COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF WATERSHED MANAGEMENT
WORCESTER, MASS.

ENHANCED IMPLEMENTATION PLAN: PRELIMINARY EVALUATION OF CURRENT STORMWATER AND NONPOINT SOURCE CONTROL EFFORTS IN MASSACHUSETTS

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I Background for Nonpoint Source Best Management Practice Determinations as Part of the Long Island Sound Study

Over the past decade water quality issues in Long Island Sound (LIS) and its watershed have been studied extensively. The Long Island Sound Study (LISS), through its Comprehensive Conservation and Management Plan (CCMP), has identified low dissolved oxygen (DO), also known as hypoxia, as one of the Sound's most pressing problem. Typically, more than half of the Sound's 1,300 square miles of bottom waters are impacted by hypoxia during the late summer, rendering them unsuitable for fish and other living resources. Water quality monitoring conducted over the past 15 years has shown that on average, hypoxic conditions, or areas with less than 3.0 milligrams per liter (mg/L) of DO, affect 200 square miles of bottom waters for a period of almost two months each year. LISS research, monitoring, and modeling efforts have linked the low DO occurrences to excess loading of nitrogen to the system (Tedesco, 2012).

To address the excess nitrogen, and resulting DO problems, the Connecticut Department of Energy and Environmental Protection (CT DEEP) and New York State Department of Environmental Conservation (NYS DEC) developed a Total Maximum Daily Load (TMDL) for DO. The TMDL, which was approved by the U.S. Environmental Protection Agency (EPA) in 2001, outlined necessary nitrogen reductions in order to meet water quality standards in the Sound by 2014. These nitrogen reductions include a 58.5 percent reduction from point sources (PS) nitrogen and a 10 percent reduction from nonpoint sources (NPS) nitrogen in Connecticut and New York; a 25 percent nitrogen reduction from point sources and a 10 percent nitrogen reduction in NPS in upper basin states (Massachusetts, New Hampshire and Vermont); an 18 percent reduction in nitrogen from atmospheric deposition; and discusses other potential alternatives to enhance nitrogen reduction (e.g. aeration and oyster uptake) (NEIWPCC, 2010).

The LIS TMDL divided nitrogen sources into in-basin and out-of-basin sources or loads. In-basin sources, which include sources in Connecticut and New York, and atmospheric deposition to the surface of LIS, comprise 53 percent of the watershed's nitrogen load. Out-of basin sources, which include contributions from LIS boundaries (Atlantic Ocean and New York Harbor) and tributaries north of the Connecticut border, comprise the remaining 47 percent of the watershed's nitrogen load. The out-of-basin sources can be further divided into 33.5 percent from the LIS boundaries, 12.5 percent from the Connecticut River, and 1 percent from all remaining tributaries (Farmington, Housatonic, and Thames Rivers).

LIS watershed modeling conducted to date using the Spatially Referenced Regressions on Watershed Attributes (SPARROW) and the Northeast ArcView Generalized Watershed Loading Function (AVGWLF) models have been used to estimate the baseline nitrogen contribution of each of the upper basin states to LIS. This information, combined with the nitrogen loading information contained in the LIS TMDL, can be used to estimate the contribution from each of the five LIS watershed states.

A considerable amount of nitrogen loading to the Sound originates from the Atlantic Ocean and from atmospheric deposition directly to the surface of LIS. These sources are largely uncontrollable. If one were to consider all of the sources except atmospheric deposition, the estimated nitrogen loading from state contributions are as follows: 49 percent from New York, 29 percent from Connecticut, 10 percent from Massachusetts, 7 percent from Vermont, and 5 percent from New Hampshire. Broken down further into PS and NPS loadings, PS loadings are estimated at 69 percent from New York, 24 percent from Connecticut, 5 percent from Massachusetts , 1 percent from New Hampshire, and 1 percent from Vermont. For NPS loading, the estimated contributions are: 41 percent from Connecticut, 21 percent from Massachusetts, 19 percent from Vermont, 14 percent from New Hampshire, and 5 percent from New York (please refer to Figures 7-9 presented in Section IV of this report).

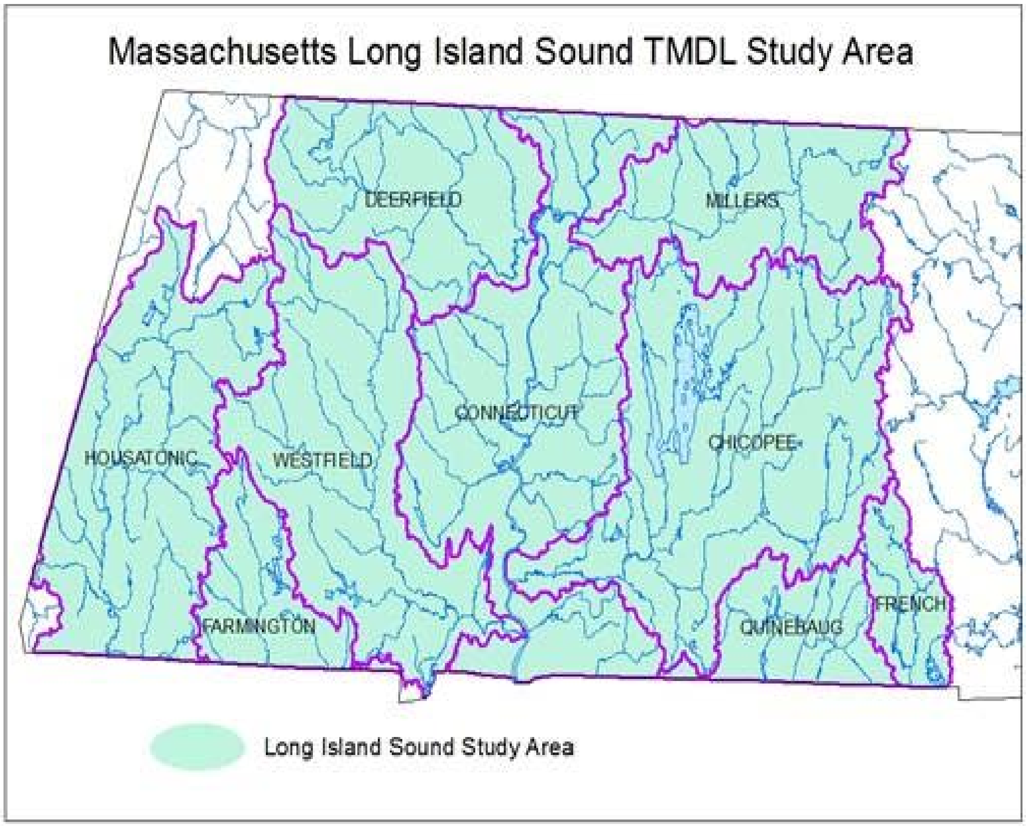
The purpose of this report, and those submitted by the other five LIS watershed states, is to qualitatively assess existing federal, state, and local NPS programs and available data that could be used to track NPS remediation measures that reduce nitrogen exports to LIS. Although each of the LIS watershed states and EPA agreed that this would be a qualitative effort, Massachusetts Department of Environmental Protection (MassDEP) decided to use this report to quantify NPS load reductions that have occurred during the last few years. MassDEP believes this detailed exercise is necessary to properly determine where data gaps exist and, more importantly, will provide guidance regarding data and information that could be used by all of the LIS watershed states to determine if the LIS TMDL NPS reduction goals are being achieved. This exercise can also assist each LIS watershed state to identify data gaps and other information that would be necessary to track future NPS nitrogen reductions.

Connecticut River Loads and Potential Impacts

Figure 1 provides a map which delineates the Massachusetts contributing watersheds to LIS. Since most of the out-of-basin sources from the upper LIS Watershed states (Massachusetts, New Hampshire, and Vermont) reach the Sound via discharge to the Connecticut River Watershed, the New England Interstate Water Pollution Control Commission (NEIWPCC) commissioned a study to develop an AVGWLF model of the Connecticut River (Evans, 2008). The results of this modeling effort estimated the delivered contributions of the four states to the Connecticut River's nitrogen load as follows: Connecticut, 55 percent; Massachusetts, 33 percent; New Hampshire, 8 percent; and Vermont, 4 percent. Further analysis, evaluating the potential impact of these loads to DO in LIS revealed the following conclusions:

- If the entire nitrogen load from the upper basin watershed was eliminated, DO in the Sound would improve by approximately 3 percent;
- Elimination of the entire nitrogen load from the Connecticut River would result in an average DO improvement in the Sound of 2 percent;
- Elimination of the entire nitrogen load from Massachusetts would result in an average improvement of DO in the Sound by approximately 1 percent;
- Elimination of the entire nitrogen load from New Hampshire would result in an average DO improvement in the Sound of about 0.8 percent; and
- Elimination of the entire nitrogen load from Vermont would result in an average DO improvement in the Sound of 1 percent.

Figure 1 - Massachusetts LIS Watershed Area



TMDL Reevaluation

The LIS TMDL called for a 58.5 percent reduction from PS in Connecticut and New York (CT DEEP and NYS DEC, 2000). Phase 4 of the LIS TMDL also called for a 25 percent reduction in PS and 10 percent reduction from NPS from the upper LIS watershed states. Although efforts are ongoing to reduce nitrogen loadings from point sources in all states, recent efforts have been focused on estimating NPS reductions, achieved since the development of the LIS TMDL. These include, but are not limited to, reductions or the elimination of combined sewer overflows (CSO) and BMP applications to urban and agricultural lands. The primary goal of this document is to estimate, where possible, activities that are taking place to reduce the NPS load, and to quantitatively estimate reductions achieved in order to document Massachusetts efforts towards achieving a 10 percent NPS nitrogen reduction called for in the LIS TMDL.

In August 2010, EPA Regions 1 and 2 and the five LIS watershed states Massachusetts agreed that a revision of the LIS TMDL should occur and that it would proceed as a five-state effort To date, many, if not most, of the PS discharges such as publicly owned treatment works (POTWs) that discharge into the Sound have been upgraded to provide enhanced nitrogen removal and the time is ripe to revisit the LIS TMDL and begin discussing NPS pollution such as urban runoff, agriculture, and even atmospheric deposition (Dunn, 2012).

A five state, EPA, NEIWPCC Workgroup has been in place for a decade to discuss TMDL revisions and progress towards meeting the LIS TMDL nitrogen reduction goals (referred to as the LIS TMDL Workgroup). This workgroup met on May 19, 2011 to discuss a number of issues relating to the LIS TMDL revision, and agreed that it was necessary to develop an enhanced implementation plan for the LIS TMDL while moving forward with a more comprehensive analysis for revising the LIS TMDL. The workgroup subsequently developed a framework for the LIS TMDL revision and the development of an enhanced implementation plan which outlined the need to identify NPS reductions (as well as data gaps) that have been observed since the 2001 approval of the LIS TMDL.

In 2011, the LISS, via the LIS TMDL Workgroup embarked on an effort to carefully review the NPS loading assessments included in the LIS TMDL. The charge was to develop methodologies in each of the states to assess urban and agricultural NPS BMPs currently in place, and to determine total nitrogen (TN) loadings reductions from the assessed BMPs. These reductions would subsequently be compared to the TN NPS load reduction allocations for each state included in the LIS TMDL.

II Drivers of Nitrogen Change

Status and Trends

Determining trends in NPS TN loads for the time period leading up to the approval of the LIS TMDL, from 1990 to 2000 is difficult at best, particularly given the lack of available data. However, NPS TN loading trends closely follow demographics and agricultural practices and there are tools available to qualitatively assess whether or not NPS TN loads have increased or decreased over time. Specifically, observations of population growth, population density, changes in developed land, change in impervious cover, and changes in agricultural practices over time are helpful in determining NPS TN loading trends.

Population Growth and Density

Between 1950 and 2010, the statewide population in Massachusetts increased by 37 percent. Over the same time period, developed land has increased well over 200 percent. Within the Massachusetts portion of the LIS watershed, population growth and land development has been much slower than the statewide averages and are estimated at approximately 23 percent and 100 percent respectively percent (PVCPC, 2010). In addition, since 1950 the population density on developed land statewide decreased by more than 50 percent from 11.19 persons per acre to 4.9 persons per acre; the increase in population density on developed land in the LIS watershed is once again considerably less than the statewide average over the same time period (EOEA, 2000).

Another way to express these statistics is that over the last 60 years or so, although the population increased statewide (and to a much lesser extent in the LIS watershed); there has been a tendency for growth in suburban areas, rather than urban areas. This situation is better known as “sprawl” and is occurring nationwide.

What is sprawl? Planners define it as low- density, single-use development on the urban fringe that is almost totally dependent on private passenger automobiles for transportation. Since World War II, sprawl has become the dominant development pattern throughout Massachusetts. All the various activities that were once concentrated in the cores of cities and towns are now spread out thinly over miles and miles of land, connected by miles and miles of highways (EOEA, 2000).

This pattern is pertinent to the LIS watershed in Massachusetts because “sprawl” can result in additional pollutant loadings, including nitrogen. Polluted stormwater runoff carries oils, nutrients, and other substances that contribute to degraded water quality in rivers, lakes, and ponds, including those within the LIS watershed.

Impervious surfaces from new development such as roads, buildings, and parking lots prevent stormwater from percolating back into the ground and recharging our rivers, wetlands, and aquifers. Sprawl can also increase air pollution because of increased vehicle usage and new development located farther from core resources.

