious cover range provided in the NLCD description.
b. Estimate the percent DCIA as a function of impervious cover (IA) using equations provided in Sutherland (2000, and adapted by EPA Region 1; see Table 7)
c. Calculate the composite loading rate using the following equation:

$$L = \frac{DC}{100} \times L_I + \left(1 - \frac{DC}{100}\right) \times L_P$$

Where:

L = Loading rate for the land category (kg/ha/yr)

DC = DCIA (%)

$L_{I,P}$ = Impervious and Pervious Loading rate from Table 6, respectively (kg/ha/yr)

Table 7. Estimated Loading Rates for Urban NCD Land Cover Categories

Urban Land Use	**NLCD Land Cover Categories**	**Estimated Impervious Cover (IA)**	**DCIA Equation[1]**	**Estimated DCIA**	**Composite Loading Rate (kg/ha/yr)**
Commercial/ Industrial	24: Developed High Intensity	90%	$0.4(IA)^{1.2}$	89%	15.3
Low Density Residential	21: Developed, Open Space	10%	$0.04(IA)^{1.7}$	2%	2.3
Medium Density Residential	22: Developed, Low Intensity	35%	$0.1(IA)^{1.5}$	21%	4.9
High Density Residential	23: Developed, Medium Intensity	65%	$0.1(IA)^{1.5}$	52%	9.2

[1]: Equation derived from Sunderland (2000); equations presented in "Estimating Change in in Impervious Area and Directly Connected Impervious Area for Massachusetts Small MS4 Permit" . The same equations have been adapted for use but slightly revised in the CT MS4 permit and outside of the New England (http://222.epq.gov/region1/npdes/sotrmwater/ma/MADCIA.pdf)

2.8 Non-Urban Loads

The recommended non-urban loading rates presented in Table 3 are derived from the AvGWLF modeling (Georgas et al., 2009; Table 8). Although loading rates were available for these non-urban land uses in the Opti-Tool model, the estimates assumed very low concentrations, and were not based on known manure or fertilizer application rates in the LIS basin. Consequently, the project team recommended using AvGWLF loads from Georgas et al. (2009). The AvGWLF model was calibrated to the LIS watershed, and a review by Tetra Tech (2018) suggest that AvGWLF estimated loads are similar to loads derived from USGS monitoring data (e.g., Moore et al., 2011) in watersheds where both methods were applied.

The forested loads estimated were also somewhat lower than the estimated yields in other studies. For example, the loading rates in forested basins in the Upper Connecticut from 2002 to 2005 (Deacon et al., 2006) ranged between 1.3 and 3.4 kg/ha. The forested loads were notably much higher than the initial estimates used in developing the TMDL, and it is important to note that, in developing the TMDL, it was assumed that some of the forest land was comprised of both forested land and low density residential development (Paul Stacey, pers. Comm). The 2016 NLCD land cover release incorporates improved algorithms for categorizing land cover (Yang et al., 2018). Consequently, it is anticipated that the land cover represented as forest in the NLCD is less likely to include residential or other urban land covers.

Table 8.Land Non-Urban Loading Rates (Georgas et al., 2009)

Land Cover Category	**Loading Rate (kg/ha/yr)**
Forest	0.7
Hay/Pasture	2.4
Row Crops	6.7

3 Crediting Methods

This section summarizes selected N tracking methods for BMPs in the Tool. The methods are drawn from a few sources, relying heavily on work from the University of New Hampshire Stormwater Center (UNH SWC) and two Chesapeake Bay Program (CBP) sources: the CAST methods, and CBP Expert Panel reports for practices that have not yet been incorporated into CAST. Although the Tool focuses on urban stormwater BMPs, other practice types (e.g., agricultural BMPs) are also included, to span the range of practices recommended by the TAC. Table 2.1 summarizes the proposed methods for each practice, and groups BMPs by sector.

3.1 Scope and Limitations of the Proposed Tool

The purpose of the Tool is to develop a common framework for calculating N reduction for BMPs implemented within LIS. The Tool is not intended to act as a calibrated watershed model, and consequently does not account for many of the interactions between land development or BMPs and natural environment:

- Apart from forest buffers as a filtering practice, adjacent land cover and watershed position is not considered when evaluating BMP effectiveness. For example, practices that discharge to forested land uses are not treated differently than those that flow through urban land at the outfall.
- Land cover changes (e.g., from urban to forested land), are accounted for immediately, with the recognition that full recovery of forest ecosystem function will occur over many years.
- Although the Tool will account for some delivery of infiltrated nitrogen to LIS, these delivery ratios are generalized. As modeling efforts progress, it may be able to account for more detailed transport of subsurface nitrogen loads.
- The methods proposed in this memo are generally accepted to calculate BMP effectiveness. There is no attempt to validate underlying processes within practices. For example, the methods do not include an attempt to partition between various N forms, or to consider potential long-term release of nitrogen from stormwater BMPs.

3.2 Calculation Methods

The Total Nitrogen (TN) reduction calculation for each practice uses one or a combination of three methods: Efficiency, Land Cover Change, or Load Reduction. Table 10 summarizes the calculation method(s) used for each practice. The TN crediting methods included in this memo rely on loading rates included in Section 2 of this report.

3.2.1 Unit Loads

For all practices, the load delivered to the practice is calculated as a Unit Load times an Area. The Unit Loads are area-weighted averages, derived from the land cover categories described in Section 2.

Efficiency (Equation 1)

Practices that use the Efficiency Method filter or otherwise reduce the delivered load of runoff that is treated by the practice:

$$R_E = \frac{UL_{DA} \times DA \times E}{100} \qquad \text{(Equation 1)}$$

Where:

- R_E = Load Reduction for Efficiency practices (mass/year)
- UL_{DA} = Area-Weighted Unit Load entering the practice (mass/area/year), using the loading rates presented in Section 2 of this report.
- DA = Drainage Area (area)
- E = Efficiency (%)

Land Cover Change (Equation 2)

For Land Cover Change practices, the benefit is calculated by converting one land cover to another. The method applies to practices such as forest planting where one land cover is converted to another.

$$R_{LC} = \left(UL_{pre} - UL_{post}\right) \times A \qquad \text{(Equation 2)}$$

Where:

- R_{LC} = Load Reduction for Land Cover Change practices (mass/year)
- UL_{pre} = Unit Load for the land cover before Practice implementation (mass/area/year)
- UL_{post} = Unit Load for the land cover after Practice implementation (mass/area/year)
- A = Practice Area (area)

Load Reduction (Equation 3 or Alternative)

For Load Reduction practices, the load reduction cannot be calculated based on drainage area or practice area. Instead, the benefit is typically calculated by comparing loads before and after practice implementation. These practices typically require customized methods to estimate the loads, as described in later sections.

$$R_{LR} = L_{pre} - L_{post} \qquad \text{(Equation 3)}$$

Where:

R_{LR} = Load Reduction for Load Reduction practices (mass/year)

L_{pre} = Load before Practice implementation (mass/year)

L_{post} = Load after Practice implementation (mass/year)

For some practices, the load reduction is simply calculated without comparing to a pre-developed condition, as may be the case for some stream restoration methods.

3.3 Data Needs and Assumptions for Missing Data

For each practice, Table 10 outlines the data needed to calculate its N load reduction. For most practices, default assumptions can be used if some data are not provided. As a rule, these default values are conservative (i.e., represent a low N removal). For example, if the street sweeper type is not provided, it is assumed that a broom sweeper (the least effective method) is used.

3.4 BMP Groups

Urban Stormwater BMPs and Stream/Buffer Restoration (Section 3.5)

These practices are implemented on developed lands and involve construction (or planting) of a single practice, or land conversion to forest.

Onsite Sewage Disposal (Section 3.6)

These practices include upgrades or conversion of septic systems and cesspools.

