

Attachment 5:

MassDOT's Nitrogen TMDL Method

Description of MassDOT's Application of TMDL Method to Nitrogen in Groundwater-Controlled Massachusetts Watersheds

Introduction

The Massachusetts Department of Transportation (MassDOT) owns and operates stormwater collection systems along its roadways throughout Massachusetts. In urbanized areas, discharges from these stormwater collection systems are regulated under a Municipal Separate Storm Sewer Systems (MS4) National Pollutant Discharge Elimination System (NPDES) general permit issued by the United States Environmental Protection Agency (USEPA). This permit requires that MassDOT's MS4 discharges to impaired water bodies be consistent with any State or EPA established final Total Maximum Daily Loads (TMDLs) for that water body and any applicable Waste Load Allocations (WLAs).

MassDOT has developed a NPDES Storm Water Management Plan (SWMP; MassHighway, 2009) pursuant to the requirements of its NPDES general permit. The SWMP includes several protocols used to address pollutant loading from MassDOT's stormwater discharges to the State's impaired water bodies. However, MassDOT felt that the current protocols outlined in the SWMP to date needed to be refined to be appropriate for groundwater-controlled watersheds that exist on Cape Cod, parts of southeastern Massachusetts, and Martha's Vineyard and Nantucket versus the surface water controlled watersheds that exist elsewhere in the Commonwealth. In these groundwater-controlled locations, coarse textured soils dominate the landscape, resulting in rapid infiltration and reduced surface runoff. Some pollutants of concern, such as nitrogen, enter groundwater and travel with little to no attenuation (White, 2003) to coastal ponds and embayments. Nitrogen has been identified as a key nutrient in coastal waters. Excess nitrogen loading to coastal ponds and embayments leads to eutrophication of these water bodies. In these situations, reduction of nitrogen at the source or attenuation prior to entry to groundwater is critical to reducing loading.

For those impaired water bodies with an established nitrogen TMDL in groundwater-controlled watersheds, MassDOT will use the following assessment methodology, as modified from Best Management Practice (BMP) 7R (MassHighway, 2010) of the SWMP. For brevity, MassDOT has termed this methodology "MassDOT's Nitrogen TMDL Method." This methodology relies on research performed by the United States Geological Survey (USGS) for the Massachusetts Estuaries Program and conservatively assumes that the entire nitrogen load from runoff that infiltrates into groundwater ultimately drains to the impaired water body (Walter et. al. 2004) without a load reduction. The methodology is summarized as follows:

1. Identify impaired water bodies with final Nitrogen TMDLs in groundwater-controlled watersheds on Cape Cod and in adjacent Southeastern Massachusetts communities, and identify which of these include MassDOT property within their watersheds. Through the Massachusetts Estuaries Program, USGS has completed modeling to identify the groundwater-controlled watershed boundaries of impaired waters on Cape Cod, parts of southeastern Massachusetts, Martha's Vineyard, and Nantucket; the groundwater-

controlled watershed boundaries identified by USGS correspond to those which the Massachusetts Estuaries Program and MassDEP used to develop TMDLs for these receiving waters. Urbanized areas are defined by the Massachusetts 2000 Urban Boundaries data layer and the 2010 U.S. census data. USEPA has provided an urbanized area GIS layer to be used for the Impaired Waters Program.

2. Conduct a desktop review and, if necessary, perform a site investigation, of waters with nitrogen TMDLs to determine if there are stormwater discharges from MassDOT urbanized areas. Stormwater discharges may flow directly to the water body or may infiltrate into groundwater first before draining into the water body.
3. Assess whether the nitrogen target load identified in the TMDL for stormwater is being met.
 - 3a. Calculate the relevant areal target load.
 - 3b. Calculate loading from MassDOT direct stormwater discharges and groundwater discharges.
 - 3c. Determine if MassDOT contributions are significant contributors to the load to the impaired water body or represent a negligible source.
 - 3d. Assess target load relative to loading from MassDOT.
4. If additional stormwater BMPs are recommended in the assessment, select, design and implement BMPs suitable for nitrogen removal from stormwater runoff from MassDOT roads in urbanized areas.
5. Document the results of the assessment.

This report is intended to describe the assessment methodology as modified from BMP 7R of the SWMP and includes detailed step-by-step instructions for each component thereof as they apply to nitrogen loadings to groundwater-controlled watersheds on Cape Cod, the islands and adjacent southeastern communities dominated by coarse textured soils.

MassDOT's Nitrogen TMDL Method for Groundwater-Controlled Watersheds

MassDOT's Nitrogen TMDL Method has been developed exclusively for assessing MassDOT discharges to impaired water bodies in groundwater-controlled watersheds with TMDLs for total nitrogen (TN). MassDOT has developed additional procedures for assessing compliance with TMDLs in other locations across the state of Massachusetts.

MassDOT developed a supplementary worksheet, identified as the Nitrogen TMDL worksheet, to assist in performing the calculations required for each assessment and documenting the necessary information. This report provides guidance for using the Nitrogen TMDL Method both with and without the use of the supplementary worksheet. However, it is strongly recommended that the worksheet be used. Screenshots are included as Attachment 1 at the end of the report to illustrate various user inputs (shaded in blue) and worksheet outputs (shaded in yellow).

MassDOT's Nitrogen TMDL Method uses data from TMDL reports and associated guidance published by MassDEP and USEPA. MassDEP's TMDL reports can be accessed at the following URL: <http://www.mass.gov/eea/agencies/massdep/water/watersheds/total-maximum-daily-loads->

[tmdls.html#19](#). USEPA's guidance on developing, implementing, and complying with TMDLs can be accessed at the following URL: <http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/index.cfm>.

Several steps of MassDOT's Nitrogen TMDL Method require the user to perform a desktop analysis to develop an understanding of local flow patterns within the watershed of the subject TMDL water body and within MassDOT's right-of-way. The desktop analysis is intended to be completed in a Geographic Information System (GIS) environment in order to simultaneously analyze multiple sets of geospatial data. It is recommended that the user be familiar with GIS software before performing an assessment using the methodology described herein.

Figure 1 summarizes MassDOT's Nitrogen TMDL Method. The following sections describe in detail the steps necessary to complete an assessment of MassDOT's stormwater discharges to an impaired water body under the jurisdiction of a State- or USEPA-established nitrogen TMDL using MassDOT's Nitrogen TMDL Method. See Attachment 1 for an example of the methodology applied to a nitrogen-impaired water body on Cape Cod and for additional background on the calculations.