Figure 2 provides a snapshot of population changes in the LIS watershed between 1990 and 2000. This figure demonstrates that communities immediately straddling the Connecticut River mainstem (such as Springfield, West Springfield, Longmeadow, Chicopee, Holyoke, Northampton, Amherst, Hatfield, East Hampton, and South Hadley) had population changes ranging from a 5 percent decrease to a slight 2 percent increase, while communities just outside of this corridor to the east and west demonstrated growth rates greater than 5 percent. Such an observation indicates that sprawl is beginning to occur in the Connecticut River Valley although to a much lesser extent than the rest of Massachusetts.

Figure 3 illustrates population changes between 2000 and 2010. This figure documents a similar pattern in population changes in communities adjacent to the Connecticut River mainstem with very slight to no increase in population (averaging 0.7 percent) over this ten-year period. Communities just outside this corridor to the east and west (such as Westfield, Southwick, Russell, Montgomery, Southampton, Westhampton, Williamsburg, Goshen, Hadley, Amherst, Belchertown, Wilbraham, and East Longmeadow) show a higher growth rate, averaging 9.8 percent. A comparison of figures 2 and 3 indicate that although population trends in the LIS watershed are relatively small, the watershed has still experienced increases in sprawl throughout much of the area during the entire 20 year period, from 1990 to 2010. Land traditionally left to open space, forests, and even agriculture are increasingly being taken up by human settlement patterns which include new residential subdivisions, roadways with adjacent off-site support structures, commercial and shopping areas, and public service areas including new schools, libraries, Department of Public Works (DPW) yards, offices, and other public support functions.

While much of the rest of the Massachusetts LIS watershed outside the area covered in Figures 2 and 3 is largely rural, there has been some encroachment of developed lands in these areas from 1990-2010. Encroachment is happening along and to either side of roadways, and in newly established residential subdivision areas throughout the region. Most of the communities in these areas are small in population and have well under 5,000 persons. Many are in the 1,000 to 2,000 population range, and have not seen significant population increases over the 20 year period. In most cases, population growth rates in these more rural areas have been less than 5 percent over the 20 year period. At the same time, overall agricultural, forest, and open space land use in these same areas have seen relative declines over the same period (Dominick, 2013).