Agricultural Practices (Section 3.7)

These practices are applied in the agricultural setting and include measures that filter agricultural runoff or reduce fertilizer application.

Natural Areas Practices (Section 3.8)

These practices involve conversion of non-urban (often agricultural or degraded) lands to natural features such as a riparian buffer, wetland or forest.

Municipal Operations (Section 3.9)

These practices reflect two of the Six Minimum Control Measures (MCMs) in the MS4 permits for LIS states, including: MCM3 (Illicit Discharge Detection and Elimination), and MCM 6 (Pollution Prevention/ Good Housekeeping for Municipal Operators). The MCM 6 activities represented include catch basin cleaning and street sweeping.

Table 9. Acronyms

BMP	Best Management Practice
CBP	Chesapeake Bay Program
DA	Drainage Area
FW	Forestry Workgroup
HSG	Hydrologic Soil Group
HGMR	Hydrogeomorphic Region
IC	Impervious Cover
ISR	Internal Storage Reservoir
LC	Land Cover
OSDS	Onsite Sewage Disposal System
P	Precipitation
RR	Runoff Reduction
ST	Stormwater Treatment
UNH	University of New Hampshire

Table 10. Proposed Methods for Calculating Bmp Nitrogen Removal[1]

<table>
<tr><th>BMP Type
(See Appendix B for Definitions)</th><th>Calculation Type</th><th>Method</th><th>Input Data for N Calculation[2]</th><th>Assumptions for Missing Data</th><th>Notes and Source of Method</th></tr>
<tr><td colspan="6">Urban Stormwater BMPs and Stream/ Buffer Restoration (See Section 3.5)</td></tr>
<tr><td>Bioretention w/ an Underdrain</td><td>Efficiency</td><td>UNH Curves for Biofiltration (with or without ISR)</td><td>DA*, IC*,
P, ISR, HSG</td><td>P=0.6”
No ISR
HSG A</td><td rowspan="3">Method for Structural Stormwater BMPs uses performance curves from the UNH Stormwater Center (UNHSC, 2019). Curves are included in Appendix C of this Document.</td></tr>
<tr><td>Other Stormwater BMPs w/ UNH Curves</td><td>Efficiency</td><td>UNH Practice Curves</td><td>DA*, IC*
P, HSG</td><td>P=0.6”
HSG A</td></tr>
<tr><td>Porous/ Permeable Pavement</td><td>Efficiency</td><td>Assume 77% N Efficiency.
Reduce effectiveness to account for Infiltrated Nitrogen Migrating to LIS.</td><td>DA*, IC*, HSG</td><td>N/A</td></tr>
<tr><td>Any Runoff Reduction Practice (except Porous/ Permeable Pavement) (See Table 11 for a list)</td><td>Efficiency</td><td>RR Curves from CBP[3]. Reduce effectiveness to account for Infiltrated Nitrogen Migrating to LIS. (Figure 3)

Adjust effectiveness to account for N that is not attenuated in the groundwater (Table 12).</td><td>DA*, IC*, P, HSG</td><td rowspan="2">P=0.6”
HSG A</td><td rowspan="2">CBP Expert Panel for Urban Stormwater Retrofit Practices
(Bahr et al., 2012)</td></tr>
<tr><td>Any Stormwater Treatment Practice without a UNH Curve</td><td>Efficiency</td><td>STP Curves from CBP.</td><td>DA*, IC*, P, HSG</td></tr>
<tr><td>Urban Forest Buffer</td><td>Efficiency/
Land Cover Change</td><td>Convert Area from Turf to Forest.
DA equal to Buffer Area
Assume 25% N Filtering for width >35’</td><td>Buffer Area*,
Buffer Width
Soil HSG</td><td>HSG A
If no width provided, assume no filtering.</td><td rowspan="2">Methods documented in CBP-FW (2018)</td></tr>
<tr><td>Urban Forest Planting</td><td>Land Cover Change</td><td>Land Conversion
(Turf to Forest)</td><td>Forested Area*
Soil HSG</td><td>HSG A</td></tr>
<tr><td>Urban Stream Restoration*</td><td>Load Reduction</td><td>Project documents nitrogen reduction.
For guidance, use CBP Stream Protocols.</td><td>Documented load reduction*</td><td>N/A</td><td>Schueler et al. (2014a) provides guidance for how to evaluate N reduction.</td></tr>
<tr><td colspan="6">1: Table 9 summarizes the acronyms used in this table.
2: * Indicates data are required to calculate nitrogen reduction.
3: The infiltration curves included in the Tool are not consistent with some EPA tools such as Opti-Tool and could be revisited in the future.</td></tr>
</table>

BMP Type (See Appendix B for Definitions)	Calculation Type	Method	Input Data for N Calculation[2]	Assumptions for Missing Data	Notes and Source of Method
Onsite Sewage Disposal (See Section 3.6)					
OSDS Connection	Load Reduction	Eliminate delivered load	Original OSDS Type* Individuals Served Distance to Embayment (<200m, >200m) *or* Location on Long Island's North Shore[4]	Distance >200m	OSDS loads derived from Vaudrey et al. (2016) and SCDHS (2020) See Table 13.
Septic System Upgrade	Load Reduction	Adjust Load by Converting Efficiency of Alternative.	Original OSDS Type* Efficiency of Alternative* Individuals Served Distance to Embayment (<200m, >200m) *or* Location on Long Island's North Shore[3]		

1: Table 1 summarizes the acronyms used in this table.
2: * Indicates data are required to calculate N reduction.
4: The Tool developed as a part of this project does not include the New York State portion of the watershed, but this report does include a description of research used to quantify movement through the sandy soils of Long Island's North Shore.

BMP Type (See Appendix B for Definitions)	Calculation Type	Method	Input Data for N Calculation²	Assumptions for Missing Data	Notes and Source of Method
Agricultural Practices (See Section 3.7)					
Grass Buffer	Efficiency/ Land Cover Change	Efficiencies: 13% (for HUC 12s abutting LIS) 21% for other HUC 12s Efficiencies applied to 35' minimum buffer width Land Area treated is 4X buffer area Land Conversion: Buffer Area Converted to Pasture/Hay	Buffer Area* LC Buffer Width	LC is Pasture/Hay If no buffer width provided, do not calculate filtering benefit.	Adapted from CBP (2018), Practice A-12. HUC 12s abutting and not abutting LIS assigned efficiencies for the Coastal Plain Lowland and Coastal Plain Upland Hydrogeomorphic Regions (HGMRs), respectively.
Forest Buffer	Efficiency/ Land Cover Change	Efficiencies: 19% (for HUC 12s abutting LIS) 31% for other HUC 12s Efficiencies applied to 35' minimum buffer width Land Area treated is 4X buffer area Land Conversion: Buffer Area Converted to Forest			
Conservation	Efficiency	8% of load from reported Area	Area*	None Assumes Cropland and applies to entire farm area	Adapted from CBP (2018), Practice A-24.
Manure Incorporation or Injection	Efficiency	Incorporation: 8% N Removal Injection: 12% N Removal	Area* and Type of Incorporation	Assume Cropland Assume Incorporation if No Type Provided	Adapted from CBP (2018), Practice A-17.

1: Table 1 summarizes the acronyms used in this table.
2: * Indicates data are required to calculate nitrogen reduction.