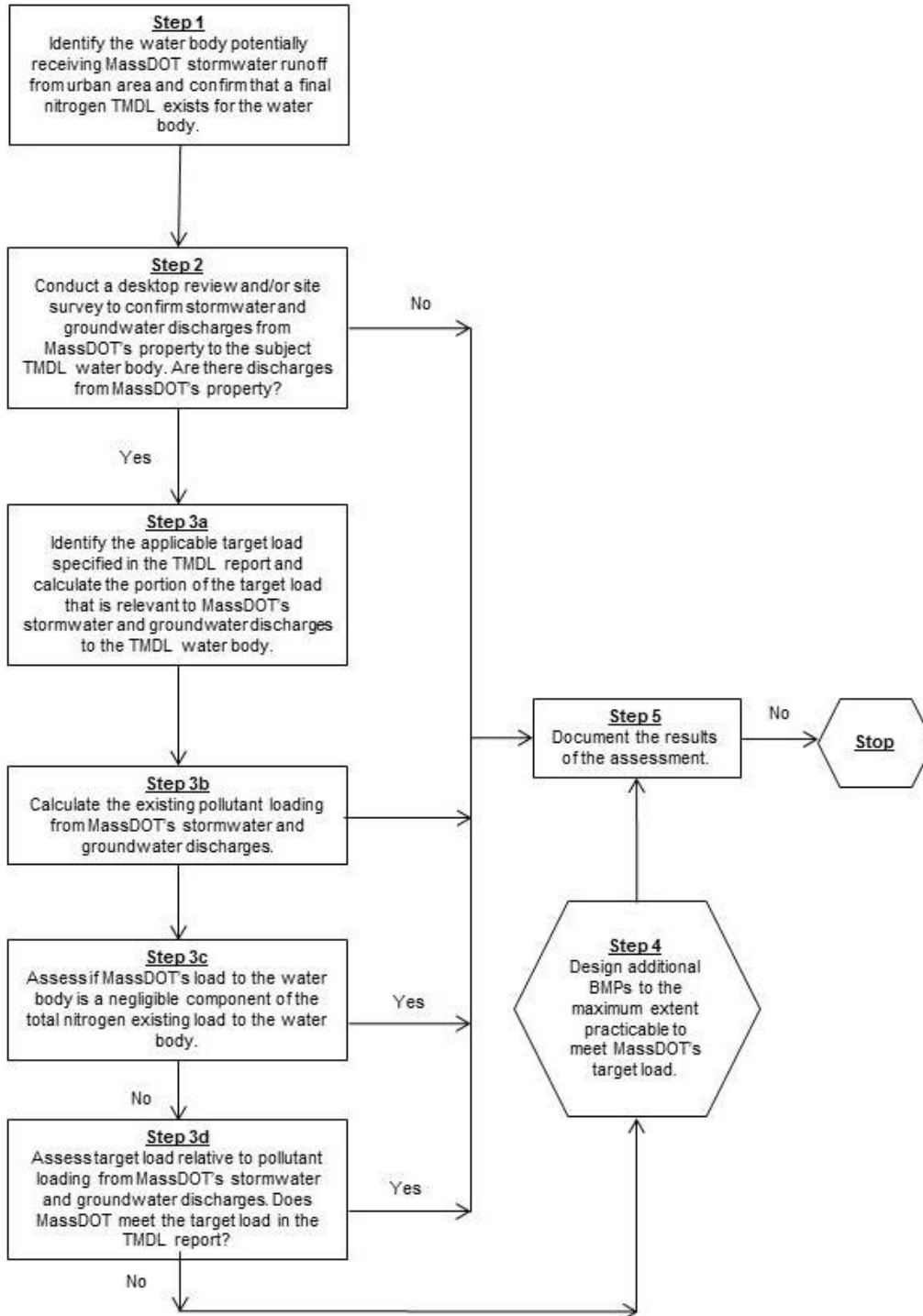


Figure 1. Flow Chart Illustrating MassDOT's Nitrogen TMDL Method

Step 1. Identify Waters with Final Nitrogen TMDLs to Which MassDOT's Urbanized Roadways May Potentially Discharge Stormwater

Identify the impaired water body in a groundwater-controlled watershed that receives stormwater from one or more of MassDOT's urbanized roadways.

Using MassDEP's most recent *Final Massachusetts Integrated List of Waters*, identify the impairment(s) of the subject water body and verify that a nitrogen TMDL has been finalized to address one or more of the impairments. Read the TMDL report(s). Proceed to Step 2.

Step 2. Conduct Desktop Review and/or Perform a Site Survey of Waters with Nitrogen TMDLs

Perform a desktop analysis to confirm there are stormwater outlets or sheet flow from MassDOT's urban property that are within the groundwater-controlled watershed of the subject water body.

Through the Massachusetts Estuaries Program, USGS used groundwater models to define the watersheds to nitrogen-impaired waters in southeastern Massachusetts (Walter et. al. 2004). These watersheds correspond to those used by the Massachusetts Estuaries Program and MassDEP to establish Nitrogen TMDLs and WLAs in the geographic areas covered by this methodology. Urbanized roadways are defined as those which fall within the urbanized areas defined by the Massachusetts 2000 Urban Boundaries datalayer and the 2010 U.S. census data. USEPA provided a GIS dataset combining these urban layers and shared it with MassDOT to be used for impaired waters assessments. Additional data sources for the desktop analysis should include MassDOT construction or as-built drainage plans, aerial imagery, MassDOT outfall inventory layer, the MassDOT Survey Control and Layout Plans website to determine the extent of MassDOT property (http://www.mhd.state.ma.us/LayoutsMapping/mapping.asp?ACTION=FullExtent&ACTIVE_LAYER=All_LAYERS), the MassGIS Impervious Surface Layer, and any other GIS datasets which may be of use.

If the desktop analysis reveals MassDOT stormwater discharges either through overland flow or subsurface flow within the watershed, then conduct a field visit to verify the stormwater discharges exist and to confirm the watershed from MassDOT property is contributing stormwater runoff. Proceed to Step 3.

If the desktop analysis confirms that there are no stormwater discharges from MassDOT's property within the watershed, then proceed to Step 5.

Step 3. Assess Whether Target Load for Stormwater Discharges Is Being Met

When MassDOT urbanized area drains to a water body covered by a nitrogen TMDL, either through direct stormwater discharges or infiltration through groundwater, assess whether the target nitrogen load is being met through existing stormwater control measures or if additional control measures may be necessary. If the existing MassDOT nitrogen load is very small compared to the existing total nitrogen load to the water body, the existing MassDOT nitrogen load may be considered negligible. This assessment will be conducted using the steps outlined below.

Step 3a. Calculate the Relevant Areal Target Load

Nitrogen TMDL reports in southeastern Massachusetts typically do not specify a single WLA or target load for stormwater discharges within the watershed of the water body. Therefore, calculations must be performed to determine the portion of the applicable target load that is relevant to MassDOT's stormwater runoff to the water body.

Calculate the Areal Target Load

Many of the TMDLs for water bodies in groundwater-controlled watersheds specify a target nitrogen load for the total watershed. The total watershed in the TMDLs includes both groundwater and surface water. The total watershed load may include sources of nitrogen from septic systems, stormwater runoff, fertilizers, and natural background sources.

Using the corresponding TMDL data, calculate the target load that can be applied to roadway stormwater runoff. This should be done by identifying the total watershed target load and subtracting out all sources that are not related to stormwater. The total watershed load is typically referred to as the "Target Controllable Threshold Watershed Load" in the Nitrogen TMDLs and can typically be found in Tables 4 and 5 of the TMDL report. The same table usually identifies targets for sources not related to stormwater including uncontrollable sources of nitrogen such as atmospheric deposition and benthic flux. The septic system target load should also be identified (typically can be found in the TMDL's respective Appendix B). The total controllable watershed load subtracted by all sources not related to stormwater (i.e. wastewater effluent, benthic flux, atmospheric deposition, and septic systems) will be identified as the applicable watershed target load. The TMDLs are not structured exactly the same so the sources not related to stormwater will differ between reports and it is up to the user's discretion to subtract out all relevant sources. Given the data present in the vast majority of the TMDL reports, it is likely that other non-roadway sources of stormwater runoff which may contribute significant nitrogen load to the receiving water will remain in the calculated target load, such as golf courses and residential lawns. However, the resulting DOT watershed load target calculated will represent the best estimate of MassDOT's target load using available information. Many land uses typically have higher nitrogen load contributions than roadway, such as residential land uses including septic systems and fertilized lawn areas (MassDEP, 2007),

Using the applicable watershed target load and its corresponding area (typically the entire watershed), calculate the target areal load by dividing the applicable watershed target load by the corresponding area. These calculations can be performed using the Nitrogen TMDL worksheet. See the example in Attachment 1 for more details.