Figure 2- Percent Change in Population 1990-2000

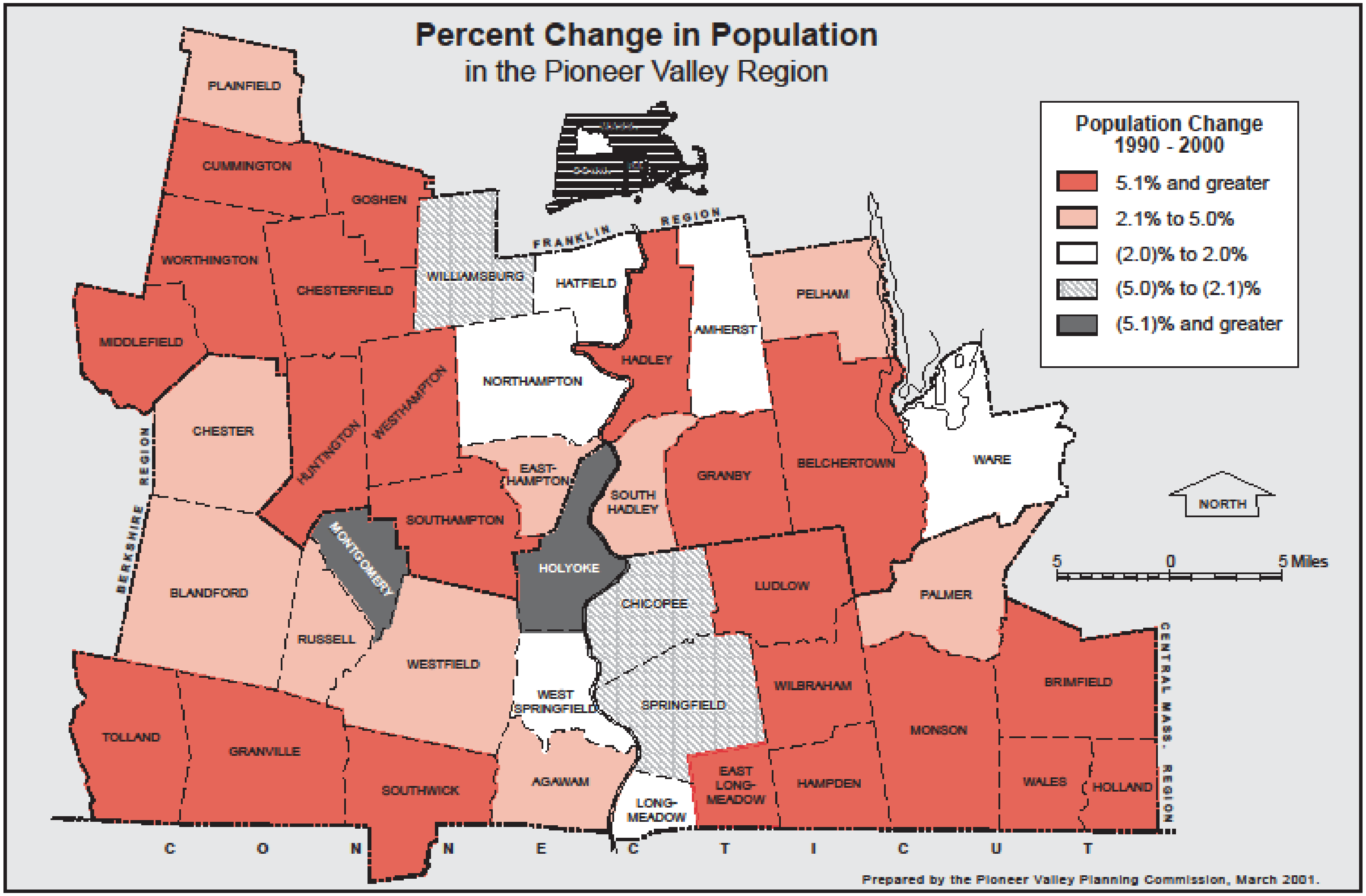


Figure 3- Percent Population Change, 2000- 2010: Pioneer Valley

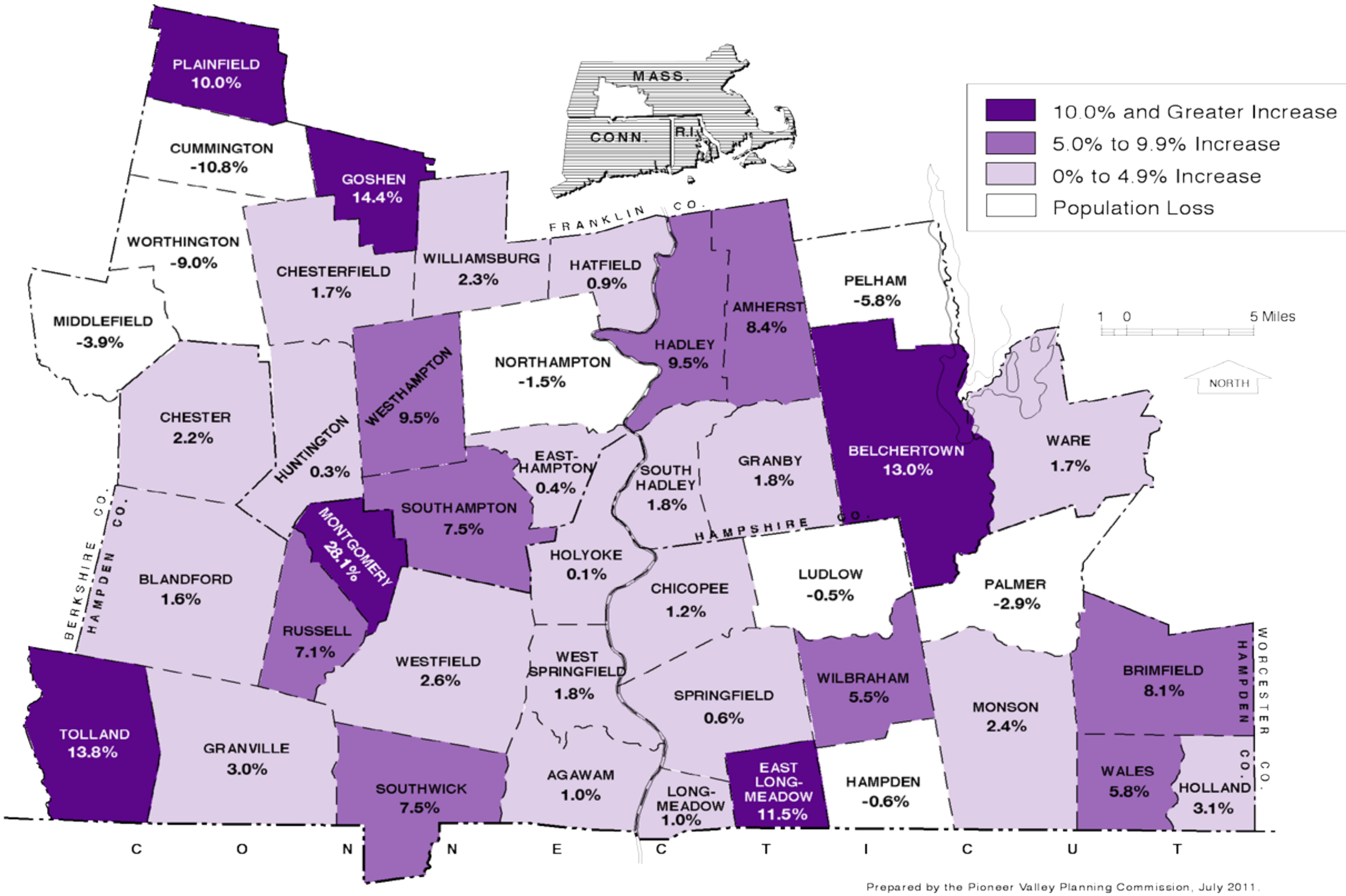


Figure 4 - Changes to Developed Land Cover in Massachusetts 2001-2006

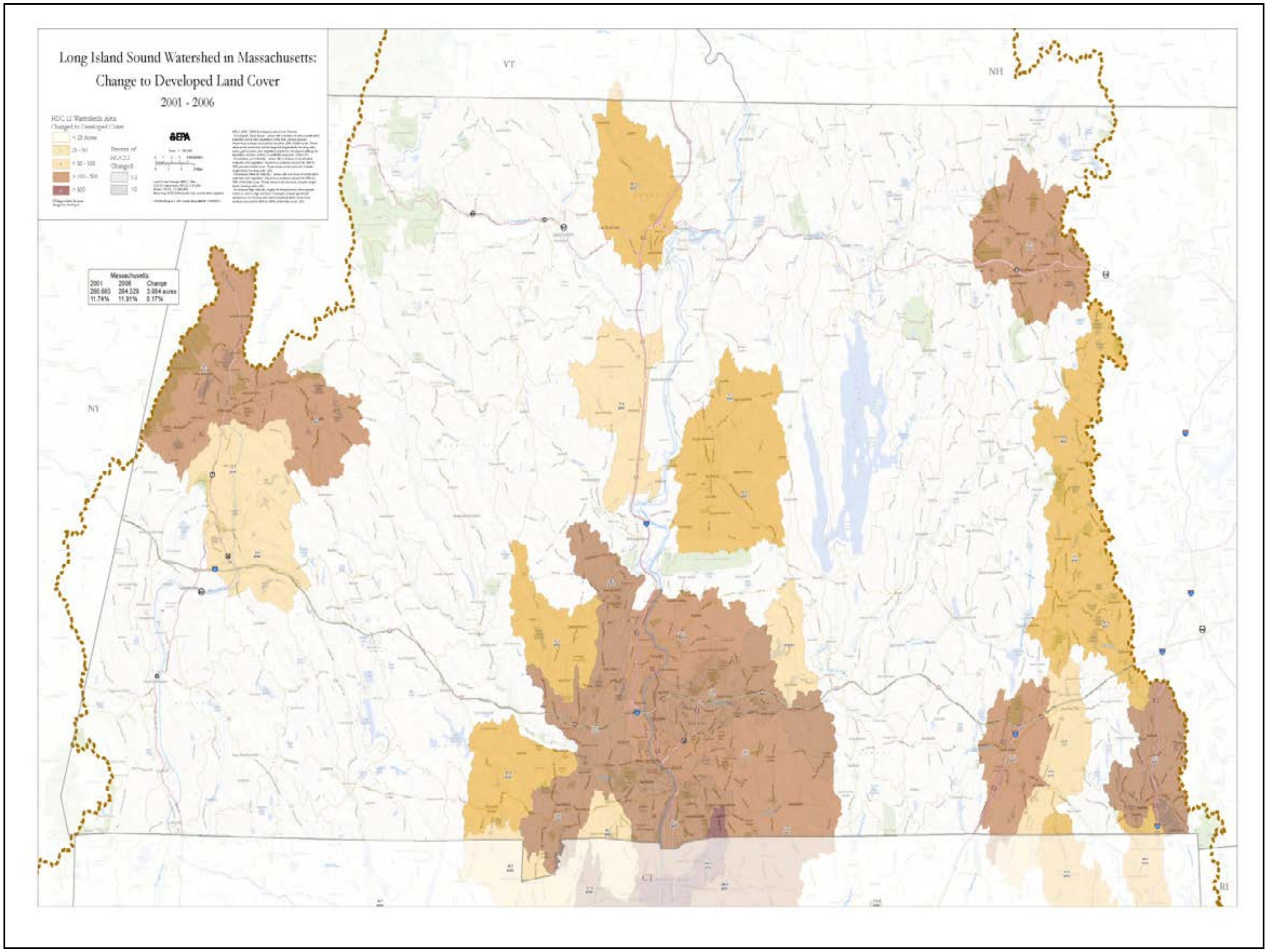
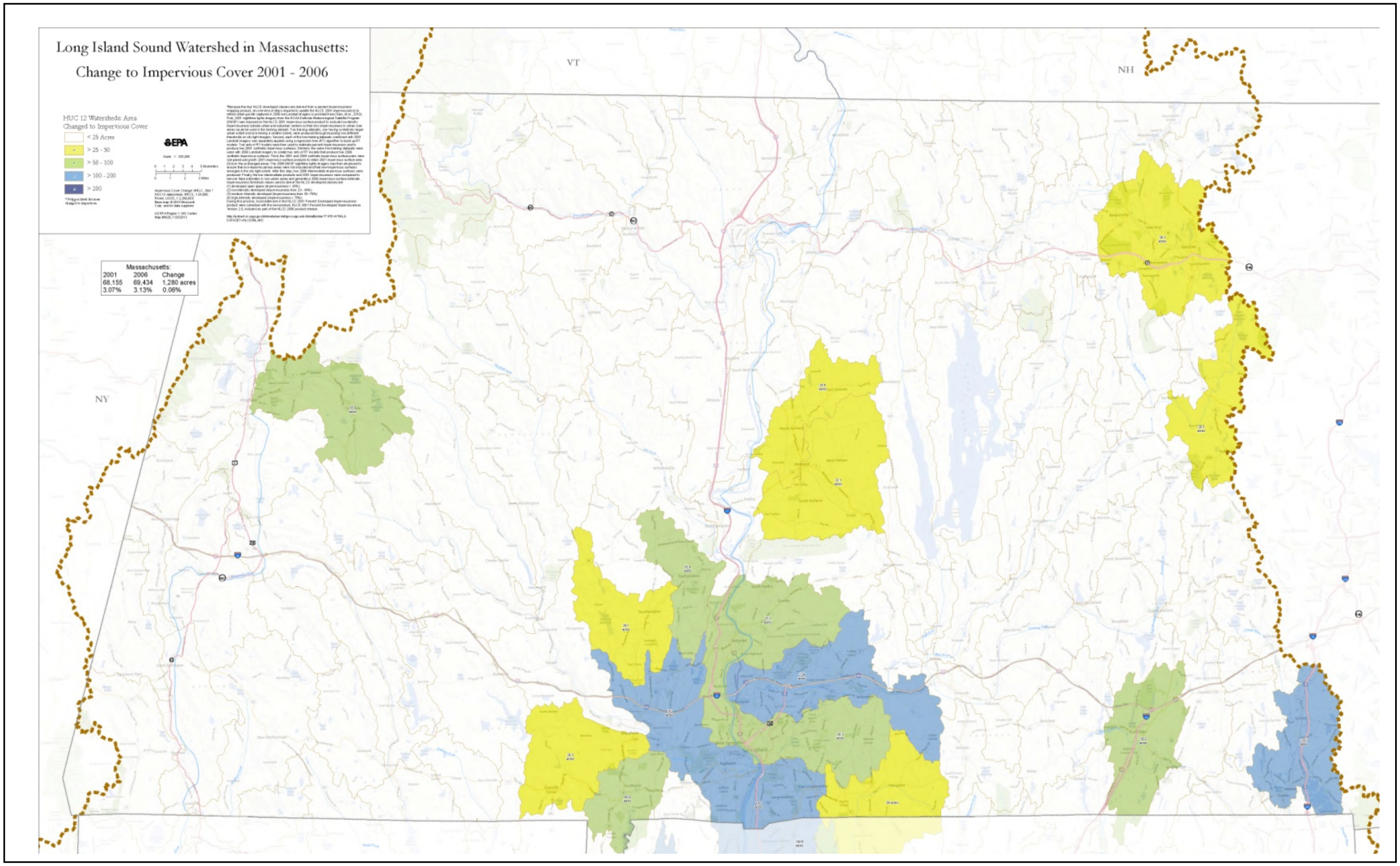


Figure 5 – Changes to Impervious Cover in Massachusetts 2001-2006



Changes in Developed Land and Impervious Cover

Figures 2 and 3 demonstrate that urban sprawl is occurring within the Massachusetts LIS watershed, but to a lesser extent than in other areas of the state. To further investigate this trend, an evaluation of land use change was made over a five-year period from 2001-2006. The evaluation was intended to look at developed land and impervious cover trends within the Massachusetts LIS watershed.

Whereas Figures 2 and 3 demonstrate that the greatest population growth occurred away from older urbanized centers, Figures 4 and 5 show the greatest growth in developed land cover and impervious land cover tended to be located nearer, or within, older urbanized- core centers (Springfield, Western Springfield, Agawam, Holyoke, Chicopee, Worcester, Pittsfield, etc). This indicates that even though population growth, which in-itself would generate changes in land use, has been negligible over the past 20 years, development, as shown by changes in developed land cover and increases in impervious surfaces, is still occurring in these older urbanized, core areas. The patterns indicated in Figures 4 and 5 clearly demonstrate that lands formerly in open space, forested, and agricultural use have steadily declined and have been used to develop new housing subdivisions, industries, shopping centers and malls, and roadways.

Overall, the analyses of Figures 2 through 5 demonstrate that sprawl has been widespread across much of the Massachusetts LIS watershed over the five-year period examined (2001 to 2006). Only those communities located far from major population centers (e.g., communities not shaded in Figures 2 through 5) have escaped sprawl. It should also be noted, that although there are "hotspots," where increases in impervious cover and land use changes are occurring overall throughout the watershed. Changes to developed land use cover (0.17 percent) and impervious cover (0.06 percent) were insignificant during the five-year period examined and we are therefore assuming that they did not change a great deal during the time the LIS TMDL was being developed (1990 to 2000).

Changes in Agricultural Land

Agriculture, consisting of cropland and pasture, has seen steady declines throughout the Massachusetts LIS watershed between 1985 and 2005. This is primarily a result of development in these formerly farmed areas. Many of these farmlands have been sold to developers to build roadways, shopping centers and malls, new businesses and industries, recreation areas, and residential sub- divisions. Overall, the Massachusetts LIS watershed has seen declines in agricultural acreage by over 29 percent between 1985 and 2005.

The Connecticut River watershed in Massachusetts (composed of the Connecticut, Westfield, Millers and Deerfield River Basins) has seen steady declines in overall agricultural acreage, from 148,667 acres in 1985, to 129,277 acres in 1999, to 107,800 acres in 2005. This represents an overall decline of 27.4 percent over the 20-year period. The Housatonic River watershed in Massachusetts has seen declines from 37,577 acres in agriculture in 1985, to 33,941 acres in 1999, to 25,541 acres in 2005, or a 32 percent decline over the 20-year period. The Thames River watershed located in Massachusetts (consisting of the French and Quinebaug Basins) has seen declines from 12,372 acres in agriculture in 1985, to 10,005 acres in 1999, to 7,879 acres in 2005, or a 36 percent decline over the 20-year period. The Farmington River watershed in Massachusetts has seen a decline from 4,755 acres in 1985, to 3,471 acres in 1999, to 2,695 acres in 2005, or a 43 percent decline over the same 20-year period.

III Nonpoint Source Best Management Practices Assessment Process in Massachusetts

In late 2011, the LIS TMDL Workgroup began developing a plan to assess, and if possible, quantify current NPS BMPs implemented since the LIS TMDL was approved in 2001. Based on on-going LIS TMDL Workgroup discussions, it was agreed that the state participants would conduct a NPS assessment that would, in general, contain the components and actions outlined below. Some initial observations are also provided:

- Conduct a qualitative evaluation of NPS BMPs in the LIS watershed. For Massachusetts, that includes portions of the following basins: (1) the Connecticut River basin (including the Deerfield, Millers, Westfield, Chicopee, and Farmington River basins); (2) the Housatonic River basin; and (3) the French-Quinebaug River basin (See Figure 1). The LIS TMDL goal for upstream states, including Massachusetts, is to achieve and document a 10 percent reduction in NPS TN loadings from the baseline established in the TMDL. Theoretically, these reductions would be achieved from both agriculture and urban BMPs currently in place. Massachusetts has attempted, based on existing information, to document and quantify reductions from the baseline established in the LIS TMDL.
- Identify NPS controlling and contributing agencies. MassDEP contacted and obtained information on NPS BMPs presently in place from well over 100 identified information sources within Massachusetts, including regional planning agencies, watershed organizations, and individuals.
- Identify and assess contributing land uses. The principal land-use components in the Massachusetts NPS BMP study were determined to include: (1) Agricultural, (2) Urban-Suburban, (3) Transportation- Roadways, and (4) Forestry- Open Space.

    1. **Agricultural land-use.** The lead agency for agricultural NPS BMP projects in Massachusetts was determined to be the Natural Resource Conservation Service (NRCS). The Massachusetts Department of Agriculture (MDAR) and the University of Massachusetts (UMass) Extension Program in Amherst were identified as two other possible agencies that might support agricultural BMP projects. Several meetings occurred with key Massachusetts NRCS staff, resulting in NRCS providing a NPS BMP database that included well over 5,500 separate NRCS projects. Summaries of information captured in this database since 2008 are provided in Section VII of this report.
    2. **Urban and suburban stormwater land-use**. One hundred and twelve communities were identified within the Massachusetts LIS watershed, of which 38 have a Municipal Separate Storm Sewer System (MS4) Phase II Stormwater permit. The remaining 74 did not have MS4 coverage. Massachusetts developed a NPS BMP community survey instrument. Both MS4 and non-MS4 communities were contacted, with explanations about the overall LISS project, a copy of the BMP survey, and instructions for completing the survey. Results were tabulated on an Excel database (see Appendix 6) with accompanying TN loadings reductions. Summaries of these results are provided in Section VI of this report.
    3. **Transportation- roadways**. The Massachusetts Department of Transportation (MassDOT) was contacted as the principal lead agency for roadway BMPs. Three MassDOT District Offices (Districts 1, 2 and 3) cover the Massachusetts LIS watershed. Each district office utilized relevant portions of the NPS BMP survey instrument to create an assessment of BMPs within their particular jurisdiction.

Information reported by each of the Districts, with accompanying TN loadings reductions, is provided in Section VIII of this report.

4. **Forestry- open space.** The Massachusetts Department of Conservation and Recreation (DCR), Forestry Division, and Quabbin Land Management Division were contacted and ask to complete the NPS BMP survey in order to collect information on forestry BMPs.
5. **Massachusetts Section 319 Grant Program.** A request was made to EPA Region 1 to provide TN reductions from relevant 319 projects conducted since 2001 that are included in their 319 grant reporting database. Results are summarized in Section IX of this report.

- Research inquiries were made on similar NPS BMP assessment studies associated with TN removal conducted throughout the US. Specifically, data and NPS BMP removal efficiencies information was obtained from the Chesapeake Bay Program (CBP).The CBP has been working to reduce NPS loading to the Chesapeake Bay watershed for over 15 years, with millions of dollars spent thus far on related water quality studies and projects. The Program developed a "Non-Point Source BMP and Efficiencies Scenario Builder Table" (Appendix 1 in this report), to estimate TN loadings reductions estimates for certain BMPs, which MassDEP used for this effort.
- Similar inquiries were made for catch basin cleaning, street sweeping, and yard/lawn waste removal detritus collected by communities, and to MassDOT. The Center for Watershed Protection has developed estimates for actual TN loading content (in pounds per ton of catch basin and street sweeping detritus collected.

IV Massachusetts TN Export Loadings and Target (10 percent) Reductions

Summary of Previous Studies

Figure 1 provides an overview of those watersheds in Massachusetts that are within the LIS watershed. When MassDEP began its NPS BMP assessment efforts late in 2011, the Department wanted to specifically identify and, if possible quantify, Massachusetts' TN loading to the LIS watershed. Quantifying state reductions in TN loading from NPS BMPs was necessary so that the state could determine if its LIS TMDL 10 percent NPS TN reduction targets had been achieved.

The primary focus of previous LISS studies was to establish TN loadings from the Connecticut River since this was the single largest freshwater source to the Sound. It was noted that additional quantification would be necessary for other watersheds within Massachusetts that also contribute to the Sound. These watersheds include the Housatonic, Farmington, and the Thames River watersheds, and the French and Quinebaug Rivers in Massachusetts. After the formation of the LIS TMDL Workgroup, the workgroup commissioned a series of studies to assess the amount of nitrogen originating from the upper Connecticut River basin that is delivered to Long Island Sound. The workgroup began this effort by reviewing potential models that could be used to assess nitrogen loading from the upper Connecticut River basin to the Sound. After reviewing several models, the workgroup chose to work with U.S. Geological Survey (USGS) to re-calibrate the SPARROW model for New England, specifically for the Connecticut River Watershed, and used this newly calibrated model to estimate the sources and contributions of nitrogen from the Connecticut River delivered to the Sound (NEIWPCC, 2011).