BMP Type (See Appendix B for Definitions)	Calculation Type	Method	Input Data for N Calculation[2]	Assumptions for Missing Data	Notes and Source of Method
Cover Crop	Efficiency	29% of load from reported Area	Area*	None Assumes Cropland	Adapted from CBP (2018), Practice A-4. Assumes a drilled winter wheat planted within two weeks before frost. Practice only applies in years where it is used
Residue and Tillage Management	Efficiency	Conservation Tillage (30-59% Residue): 4% Reduction Hi Residue Tillage (>59% Residue): 12% Reduction	Area* and Level of Tillage	If specific type is not described, assume Conservation Tillage Assume Cropland	Adapted from CBP (2018), Practice A-3.
Denitrifying Ditch Bioreactor	Efficiency	20% Pollutant Removal	Drainage Area*	Assume Cropland	Derived from Source data for the CAST Tool (CBP, 2020)
Natural Areas Practices (Section 3.8)					
Wetland Creation	Efficiency/ Land Cover Change	30% Efficiency Convert LC in wetland area to Forest	Wetland Area* LC DA Wetland in Floodplain?	• LC is Pasture/Hay • DA depends on location (See Table 14) • Wetland in Upland	Efficiency from Law et al. (2019) DAs from Mason et al. (2016)
Wetland Restoration	Efficiency/ Land Cover Change	42% Efficiency Convert LC in wetland area to Forest	Wetland Area* LC DA Wetland in Floodplain?	• LC is Pasture/Hay • DA depends on location (See Table 14) • Wetland in Upland	Method from Mason et al. (2016)
Forest Regeneration	Land Cover Change	Convert LC to Forest	Forest Area* LC	LC is Pasture/Hay	Adapted from CBP (2018), Practice A-23.

1: Table 1 summarizes the acronyms used in this table.
2: * Indicates data are required to calculate nitrogen reduction.

BMP Type (See Appendix B for Definitions)	Calculation Type	Method	Input Data for N Calculation[2]	Assumptions for Missing Data	Notes and Source of Method
Municipal Operations (Section 6)					
Illicit Discharge Detection and Elimination (IDDE)[5]	Load Reduction. Alternative Method: Efficiency	Load Reductions for Individual Discharges (See Table 15) Or Program Reduction: 0.2% Reduction of Load from Pervious Land	***Individual Reductions:*** Monitoring Data or Load Characterization* ***Program reduction:*** Document Advanced Program* Pervious Area in Community or Catchment** HSG	If specific loads are not enumerated, use efficiency method (Schueler et al., 2014). Assume HSG A if HSG is not provided.	Schueler et al. (2014). CBP Expert Panel report on Grey Infrastructure.
Street Sweeping	Efficiency	Efficiency factors depending on Sweeper Type/ Frequency (Table 16)	IA Swept* Sweeper Type Sweeper Frequency Fraction of Year Swept	Broom Sweeper Sweep Once/Month Implement 75% of Year	US EPA (2017). NH Stormwater Permit Appendix F.
Catch Basin Cleaning	Load Reduction	Calculate Load from Sediment Collected in Catch Basins. Use Assumptions in Table 17.	Mass Collected in Catch Basins* Organic Fraction (By Mass) Nitrogen Concentration	Assume Sediment (non-Organic) Use N Enrichment from Table 17	Derived from Schueler et al. (2015). CBP Expert Panel on Street and Storm Drain Cleaning Practices.

1: Table 9 summarizes the acronyms used in this table.
2: * Indicates data are required to calculate nitrogen reduction.
5: For IDDE, the * indicates a required value for a particular method. For example, reported reduction is only required for Method 1.

3.5 Urban Stormwater BMPs and Stream/Buffer Restoration

These practices include structural stormwater BMPs, along with urban forest buffers, urban forest planting, and urban stream restoration.

3.5.1 Structural Stormwater BMPs

Structural stormwater BMPs are Efficiency practices, as described in Equation 1, but the equation may be modified depending on the land cover draining to the drainage area, type and location of the practice, as described in this section.

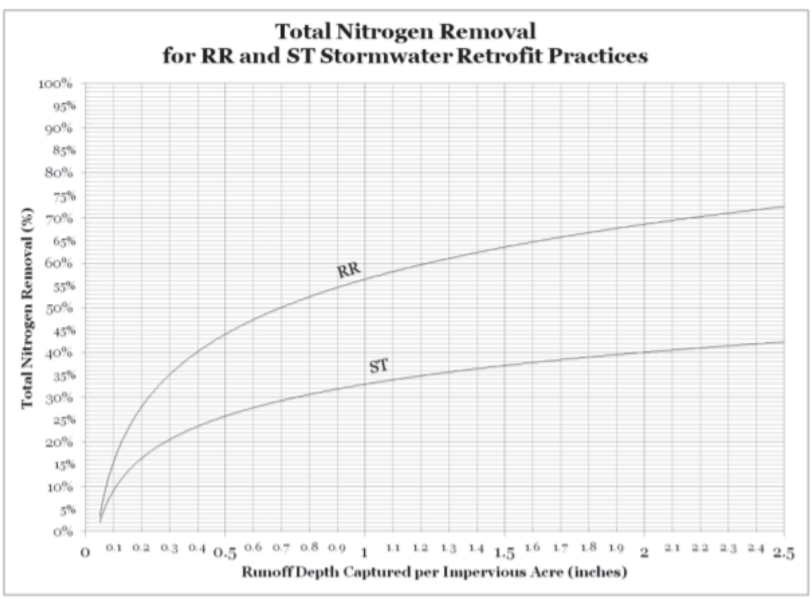
Loads from the Drainage Area

Annual unit loads calculated based on the land cover and (for pervious land covers) the HSG. Unit loads are summarized in Section 2.

Efficiencies

Efficiencies are primarily derived from either the UNH-SC Curves included in Appendix A or the CBP Retrofit Curves (Figure 3). For both sets of curves, the efficiency depends on the runoff depth captured by the practice (i.e., the practice design storm) for water quality or runoff reduction. In general, the UNH curves were used when they were available, except for the infiltration practice curves. The UNH curves rely on both the practice volume and the soil infiltration rate, rather than the design volume, and the N reduction rate derived from these curves is very high relative to other BMP efficiency assumptions (See Table 11 for a list of RR practices).[2]

The UNH curves are specific to practices, and efficiencies for bioretention depend on whether an Internal Storage Reservoir (ISR) is present. Practices with this design have improved nitrogen efficiencies. In addition, some bioretention practices provide infiltration, and should use the RR curve (Figure 3). The RR curve in Figure 3 incorporates an assumption that 82% of the nitrogen infiltrated into the ground is attenuated. This may not be true in embayments of LIS, and the Tool incorporates assumptions to adjust for these HUC 12s.



[2] Since the methods included in this report were developed, the Opti-Tool incorporated a revised set of infiltration curves, which could potentially be incorporated into the LISBTT tool.

Figure 3. Retrofit Removal Adjustor Curve for Total Nitrogen Removal from Runoff Reduction and Stormwater Treatment Practices (Bahr et al., 2012)

Table 11. Runoff Reduction Practices

• Infiltration Trench • Bioretention without an Underdrain • Infiltration Basin • Dry Swale w/o Underdrain • Rainwater Harvesting

Adjustments for Groundwater Attenuation

For structural practices that rely on attenuation in groundwater, either in the vadose zone or in the aquifer, the position in the watershed is important. The curve in Figure 3 makes a blanket assumption that 82% of the load infiltrated to a practice is attenuated (i.e., not delivered to the receiving water). The 82% value is derived from the following assumptions (Barr et al., 2012):

1) Nitrate has the potential to be transported through groundwater pathways.
2) 30% of N is in the form of nitrate
3) 60% of the nitrate is transported through BMPs and the soil to reach the receiving water
4) Taken together, these factors result in 18% of the infiltrated nitrogen transported to surface waters, or 82% attenuation.