Calculate the Target Load for MassDOT

Next, calculate the relevant target load for MassDOT. Delineate the pervious and impervious areas of MassDOT's property that contribute stormwater to the subject water body or infiltrate in to groundwater and drain to the water body to determine the total area of MassDOT property within the groundwatershed. Data sources for this delineation should include USGS groundwater-controlled watershed data, construction or as-built plans, aerial imagery, the Impervious Surface datalayer downloaded from MassGIS, and other GIS datasets that may be of use. After calculating total area of MassDOT property, multiply it by the target areal load determined in Step 3a above.

Step 3b. Calculate Loading from MassDOT Stormwater

This step is broken up into two parts as described below. First, calculate the estimated loading of the nitrogen from MassDOT's property to the subject water body. Then, quantify the nitrogen mitigation provided by any existing BMPs.

Calculate MassDOT's Total Estimated Pre-BMP Nitrogen Load

Use the delineation of MassDOT property developed in Step 3a and the loading rates for pervious and impervious areas listed in Table 1 below to calculate MassDOT's total estimated pre-BMP nitrogen load to the subject water body. These calculations can be performed using the Nitrogen TMDL worksheet. See the example in Attachment 1 for more details.

The loading rates provided in Table 1 were developed using a U.S. Geological Survey (USGS) model developed to estimate downstream event mean concentrations of various pollutants based on information from the Highway Runoff Database, as well as precipitation data, storm flow, water quality, and mitigation measures. MassDOT used the USGS SELDM model to estimate annual nitrogen loads from its property. Nitrogen loading from a one-square foot area of MassDOT roadway was estimated using the Ecoregion 84, which is representative of coastal regions ecological system at the latitude and longitude of the center of Cape Cod, triangulation of the precipitation datasets for New Bedford and Hyannis, and the included relevant datasets associated with these selected parameters. These loading rates are not dependent on soil types present. Based on running the SELDM model with these parameters for impervious and pervious areas, MassDOT estimates the nitrogen loading from impervious areas as 8.5 lbs/acre/yr and from pervious areas as 2.5 lbs/acre/yr.

Table 1. Loading Rates for MassDOT's Pervious and Impervious Property

Pollutant	Loading Rate (lb/acre/yr)	
	Impervious	Pervious
Total Nitrogen (TN) ¹	8.5	2.5

¹ Developed based on USGS SELDM (Granato, G.E., 2013)

Quantify the Treatment Provided by Existing BMPs

Perform a desktop analysis to identify any existing BMPs that may address stormwater from MassDOT's property to the subject water body. This may be incorporated into the desktop analysis required under Step 2. Data sources for identifying any existing BMPs should include construction or as-built plans and aerial imagery. Review design plans, as-built plans, permit applications, and any other available documentation for the following BMP-specific information:

- BMP dimensions (depth, width, length, etc.)
- Inlet structures (type, orifice size, invert elevations, etc.)
- Outlet structures (type, orifice size, invert elevations, etc.)
- Contributing watershed information (size, land cover, etc.)

The data collected during the desktop analysis should subsequently be verified with a site visit. Confirm the presence, type, function, and characteristics (dimensions, inlet and outlet structures, wet or dry conditions, and working condition) of existing BMPs. Verify the drainage patterns and watershed boundaries delineated during the desktop analysis and evaluate the watersheds of existing BMPs. This may be incorporated into the site visit required under Step 2.

Classify existing BMPs based on the guidance provided as Attachment 2 at the end of this report. Attachment 2 is a revised guidance document from BMP 7R (MassHighway, 2010)

and focuses on typical MassDOT BMPs and BMPs appropriate for nitrogen removal. The guidance provides reduction rates for nitrogen based on BMP type which are used in the Nitrogen TMDL worksheet.

Step 3c. Determine whether MassDOT Loads to the Impaired Water Body are Negligible

The nitrogen TMDLs for coastal ponds and embayments suggest that septic systems and lawn fertilizer are major components of the nitrogen load (MassDEP 2013). It is possible that nitrogen loading from MassDOT roads represents a very small “negligible” amount in some watersheds, which does not substantially contribute to the impairment. In these cases, removing nitrogen from DOT runoff would do little, if anything, to improve the water quality of the receiving water body.

Determine if MassDOT remaining nitrogen loads as calculated in step 3b (which includes both direct stormwater discharges and groundwater discharges) represent a very small amount relative to the total existing nitrogen load to the resource, and therefore would be considered negligible. In TMDLs established for nitrogen impaired waters in the Cape Cod area, MassDEP identifies that category specific nitrogen loads as high as 3.29% of the total nitrogen watershed load were considered negligible compared to other sources (MassDEP, 2007). Based on this MassDEP published evaluation, MassDOT has determined that MassDOT property loadings less than 3.5% can be considered as negligible contributions to the resource. The total nitrogen load to the receiving water body can be identified in the TMDL report.

If MassDOT’s load is considered negligible, proceed to Step 5.

Step 3d. Assess Target Load Relative to Loading from MassDOT

This step analyzes the results from Steps 3a and 3b to determine if existing conditions provide enough nitrogen treatment or if more nitrogen treatment is necessary to meet the target load.

First, determine MassDOT’s recommended Pre-BMP load reduction by subtracting the target load for MassDOT contributing property calculated in Step 3a from MassDOT’s total estimated pre-BMP nitrogen load calculated in the first part of Step 3b.

Next, compare the treatment provided by MassDOT’s existing BMPs, quantified in the second part of Step 3b, to the recommended Pre-BMP load reduction. If MassDOT’s load reduction provided by existing BMPs is more than or equal to the recommended Pre-BMP load reduction, then MassDOT is in compliance with the TMDL for its discharges to the subject water body. If MassDOT’s load reduction provided by existing BMPs is less than the recommended Pre-BMP load reduction, then opportunities for reducing the nitrogen load should be considered to meet the target.

Step 4. Select, Design and Implement BMPs

If Step 3 determines that additional BMPs may be necessary to meet MassDOT’s target load and that the contribution is not negligible, MassDOT will implement additional BMPs to the maximum extent practicable and follow the BMP recommendations as described below.

First, determine whether it is practicable to construct additional BMPs to address runoff from MassDOT’s contributing property to the subject water body. There are a variety of data sources that are useful for this purpose, including aerial photography, construction or as-built plans of the existing roadway and stormwater system, MassDOT Survey Control and Layout Plans website to determine the extent of MassDOT property

(http://www.mhd.state.ma.us/LayoutsMapping/mapping.asp?ACTION=FullExtent&ACTIVE_LAYER=All_LAYERS), SSURGO-certified soils data available through MassGIS, etc. In some instances it

may not be practicable under the confines of the Retrofit Program to construct any additional BMPs due to site constraints such as lack of available space, presence of underground utilities, presence of incompatible soils, presence of wetlands, etc. When this is the case, report the findings to MassDOT and provide information to finalize the assessment for the water body. In the final assessment report, thoroughly document all site constraints hindering the construction of additional BMPs.