The goals of the SPARROW study were: 1) to predict ranges of nutrient concentrations in surface waters, 2) identify the environmental factors that are statistically significant predictors of nutrient concentrations in streams, 3) evaluate monitoring efforts for better determination of nutrient loads, and 4) evaluate management options for reducing nutrient loads to achieve water quality goals. The SPARROW model was calibrated for the years 1992-1993, similar to the time period used to develop the LIS TMDL PS and NPS load allocations. The SPARROW model output did indicate that there was very little annual nitrogen attenuation in the Connecticut River. These study results helped to target needs for future monitoring and modeling efforts. Since the original study, there have been at least two different SPARROW model iterations to estimate nitrogen loadings to the LIS watershed. These results have been compared to the estimated nitrogen loadings included in the LIS TMDL.

Upon completion of the SPARROW modeling runs, USGS conducted two additional monitoring efforts to validate the SPARROW model results. The first was a three-year monitoring program (from 2002 to 2005) in the upper Connecticut River basin to determine loads originating from New Hampshire and Vermont as well as at the Connecticut/Massachusetts state line. The second study attempted to quantify nitrogen attenuation or loss, in the upper Connecticut River Basin. Quantifying nitrogen attenuation is important to better estimate the percentage of nitrogen from the upper Connecticut River basin that ultimately reaches the Sound.

After these initial studies were completed, the LIS TMDL Workgroup attempted to address variations in predicted nitrogen loading and to estimate the amount of nitrogen loading contributed by each of the upper Connecticut River states (Streich, 2012). Although the LIS TMDL includes delivered tributary loads for both PS and NPS to the Sound, it did not attempt to estimate the individual loads from each of the upper basin states nor disaggregate them into PS and NPS loads.

To find a consistent accounting of loads for the Connecticut River States, a new model was developed, the Northeast AVGWLF model. This model was chosen because it included the ability to incorporate BMPs throughout the watershed and estimate the cost of compliance. The model was calibrated based on the 3-year USGS monitoring program previously described. The model was then run to determine the sources of nitrogen loading throughout the watershed and also to look at the costs and reductions in nitrogen loading resulting from the implementation of PS and NPS BMPs throughout the watershed. This project was completed in 2008 (Evans, 2008). Loading results from each of these efforts is provided in Figure 6.

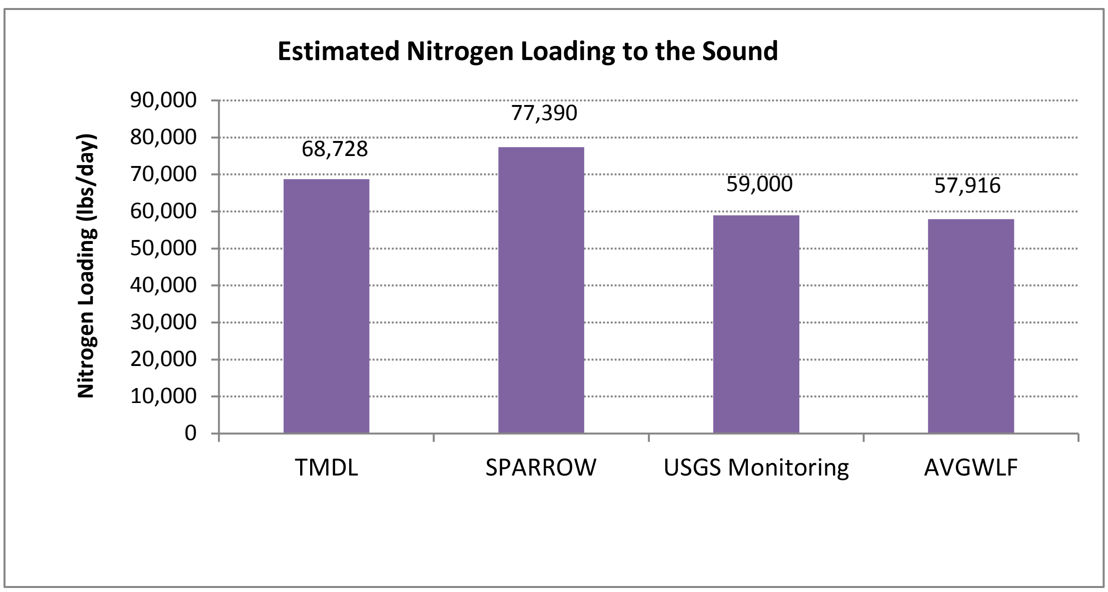
The results from the AVGWLF modeling effort indicated that each state along the Connecticut River contributes approximately the same amount of NPS nitrogen to the watershed, with the exception of Vermont whose contribution is slightly larger, likely due to agricultural activities within the state (Figure 7). On the PS side of the equation, Connecticut and Massachusetts are the largest contributors of PS nitrogen to the Connecticut River (Figure 7).The Northeast AVGWLF results confirm total nitrogen modeling results from earlier 1992-1993 SPARROW modeling runs (Figures 8 and 9). Given that comparisons were similar and that the SPARROW model results showed NPS nitrogen loads by source, it was used to estimate the source contributions for Massachusetts. It should be noted that the largest source of nitrogen loading from each of the Connecticut River watershed states is atmospheric deposition, with the exception of Massachusetts where PS loads were estimated to be the largest source of nitrogen.

The bullets below summarize the results of all of the studies noted above.

- Total nitrogen loading estimates for the upper Connecticut River basin as delivered to the Sound ranged from 57,916 pounds per day (lbs/day) to 77,390 lbs/day (Moore et al., 2004; Deacon et al., 2006; and Evans, 2008). These estimates do vary slightly in their assumptions. The 2000 LIS TMDL assessment and the SPARROW modeling results reflect the 1990-1993 time period. The Northeast AVGWLF model was calibrated based on USGS monitoring data collected between 2002 and 2005.
- USGS evaluated nitrogen attenuation in the Connecticut River. Modeling and monitoring efforts estimated variable nitrogen loss in the Connecticut River ranging from zero to as much as 18 percent (Smith, et al. 2008). Previous studies conducted by CT DEEP and LISS estimated nitrogen attenuation in the Connecticut River below the Massachusetts border to range from 5 to 13 percent (Aqua Terra and HydroQual, 2001). These studies indicated that a large portion of the nitrogen load measured at the Connecticut/Massachusetts border is delivered to the Sound.
- USGS's 3-year monitoring results in the Connecticut River showed an annual TN load leaving Massachusetts of approximately 59,000 lbs/day- within the range of the nitrogen loading modeling results.

Results from the studies indicated that although the total nitrogen loading estimates between all these reports were in fair agreement, the estimates by source category varied significantly and were inconsistent when calculated primarily because different land use categories were used for each effort (Figures 8 and 9).

Figure 6- Estimated Nitrogen Loading from the upper Connecticut River to LIS



Note: All data represent nitrogen loading from the upper Connecticut River basin as delivered to the Sound, except for the USGS monitoring data. The monitoring data represents the nitrogen load in the Connecticut River at the Connecticut/Massachusetts border (CTDEEP and NYSDEC, 2001; Moore et al., 2004; Deacon et al., 2006; and Evans, 2008). It should be noted that these projects represent different time frames. The SPARROW modeling and LIS TMDL assessment represent the 1990-1993 time period and the USGS monitoring and AVGWLF modeling represent the 2002-2005 time period (NEIWPCC, 2011).

Figure 7- PS and NPS Nitrogen Load Contributions to the Connecticut River based on the Northeast AVGLWF Modeling Runs (Evans, 2008)

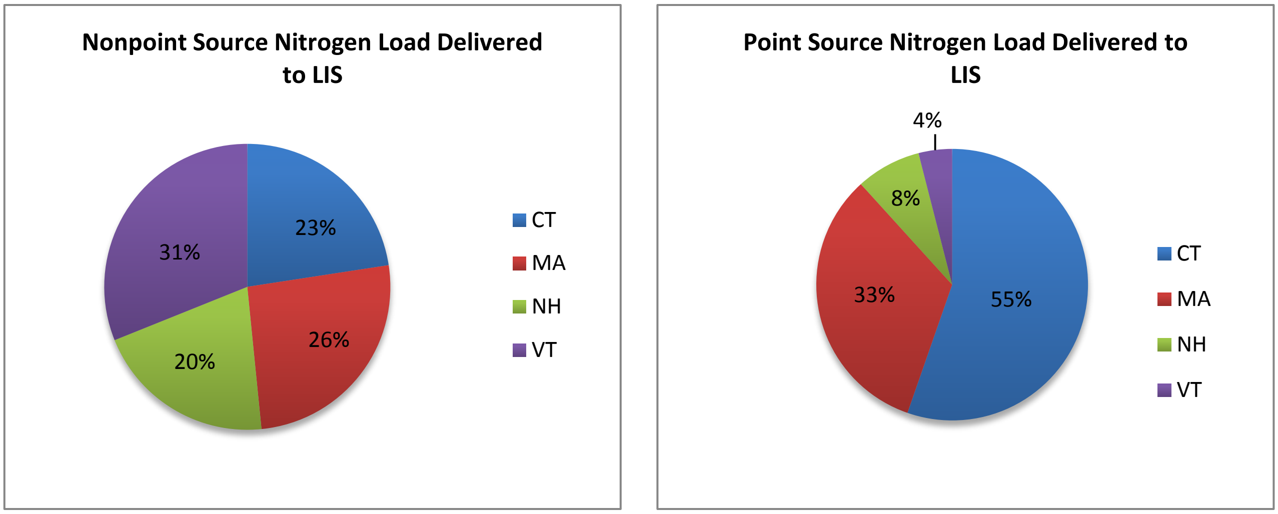


Figure 8 - Percent Contribution by Source to the Connecticut River

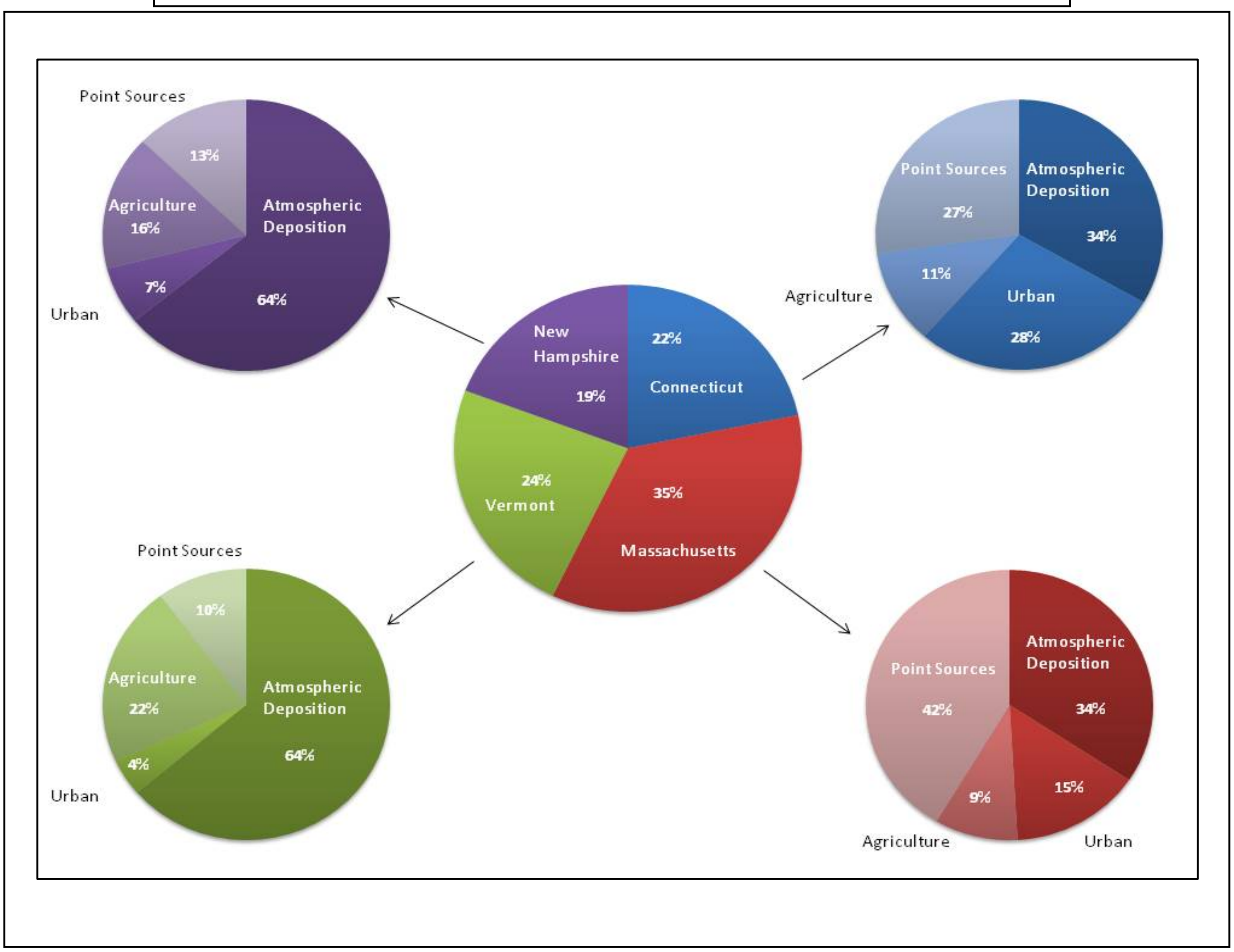
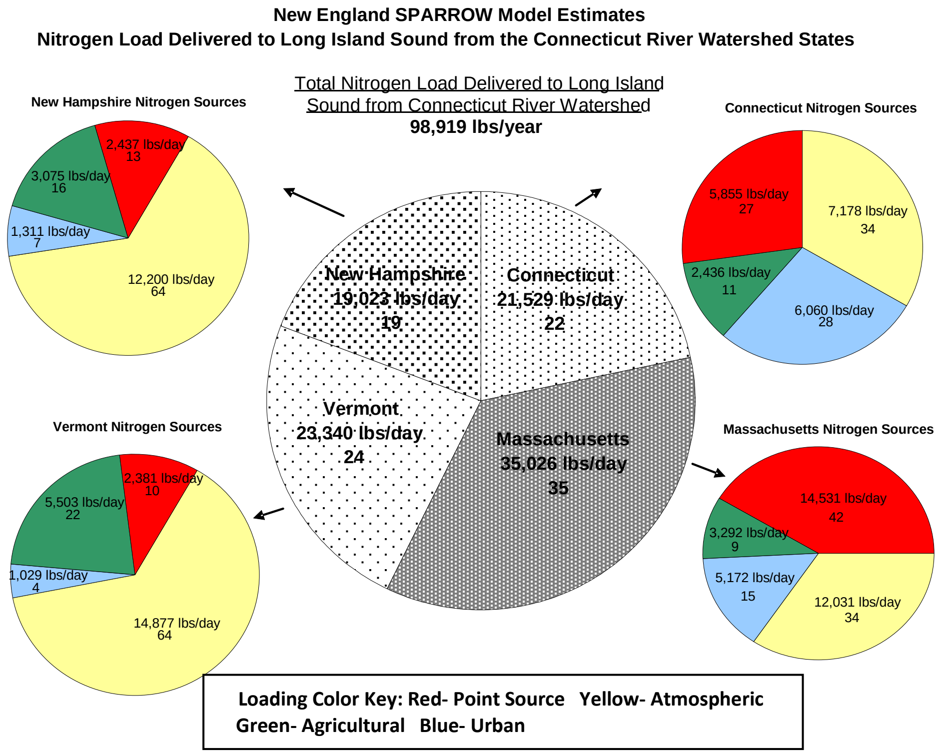