Depending on the location in the LIS watershed, a different attenuation rate may be appropriate. Default attenuation rates are applied to all infiltrated stormwater, regardless of the design treatment depth, and values for areas near the coast of LIS are derived from two studies. The first was work in LIS using the Nitrogen Loading Model (Vaudrey et al., 2016), which evaluated loads to embayments from various sources, including septic systems and cesspools. These systems behave similarly to stormwater practices in that they inject water with a nitrogen concentration into the groundwater through the vadose zone. In Vaudrey et al. (2016) specific delivery ratios are provided for three conditions: lower watersheds draining to embayments within a 200 m buffer; lower watersheds greater than 200 m away, and upper watersheds. The attenuation in the first two conditions was directly calculated to be 34% and 43% (Table 12; Equation 4).

A more recent study in Suffolk County (SCDHS, 2020) found that the soils on Long Island's North Shore provide almost no attenuation beyond the Vadose Zone, except in Glacial Moraine soils. The Tool uses the assumed 10% attenuation found in this study to characterize groundwater loads from any HUC 12s on Long Island.

The upper watershed attenuation rate (i.e., HUC 12s not abutting LIS) was assumed to be equal to the default CBP attenuation of 82%.

$$A = 100 - \frac{D_v \times D_A}{100} \qquad \text{(Equation 4)}$$

Where:

A	=	Attenuation (%)
D_v	=	Delivery through the Vadose Zone (%)
D_A	=	Delivery through the Aquifer (%)

Adjustments were calculated as a simple ratio. For example, since HUC 12s abutting LIS and within the buffer provide only 34% nitrogen attenuation, the assumed benefit is multiplied by the factor 0.4

(34%/82%). The N load benefit is reduced by multiplying the calculated benefit by the adjustment factor.

Table 12. Efficiency Adjustments and Groundwater Attenuation

(ADAPTED FROM VAUDREY ET AL., 2016)

Watershed/ Position	Attenuation	Adjustment Factor[4]
HUC 12 Does Not Abut LIS[1]	82%	1.00
HUC 12 Abuts LIS >200m from Embayment or Shore[2]	43%	0.52
HUC 12 Abuts LIS <200m from Embayment or Shore[3]	34%	0.40
HUC 12s on Long Is(SCDHS, 2020)[4]	10%	0.12

1. Adopts the CBP assumption of 82% N attenuation (Barr et al., 2012).
2. Vaudrey (2016; slide 20) provides estimates of 66% delivery through the vadose zone and 85% delivery through the aquifer in this region. Calculated using Equation 4
3. Vaudrey (2016; slide 20) provides estimates of 66% delivery through the vadose zone and 0% attenuation in the aquifer in this region. Calculated using Equation 4.
4. While the Tool does not include the New York State portion of the LIS watershed, research documenting attenuation in the sandy soils of Long Island's Northern Shore are documented here.
5. The adjustment factor is the ratio between the attenuation and 0.82.

Load Reduction Cap for Urban BMPs

One disadvantage of using efficiency-based methods is that they do not account for poor performance of these practices at low influent concentrations. The concept of "irreducible concentrations" is described further in Schueler (2000). Further, urban BMPs cannot reproduce the ecosystem functions of forest land covers. Consequently, the Tool limits the performance of urban BMPs using a Reference Land Cover of Urban Open Space and assumes that the BMPs cannot reduce the load below this reference.

Modified Load Reduction Equation for Urban Stormwater BMPs

Combining these two adjustments (the groundwater delivery Adjustment Factor and the Load Reduction Cap), the load reduction for urban stormwater practices is expressed by Equation 5.

$$R_{E-SU} = Minimum\left(R_E \times AF_I, DA \times (UL_{DA} - UL_{OS})\right) \qquad \text{(Equation 5)}$$

Where:

R_{E-SU} = Load Reduction for Structural Urban BMPs (mass/year)
R_E = Efficiency Reduction Calculated using Equation 1
AF_I = Infiltration Adjustment Factor from Table 12 (assumed to be 1 for non-infiltration practices)
DA = Drainage Area (area)
UL_{DA} = Unit Load entering the practice (mass/area/year)
UL_{OS} = Unit Load of Urban Open Space (mass/area/year); See Caraco (2020) for rate

3.5.2 Forest Buffer and Forest Planting

Both practices include a land-cover change component, so that the area planted in forest, either as a buffer or as a forest planting, is converted from turf to forest, using the loading rates provided in Section 2. Forest buffers provide a supplemental benefit by filtering runoff as it flows over the forest buffer. Rather than delineating a specific drainage area, it is assumed that a turf area equivalent to the buffer drains to and is treated by the forest buffer, as long as the buffer width is at least 35', as per the recommendation of the Chesapeake Bay Program practice guidance (CBP, 2018)

3.5.3 Urban Stream Restoration

Urban stream repair and stream restoration is a complex process that can use a variety of specific practices. Although default values (nitrogen removal per linear feet of restoration) are available in the CAST model, more recent work has focused on specific protocols to quantify the benefits of stream restoration depending on factors such as the location in the watershed and the practices implemented. In the Tool, the current recommendation is for the user to report a nitrogen removal along with a justification for the estimated nitrogen reduction (e.g., pre- and post- monitoring or estimated sediment reduction and nitrogen enrichment). The CBP Expert Panel on Stream Restoration (Schueler et al., 2014a), can help quantify the benefits of urban stream restoration for specific methods.

3.6 OSDS Conversion and Upgrade

For OSDS Systems, loads are derived based on the number of households or individuals where a system is either upgraded or taken offline (i.e., directed to a Wastewater Treatment Plant or WWTP). The default initial loads for traditional systems are provided in Table 5 and calculated using Equation 6. For conversion to a WWTP, the calculated loads would be eliminated. If a system is modified (i.e., changed to an improved system), the reduction is calculated by eliminating the load. The default load per household is calculated by assuming a household size of 2.5 people (US Census Bureau, 2020).

Table 13. Assumed OSDS N Delivered Loads Based on Watershed Position
(ADAPTED FROM VAUDREY ET AL., 2016)[1,2]

System Type	Practice Efficiency (exiting leach field)	N Delivered Load to LIS by Zone (kg /person/yr)			
		HUC 12 Does not Abut LIS[3]	Abuts LIS >200 M[4]	Abuts LIS <200 M[5]	North Shore of Long Island, NY
Cesspool or Suffolk County Vertical Septic	5%	0.8	2.6	3.0	4.1
Septic System	40%	0.5	1.6	1.9	2.6

1: Assumes 4.8 kg N/person/yr and delivery percentages presented in Vaudrey (2016)
2: Delivery calculated using Equation 4
3: Assumes 82% attenuation below leaching fields (From Table 12).
4: Assumes 43% attenuation below leaching fields (From Table 12).
5: Assumes 34% attenuation below leaching fields (From Table 12).
6: Assumes 10% attenuation below leaching fields

$$DL = SL \times \left(1 - \frac{E}{100}\right) \times \left(1 - \frac{A}{100}\right) \qquad \text{(Equation 6)}$$

Where:

DL	=	Annual Load Delivered to LIS (kg/person/yr)
SL	=	Annual Sewage Load (kg/person/yr)
E	=	System Efficiency (%) from Table 13
A	=	Attenuation (%) from Table 12

If an improved system is used, the user enters either the estimated efficiency of the new system or the load delivered to the Vadose zone. The load reduction will then be calculated using Equation 7.

$$R_{OSDs} = LR_{existing} \times N \times \frac{E_{new} - E_{existing}}{100 - E_{existing}} \qquad \text{(Equation 7)}$$

Where:

R_{OSDS}	=	Load Reduction for the OSDS Conversion (mass/year)
$LR_{existing}$	=	Loading Before Conversion (mass/person/year)
N	=	Number of people (can estimate 2.5 individuals/household)
E_{new}	=	New system efficiency (assume 100% for connection to WWTP)
$E_{existing}$	=	Existing system efficiency

3.7 Agricultural Practices

Methods and efficiencies for the agricultural practices were derived from Chesapeake Bay methods. The buffer practices use a combination of land cover change and efficiencies, while the other agricultural practices use a simple efficiency method.