If the installation of additional BMPs seems practicable, identify locations where BMPs may be constructed. Select BMPs that may be retrofitted into the existing roadway and stormwater infrastructure but will also provide a significant reduction in nitrogen loading to the subject water body. Consider the following while selecting additional BMPs:

- The estimated nitrogen reduction efficiencies for structural BMPs based on the percent reductions assigned to each in the Nitrogen TMDL worksheet;
- BMP recommendations or performance requirements for highway dischargers listed in the TMDL report (or in other performance agreements or memoranda of understanding);
- Existing stormwater and highway infrastructure;
- The nature and extent of site constraints that may limit the scope of BMP construction;
- Any existing literature regarding appropriate BMPs for nitrogen, including any guidance issued by the EPA or MassDEP. BMPs that are not in the Appendix 2 Table may be used for nitrogen removal with proper documentation of removal rates based on literature results;
- The overall magnitude of MassDOT's stormwater discharges and the degree to which its estimated nitrogen loads differ from the target load; and
- Consider stormwater BMPs for construction that are appropriate for removing nitrogen. BMPs that provide biological uptake will remove nitrogen effectively; therefore, bioretention areas, vegetated infiltration basins, vegetated filter strips, and gravel wetlands are typically the best BMPs to remove a portion of the nitrogen load. See Attachment 2, BMP Classification and Nitrogen Reduction Methodology, for more details on nitrogen load reductions.

Quantify the nitrogen reductions provided by the recommended BMPs in the same manner as described for existing BMPs in Step 3b: "Quantify the Treatment Provided by Existing BMPs." First calculate an existing nitrogen load from the catchment area that will drain to the recommended BMP via surface water flow, then assign a nitrogen load reduction credit to each recommended BMP using the percent reduction values specified in Attachment 2, and finally multiply the watershed nitrogen loads by the corresponding percent reduction values to obtain the nitrogen load reduction provided by each recommended BMP. These calculations can be performed using the Nitrogen TMDL worksheet. See the example in Attachment 1 for more details.

Recommend additional BMPs to meet the MassDOT target or to the maximum extent practicable. Document any site constraints or other limitations preventing MassDOT from meeting the load reduction target.

Proceed to Step 5.

Step 5. Document Results of Assessment

As referenced in BMP 7R of MassDOT's SWMP (MassHighway, 2010), MassDOT will include in its reports to the EPA updates on its progress in assessing and mitigating 303(d) impaired waters,

including waters with TMDLs. This methodology, as modified from BMP 7R, will follow this same commitment and report MassDOT's progress on assessing and mitigating nitrogen-impaired waters with final TMDLs in groundwater-contributing watersheds.

For waters with TMDLs reviewed using the above methodology, document the results of the assessment in a standardized format. This should include the following at a minimum:

- the name and segment number of the water body with a nitrogen TMDL
- the applicable target load
- the estimated load from MassDOT
- any BMP recommendations, performance requirements, or other Performance Agreement or Memorandum of Understanding applicable to the TMDL
- a summary of MassDOT's assessment and/or mitigation plan

Any relevant calculations, documentation, data sources for the assessment, etc. should be compiled and kept on file. MassDOT's reports to the EPA should clearly document the basis of any conclusions reached as a result of the assessment regarding the need or lack of need for BMPs at specific sites.

Summary

As part of its NPDES MS4 stormwater permit, MassDOT is required to address the discharge of pollutants from its stormwater systems to impaired water bodies identified in MassDEP's *Final Massachusetts Integrated List of Waters*. MassDOT's SWMP (MassHighway, 2009) identifies several methods for addressing its stormwater discharges to impaired water bodies depending on whether or not they are covered by a TMDL.

Because groundwater-controlled watersheds such as those on Cape Cod, parts of southeastern Massachusetts, and Martha's Vineyard and Nantucket are characterized by coarse textured soils, stormwater rapidly infiltrates. Conservative pollutants, such as nitrogen, enter groundwater and are assumed to travel to coastal embayments without significant attenuation (White, 2003). In these situations, reduction of nitrogen at the source or attenuation prior to entry to groundwater is critical to reducing loading. This method specifically focuses on water bodies covered by TMDLs for conservative substances such as nitrogen. To assess impaired water bodies that are covered by a nitrogen TMDL, MassDOT uses the applicable watershed target load to compare with loading from MassDOT urbanized areas. MassDOT calculates the nitrogen loading from its property and the nitrogen load reduction provided by any existing BMPs and compares the resulting values to the target load identified in the TMDL report. In cases where MassDOT's nitrogen loading exceeds the target load, MassDOT looks for opportunities to implement additional BMPs. This method allows MassDOT to identify locations where they are already meeting nitrogen TMDLs for impaired waters and locations where additional BMPs should be considered.

References

AECOM. Unpublished Nutrient Loading Data. (2011). AECOM Lake Loading Response Model (LLRM).

- ENSR. (2006). Stormwater TMDL Implementation Support Manual for US Environmental Protection Agency Region 1. ENSR International & EPA Region 1, Boston, MA. Project No.: 10598-001-500. Retrieved from:
<http://www.epa.gov/region1/eco/tmdl/pdfs/Stormwater-TMDL-Implementation-Support-Manual.pdf>
- Granato, G.E., 2013, Stochastic empirical loading and dilution model (SELDLM) version 1.0.0: U.S. Geological Survey Techniques and Methods, book 4, chap. C3, 112 p. Available at:
<http://pubs.usgs.gov/tm/04/c03>
- Massachusetts Department of Environmental Protection (Mass DEP) 2007. Final Total Maximum Daily Load for Total Nitrogen in the Pleasant Bay System, Massachusetts (CN 244.0). Available at: <http://www.mass.gov/eea/docs/dep/water/resources/n-thru-y/pbtml.pdf>
- MassDEP. (2008). Massachusetts Stormwater Handbook. February 2008. Retrieved from:
<http://www.mass.gov/dep/water/laws/policies.htm#storm>
- MassDEP. (2013). The Massachusetts Department of Environmental Protections webpage providing access to all of the Total Maximum Daily Load reports for the state. Accessed August 20, 2013. <http://www.mass.gov/eea/agencies/massdep/water/watersheds/total-maximum-daily-loads-tmdls.html>
- Massachusetts Highway Department (MassHighway). (2004). MassHighway Stormwater Handbook: Stormwater Management for Highways and Bridges. May 2004. Retrieved from:
http://www.mhd.state.ma.us/downloads/projdev/2009/mhd_stormwater_handbook.pdf
- Massachusetts Highway Department (MassHighway). (2009). NPDES Storm Water Management Plan for MassHighway Owned and Operated Highways. December 23, 2009. Retrieved from: <http://www.mhd.state.ma.us/downloads/projDev/SWMP20091223.pdf>
- Massachusetts Highway Department (MassHighway). (2010). BMP 7R: TMDL Watershed Review. July 22, 2010. Retrieved from:
http://www.mhd.state.ma.us/downloads/projDev/BMP_7R_TMDL_WatershedReview.pdf
- Smith, K.P., and Granato, G.E., 2010. Quality of storm water runoff discharged from Massachusetts highways, 2005-07: U.S. Geological Survey Scientific Investigations Report 2009-5269, 198 p.
- United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS). (1986). TR-55: Urban Hydrology for Small Watersheds. Available at:
<ftp://ftp.wcc.nrcs.usda.gov/wntsc/H&H/other/TR55documentation.pdf>
- United States Department of Agriculture Natural Resource Conservation Service (USDA NRCS). (2010). Part 618-Soil Properties and Qualities. Available at:
<http://soils.usda.gov/technical/handbook/contents/part618.html#36>
- United States Environmental Protection Agency (USEPA). (2010). Stormwater Best Management Practices (BMP) Performance Analysis. Retrieved from:
<http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/BMP-Performance-Analysis-Report.pdf>
- Walter, D.A., Masterson, J.P., and Hess, K.M., 2004, Ground-Water Recharge Areas and Travel times to Pumped Wells, Ponds, Streams, and Coastal Water Bodies, Cape Cod,