Figure 9- State Nitrogen Load by Source delivered to LIS, according to the SPARROW modeling results, in the Connecticut River watershed (Moore et al., 2004)



MassDEP Loading Analysis

Since the stated goal of the LIS TMDL was for the upper basin states to achieve a 10 percent reduction in NPS, MassDEP attempted to quantify the amount of TN removed from the watershed resulting from recent BMP applications to urban and agricultural lands. The SPARROW model provides one way for estimating TN loading from specific NPS categories and established a baseline for the TMDL modeling effort, thereby allowing for the calculation of a10 percent reduction. However, the SPARROW model was only run for the Connecticut River watershed and did not represent loadings from other contributing watersheds in Massachusetts.

To be consistent with assumptions made during the development of the LIS TMDL, MassDEP decided to use the same loading coefficients and land uses upon which the TMDL was based. The TMDL provides loading calculations based on a number of in-basin management zones along with estimated delivery factors to the Sound. The TMDL does not quantify the NPS TN loads originating from different land uses in the upper basin states. A technical support document titled "Nitrogen Loading Estimates to Long Island Sound, Review Draft, July 2000" developed by the CT DEEP did document tributary loadings originating above the Connecticut/Massachusetts state line into each management zone (Appendix 7).

The management zones and loadings included in CT DEEP's technical document are provided in Table 8 of that document. Tier 1-trib represents loadings from Massachusetts to the Thames River watershed (no contribution from New Hampshire or Vermont). Zone 2-4-trib represents loadings from Massachusetts to the Farmington

River watershed (no contribution from New Hampshire or Vermont). Zone 2-trib represents loadings from all three upper states through the Connecticut River watershed system and zone 4-trib represents the loadings from Massachusetts via the Housatonic River watershed. Table 8 summarizes the acreage, loadings and delivery factors for each zone/tier for urban, agriculture, forest, and point sources. Table 10 in this document further breaks these loadings down into terrestrial and atmospheric loadings.

The intent of this paper is not to recalculate each load. The paper cited above can be reviewed for that purpose. Our goal, however, was to use consistent loading export coefficients to determine the Massachusetts' contribution. The export coefficients used in that analysis are provided in Table 4 of that document and are converted to pounds per acre per year (lbs/acre/yr) in Table 1 below. This same process could be used to estimate loadings from the other upper basin states in the LIS TMDL workgroup as well. Using these coefficients allowed MassDEP to estimate a TN export load, along with a 10 percent reduction target for both agriculture and urban land-uses. Though 10 percent loading reduction targets for forested land-uses was determined in the LIS TMDL, loading reductions for this particular land use were not calculated for this particular study.

As previously noted, the tributary loadings for Thames River watershed (Tier 1-trib), the Farmington River watershed (Zone 2-4-trib), and the Housatonic River Watershed (zone 4-trib) were directly calculated for Massachusetts since none of those watersheds extend to New Hampshire or Vermont. However, the loadings for the Connecticut River watershed (Zone 2-trib) included contributions from all three upper basin states. In order to estimate the TN loads originating in Massachusetts, urban and agricultural land use coverages were estimated and then multiplied by the TN loading for each land use, as calculated in the LIS TMDL support document (Figure 9).

Table 1 summarizes forest, agriculture, and urban land- use export loading rate coefficients (in lbs/acre/yr) for Massachusetts. MassDEP also utilized these coefficients to quantify TN loading reduction credits for urban and agricultural land uses. Table 2 provides the breakdown of Massachusetts urban, agriculture, and forest TN loads delivered to LIS from the Connecticut River and tributary basins according to the LIS TMDL. These estimates consider both terrestrial and atmospheric sources, and delivery factors, i.e., attenuation for each basin. Although Tables 1 and 2 list export coefficients and tributary loadings for forestry; TN loading reduction credits were not considered for this particular land use for reasons explained in Section IV of this report. Table 3 provides a summary of delivered TN loads in tons per year (tons/yr) to LIS from Massachusetts tributary basins, for urban, agriculture, and forest land uses, as well as 10 percent TN target reductions for all the basins for both urban and agricultural land uses.

Table 1- Massachusetts Loading Rates (lbs/acre/year)

Land Use	**Terrestrial**	**Atmospheric**	**Total**
Forest	0.8	3.0	3.8
Agriculture	3.74	3.0	6.7
Urban	5.8	6.1	11.9

Table 2- Delivered Nitrogen Loads (Applying the Delivery Factor) from Terrestrial and Atmospheric Sources (lbs/yr [Tons/yr]) in the Massachusetts LIS Watershed[1]

Watershed	Urban Terrestrial lbs/yr (tons/yr)	Agriculture Terrestrial lbs/yr (tons/yr)	Forest Terrestrial lbs/yr (tons/yr)	Total Terrestrial lbs/yr (tons/yr)	Urban Atmospheric lbs/yr (tons/yr)	Agriculture Atmospheric lbs/yr (tons/yr)	Forest Atmospheric lbs/yr (tons/yr)	Total Atmospheric lbs/yr (tons/yr)	Total Urban Load to LIS lbs/yr (tons/yr)	Total Agriculture Load to LIS lbs/yr (tons/yr)
Thames (Delivery Factor =0.49)	41,504 (20.7)	37,463 (18.7)	43,501 (21.75)	122,467 (61.15)	43,626 (21.8)	30,051 (15.0)	163,141 (81.6)	236,817 (118.4)	85,130 (42.5)	67,513 (33.7)
Housatonic (DF=0.44)	48,114 (24.0)	103,422 (51.7)	81,852 (40.9)	233,388 (116.8)	50,603 (25.3)	82,959 (41.5)	306,945 (153.5)	440,506 (220.3)	99,014 (49.3)	186,381 (93.2)
Farmington (DF=0.81)	20,731 (10.4)	9,680 (4.8)	24,054 (12.0)	54,465 (27.2)	20,950 (10.5)	7765 (3.9)	90,203 (45.1)	173,383 (86.7)	41,681 (20.9)	17,445 (8.7)
Connecticut (Massachusetts Portion*) DF=0.65	881,375 (439.8)	399,417 (199.3)	Not determined for this study	Not determined for this study	926,963 (462.5)	331,116 (165.2)	Not determined for this study	Not determined for this study	1,808,338 (902.3)	670,533 (364.5)

[1] Values are not identical to those provide in the CT DEEP technical document due to round-off error.

*Massachusetts Portion: For Urban, 38.1 percent (.381) of the Massachusetts, New Hampshire, Vermont Total from NEIWPCC, 2010 Sparrow; for Agriculture, 23 percent (.23) of Massachusetts, New Hampshire, Vermont Total from NEIWPCC Sparrow.

Table 3- Delivered Loads (Delivery Factor Applied), and 10 Percent Reduction Targets to LIS (tons/yr)

Watershed	Urban (Tons/yr)	Agriculture (Tons/yr)	Forest* (Tons/yr)	Total (urban and agriculture, not forests) (Tons/yr)	10 percent Urban Reduction Target (Tons/yr)	10 percent Agriculture Reduction Target (Tons/yr)
Thames (0.49)	42.5	33.7	103.3*	76.2	4.3	3.4
Housatonic (0.44)	49.3	93.2	194.4*	142.5	4.9	9.3
Farmington (0.81)	20.9	8.7	57.0*	29.6	2.1	0.9
Connecticut-Massachusetts portion(0.65)	902.3	364.5	Not determined for this study	1266.8	90.2	36.5

*Forest loadings for Massachusetts are not utilized for estimating TN loading reductions in the study because they are considered pre-colonial loadings.

V Strategy to Obtain Information on Current NPS BMPs in Place

Across the nation, there exist little current information or data identifying BMP removal efficiencies for TN. However, there are a few sources outlined below that can be used to estimate reductions. One of the primary sources for information on this topic is CBP and its associated nutrient reduction efforts. CBP was established over 15 years. The program has invested in millions of dollars for water quality studies and projects including those intended to quantify BMP nitrogen removal efficiencies. CBP currently estimates TN loadings reductions using methods outlined in "Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder" developed by the CBP (2011), (Appendix 1). This scenario builder lists dozens of agricultural and urban BMPs, with suggested (TN) percentage reduction efficiencies. Examples of agricultural BMPs include cover crops, prescribed grazing, barnyard runoff control, and wetland restoration. Examples of urban BMPs include forest buffers, wet and dry detention ponds, infiltration practices, erosion and sediment controls. Another source for estimating BMP TN reduction capabilities for urban BMPs is "CSN Technical Bulletin # 9, Nutrient Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed," prepared by the Chesapeake Bay Network, (Chesapeake Stormwater Network, 2011) (Appendix 4). Examples of urban BMPs discussed in that document include street sweeping, urban fertilizer management, septic pump- outs, septic tie-ins with sewers, and illicit discharge elimination.

In addition to the above sources, MassDEP made similar research inquiries regarding TN removal efficiencies and documented TN loading coefficients for specific stormwater housekeeping type BMPs. These BMPs include catch basin cleaning, street sweeping, and yard/lawn waste removal. The Chesapeake Bay Network has completed studies that estimate TN loading content (pounds per ton) of catch basin, street sweeping, stormwater outfall, and other related BMP detritus collections. Examples of preliminary TN content percentages are contained in the Appendix 2 attached to this report, "Average Nutrient Concentrations of Sediment Related to Common O &

M Activities Table." Professor Milt Ostrofsky of Allegheny College has conducted research on nitrogen content in typical autumn shed leaves in the Northeast; Professors Uta Krogmann and Joseph H. Heckman of the Rutgers University Extension Service have conducted research on nitrogen content in typical grass clippings. These researchers have developed TN content estimates for small branch- brush wastes (typical in yard waste pickup by communities). Appendix 5 summarizes the findings of these experts.

Many of the agricultural, urban- suburban, and transportation- roadway BMPs included within this report have suggested TN loadings reduction estimates from the resource appendices indicated above. Determining appropriate load reductions require BMP statistics such as acreage coverage, or weight (pounds per ton) of detritus collected. The biggest challenge in the Massachusetts assessment process was obtaining acreage or debris weight statistics on BMPs from communities, agricultural, and highway agencies. This data is necessary in order to apply the specific TN reduction efficiency or weight guidelines for the particular BMP suggested in the above mentioned resource works. In many cases, there are no BMP records that include acreages or the weight of debris collected.

The principal land-use and program components considered in this report include: (1) Agricultural; (2) Urban-Suburban (Stormwater); (3) Transportation- Roadways; (4) Forestry- Open Space; (5) Combined Sewer Overflows (CSOs); (6) Section 319 Non- Point Source Grant projects. The following outlines the approach used for each category.

Assessment Approach for Urban and Roadway BMPs

In order to gather BMP information from LIS watershed communities in Massachusetts, MassDEP developed a succinct BMP survey, with an accompanying narrative explaining the LIS TMDL and its goals (Appendix 3). The survey instrument was designed to obtain information and statistics necessary to estimate T) loading reductions for those BMPs reported to be in place by these communities. For urban communities, MassDEP developed a list of personnel contacts for the 38 MS4 Stormwater Phase II Communities within Massachusetts' LIS watershed. The MassDEP Western Regional Office provided recommendations on suggested town officials to contact, with names, phone numbers, and email addresses. MS4 regulated communities are required by federal and state policies and regulations to implement stormwater management activities according to the stormwater program's "six minimum control measures." There are an additional 74 non-MS4 Massachusetts communities within the Sound's watershed, many of which have a very small population (less than 5,000 people). As with the MS4 communities, a separate personnel contact list was prepared, consisting of names and email addresses of appropriate town officials, with the intention of making, at least, initial contact with them.