3.7.1 Forest and Grass Buffers

These practices are similar to the urban forest buffer practice, but it is assumed that agricultural buffers have different efficiencies and are able to treat a larger drainage area. The land cover conversion applies to the buffer area and credited for all buffers. The original land cover is assumed to be hay or pasture if no land cover is provided.

Filtering is applied only to buffers that have a minimum width of 35'. CBP guidance (CBP, 2018) provides different efficiencies based on the Chesapeake Bay Hydrogeomorphic region (HGMR). While there are not data to support specific efficiencies for different regions of LIS, a simplified approach was used to equate LIS locations with HGMRs. HUC 12s adjacent to LIS were assumed to have efficiencies similar to the Coastal Lowland HGMR, while other HUC 12s in LIS were equated with the Coastal Plain Upland HGMR, with resulting efficiencies reported in Table 10. Efficiencies are applied to the land use draining to the buffer, and the drainage area is assumed to be 4X the buffer area.

3.8 Other Agricultural Practices

Other agricultural practices receive an efficiency credit, applied to the land cover on which they are implemented. Nutrient Management Plans, Cover Crops and Denitrifying Ditch Bioreactors receive a single efficiency applied to the appropriate land cover (8%, 29% and 20%, respectively). Manure incorporation and Residue/Tillage Management receive different efficiencies depending on the specific method, with Manure Incorporation or Injection depending on the specific practice (incorporation vs injection), and Residue/Tillage Management depending on the amount of residue. These efficiencies represent the effectiveness of reducing N application rate.

3.9 Natural Areas Practices

Natural areas practices include wetland creation and restoration, and forest restoration, and methods are derived from CBP methods.

3.9.1 Wetland Creation and Restoration

Both wetland creation and restoration receive an efficiency credit applied to their drainage areas (30% for wetland creation and 42% for wetland restoration). Because many wetland restoration and creation projects are completed in an agricultural setting, the drainage areas are not often reported. As a result, the CBP developed drainage area ratios for wetlands implemented in the floodplain or in upland areas. The drainage area ratios recommended in Table 14 are equivalent to the values for the Coastal Plain Lowland for HUC 12s adjacent to LIS, and Outer Coastal Plain -Poorly Drained for HUC 12s that are not adjacent to LIS.

Table 14. Wetland Drainage Area Assumptions (Mason et al., 2016)

RATIO OF DRAINAGE AREA TO WETLAND AREA

Location in LIS	Wetland in Floodplain	Upland Wetland
HUC 12 is adjacent to the LIS	3	2
HUC 12 is not adjacent to the LIS	2	1

Both wetland practices receive a separate credit for land conversion, so that the area of the wetland is converted from the original land cover to forest.

3.9.2 Forest Regeneration

Forest Regeneration is a simple land cover change practice, where the area forested is converted from the original land cover to forest.

3.10 Municipal Operations

Municipal operations include practices that are implemented at the level of a municipality or MS4. The specific practices recommended for the Tool include: IDDE, Street Sweeping and Catch Basin Cleaning.

3.10.1 IDDE

Although IDDE programs have been implemented around the nation as a part of the Phase 1 and Phase 2 National Pollutant Discharge Elimination System (NPDES) Stormwater MS4 permits, there have been few efforts to document specific nitrogen-removal benefits of IDDE methods. The CBP effort was a unique attempt to calculate these benefits, and these methods are included here. IDDE programs reduce non-stormwater loads by eliminating discharges to the sewer system. A CBP expert panel (Schueler et al., 2014) developed a two-tiered system for calculating load reductions. The simpler (programmatic) approach assumes a very low efficiency applied to loads from pervious surfaces, and the alternative allows municipalities to document load reductions from specific reductions. The Tool includes opportunities to document three specific types of removals/repairs: Illicit Connection removals, sanitary sewer overflow (SSO) reductions and sewer repairs (See Table 7 for N crediting methods).

Method 1: Watershed or Community Scale Calculation

In this method, a default value is applied to communities or watersheds where "Advanced IDDE" is applied, including frequent outfall screening, chemical monitoring and documenting infrastructure condition. The default N reduction is calculated using Equation 8.

$$R_{IDDE} = L_{pervious} \times 0.002 \qquad \text{(Equation 8)}$$

Where:

R_{IDDE} = Load Reduction from advanced IDDE (mass/year)
$L_{pervious}$ = Load from pervious surfaces in the drainage area or community (mass/year)

Method 2: Document Reductions from Removing Specific Discharges

In this method, a community would document the removal of specific discharges, using approaches outlined in Table 15.

Table 15. Methods to Calculate Removal of Specific Discharges

BMP	**Description**	**Nitrogen Crediting Method**
Illicit Connection Removal	Repair a Sewage or Industrial Connection to the Storm Drain System	Estimate Load by documenting Annual Flow Rate and Concentration from the Discharge
SSO Reduction	Repairs to reduce the frequency of SSO Events	Document the number of and flow from SSOs before and after repairs. Calculate load reduction.
Sewer Repairs	Repair leaky or damaged sewer pipes	Monitor dry weather flow before and after repairs to document load reduction.

3.10.2 Street Sweeping

The calculation for street sweeping uses efficiency estimates from New Hampshire's MS4 permit, using methods proposed for MS4s with TMDLs. The efficiencies are summarized in Table 16 and based on efficiency and sweeping method. The efficiencies are applied to the load from the street area swept. The efficiencies reported in this table apply only to the streets that receive this frequency of sweeping. This is critical in reporting. For example, a community that reports sweeping all streets monthly needs to clarify that this monthly sweeping applies to all streets, rather than a monthly sweeping program that rotates street miles swept.

Table 16. STREET SWEEPER NITROGEN REMOVAL EFFICIENCY (US EPA, 2017)

Sweeping Program		Sweeper Technology		
		Mechanical Broom	**Vacuum Assisted**	**High-Efficiency Regenerative Air**
Frequency	**2/year (spring and fall)**	1%	2%	2%
	Monthly	3%	4%	8%
	Weekly	6%	7%	10%

3.10.3 Catch Basin Cleaning

Catch Basin Cleaning benefits are calculated using a method adapted from the CBP expert panel on Catch Basin Cleaning and Street Sweeping (Schueler et al., 2015). The method relies on measuring the wet weight of material collected from catch basins. The CBP method assigns two different N-enrichment factors, depending on whether the material is organic (e.g., leaves) or sediment. As a default value, Table 17 includes a factor that is equivalent to 90% of the sediment enrichment. This value assumes that 10% of the material is trash, which has no N enrichment. This 10% value is derived from monitoring in Baltimore County, MD (included as Appendix F of Schueler, 2015) which found that about 9% of the mass of material collected from catch basins was trash.

Table 17. Catch Basin Material N Enrichment

(ADAPTED FROM SCHUELER ET AL., 2015)

Catch Basin Material	N Enrichment (Fraction of Wet Mass)
Organic Material	0.00222
Sediment	0.00189
Trash	0.00000
Unidentified	0.00170

4 Tracking Tool and Pilot Applications

The loading rates, land cover selection and BMP Crediting techniques described in Sections 2 and 3 of this report were used to develop the Tool, which was used in three pilot applications. While the Tool is not approved for compliance with the TMDL, it serves the role in this project of acting as a "proof of concept" to identify 1) if BMP information that is currently available can be used to quantify BMP benefits at the watershed scale; 2) additional data that should be collected in the future to better quantify BMP effectiveness and 3) data gaps and information that should be included in a future Sound-Wide, regulatory tracking tool. Appendix D includes a User's Guide for the Tool.

4.1 Pilot Test Areas

The original scope called for testing the Tool in up to three communities, but COVID-19 stressed local governments, both due to low revenues which resulted in furloughs, combined with additional burden at the local level to manage the epidemic. As an alternative, the project team identified two different sources of publicly available data, including: 1) New Haven Connecticut's Bioswale database; and 2) Combined NPDES MS4 Permit data submitted to the State of Connecticut, and tested for the Town of East Lyme.