6/6/2014



Massachusetts, Scientific Investigations Map I-2857, 1 sheet. Available at:
<http://pubs.water.usgs.gov/sim20042857>

White, L. M. 2003. The Contribution of Lawn Fertilizer to the Nitrogen Loading of Cape Cod Embayments. Master's Thesis, University of Rhode Island.

[This page intentionally left blank.]

Attachment 1

Nitrogen TMDL worksheet Screenshot and Example

[This page intentionally left blank.]

Example Assessment

This example describes the step-by-step calculations needed to implement MassDOT's Nitrogen TMDL Method, and how to use the Nitrogen TMDL worksheet to complete these calculations. Additional description of each step in the methodology is contained within the main body of the MassDOT Nitrogen TMDL Method text. The below example describes calculations and Nitrogen TMDL worksheet components for Steps 3 through 4 of the methodology. Figures 2, 3 and 4 at the end of this example, provide the complete Nitrogen TMDL worksheet associated with the example described below. Values with a blue highlighted box must be entered by the user, while yellow highlighted values are calculated by the spreadsheet, and white numbers are constants.

Step 3. Assess Whether Target Load for Stormwater Discharges Is Being Met

Step 3a. Calculate the Relevant Areal Target Load

Calculate the Areal Target Load

Many of the TMDLs for water bodies in groundwater-controlled watersheds specify a target nitrogen load for the total watershed which includes both groundwater and surface water. Therefore, the total watershed load may include sources of nitrogen from septic systems, stormwater runoff, fertilizers, and natural background sources.

Using the corresponding TMDL data, calculate the target load that can be applied to roadway stormwater runoff by identifying the total watershed target load and subtracting out all sources that are not related to stormwater. The calculated number of the total watershed load subtracted by all sources not related to stormwater (i.e. wastewater effluent, benthic flux, atmospheric deposition, and septic systems) will be identified as the applicable watershed target load.

Using the applicable watershed target load and its corresponding area (typically the entire watershed); calculate the target areal load as follows:

$$\text{Areal Target Load (lb/ac/yr)} = \frac{\text{Applicable Watershed Target Load (lb/yr)}}{\text{Area Covered by Load (ac)}}$$

These calculations may be performed using the Nitrogen TMDL worksheet. Refer to the section in the worksheet titled "TMDL Load Calculations." A screenshot of this portion of the Nitrogen TMDL worksheet is shown below.

TMDL Load Calculations

Total Watershed Target Load	4313 lb/yr
Target Load from Sources Unrelated to Stormwater	1769 lb/yr
Applicable Watershed Target Load	2544 lb/yr
Watershed Area for Target Load	868 ac
Areal Target Load	2.9 lb/ac/yr

Calculate the Target Load for MassDOT

Next, calculate the relevant target load for MassDOT. Enter the impervious and pervious area (in acres) in the section in the worksheet titled "Pre-BMP Loading Calculations for MassDOT's Contributing Property." The contributing property includes both direct discharges from urban MS4 areas as well as groundwater discharge from urban MS4 areas. The worksheet will return values for total area (ac). A screenshot of this portion of the Nitrogen TMDL worksheet is shown below.

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	2.8 ac
Pervious Area	1.5 ac
Total Area	4.3 ac

Multiply the areal target load by the total area of MassDOT's property that contributes stormwater directly to the subject water body or to groundwater to obtain the target load for MassDOT's contributing property. This calculation should be performed as follows:

$$\begin{aligned}
 &\text{Target Load for MassDOT (lb/yr)} \\
 &= \text{Areal Target Load (lb/ac/yr)} \\
 &\times \text{Total Area of MassDOT's Contributing Property including discharge to groundwater (ac)}
 \end{aligned}$$

Loading from MassDOT's Contributing Property

Target Load for MassDOT's Contributing Property	12.5 lb/yr
MassDOT's Recommended Load Reduction	15.1 lb/yr

This calculation may be performed using the Nitrogen TMDL worksheet. Refer to the section in the worksheet titled "Loading from MassDOT's Contributing Property."

Step 3b. Calculate Loading from MassDOT Stormwater

This step is completed in two parts as described below. First, calculate the estimated loading of the nitrogen from MassDOT's property to the subject water body. Then, quantify the nitrogen mitigation provided by any existing BMPs.

Calculate MassDOT's Total Estimated Pre-BMP Nitrogen Load

If the Nitrogen TMDL worksheet is used for the assessment, the user should have completed the input for the site name and subject impaired water body under the Site Information section at the top of the worksheet. The worksheet will assess for the pollutant total nitrogen (TN).

Site Information

Site Name	[Sample] Tiny Brook
Impaired Water	[Sample] MA123456
Pollutant	Total Nitrogen

Use the delineation developed in Step 3a and the loading rates for pervious and impervious areas listed in Table 1 below to calculate MassDOT's total estimated pre-BMP nitrogen load to the subject water body for nitrogen. This calculation should be performed as follows:

$$\text{MassDOT's Total Estimated Pre - BMP Pollutant Load (lb/yr)} = \\ \text{Impervious Area (ac)} \times \text{Impervious Loading Rate ((lb/ac) / yr)} + \\ \text{Pervious Area (ac)} \times \text{Pervious Loading Rate (lb / ac / yr)}$$

Table 2. Loading Rates for MassDOT's Pervious and Impervious Property

Pollutant	Loading Rate (lb/acre/yr)	
	Impervious	Pervious
Total Nitrogen (TN) ¹	8.5	2.5

¹Developed based on USGS SELDM (Granato, G.E., 2013)

This calculation may be performed using the Nitrogen TMDL worksheet. Refer to the section in the worksheet titled "Pre-BMP Loading Calculations for MassDOT's Contributing Property". A screenshot of this portion of the Nitrogen TMDL worksheet is shown below.

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	2.8 ac
Pervious Area	1.5 ac
Total Area	4.3 ac
Estimated Loading Rate for Impervious Area	8.5 lb/ac/yr
Estimated Loading Rate for Pervious Area	2.5 lb/ac/yr
Total Estimated Pre-BMP MassDOT Load	27.6 lb/yr

The worksheet will return values for the estimated loading rate for impervious area (lb/ac/yr), estimated loading rate for pervious area (lb/ac/yr), total estimated pre-BMP loading rate (lb/ac/yr), and total estimated pre-BMP MassDOT load (lb/yr).