The survey was sent via email to key contacts in all the 112 MS4 and non- MS4 communities within the LIS watershed. Necessary follow-up occurred via telephone calls and further email contact. Results for each community were compiled in excel spreadsheets, with estimated TN loading credits or reductions determined for as many of the reported BMPs as possible. Total TN reductions were then compared with the target urban TN NPS reduction goals determined from the LIS TMDL for Massachusetts.

Assessment Approach for Agricultural NPS BMPs

After initial inquiries were made, it was determined that MDAR, the UMass (Amherst) Agricultural Extension Service, and NRCS would be principal agencies for obtaining useful information on agricultural related NPS BMPs currently in place within the Massachusetts LIS watershed. NRCS provides resources, including grants, to assist farmers with erosion, nutrient runoff, and other waste Control measures. NRCS provided MassDEP with an early version of a Massachusetts based listing of their projects, which consisted of approximately 500 BMP projects in the Massachusetts LIS watershed, however, this list did not specify the type or description of the actual BMPs put in place by the projects, nor the areal (acreage) coverage of each of these. MassDEP asked NRCS to provide more specific information on each project, such as the type of BMP, its explanatory definition, and accompanying statistics on each reported BMP, such as acreage coverage, so that possible TN reduction credits could be determined as part of the current Massachusetts NPS BMP assessment effort. It should be noted that in order to ensure that NRCS did not violate their disclosure agreements, MassDEP did not request specific names and addresses where those BMPs were implemented. Instead, what was provided was the particular watershed where each BMP was put in place.

The UMass Agricultural Extension Service was another logical point of contact for possible information on BMPs recently implemented on Massachusetts farmland or orchard areas. The UMass Agricultural Extension Services and Programs primarily provide research and grant support for agricultural academic majors and UMass professors. MDAR also assist farms/farmers with BMP implementation involving soil conservation and nutrient reductions. Mass DEP requested available BMP information from both UMass and MDAR.

Assessment Approach for MassDOT Roadway BMPs

There are approximately 5,000 road and highway miles within the Massachusetts LIS watershed maintained by the MassDOT. State roadways have rights of way on either side of the roadway for conducting necessary roadway support functions, including installation of BMPs to control drainage of stormwater and pollutants on and off the roadway, as well as for erosion and sediment controls. These controls (BMPs) do remove TN, to some extent. Common BMPs utilized by MassDOT on and just off their roadways include, catch basin cleaning, street sweeping, construction of catch basin retrofits with deep sumps, construction of swales, bioswales, dry and wet detention ponds, infiltration and filtering practices, erosion and sediment controls, as well as tree planting.

There are three MassDOT highway districts in the Massachusetts LIS watershed. District 1 (extreme western portion of Massachusetts) comprises the Housatonic, Farmington, Westfield, and Deerfield watersheds, as well as the northwest extremity of the mainstem Connecticut River watershed. District 2 (Connecticut River Valley-eastward into Central Massachusetts) consists of the mainstem Connecticut River watershed, the western three/fourths of the Chicopee River watershed, the Quaboag and Ware River watersheds, the western four/fifths of the Millers watershed, and the western one/third of the Quinebaug River watershed. District 3 (Central Massachusetts) consists of eastern two/thirds of the Quinebaug River watershed, the French River watershed, the eastern one/fourth of the Chicopee, Quaboag, and Ware River watersheds and the eastern one/fifth of the Millers River watershed.

Initial inquiry was made with MassDOT officials in Boston, and materials were provided to them describing the LISS project including the BMP survey, with explanations as to how MassDOT BMP activities might fit into the project’s goal of determining estimated TN reductions for the Massachusetts LIS watershed. Each of the three District offices received a copy of the BMP survey (the same survey provided to the communities) and listing (MassDEP, 2012b) (Appendix 3). Each District office was instructed to complete the form by reporting on BMPs from the list that are currently in place, and to provide suggested statistical information on each BMP.

Assessment of Forestry- Open Space Land-Use

DCR's Forestry and Quabbin Land Management Divisions were contacted regarding this assessment project. Forestry related BMPs generally have negligible effects as far as TN reductions. In this regard, forestry experts associated with the CBP generally advised that existing forests that are clear cut followed by replanting, even with the use of BMPs to prevent TN erosion during and after the cutting, probably result in no significant overall decreases in TN loadings. In fact, these activities may lead to temporary increases in TN loadings within the affected watershed areas. In addition, for the purposes of this report forests were considered to be part of the pre-colonial or natural condition and therefore were not considered further for TN reductions.

Assessment Approach for Section 319 Grant Program in Massachusetts

EPA Region 1 was asked to provide TN reduction information from relevant 319 projects conducted in the Massachusetts LIS watershed since 2001. Within the watershed, approximately 18 NPS 319 projects have occurred since 2001. Many have involved installation of BMPs that control various pollutants, including some that control TN. EPA Region 1 maintains the Grant Reporting and Tracking System (GRTS) for the Region, which estimates TN removal, and other relevant pollutant(s) reductions from implementation components of 319 projects. It was recommended by the LIS TMDL workgroup that the EPA provide TN estimate reductions from the GRTS database for each watershed state.

Assessment of Combined Sewer Overflow (CSO) Abatement Work on the Lower Chicopee Basin

The MassDEP Western Regional Office has been engaged for at least the past decade in eliminating or reducing CSO flows entering the Lower Chicopee River basin (and ultimately into the Connecticut River mainstem). Over $50 million in CSO abatement work has been dedicated to this effort, resulting in fully shutting off 7 major CSO flows, plus alleviating several others. This work has resulted in the reduction of 1 billion gallons of CSO flow each year, making 21 miles of the Lower Chicopee "CSO free." MassDEP's Western Regional Office provided an estimate of TN reductions to the Chicopee River for this effort.

VI Assessment of Urban BMPs Currently in Place

Massachusetts Stormwater Control Programs for Communities (Including the Current MS4 Stormwater Program)

The prime impetus for applying urban and community related BMPs to control stormwater runoff relate to four federal and state stormwater programs in place in Massachusetts: (1) the Federal Construction General Permit which regulates all construction activities that disturb an acre or more of land; (2) the MS4 permit, requiring 247 Massachusetts Communities and a number of independent authorities and state agencies to perform stormwater management activities under the program's "six minimum control measures;" (3) the Massachusetts State Wetlands Protection Regulations, which require projects within a "wetlands jurisdictional area" to meet the 10 Massachusetts Stormwater Standards including include specific stormwater BMPs that increase recharge, improve water quality, and eliminate illicit discharges; and (4) Massachusetts State Law allowing Massachusetts towns to adopt additional stormwater rules for local purposes (Civian, 2012). Table 4 provides a brief summary of regulated stormwater permit programs in Massachusetts.

Table 4 - Massachusetts' Regulated Stormwater Permit Programs

Permit	General Description	Number of Registrants	Original Issue Date/ Revised Date	Basic Requirements
Multi- Sector General Permit for the Discharge of Stormwater Associated with Industrial Activity	EPA General Permit that regulates facilities with stormwater discharges from exposure of materials outside to precipitation	1,100	1992/2008	Registration; depends on Sector (approx. 30 of them), & type of raw material stored outside; Some monitoring. requirements particularly for metals
Stormwater Associated with Commercial Activities	None in Massachusetts	N/A	N/A	N/A
General Permit for Stormwater Associated with Construction Activities	EPA Permit, certified by Massachusetts; Req. Massachusetts Stormwater Standards on any Construction Site > 1 Acre	At least in the hundreds at any point in time; Varies because of (each) project duration, etc	1995/2012	Registration; Stormwater management plan (during & post construction) that controls soils/sediment going of-site
Stormwater from Small Municipal Separate Storm Sewer Systems General Permit	Requires certain municipalities to take steps to keep the stormwater entering its storm sewer systems clean before entering water bodies.	Phase I incl. Boston and Worcester; Phase II incl. 247 Towns and other public entities such as DCR, MWRA, and MassDOT	Phase I- 1990; Phase II 1999; updated 2003/current Draft renewal being considered	Registration; develop stormwater management plans, prepare annual progress report to EPA on 6 Minimum Control Measures,
Massachusetts Wetland Act and Regulation (310 CMR 10.00)	Regulates new development and redevelopment activities in wetland resources and buffer zone.	About 5,000 NOIs filed each year	Stormwater requirements: 1996/2008	For work in resource areas and buffer zone: peak rate control, recharge, and water quality treatment.
Massachusetts 401 Water Quality Certification Regulation (314 CMR 9.00)	Regulates new development and redevelopment activities in federal waters/wetlands	About 50 applicatio ns/year	1983/2009	For work in federal waters/wetlands: peak rate control, recharge, and water quality treatment.
Underground Injection Control (310 CMR 27.00)	Requires stormwater well registration			Stormwater wells must comply with MassDEP Stormwater Standards

In general, the principal source for potential NPS BMP information from communities within the LIS watershed comes from MS4 permits. EPA's Stormwater Phase II Rule establishes an MS4 stormwater management program that is intended to improve the Nation's waterways by reducing by controlling polluted stormwater runoff. Common pollutants found in stormwater include oil and grease from roadways, pesticides and fertilizers from lawns, sediment from construction sites, and carelessly discarded trash, such as cigarette butts, paper wrappers, and plastic bottles. Polluted stormwater runoff can include TN. When deposited into nearby waterways through MS4 discharges, these pollutants in sufficient quantities can impair the waterways, thereby discouraging recreational use of the resource, contaminating drinking water supplies, and interfering with the habitat for fish, other aquatic organisms, and wildlife.

In 1990, EPA promulgated rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) stormwater program. The Phase I program for MS4s required operators of “medium” and “large” MS4s, that is, those that generally serve populations of 100,000 or greater, to implement a stormwater management program as a means to control polluted discharges from these MS4s. The Stormwater Phase II Rule (beginning in 2004) extended coverage of the NPDES stormwater program to certain “small” MS4s, but took a slightly different approach for stormwater management. The Phase II Rule automatically covers all small MS4s located in urbanized areas (UAs) as defined by the Bureau of the Census (unless waived by the NPDES permitting authority), and on a case-by-case basis those small MS4s located outside of UAs that the NPDES permitting authority designates.

Phase II Small MS4 Program Requirements necessitate that operators of regulated small MS4s design their programs to: (1) reduce the discharge of pollutants to the maximum extent practicable; (2) protect water quality; and, (3) satisfy the appropriate water quality requirements of the Clean Water Act. There are six MS4 program elements, termed “minimum control measures.”

1. **Public Education and Outreach**- Distributing educational materials and performing outreach to inform citizens about the impacts stormwater runoff discharges can have on water quality.
2. **Public Participation/Involvement**- Providing opportunities for citizens to participate in program development and implementation, including effectively publicizing public hearings and encouraging citizen representatives on a stormwater management panel.
3. **Illicit Discharge Detection and Elimination**- Developing and implementing a plan to detect and eliminate illicit discharges to the storm sewer system, including development of a system map and informing the community about hazards associated with illegal discharges and improper disposal of waste.
4. **Construction Site Runoff Control-** Developing, implementing, and enforcing an erosion and sediment control program for construction activities that disturb one or more acres of land. These controls could include silt fences and temporary stormwater detention ponds.
5. **Post-Construction Runoff Control**- Developing, implementing, and enforcing a program to address discharges of post-construction stormwater runoff from new development and redevelopment areas. Applicable controls could include preventative actions such as protecting sensitive areas, (e.g., wetlands), or the use of structural BMPs such as grassed swales or porous pavement.
6. **Pollution Prevention/Good Housekeeping**- Developing and implementing a program with the goal of preventing or reducing pollutant runoff from municipal operations. The program must include municipal staff training on pollution prevention measures and techniques, (e.g., measures such as regular street sweeping, reduction in the use of pesticides or street salt, or frequent catch-basin cleaning).

The Phase II program for MS4s is designed to accommodate a general permit approach using a Notice of Intent (NOI) as the permit application. The operator of a regulated small MS4 must include in its permit application, or NOI, its chosen BMPs and measurable goals for each minimum control measure. To help permittees identify the most appropriate BMPs for their programs, EPA has issued a menu of BMPs to serve as guidance. NPDES permitting authorities can modify the EPA menu or develop their own approaches.

The rule identifies a number of implementation options for regulated small MS4 operators. These include sharing responsibility for program development with a nearby regulated small MS4, taking advantage of existing local or state programs, or participating in the implementation of an existing Phase I MS4's stormwater program as a co-permittee. These options are intended to promote a regional approach to stormwater management, i.e., coordination on a watershed basis.

Permittees need to evaluate the effectiveness of their chosen BMPs, to determine whether the BMPs are reducing the discharge of pollutants from their systems to the maximum extent practicable, and to determine if the BMP mix is satisfying the water quality requirements of the Clean Water Act. Permittees are also required to assess their progress in achieving their program's measurable goals. While monitoring is not required under the rule, the NPDES permitting authority has the discretion to require monitoring if deemed necessary. If there is an indication of a need for improved controls, permittees can revise their mix of BMPs to create a more effective program.