4.2 New Haven Connecticut

New Haven, Connecticut maintains a geodatabase of retrofit projects implemented throughout the City. The database includes over 200 individual practices, composed primarily of bioswales, dry wells and permeable pavement (Figure 4). The database provides an excellent spatially-referenced record of BMPs implemented in the City and includes data that can be used to estimate the benefits of most practices included in the database. The pilot test used only the data in the database and compared the estimated load reductions from the BMPs to the overall load from the City of New Haven.

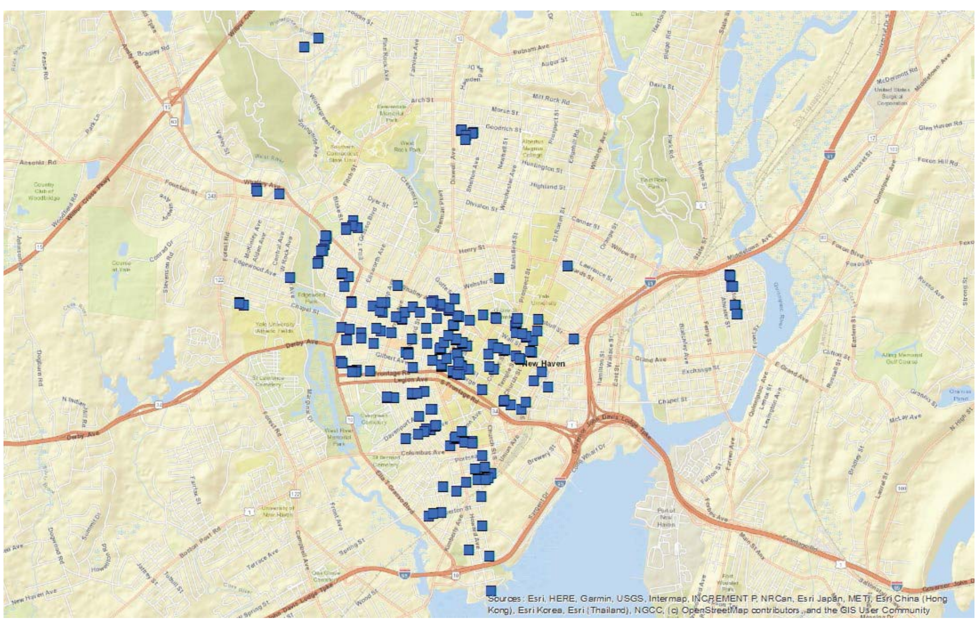


Figure 4. Retrofits in New Haven, CT

4.2.1 Loads and Land Cover

The Tool estimates areas of land cover using 1996 NLCD land cover, and for the New Haven Pilot, the loading rates were developed using the loads established for this project. The resulting initial loads delivered to the Sound are estimated to be 75,748 pounds, with most of the land cover and pollutant load originating from Developed land cover, comprising 86% of the total area and 99% of the estimated Nitrogen Load (Table 18).

Table 18. Land Cover and Nitrogen Loading in New Haven, CT

Land Cover	Area (acres)	Area (% of Total)	Nitrogen Load (lbs/yr)	Nitrogen Load (% of Total)
Developed High Intensity	1,913	16%	26,111	34%
Developed, Open Space	1,667	14%	3,421	5%
Developed, Low Intensity	2,567	21%	11,222	15%
Developed, Medium Intensity	4,129	35%	33,888	45%
Barren Land	22	<1%	14	<1%
Forest	1,211	10%	756	1%
Shrub/Scrub	12	<1%	8	<1%
Herbaceous	57	<1%	35	<1%
Wetlands	356	3%	222	<1%
Pasture/ Hay	31	<1%	67	<1%
Cultivated Crops	1	<1%	4	<1%
Total	11,965	100%	75,748	100%

4.2.2 BMP Data

The BMP data was assembled in a geodatabase (a calculation spreadsheet using the raw data is included separately as an attachment to this report). In addition to general spatial and identifying information (e.g., Project ID, Address, installation year) the database includes data describing the practices, and four fields were used to estimate the pollutant loads using the tracking spreadsheets, including 1) GI_Type; 2) Length; 3) Width and 4) Project Notes. Example data for one bioswale and one dry well are included in Table 19.

Table 19. Example BMP Data from New Haven

Field	GI_ID EW1;	Dry Well (no ID)
GI_Type	Bioswale	DW
Length	12	N/A
Width	4.5	N/A
Project Notes	Sept 2015 2.5' stone, 2' soil	900 gallon dry well by United Concrete

The data did not include a drainage area, and this area was estimated using the volume in each practice from the data in the Project Notes and dimensions.

Bioswales:

Bioswales in New Haven are similar to bioretention cells, so they are classified as such, and assumed to treat 1" of runoff, originating from impervious cover. The estimated drainage area is estimated by the following equation:

$$DA = \frac{L \times W \times \left(0.25 \times D_{soil} + 0.4 \times D_{stone} + D_{pond}\right)}{P \times 0.95 \times 3{,}630}$$

Where:

DA	=	Drainage Area (acres)
L	=	Practice Length (feet)
W	=	Practice Width (feet)
0.25	=	Soil Porosity
D_{soil}	=	Soil Depth (ft)
0.4	=	Stone Porosity
D_{stone}	=	Stone Depth (ft)
D_{pond}	=	Ponding Depth (ft)
P	=	Design Storm Depth (inches); 1"
0.95	=	Runoff Coefficient for impervious cover
1/3,630	=	Conversion factor (from cf/inch to acres)

Using this equation and provided data, the bioswales typically treated an area in the range of 22 to 27 times the bioretention surface area. For some locations, no notes were provided to quantify the specific design. In these cases, we made the slightly conservative assumption that the practice treated 20 sf/sf of bioretention area.

Dry Wells:

Dry wells as described in this database are engineered chambers, by gallons of capacity. For these practices, we again assumed each practice treats 1" of impervious cover. The practice area was then calculated using the volume in the dry well (reported in gallons):

$$DA = \frac{V_{dry\ well}}{P \times 0.95 \times 3{,}630 \times 7.48}$$

Where:

$V_{dry\ well}$	=	Dry Well Volume (gallons)
7.48	=	Conversion factor (gallons/cf)

In one case, the product number was included rather than a design volume (8' Diameter United Dry Well). For this practice, we assumed a 1,000 gallon capacity, which was the minimum volume for this item (https://sheaconcrete.com/sites/default/files/pdf/DW8Dia.pdf). It appears from the Project Notes that three of these were installed together, but that design constraints resulted in only one receiving its designed drainage area.

Other Practices:

Other practices in the database included several porous concrete installations, one practice described as "Other," and two practices described as Rain Gardens. In this pilot application, we did not assign pollutant removals to these practices because of the following limitations: 1) It was not possible to characterize the "Other" practice with the available data; 2) The rain gardens were described as having a 1' depth of ponding in the middle, but no treatment underneath. It was unclear if the 1' ponding depth was a maximum or extended for only a portion of the practice, and if the soil was amended in some way making it difficult to estimate the treatment provided by this practice; 3) No drainage area or practice size was included for the porous concrete installations, and in notes they were described as very small.

4.2.3 Estimated Load Reductions

Taken together, these BMPs are estimated to provide the following benefits:

- Capture 7.9 acres of impervious cover (Total developed land area is 10,300 acres)
- Remove 38.2 pounds per year of N
- This nitrogen capture represents only 0.05% of the total nitrogen load from the City of New Haven.