Quantify the Treatment Provided by Existing BMPs

Assign a nitrogen load reduction rate to each existing BMP using the percent reduction values specified in Attachment 2 at the end of this report. Multiply the pre-BMP nitrogen load for the catchment area draining to that BMP calculated above by the corresponding percent reduction values to obtain the load reduction provided by each existing BMP. This calculation should be performed as follows:

$$\text{BMP Pollutant Load Reduction (lb/yr)} \\ = \text{Pre - BMP Pollutant Load (lb/yr)} \times \text{Percent Reduction (\%)} \\$$

This calculation may be performed using the Nitrogen TMDL worksheet. Refer to the section in the worksheet titled "Load Reduction Provided by MassDOT BMPs under Existing Conditions." The user should input values for the following:

- BMP name
- BMP type
- soil classification of the BMP area (not required for reduction calculations)
- contributing watershed from impervious area (sf)
- contributing watershed from pervious area (sf)
- BMP surface area (sf) (if applicable)

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area, Excluding BMP area (square feet)	BMP Surface Area If Applicable (square feet)
Sample Existing BMP 1	Oil Grit Separator	D	60,000	5,000	-
Sample Existing BMP 2	Vegetated Filter Strip	A - Loamy Sand 2.41 in/hr	18,000	1,500	2,000
Sample Series - Bioretention Area A	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	20,000	18,000	1,500
Sample Series - Bioretention Area B	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	2,000
Sample Series - Bioretention Area C	Bioretention Area/Rain Garden	A - Loamy Sand 2.41 in/hr	4,000	2,000	2,000
Sample Series - Bioretention Area D	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	500

For BMPs in series, the user must also input the impervious area remaining after nitrogen load reduction credits from the upstream BMP have been applied (sf).

The Nitrogen TMDL worksheet will return values for the following:

- pre-BMP nitrogen load (lb/yr)
- percent load reduction provided by the BMP (based on values identified in Attachment 2)
- total load reduction provided by the BMP (lb/yr)
- post-BMP nitrogen load (lb/yr).

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lb/yr)	Post-BMP Load (lb/yr)	Comments
Sample Existing BMP 1	11.99	0%	0.00	11.99	Oil grit separator treating runoff from Route 499 from STA 6+30 to STA 10+65
Sample Existing BMP 2	3.71	50%	1.86	1.86	Vegetated filter strip along southbound shoulder of Route 499 from STA 5+10 to STA 5+90
Sample Series - Bioretention Area A	5.02	42%	2.11	2.91	
Sample Series - Bioretention Area B	3.03	42%	1.27	1.76	
Sample Series - Bioretention Area C	2.77	42%	1.16	1.60	
Sample Series - Bioretention Area D	1.63	42%	0.69	0.95	

MassDOT:
 For BMP in series, if any additional impervious and/or pervious area contributes to one of the BMPs in the series, the Pre-BMP load will be calculated using any new directly contributing pervious or impervious watershed area multiplied by the load rates plus the remaining BMP load from the upstream BMP.

MassDOT:
 For BMP in series, the Pre-BMP Load will equal the resulting load (Post-BMP Load) from the upstream BMP.

If there are existing BMPs owned by MassDOT that receive stormwater from non-MassDOT property, calculate the nitrogen load reduction provided by these BMPs using the same methodology as described above but include both MassDOT and non-MassDOT area in the watershed to determine the percent of nitrogen removal the BMP provides. Then use this percentage removal to determine the nitrogen reduction specifically for MassDOT property. These calculations can be performed using the Nitrogen TMDL worksheet. Refer to the section titled "Credit for Non-MassDOT Property Treated by Existing MassDOT BMPs."

The Nitrogen TMDL worksheet summarizes the nitrogen load reduction provided by existing BMPs in the "MassDOT's Load Reduction Summary" section of the worksheet shown in Figure 2.

Step 3c. Determine whether MassDOT Loads to the Impaired Water Body are negligible

Determine if MassDOT remaining nitrogen loads as calculated in Step 3b (which includes both direct stormwater discharges and groundwater discharges) represent a very small amount relative to the total existing nitrogen load to the receiving water. In TMDLs established for nitrogen impaired waters in the Cape Cod area, MassDEP identifies that category specific nitrogen loads as high as 3.29% of the total nitrogen watershed load were considered negligible compared to other sources (MassDEP, 2007). Based on this MassDEP published evaluation, MassDOT has determined that MassDOT property loadings less than 3.5% can be considered as negligible contributions to the resource. The total nitrogen load to the receiving water body can be identified in the TMDL report.

The worksheet automatically returns this calculation when the total existing load to the water body is entered under the TMDL Load Calculations section. A screen shot of this portion of the worksheet is provided below.

Total Existing Load to Water Body	18315 lb/yr
Percent of Total Existing Load that is from MassDOT Property	0.15%

Step 3d. Assess Target Load Relative to Loading from MassDOT

First, determine MassDOT's recommended Pre-BMP load reduction by subtracting the target load for MassDOT contributing property calculated in Step 3a from MassDOT's total estimated pre-BMP nitrogen load calculated in the first part of Step 3b. This calculation should be performed as follows:

$$\begin{aligned}
 &\text{Recommended Pre - BMP Load Reduction (lb/yr)} \\
 &= \text{Total Estimated Pre - BMP Pollutant Load (lb/yr)} \\
 &\quad - \text{Target Load from MassDOT's Contributing Property (lb/yr)}
 \end{aligned}$$

The worksheet automatically returns this calculation when Steps 3a and 3b are performed. This portion of the worksheet is shown in the screenshot below.

Loading from MassDOT's Contributing Property

Total Estimated MassDOT Load (calculated above)	27.6 lb/yr
Target Load for MassDOT's Contributing Property	12.5 lb/yr
MassDOT's Recommended Load Reduction	15.1 lb/yr

Next, compare the treatment provided by MassDOT's existing BMPs, quantified in the second part of Step 3b, to the recommended Pre-BMP load reduction. If MassDOT's load reduction provided by existing BMPs is more than or equal to the recommended Pre-BMP load reduction, then MassDOT is in compliance with the TMDL for its discharges to the subject water body. If MassDOT's load reduction provided by existing BMPs is less than the recommended Pre-BMP load reduction, then opportunities for reducing the nitrogen load should be considered. For example, a vegetated filter strip or a gravel wetland could be constructed to intercept flow prior to discharging to the water body.

To determine MassDOT's final recommended load reduction, subtract the load reduction provided by existing BMPs from the recommended Pre-BMP load reduction. This value is the remaining nitrogen load that recommended BMPs should aim to treat and is automatically calculated in the last line of the section. This portion of the worksheet is shown in the screenshot below.

MassDOT's Load Reduction Summary

Reduction Provided by Existing BMPs	7.1 lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BMPs	2.1 lb/yr
Reduction Provided by Proposed BMPs	0.6 lb/yr
Reduction provided by Existing and Proposed BMPs	9.8 lb/yr
MassDOT's Remaining Load Reduction	5.3 lb/yr

Refer to the section in the Nitrogen TMDL worksheet titled "Loading from MassDOT's Contributing Property" for assistance in this determination. Since calculations for these items are based upon previous calculations, no input is required from the user.