The Community BMP Evaluation Process Used in Massachusetts

Within the Massachusetts LIS watershed, there are 38 communities covered under the Phase II MS4 permit program. BMP installation to control pollutants in stormwater is a requirement under the "six minimum measures" in each of these regulated communities. The MS4 permit requires annual reporting to EPA on the progress made to address the "six minimum measures" by community. All MS4 communities are required to submit annual progress reports to the EPA Region 1. For this particular project, review of several years of the reports from the 38 communities indicated for those reporting various BMPs in place, many did not provide the type of BMP statistics, such as weight of detritus collected for street sweeping, or acreages for BMPs such as swales, necessary to determine TN reduction credits. In addition, there are 74 non-MS4 permitted communities within the Massachusetts LIS watershed, many of which were smaller in population than the MS4 communities. To capture BMP information from these additional 74 communities, a BMP survey instrument, as discussed in Section V, was developed (see Appendix 3), and sent via email to each MS4 community. All BMPs reported from survey responses that had potential for reducing TN were identified on Excel spreadsheets, by community, and are included in Appendix 6,"Community Stormwater BMP Survey Results for LISS," which accompanies this report.

1. Massachusetts Survey Results and Estimated TN Load Reductions

Out of 38 MS4 communities contacted to fill out the BMP survey in the LIS watershed, 31 responded with BMP information that had useable statistics for determining potential TN reductions. The remaining 7 communities reported BMPs with no useable statistics. Significant time and effort was required to make follow-up contact with communities in an effort to obtain statistical information necessary to determine potential TN reductions. Most of the communities initially returned survey forms with BMPs checked off as "in place," but with insufficient data to make TN reduction determinations. Table 5 summarizes the survey information returned by the communities with BMPs reported in place. This includes a separate and combined listing of BMPs in place for MS4 communities.

From the MS4 and non-MS4 communities that provided BMP information, a total of 399 BMPs were reported. Of this total, 271 of these BMPs had useable information and statistics whereby TN loading reductions could be estimated. Appendix 6, "Community Stormwater BMP Survey Results for the LISS," contains Excel files for all BMPs reported by MS4 and non-MS4 communities. Each file lists, by column: (A) the community; (B) the type of urban BMP found in place; (C) its size or acreage, number of units, system size, or weight of detritus removed; (D) the process, and reference for determining the TN reduction ; and, (E) if appropriate, the TN removed per year for the BMP.

Principal references used in determining Urban- Community BMP TN reduction credits include:

- Appendix 1- "Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder", Chesapeake Bay Project.
- Appendix 2- "Average Nutrient Concentrations of Sediment related to Common O & M Practices", Tom Schueler, Chesapeake Stormwater Network.
- Appendix 4- "CSN Technical Bulletin #9, Nutrient Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed", Chesapeake Stormwater Network
- Appendix 5- "Yardwaste N/TN Loading Calculations", Professors Milt Ostrofsky, Allegheny College, and Professors Uta Krogmann and Joseph Heckman of the Rutgers University Extension Program.

Table 5-BMPs Reported by Communities

Urban BMPs Type	Number of MS4 Communities Reporting BMP	Number of Non-MS4 Communities Reporting BMP	Total Number of MS4 and Non-MS4 Communities Reporting Useable Stats
Catch Basin Cleaning	33	14	41
Catch Basin Retrofits- Deep Sump/ Hood Installation	6	3	9
Street Sweeping	33	14	43
Lawn Fertilization Education Programs	15	0	6
Wetlands Education Brochures	1	0	1
Leaf and Yard Waste Removal, with Proper Composting or Disposal	26	4	26
Swales (Constructed)	8	6	8
Bioswales, Bioretention	14	5	11
Grassy Swales	3	2	5
Nutrient Management Programs,(e.g., Lake/ Pond, or Town DPW Yards, or other Town Properties)	5	2	3
Impervious Surfaces Reduction	5	0	3
Tree Planting/ Reforestation/ Forest Buffers	10	3	8
Urban Stream Restoration	4	0	4
Wet Detention Ponds and/or Wetlands Installation	11	5	12
Dry Detention Ponds	12	3	13
Infiltration Basins/Practices/Stabilization Basins	10	4	10
Rain Gardens, Underdrain Infiltration Systems Installed	9	0	8
Filtering Practices	1	1	2
Erosion and Sediment Controls, as a result of Construction Control By-Laws in Place	22	4	0
Groundwater Overlay District related BMPs	8	0	2
Cluster Zoning; Min. Lot Size; LID Related BMPs	6	2	1
Vegetated Open Channel(within, or at the edge of channel)	2	0	2
Permeable Pavement with or without Sand, Vegetation	0	0	0
Stormwater Management Plan	1	1	0
Illicit Connections Found	16	2	0

Urban BMPs Type	Number of MS4 Communities Reporting BMP	Number of Non-MS4 Communities Reporting BMP	Total Number of MS4 and Non-MS4 Communities Reporting Useable Stats
Illicit Connections Corrected	13	0	13
Illicit connections &/or Sewer Tie- in Ordinances Passed	3	0	0
Septic Connections to Sewer	15	3	15
Septic Denitrification	2	0	13
Septic Pumping	13	7	8
Stormceptor™ Stormwater BMPs	3	0	3
MA Title 5 Advanced Wastewater Systems	3	1	1
Groundwater Discharge Plants to Replace Title 5 Systems	0	0	0
TOTALS FOR BMPs	313	86	271

An overview of the TN reduction calculations that were made for appropriate BMPs are included in Column D of Appendix 6. Appendix 6 documents how the TN reduction was determined, listing the reference (appendix number, and page) and the process utilized in determining the actual TN loading reduction for the particular BMP reported. Column E lists the TN removed, in lbs/year for each BMP when it could be determined.

For housekeeping BMPs such as street sweeping and catch basin cleaning, "Average Nutrient Concentrations of Sediment related to Common O & M Practices," developed by Tom Schueler was utilized to calculate TN loading reduction estimates. For yard waste removals by the specific community, Appendix 5 "Yardwaste N/TN Loading Calculations," was utilized to estimate TN loading reductions. For BMPs necessitating acreage data to determine TN reduction estimates (e.g. BMPs such as swales, bioswales, infiltration practices, wet and dry detention basins, vegetated wet ponds, etc.), the following two references were commonly utilized: "Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder," and "CSN Technical Bulletin #9, Nutrient Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed." MassDEP used the following procedures and assumptions to determine TN loading reductions estimates for all BMPs:

1. The export loading coefficient for urban areas from the LIS TMDL was used to calculate urban TN loading for the Massachusetts portion of LIS watershed (11.9 lbs/acre/yr) as described in Section IV.
2. BMP reduction efficiencies or credit information identified in the appropriate references (Appendices 1 through 5) listed above were applied, as well as the acreage statistics listed in column C of the Urban BMP Excel spreadsheet (Appendix 6).
3. The TN loading reduction efficiency percentage was multiplied times the export loading coefficient (11.9 lbs/acre/yr), times the total acres for the particular BMP listed in Column C of the urban BMP spreadsheet to determine the total estimated TN reduction.

4. The total TN reduction credit (lbs/yr) was calculated by adding up the TN reductions for each BMP at the bottom of each sheet and summing the reductions for all communities.

In order to determine if the 10 percent reduction identified in the LIS TMDL has been achieved, the TN reduction estimates were compared with the urban TN annual reduction targets determined in Section IV for the Massachusetts LIS watershed (Connecticut, Thames and Housatonic River basins). Table 6 provides a summary of the total TN loading reductions identified for each implemented BMP reported by the communities within the Massachusetts portion of the LIS watershed.

Table 6- Massachusetts Loading Reductions Associated with Urban BMPs

Urban BMP TYPE/DESCRIPTION	Total Acreage, units, Lbs or/Tons Detritus Removed	Total TN Reductions in Lbs/ Year
Catch Basin Cleaning	10,424 Tons/Yr	42,539
Street Sweeping	36,072 Tons/Yr	126,252
Leaf and Yard Waste Removal, with Proper Composting or Disposal	39,077 Tons/Yr	524,415
Septic System Connections to Sewer	155 Tie- ins	1,022
Septic System Pumping	5,935 Units/yr	3,560
Dry Detention Ponds	76 Acres	99
Urban Stream Restoration	1.2 Mile	127
Wet/Dry Detention Ponds (both Wet and Dry in same site area)	64 Acres	49
Tree Planting/ Reforestation/ Forest Buffers	93 Acres	280
Vegetated Open Channel(within, or at the edge of channel)	4 Acres	14
Wet Detention Ponds and/or Wetlands Installation	25 Acres	61
Swales & Bioswales, (Constructed)	54 Acres	446
Infiltration Basins/Practices/Stabilization Basins	44 Acres	424
Permeable Pavement with or without Sand, Vegetation	1.5 Acres	15
Nutrient Management Programs,(e.g., Lake/ Pond, or Town DPW Yards, or other Town Properties)	1,047 Acres	2,119
TOTAL NITROGEN (TN) REDUCTIONS FOR ALL BMPs		701,422

Comparison of Estimated TN Reductions to 10 percent Reduction Target

- The total estimated urban BMP TN loading reduction based on BMP implementation is estimated to be 701,422 lbs/yr.

- The total estimated MassDOT_BMP TN loading reduction based on BMP implementation (see Section VIII) is estimated to be 78,627 lbs/yr.
- The combined estimated urban and MassDOT TN loading reduction based on BMP implementation is estimated to be 780,049 lbs/yr.
- The 10 percent urban NPS reduction target in the 2000 LIS TMDL (see Table 3) is 180,460 lbs/yr.
- Therefore, MassDEP estimates that the state has exceeded its urban NPS TN load reductions by an estimated 599,589 lbs/yr (332 percent over target).

VIII. Assessment of Agricultural BMPs Currently in Place

The primary source of agricultural BMP information collected for this effort was acquired from NRCS. MassDEP received a list of approximately 500 agricultural projects from NRCS that have been implemented over the last few years, but lacked detail, such as the type of BMP utilized on each farming parcel, the definition of each BMP, the acreage of the BMP coverage, and the timeframe for BMP implementation. NRCS agreed to provide MassDEP will with information that did not specify the specific location of the BMP.

NRCS provided an Environmental Quality Incentives Program (EQIP) project list, which consisted of approximately 5,500 separate NRCS farm projects implemented since 2001 with accompanying information on the approximate location, type of BMP and definition, the size coverage (acreage) of each BMP, and other pertinent information related to NRCS activities. NRCS specifically requested that this project list not be included in this report nor be distributed. NRCS did agree to allow MassDEP to provide a summary of the project list which is provided in Table 7 below. This table includes a listing of principal agricultural BMPs by watershed, the number of each BMP reported, with total BMP implementation coverage in acres for each watershed. In addition, Table 7 identifies applicable TN reduction efficiencies for each listed BMP.

Nine principal NPS agricultural BMPs were identified from the NRCS EQIP project list as the most commonly utilized in Massachusetts. NRCS formal classifications and definitions include the following:

1. **Composting Facility (NRCS #317)**: A composting facility is installed for the purpose of biological stabilization of waste organic material. The main purpose of this practice is to biologically treat waste organic material and produce humus- like material that can be recycled as a soil amendment (add- in) or organic fertilizer.
2. **Conservation Cover (NRCS #327):** This practice involves establishing and maintaining a protective cover of perennial vegetation on land retired from agricultural production. This practice reduces soil erosion and associated sedimentation from barren soil, improves water quality, and enhances wildlife habitat.
3. **Cover Crop (NRCS #340)**: This practice consists of growing a crop of grass, small grain, or legumes during off season periods of prime production periods for cropland, orchards, or vineyards. This practice mainly helps to prevent soil erosion from barren soil, and it also helps to improve overall soil fertility.
4. **Field Border (NRCS #386):** This practice consists of establishing a strip of perennial grass or shrubs at or around the edge of a field, to prevent soil erosion, provide pollution control, as well as provide a wildlife cover.
5. **Prescribed Grazing (NRCS #528)**: This practice involves the controlled harvest of vegetation by grazing animals, where removal of herbage by the grazing animals is

in accordance to animal consumption patterns and plant sensitivities, such that enough vegetation is left to prevent accelerated soil erosion.

6. **Residue and Tillage Management: No-Till/Strip-Till/Direct Seed (NRCS #329):** This practice maintains most of the crop residue on the soil surface throughout the year. The only tillage performed is a very narrow strip prepared by tractor sweeps, after which seeding and herbicide applications can occur. Benefits of this practice include reduction of soil erosion, and addition of organic material to the soil.
7. **Riparian Forest Buffer (NRCS #391):** A riparian forest buffer is an area (strip) of trees and/or shrubs located just adjacent to, or bordering a body of water. This strip of vegetation extends outward from the water body to: (1) create shade to reduce water body temperature; (2) improve habitat for wildlife and aquatic animals/organisms; (3) provide a food source for wildlife and aquatic animals/organisms; and (4) provide a buffer to filter out sediments and pollutants such as organic matter, fertilizer, and pesticides.
8. **Riparian Herbaceous Cover (NRCS #390):** The purpose of this practice is to establish or manage grasses, and/or sedges, rushes, mosses, ferns, or legumes as a transitional zone between upland drier areas and lower elevation aquatic habitats. Net effects of the practice include: (1) providing food and cover for fish, aquatic organisms, livestock and wildlife; (2) improve water quality, trap sediments, and increase water storage capacity; (3) reduce soil erosion; (4) increase carbon storage capacity in the biomass; and (5) enhance stream bank protection.
9. **Waste Storage Facility (NRCS #313):** This practice usually consists of some sort of constructed containment or enclosed facility to provide for temporary storage of waste material from the production of agricultural products, consisting of animal waste products or contaminated runoff from other types of agricultural activities.