The load reductions may seem small, but it is important to remember that the practices included in the database are typically very small retrofits (on the order of 75 square feet), and some practices were not included. At the same time, retrofitting in urban areas is time-consuming, and these practices were implemented over about 10 years, with the majority implemented over the 5-year period from 2015 to 2019.

4.2.4 Data Challenges and Limitations

Since this database was not developed for the purposes of tracking BMPs using the Tool, some data needed to be estimated, and the process was more time-consuming than it would have been if reporting were customized for the Tool. Some key specific changes might include:

1) Practice drainage areas and design storms were estimated for the pilot testing, but if data were reported for the purposes of tracking, these elements should be included.
2) The practice notes were useful, but required hand calculations, and consistent reporting would make these data more uniform.
3) Some judgement was needed to "crosswalk" the practice types with practices included in the Tool. For regulatory tracking, a specific process will be needed to represent and define practices consistently.

4.3 MS4 Data: East Lyme, Connecticut

BMP removal benefits were estimated for East Lyme using MS4-Scale data provided to the CT DEEP. These data are more aggregated (to the scale of the MS4) than the data from New Haven, which included design data for each individual practice. In addition, the MS4 data included both structural and non-structural BMPs. The data are consistent with required reporting for the state and, consequently, they are a good initial indication of whether the data reporting requirements allow for BMP nitrogen reduction crediting.

4.3.1 Loads and Land Cover

East Lyme has much more forest land than New Haven, with Developed land representing only 22% of the land area, but approximately 67% of the total N load. The total estimated N load is 33,604 lbs/year, from a 21,648-acre watershed (Table 20).

Table 20. Land Cover and Nitrogen Loading in East Lyme, CT

Land Cover	Area (acres)	Area (% of Total)	Nitrogen Load (lbs/yr)	Nitrogen Load (% of Total)
Developed High Intensity	187	1%	2,553	8%
Developed, Open Space	1,786	8%	3,666	11%
Developed, Low Intensity	1,789	8%	7,820	23%
Developed, Medium Intensity	1,013	5%	8,319	25%
Barren Land	150	1%	94	<1%
Forest	13,822	64%	8,632	26%
Shrub/Scrub	135	1%	84	<1%
Herbaceous	417	2%	261	1%
Wetlands	1,966	9%	1,228	4%
Pasture/ Hay	348	2%	745	2%
Cultivated Crops	34	<1%	202	1%
Total	21,648	100%	33,604	100%

4.3.2 BMP Data

Connecticut's MS4 reporting data has been assembled at MS4 scale and includes data on the NPDES permit minimum reporting requirements. While some of the data could be used to estimate BMP load reductions, other data could not be translated into a pollutant load reduction using the Tool (Table 21).

Table 21. MS4 BMP Data Reported to CT DEEP

Reporting Metric	Data Reported	How it Is Used in the Pilot
Public Education	Yes/or no to specific methods of outreach	The data cannot be quantified and were not included.
IDDE-Citizen Reporting	Number of discharges reported and addressed, whether the community has IDDE legal authority.	Without more specific information about the individual discharges, the benefits could not be quantified.
IDDE Metrics	Number of outfalls, interconnection, % completion for outfall and system mapping, screening and investigations (%) and % Investigated	Data is not sufficient to determine if the community has an “advanced program” as defined for the Tool. At a first glance, East Lyme would not qualify as it does not have IDDE authority and has not mapped all of its outfalls.
Post-Construction Reporting Metrics	IC Disconnection area, # of retrofits and cost.	Reflected as treatment by a bioretention practice.
Pollution Prevention Metrics	Street Sweeping Curb Miles Swept and Volume of material collected # of catch basins (priority and non-priority basins) # cleaned (priority and non-priority basins) Volume removed from catch basins (total and from impaired waters)	Use miles swept to estimate street sweeping and volume removed to estimate catch basins.

Street Sweeping:

The Tool estimates street sweeping effectiveness using three metrics: 1) Area swept; 2) Type of Sweeper and 3) Frequency. The data provided do not align exactly with these metrics, but the curb miles swept can be converted to an area swept at an assumed frequency and sweeper type, using the following assumptions:

- The total area swept is converted to acres by assuming that an 8’ wide swath is swept.
- The sweeper is vacuum-assisted
- The frequency is 2x/year
- The total area swept is then adjusted to account for the frequency (i.e., cut in half due to the twice per year estimate).

Taken together the total area swept is represented by:

$$A_{swept} = {CM \times W \times 0.12}/{F}$$

Where:

A_{swept}	=	Area Swept (acres)
CM	=	Curb Miles Swept
W	=	Width Swept (assume 8’)
0.12	=	Conversion (mile-feet to are)
F	=	Sweeping Frequency (#/year)

Catch Basin Cleaning:
The reported volume removed (in tons) is the only data needed to estimate the reductions associated with this practice.

Directly Connected Impervious Area (DCIA) Reduction:
It is assumed that impervious cover is reduced by capturing a 100% impervious drainage area, using a practice designed to treat 1" of stormwater runoff. We assumed that a bioretention with an underdrain and no internal storage was a good reflection of typical retrofit practices used in the region.

Assumption Regarding Geography
Since the BMPs are aggregated to the scale of the Town, it is not clear which HUC 12 the practices lie in. We assumed that the BMPs drain to the Pattagansett River - Frontal Long Island Sound[3]. The loads would not vary very much by changing the drainage area, but spatial data would be useful to allocate loads between basins.

4.3.3 Estimated Load Reductions

Taken together, the three practices reduce the total load by 220 pounds per year, representing about 0.7% of the total load from East Lyme, and 1% of the Urban Load:

- Disconnections reduced the load by 69 lbs/yr
- Street sweeping reduced the load by 67 lbs/yr
- Catch basin cleaning reduced the load by 85 lbs/yr

4.3.4 Data Challenges and Limitations

With data aggregated at this scale and summarized by practice, some details are missing, and the loads are estimated with a series of assumptions. For a regulatory crediting tool, more detailed data would be needed to quantify the reductions at an appropriate confidence level. In particular, identifying the total drainage area to specific practices would better represent the DCIA Reduction practice, and the curb-miles swept metric is not a perfect reflection of the methods used in the Tool. For street sweeping, other crediting methods may be considered in the future, or different data could be collected. In addition, the IDDE practices have the potential to reduce N, but there are no data quantifying the benefits of removing specific discharges. This practice is difficult to quantify but may be worth investigating further. Finally, it would be preferable to report practices with a spatial component to better understand where activities occur within each community.

[3] The term "Frontal Long Island Sound" refers to HUC 12 Units that include both the watershed of a river or stream and adjacent land that directly drains or is "Frontal" to the Long Island Sound.

5 Lessons Learned and Next Steps

The process of developing the Tracking Tool for this project highlighted some issues that need to be resolved to develop the proposed LISBTT tool, and also uncovered some opportunities to collaborate with other ongoing efforts. This section identifies these issues and recommends next steps to address the problems and capitalize on these opportunities.

5.1 Lessons Learned

5.1.1 Base Year

Early in this project, it was assumed that the base year for any tool would be either 2017 (the year of the most recent NPDES permits) or 2016 (the year of the most recent NLCD Land Cover dataset). As the project proceeded, however, concerns were raised regarding how to track progress relative to the original (2000) TMDL which was actually based on a 1992 land cover layer. This issue was discussed with TAC members, but the Tool relies on 2016 NLCD data, due to its availability, scale, and ability to integrate with other studies. This issue does need to be formally addressed by regulators at the state and federal levels, with some options including:

1) Use the newer (2016) land cover but assign a factor that allows for a translation between the 2016 baseline and the TMDL baseline.
2) Use the base year and land cover assumptions of the Tool, with the 2016 year serving as a reference point to track progress (in lbs/year) from 2016 forward, under the assumption that the BMPs implemented from 2000 to 2016 either cannot be easily tracked or in sum amount to an insignificant reduction.
3) Do not include a baseline year at all, and only use the tool to track the benefit of individual practices, expressed in mass of pollutant reduction.
4) Develop a strategy to reconcile the base year of the TMDL with the goals established in the US EPA's Nitrogen Reduction Strategy for Long Island Sound.