Step 4. Select, Design and Implement BMPs

Quantify the nitrogen reductions provided by the recommended BMPs in the same manner as described for existing BMPs in Step 3b: "Quantify the Treatment Provided by Existing BMPs." First calculate an existing nitrogen load from the catchment area that will drain to the recommended BMP, then assign a nitrogen load reduction credit to each recommended BMP using the percent reduction values specified in Attachment 2, and finally multiply the watershed nitrogen loads by the corresponding percent reduction values to obtain the nitrogen load reduction provided by each recommended BMP. Below is a screenshot of the worksheet that will assist in the recommended BMP calculations.

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area Excluding BMP area (square feet)	BMP Surface Area If Applicable (square feet)	Pr-
Sample Existing BMP 1	Oil Grit Separator	D	60,000	5,000	-	
Sample Existing BMP 2	Vegetated Filter Strip	A - Loamy Sand 2.41 in/hr	18,000	1,500	2,000	
Sample Series - Bioretention Area A	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	20,000	18,000	1,500	
Sample Series - Bioretention Area B	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	2,000	
Sample Series - Bioretention Area C	Bioretention Area/Rain Garden	A - Loamy Sand 2.41 in/hr	4,000	2,000	2,000	
Sample Series - Bioretention Area D	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	500	

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lb/yr)	Post-BMP Load (lb/yr)	Comments
Sample Existing BMP 1	11.99	0%	0.00	11.99	Oil grit separator treating runoff from Route 499 from STA 6+30 to STA 10+65
Sample Existing BMP 2	3.71	50%	1.86	1.86	Vegetated filter strip along southbound shoulder of Route 499 from STA 5+10 to STA 5+90
Sample Series - Bioretention Area A	5.02	42%	2.11	2.91	
Sample Series - Bioretention Area B	3.03	42%	1.27	1.76	
Sample Series - Bioretention Area C	2.77	42%	1.16	1.60	
Sample Series - Bioretention Area D	1.63	42%	0.69	0.95	

MassDOT:
For BMP in series, if any additional impervious and/or pervious area contributes to one of the BMPs in the series, the Pre-BMP load will be calculated using any new directly contributing pervious or impervious watershed area multiplied by the load rates plus the remaining BMP load from the upstream BMP.

MassDOT:
For BMP in series, the Pre-BMP Load will equal the resulting load (Post-BMP Load) from the upstream BMP.

Sum the nitrogen load reductions provided by the recommended BMPs and compare to MassDOT's recommended load reduction calculated in Step 3c. As described in Step 3b, the worksheet summarizes the nitrogen load reductions provided by existing and recommended BMPs in the "MassDOT's Load Reduction Summary" section of the worksheet. If possible, the nitrogen load reduction provided by the existing and recommended BMPs should equal or exceed MassDOT's recommended load reduction. Considering site-specific limitations, this may not be possible.

MassDOT's Load Reduction Summary

Reduction Provided by Existing BMPs	7.1 lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BMPs	2.1 lb/yr
Reduction Provided by Proposed BMPs	0.6 lb/yr
Reduction provided by Existing and Proposed BMPs	9.8 lb/yr
MassDOT's Remaining Load Reduction	5.2 lb/yr



Site Information

Site Name	[Sample] Tiny Brook	Input
Impaired Water	[Sample] MA123456	Calculated
Pollutant	Total Nitrogen	

NOTE: This spreadsheet has been designed for units consisting of pounds (lb), acres (ac), and years (yr). For all other units, please convert.

1 acre = 43,560 square feet
 1 hectare = 2.47105381 acres
 1 kilogram = 2.20462262 pounds

Pre-BMP Loading Calculations for MassDOT's Contributing Property

Impervious Area	2.8 ac	
Pervious Area	1.5 ac	
Total Area	4.3 ac	
Estimated Loading Rate for Impervious Area	8.5 lb/ac/yr	See "LoadingRateLookup" Tab for source notes.
Estimated Loading Rate for Pervious Area	2.5 lb/ac/yr	See "LoadingRateLookup" Tab for source notes.
Total Estimated Pre-BMP MassDOT Load	27.6 lb/yr	

TMDL Load Calculations

Total Watershed Target Load	4313 lb/yr
Target Load from Sources Unrelated to Stormwater	1769 lb/yr
Applicable Watershed Target Load	2544 lb/yr
Watershed Area for Target Load	868 ac
Areal Target Load	2.9 lb/ac/yr
Total Existing Load to Water Body	18315 lb/yr
Percent of Total Existing Load that is from MassDOT Property	0.15%

TMDL Page No.	TMDL Notes
p. 18	5.36 kg/day - Target Threshold Watershed Load - includes septic, runoff, fertilizer and natural background
p. 24	2.198 kg/day - This includes Septic only - Data from Appendix B (must convert from kg per day to lb /yr)
	This only includes runoff, fertilizer and natural background
	Area calculated from GIS (watershed area ex. Tiny Brook)

TMDL Page No.	TMDL Notes
p. 12	22.76 kg/day - Table 3 - total existing load to water body

Loading from MassDOT's Contributing Property

Total Estimated MassDOT Load (calculated above)	27.6 lb/yr
Target Load for MassDOT's Contributing Property	12.5 lb/yr
MassDOT's Recommended Load Reduction	15.1 lb/yr

MassDOT's Load Reduction Summary

Reduction Provided by Existing BMPs	7.1 lb/yr
Credit for Non-MassDOT Property Treated by MassDOT BMPs	2.1 lb/yr
Reduction Provided by Proposed BMPs	0.6 lb/yr
Reduction provided by Existing and Proposed BMPs	9.8 lb/yr
MassDOT's Remaining Load Reduction	5.3 lb/yr

Figure 2: Screenshot from Nitrogen TMDL worksheet showing MassDOT's Nitrogen Loading Calculations

Load Reduction Provided by MassDOT BMPs under Existing Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed Area (square feet)	Directly Contributing Pervious Area, Excluding BMP (square feet)	If Applicable BMP Surface Area (square feet)	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lbs/yr)	Post-BMP Load (lbs/yr)
Sample Existing BMP 1	Oil Grit Separator	D	60,000	5,000	-	11.99	0%	0.00	11.99
Sample Existing BMP 2	Vegetated Filter Strip	A - Loamy Sand 2.41 in/hr	18,000	1,500	2,000	3.71	50%	1.86	1.86
Sample Series - Bioretention Area A	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	20,000	18,000	1,500	5.02	42%	2.11	2.91
Sample Series - Bioretention Area B	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	2,000	3.03	42%	1.27	1.76
Sample Series - Bioretention Area C	Bioretention Area/Rain Garden	A - Loamy Sand 2.41 in/hr	4,000	2,000	2,000	2.77	42%	1.16	1.60
Sample Series - Bioretention Area D	Bioretention Area/Rain Garden	A - Sand 8.27 in/hr	-	-	500	1.63	42%	0.69	0.95
						<div> <p>MassDOT: For BMP in series, if any additional impervious and/or pervious area contributes to one of the BMPs in the series, the Pre-BMP load will be calculated using any new directly contributing pervious or impervious watershed area multiplied by the load rates plus the remaining BMP load from the upstream BMP.</p> </div> <div> <p>MassDOT: For BMP in series, the Pre-BMP Load will equal the resulting load (Post-BMP Load) from the upstream BMP.</p> </div>			
						Total		7.1	lb/yr

Figure 3: Screenshot from Nitrogen TMDL worksheet Showing Nitrogen Load Reduction Calculations for Existing BMPs

Load Reduction Provided by MassDOT BMPs under Proposed Conditions

BMP Name	BMP Type	Soil Classification	Directly Contributing Watershed IC Area (square feet)	Directly Contributing Watershed Pervious Area, Excluding BMP area (square feet)	BMP Surface Area (square feet)	Pre-BMP Load (lb/yr)	Load Reduction %	Load Reduction (lbs/yr)	Post-BMP Load (lbs/yr)
Sample Proposed BMP 1	Extended Detention Basin	C - Sandy Clay Loam - 0.17 in/h	10,000	2,500	3,000	2.27	15%	0.34	1.93
Sample Proposed BMP 2	Bioretention Area/Rain Garden	B - Loam 0.52 in/hr	2,000	1,500	1,000	0.53	42%	0.22	0.31

Attachment 2

BMP Classification and Nitrogen Reduction Methodology

[This page intentionally left blank.]