5.1.2 Data Formatting and Consistency

When testing the Tool with data from these two sources, we found that readily available data typically required some assumptions to be coerced into a format that could calculate N reductions from the draft tool. Some challenges included: 1) missing drainage areas; 2) missing or unclear design volumes; 3) unclear practice names; and 4) unavailable geographic information. As a starting point, we recommend working with one LIS state in the next phase to develop a single form to track BMP implementation as a part of the permitting process, and to make the form consistent with or inform MS4 reporting requirements.

5.1.3 Adapting Loading Rates Over Time

The loading rates in the Tool include those from the original TMDL, as well as rates developed through a literature survey and with the TAC as a part of this project. One challenge throughout the project as it progressed was how to integrate results from multiple ongoing modeling and monitoring efforts. For example, while the project team did attempt to review as much recent data as possible, efforts at the state level, such as the CT DEEP ongoing efforts to update its Connecticut Watershed Model which will be available in 2022, and consequently were not incorporated at this time.

5.1.4 Surface Water Attenuation Assumptions

The Tool uses two sets of loading rates, including the original TMDL rates and a set of values selected to be consistent with existing modeling efforts and tracking tools used in the region. Further, it assumes that no attenuation occurs in surface waters. This assumption was based on literature and recent monitoring data which suggested almost no N attenuation in river mainstems. At the same time, it incorporates a "placeholder" for surface water attenuation, but currently assumes 100% delivery. Ongoing modeling and monitoring efforts can potentially be used to update these assumptions over time. Related to this issue, the Tool does not account in any way for the landscape position of any BMP, so that the effects of large-scale land conservation efforts may be underrepresented in the tool.

5.1.5 Groundwater Loading and Attenuation

One challenge of this project was how to understand existing N loading rates from groundwater. The Tool does not currently distinguish between surface and groundwater loads but does include some considerations of groundwater delivery for two types of BMPs: 1) practices that achieve infiltration and 2) OSDSs. Both Connecticut and New York State and have been working to evaluate groundwater loads to LIS. In New York State, Suffolk County's Subwatershed Wastewater Plan (SFDHS, 2020) evaluated subsurface loads in this county where the majority of loads reach LIS via groundwater pathways. In Connecticut, the USGS is currently studying groundwater pathways to groundwater, and the Connecticut Watershed Model will incorporate a groundwater component.

5.1.6 Process for Updating and Incorporating Land Cover

The tool developed as a part of this project serves as a static snapshot in time, reflecting the sum of BMPs implemented against one baseline. In the future, a process will be needed to adjust for land cover changes. For example, the Chesapeake Bay CAST model incorporates a process to update land cover periodically. When the land cover is updated, the benefits of some practices also need to be adjusted as well. For example, practices that convert turf to forest have a timeframe associated with them to ensure that the CAST tool does not double count the water quality benefits of the practice once the land cover change is captured in the updated land cover layer. After this timeframe (e.g., 10 years, which allows sufficient time for newly planted trees to grow large enough to be captured on satellite imagery), the practice "expires" and the benefits are instead accounted for through the change in associated land cover loading rate.

5.1.7 Work with Non-Urban BMPs

Although the Tool includes some agricultural and other non-urban BMPs, the pilot studies did not include any of these examples. Agricultural data may not be available at the same spatial scale (e.g., total acres of a given practice by County) due to privacy concerns. If the LISBTT tool ultimately tracks non-urban BMPs, some method may be needed to reconcile the spatial scales of available data.

5.1.8 Collaboration with Other Tracking Efforts

Currently, several tracking projects are in place in the NEIWPCC region, and NEIWPCC has convened the Tracking and Accounting Collaborative (TACo) to help states track and account for nonpoint pollution. TACo provides an excellent opportunity to ensure that the LIS Tracking Tool is consistent in several key metrics, including: 1) using accepted crediting methodologies; 2) similar inputs and 3) Data storage and sharing so that inputs can easily be used across different tracking tools used in the region.

5.1.9 Identifying the Users of the Long Island Sound Stormwater BMP Tracking Tool (LISBTT)

For any tracking tool, there is a balance between getting as much data as possible and ensuring that data are consistent and accurate. The Tool developed during this project represents a first phase toward developing the LISBTT tool, which will be web-based, allowing for multiple users to enter data and use the tool to test scenarios or evaluate progress. In the next phase of this project, the project team should work to identify who would use LISBTT for two separate purposes:

1) Entering "Official" Data
Ultimately, LISBTT should act as a repository of BMPs implemented within the LIS watershed, and it will be important to ensure that the data entered are accurate and complete, and that the data-entry process is not burdensome, particularly to small governments at the MS4 level. In addition to state government agencies, it may be efficient or appropriate to identify other regional entities that will eventually be authorized to enter these data.

2) Scenario-Building and Tracking:
The LISBTT tool will allow users to develop scenarios, for example evaluating the potential benefits of BMPs implemented within a municipal boundary or within a watershed. This group would be quite broad and could potentially include towns or other municipalities regulated by a TMDL, watershed groups interested in developing a local watershed plan, or grant-applicants attempting to quantify the benefits of proposed activities. Similar to this scenario-building tool, this same group may wish to quantify or evaluate the progress made to date by practices included in the BMPs officially accounted for in LISBTT.

5.1.10 Review Methods to Encourage Data Entry

After potential users are identified to enter BMP data into LISBTT, there still must be some mechanism to ensure that these users enter data into the tool. Both recording all of the necessary data and entering it into a tool is time consuming, and data entry directly into the tool, or supplied to a state or regional entity, needs to either be encouraged or required. One potential mechanism is to require either data entry or reporting as a part of each state's NPDES MS4 permit.

5.1.11 Consistent Standards and Definitions and Adding New BMPs

For most practices in the current form of the Tool, practice definitions refer to an outside reference such as a design manual or other source, but a process will be needed to both define and evaluate the benefits of new practices using an Expert Panel or similar process. Further, some process needs to be developed to account for experimental or provisional practices. In its current form, users may enter "Custom" BMPs, such as a generic urban BMP with a defined efficiency, but some controls will need to be put in place to define which practices are approved and accounted for.

5.2 Recommended Steps for Phase II

At the time of proposal submission, the project team submitted a scope that was scaled back from the original scope suggested in NEIWPCC's 2019 RFP due to budget constraints. The original project goal was "To develop and implement the CAST tracking and accounting system, based on the recommendations of Phase I, to evaluate N reductions from stormwater and nonpoint sources." It was determined by the project team that some of the steps asked for in the RFP were not feasible within the timeline and budget of the project. Thus, it was always envisioned that a Phase II – Part 2 would be needed, the specifics of which would be determined by this Phase 2 – Part 1 work. Based on feedback from the TAC, and elements completed as a part of this project, recommended tasks for the next part of Phase II include the following:

1) Revisit the issue of the baseline year and land cover layer, with input from the TAC to select an appropriate year and approach.

2) Implement the Tool in additional pilot communities.
3) Conduct a land use change analysis from the selected (see #1 above) base conditions to current conditions in pilot basins.
4) Evaluate the costs and resources of implementing the Tool throughout the LIS watershed
5) Convert the Tool to a readily-shareable (potentially web-based) format (LISBTT)
6) Work directly with CT DEEP to integrate the Tool into the MS4 reporting process.

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7 Attachments

A. Meeting Presentations and Notes
B. BMP Definitions
C. BMP Performance Curves
D. Tracking Tool
E. Pilot Study Source Data
F. Baseline Memo
G. Crediting Memo