BMP Classification and Nitrogen Reduction Methodology

This attachment provides information to classify existing BMPs identified on MassDOT property and provides the reduction rates for nitrogen based on BMP type used in the Nitrogen TMDL worksheet. This attachment can also be used as guidance for the selection of conceptual BMPs.

Characterizing Existing BMPs

Using the data obtained through the desktop analysis and field verification, characterize existing BMPs according to approximate type. This attachment assumes existing BMPs are appropriately designed to treat the required water quality volume as identified in the MassDEP Stormwater Handbook or *UNH Stormwater Center 2012 Biennial Report*, as noted in Table 2-1 at the end of this Attachment.

For Cape Cod watersheds with nitrogen TMDLs, different types of BMPs may be needed to achieve water quality improvements by removing nitrogen than those typically utilized in the rest of the state for TSS treatment or volume control. Although infiltration BMPs are effective for TSS removal and volume control, they are not effective at removing nitrogen. BMPs designed to include anoxic environments (saturated zones) and that utilize biological uptake and/or denitrification, such as gravel wetlands and bioretention / rain gardens, are those that can more effectively reduce nitrogen loading from stormwater. According to recent research documented in the *University of New Hampshire (UNH) Stormwater Center 2012 Biennial Report*, gravel wetlands provide an estimated 75% reduction in nitrogen loading and bioretention / rain gardens provide an estimated 42% reduction.

Although gravel wetlands and bioretention / rain gardens provide relatively higher levels of nitrogen removal than other BMPs, they currently may not be very common on MassDOT property. Infiltration BMPs are commonly implemented on MassDOT roadways. MassDOT classifies infiltration basins and infiltration trenches as infiltration BMPs. Infiltration BMPs are designed to infiltrate runoff and therefore mimic the ability of undeveloped vegetated soils to absorb stormwater runoff. This serves to reduce runoff volumes and rates, remove pollutants as water is absorbed in the soils, and restore base flows to the receiving water body. Infiltration BMPs provide some of the highest pollutant load reduction credits for TP, TSS, and Zn, although published removal rates for total nitrogen are based on limited data (Mass DEP, 2008), or non-existent (International Stormwater BMP Database, 2011). Some published removal efficiencies for nitrogen are based on the loss of stormwater volume through infiltration and recharge into the ground, and do not include vegetative uptake or denitrification processes (VA DEQ, 2011). Therefore, the nitrogen could potentially be recharged along with the stormwater into the groundwater table. For all of these reasons, MassDOT's Nitrogen TMDL Method conservatively assumes that infiltration BMPs achieve no removal of nitrogen.

Additional BMPs that may be currently in place on MassDOT property that provide TP, TSS, and Zn removal and provide some level of total nitrogen removal under the Nitrogen TMDL Method include: constructed stormwater wetlands; wet detention basins; extended detention basins, and water quality swales with check dams (see Table 2-1).

BMPs that provide nitrogen removal are identified in Table 2-1, and details regarding the design specifications of these BMPs are provided in either the *Massachusetts Stormwater Handbook* (Mass DEP, 2008) or the *UNH 2012 Biennial Report*, as noted in Table 2-1. Using the descriptions provided by these reference documents, each existing BMP should be classified and assigned a percentage of annual nitrogen removal based on BMP type using the table's removal efficiencies. Removal rates summarized in Table 2-1 assume that existing BMPs are appropriately sized to treat the water quality volume and that the BMPs are designed and maintained in accordance with the cited reference document. If BMPs are present or proposed that are not listed in Table 2-1, then published literature values for nitrogen removal rates should be referenced and documented in the

impaired water assessment/BMP design documents to support the assigned nitrogen removal credit.

Table 2-1. Nitrogen Removal Rates for Structural Storm Water BMPs

BMP Type	BMP Nitrogen Load Reduction Credits		
	Reduction Rate	Primary Nitrogen Removal Process	Data Source Notes
Gravel Wetland	75%	Dentrification; Vegetative Uptake	3a
Bioretention Area/Rain Garden	42%	Vegetative Uptake	3a
Wet Detention Basin	25%	Vegetative Uptake	3a, 3b
Constructed Stormwater Wetland	20%	Vegetative Uptake	1a
Bio Swales	42%	Vegetative Uptake	3c
Water Quality Swale with Check Dam	10%	Vegetative Uptake	1a
Extended Detention Basin	15%	Vegetative Uptake	1a
Tree Filters	1-3%	Vegetative Uptake	3a
Infiltration Structures	0%	NT	3d, 4, 5
Porous Pavement	0%	NT	3a
Conveyance Channel	0%	NT	1
Deep Sump Catch Basin	0%	NT	1
Grass Channel	0%	NT	1
Oil Grit Separator	0%	NT	1
Outlet Sediment Trap (Plunge Pool)	0%	NT	1
Conveyance Channel, Grass Channel, Vegetated Filter Strip	0%	NT	1, 3a
Street Sweeping	0%	NT	2

NT = non treatment

Data Source Notes:

1. Massachusetts Department of Environmental Protection. February 2008. Massachusetts Stormwater Handbook.
 - a. Assumes lowest nitrogen load reduction within specified range.
 - b. Assumes nitrogen load reductions equal to those observed for infiltration trenches.
 - c. Assumes nitrogen load reductions equal to those observed for water quality swales.
 - d. Nitrogen load reductions for infiltration basins and trenches based on limited data points
2. Massachusetts Department of Transportation. May 2004. MassHighway Storm Water Handbook for Highways and Bridges.
3. University of New Hampshire Stormwater Center. October 2012. 2012 Biennial Report.
 - a. Load reductions for Total Nitrogen assumed to be similar to that for Dissolved Inorganic Nitrogen (NO₃-N).
 - b. Assumes nitrogen load reductions equal to those for wet ponds.
 - c. Assumes nitrogen load reduction equal to those for Bioretention systems
4. Virginia Department of Environmental Quality, March 2011. Introduction to the New Virginia Stormwater Designs Specifications (Based on event mean concentration removal efficiencies and loss through infiltration/introduction to stormwater - not uptake or denitrification).

5. International Stormwater Best Management Practices (BMP) Database - BMP Performance Data Summary Table, November 2011. Prepared by: Wright Water Engineers, Inc. and Geosyntec Consultants Inc. Under Support from: Water Environment Research Foundation, Federal Highway Administration, Environment and Water Resources Institute of the American Society of Civil Engineers.