1. NRCS BMP TN Load Reduction Estimates

NRCS indicated that oversight for all projects spans the project period plus approximately 3 years following project implementation. The project period for projects generally spans 3 to 4 years. As a result, for the purposes of this assessment, all NRCS projects on the EQIP project list with BMPs put in place from years 2008 to the beginning of 2012 were used to estimate TN reductions (lbs/yr) on an annual basis.

Using Appendix 1,"Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder," each of the nine principal agricultural BMP was activities were matched up with specific projects and respective BMP acreage coverages from the NRCS EQIP project list (years 2008-2012) to estimate TN loading reductions. The following 4 steps were followed to determine these loading reductions:

1. MassDEP used the TN agricultural export loading coefficient of 6.7 lbs/acre/yr as determined by the 2000 LIS TMDL for calculating TN loadings from agriculture (see Section IV of this report).
2. BMP acreage from the EQIP project list was used as well as relevant TN loading reduction efficiency or credit information as identified in the
3. The percent TN loading reduction efficiency or credit from "Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder Table" was multiplied by the export TN loading determined per acre per year (6.7 lbs/acre/yr) and again by the total acres for each BMP.

4. TN loading reduction credits for each of the nine agricultural BMPs listed for each watershed were then totaled (these totals are listed at the bottom of Table 7).
5. Finally, the estimated reductions were then compared with the overall agriculture TN annual reduction target determined in Section IV for entire Massachusetts LIS watershed (Connecticut, Thames, and Housatonic Basins).

The summary of TN information compiled from the EQIP project list for each of the nine (9) BMP categories by each individual watershed is provided in Table 7 below:

Table 7 - NRCS Total Nitrogen (TN) Reductions by BMP and Watershed

NRCS BMP TYPE (#)	Watershed	Total Number of BMPs	Total Acreage	Process/ Reference for determining TN Reduction	TN Reduction (Lbs/Yr)
COMPOSTING FACILITY (#317)	Ct. Mainstem	0	0	0.40 (Appendix 1 pp 1, Mortality Composters)	0
	Chicopee	1	3	" "	8
	Westfield	0	0	----	0
	Deerfield	0	0	----	0
	Millers	0	0	----	0
	Housatonic	0	0	----	0
	Thames	0	0	----	0
CONSERVATION COVER (#327)	Ct. Mainstem	9	175	0.39 (Appendix 1 pp 3-4 Grass Buffers, Coastal plain lowland	457
	Chicopee	8	50	"	131
	Westfield	4	25	"	65
	Deerfield	9	75	"	196
	Millers	1	2	0.39, (etc.)	5
	Housatonic	0	0	---	0
	Thames	1	7	"	18
COVER CROP (#340)	Ct. Mainstem	812	7,906	0.35(Appendix 1 pp 5, Cover Crop Std, Other Rye, Coastal Plain)	18,540
	Chicopee	111	704	"	1,651
	Westfield	107	1197	"	2,807
	Deerfield	248	2,336	"	5,478
	Millers	8	264	0.35, (etc.)	619
	Housatonic	26	163	"	382
	Thames	4	15	0.35, (etc.)	35
FIELD BORDER (#386)	Ct. Mainstem	3	16	0.39 (Appendix 1 pp 3-4 Grass Buffers, Coastal plain lowland	42
	Chicopee	0	0	---	0
	Westfield	0	0	---	0
	Deerfield	2	27	0.39, (etc.)	71
	Millers	0	0	---	0
	Housatonic	0	0	---	0
	Thames	0	0	---	0

NRCS BMP TYPE (#)	Watershed	Total Number of BMPs	Total Acreage	Process/ Reference for determining TN Reduction	TN Reduction (Lbs/Yr)
PRESCIBED GRAZING (#528)	Ct. Mainstem	99	525	0.09(Appendix 1, under Prescribed Grazing)	317
	Chicopee	125	561	"	338
	Westfield	52	334	"	201
	Deerfield	183	1,869	"	1,127
	Millers	20	99	"	60
	Housatonic	83	890	"	537
	Thames	55	414	"	250
RESIDUE AND TILLAGE MANAGEMENT (#329)	Ct. Mainstem	77	517	0.15(Appendix 1 pp 4, under Continuous No-Till)	520
	Chicopee	71	567	"	570
	Westfield	17	470	"	472
	Deerfield	21	138	"	139
	Millers	0	0	---	0
	Housatonic	0	0	---	0
	Thames	0	0	---	0
RIPARIAN FOREST BUFFER (#391)	Ct. Mainstem	39	674	0.56 (Appendix 1 pp 3,under Forest Buffer, Coastal Plain Lowlands	2,529
	Chicopee	4	82	"	308
	Westfield	2	37	"	139
	Deerfield	16	113	"	424
	Millers	0	0	---	0
	Housatonic	1	16	0.56, (etc.)	60
	Thames	0	0	---	0
RIPARIAN HERBACEOUS COVER (#390)	Ct. Mainstem	4	56	0.39 (Appendix 1 pp 3-4 Grass Buffers (incl. Herb. Cover),Coastal plain lowland	146
	Chicopee	0	0	---	0
	Westfield	0	0	---	0
	Deerfield	2	7	0.39, (etc.)	18
	Millers	0	0	---	0
	Housatonic	0	0	---	0
	Thames	0	0	---	0
WASTE STORAGE FACILITY (#313)	Ct. Mainstem	1	30	0.75 (Appendix 1, pp 1, Animal Waste Management)	151
	Chicopee	4	12	"	60
	Westfield	0	0	---	0
	Deerfield	4	41	0.75 (etc.)	206
	Millers	0	0	---	0
	Housatonic	1	23	0.75, (etc.)	116
	Thames	1	1	"	5
TOTALS		2,225	20,334		39,198

2. MDAR BMP Program and TN Load Reduction Estimates

MDAR activities are limited primarily to outreach and education in direct support of NRCS's EPICS program in Massachusetts. MDAR provided a list of 20 recent NPS BMP projects within the LIS watershed that the agency is actively involved with. Many of these projects received NRCS assistance. Table 8 provides a summary of these projects, including: BMP description, project location (county and watershed), acreage covered by the particular BMP, TN reduction (if applicable), and the reference for determining the TN reduction. The percent TN loading reduction efficiency or credit from the "Non-Point Source BMPs and Efficiencies Currently Used in Scenario Builder" was multiplied by the export TN loading (6.7 lbs/acre/yr) and again by total acreage covered by each BMP type. TN loadings were not determined for MDAR projects that received direct NRCS financial assistance, as it was assumed that TN reduction credits in these projects have were accounted for in the NRCS EQIP project list.

Table 8 - Recent Farm Related MDAR BMP Projects

MDAR BMP TYPE/DESCRIPTION	Location (County/ Watershed)	Acreage covered by the BMP	Reference for Determining TN Reduction	TN Reduction (lbs/yr)
Heavy Use Area (protective veg. cover/surfacing/install structures to prevent soil erosion -NRCS 561)/Manure Storage	Hampshire/ Westfield	60	Covered in NRCS EQIP Database	-----
Heavy Use Area (NRCS 561;313)	Franklin/ Connecticut	100	Covered in NRCS EQIP Database	-----
Manure Storage (Reception Pit) (NRCS 313)	Berkshire/ Housatonic	480	0.75 ,Appendix 1, pp 1 Animal Waste Mgt	2412
Heavy Use Area (NRCS 561)	Hampshire/ Connecticut	94	N/A (no TN reductions figured for this BMP)	N/A
Manure Storage	Worcester/ French	278	Covered in NRCS EQIP Database	-----
Zone Tillage (NRCS # –n/a)	Hampshire/ Connecticut	320	0.03,Appendix 1 pp 1,Conserv.Plans, Low Tillage	64
Manure and Milkhouse Waste Storage (NRCS 313)	Hampshire/ Connecticut	800	Covered in NRCS EQIP Database	-----
Ebb and Flow Bench System-Irrigation/Watering Control (NRCS 447)	Hampden/ Connecticut	.3	0.33,Appendix 1,pp 1,Water Control Structure	1
Compost Pad (NRCS 317)	Worcester/ Quinebaug	100	0.40, Appendix 1, pp 1, Mortality Composters	268
Fencing (NRCS 382)	Berkshire/ Housatonic	392	N/A	N/A
Manure Storage (NRCS 313)	Franklin/ Deerfield	20	0.75,Appendix 1, pp 1 Animal Waste Mgt	101
Manure Storage (NRCS 313); Feeding Pad	Berkshire/ Housatonic	150	Covered in NRCS EQIP Database	-----

MDAR BMP TYPE/DESCRIPTION	Location (County/ Watershed)	Acreage covered by the BMP	Reference for Determining TN Reduction	TN Reduction (lbs/yr)
Zone Tillage (NRCS # n/a)	Franklin/ Deerfield	150	0.03,Appendix 1 pp 1,Conserv.Plans, Low Tillage	30
Zone Tillage (NRCS # n/a)	Franklin/ Deerfield	710	0.03,Appendix 1 pp 1,Conserv.Plans, Low Tillage	143
Ebb and Flow Bench System-Irrigation/Watering Control (NRCS 447)	Franklin/ Deerfield	2	0.33,Appendix 1,pp 1,Water Control Structure	4
Fencing	Hampshire/ Connecticut	13	N/A	N/A
Pesticide Storage (NRCS- n/a)	Franklin/ Connecticut	420	N/A	N/A
Manure Storage/Feed Pad (NRCS 313)	Berkshire/ Housatonic	150	Covered in NRCS EQIP Database	---
Underground Outlet (NRCS 620)	Franklin/ Deerfield	36	0.33,Appendix 1,pp 1,Water Control Structure	80
Zone Tillage (NRCS # n/a)	Franklin/ Deerfield	350	0.03,Appendix 1 pp 1,Conserv.Plans, Low Tillage	70
TOTAL TN Reduction		4,625		3,173

Comparison of Estimated Agricultural TN Reductions to 10 percent Reduction Target

- The total estimated MDAR BMP TN loading reduction based on BMP implementation is estimated to be 3,173 lbs/yr.
- The total estimated NRCS_BMP TN loading reduction based on BMP implementation is estimated to be 39,198 lbs/yr.
- The combined estimated agricultural TN loading reduction based on BMP implementation is estimated to be 42,371 lbs/yr.
- The 10 percent agricultural NPS reduction target in the 2000 LIS TMDL (see Table 3) is 72,900 lbs/yr.
- Therefore, MassDEP estimates that the state has met 58 percent of its allocated agricultural NPS TN load reductions.

IX. Assessment of MassDOT Highway- Roadway BMPs Currently in Place

MassDOT Impaired Waters Program

MassDOT has implemented an Impaired Waters Program, a statewide program to implement stormwater improvements and minimize the effect of highway runoff associated to impaired waterbodies in the state. The resulting water quality improvements will benefit all residents and visitors to Massachusetts through improved health and recreational opportunities. The Program consists of two initiatives running on parallel tracks, first, to implement stormwater improvements associated with road and bridge projects programmed in the Statewide Transportation Improvement Program (STIP) and second, to implement stand-alone stormwater retrofit projects in impaired water segments where no roadway improvements are planned in the near future (MassDOT, 2011).

One of MassDOT's highest priority tasks is to complete a statewide watershed analysis to identify roadway areas maintained by MassDOT that contribute stormwater runoff to impaired waterbodies. Initially, as many as 684 impaired waterbody segments were identified as being within close proximity of a MassDOT roadway. Based on a GIS-based analysis and field work, the number of impaired segments receiving MassDOT stormwater was reduced to 255. The remaining 429 impaired segments were eliminated because they were upgradient of the MassDOT stormwater outfall.

The 255 impaired waterbody segments identified during this analysis will be assessed in greater detail to determine the extent to which MassDOT stormwater may contribute to the impairment(s). MassDOT intends to assess 20 percent of the 255 impaired segments annually, completing the statewide assessment within 5 years; the assessment began in 2010.

For identified impaired waterbody segments without a TMDL, MassDOT is using EPA Region 1's Impervious Cover (IC) Method. The IC Method, as described in EPA's Stormwater TMDL Implementation Support Manual (Nov. 2010), assesses potential stormwater impacts on an impaired waterway and evaluates the level of impervious cover reduction required to minimize the contribution of highway stormwater to existing impairments. The IC Method relates an aquatic system's health to the percentage of impervious cover in its contributing watershed. A significant decline in water quality (i.e., the impairment threshold) has been shown to occur when the percent of impervious cover in a watershed exceeds 10 percent, and severe impairment can be expected when impervious cover within a watershed exceeds 25 percent. Consistent with the findings of EPA and others, when a watershed has less than 9 percent impervious cover, MassDOT concludes that stormwater would not be a likely cause of the water quality impairment.

A watershed's "effective impervious cover" is determined by calculating the amount of connected impervious area within a particular watershed that directly discharges to a nearby water body. Through this program, MassDOT seeks to reduce its contribution to the effective impervious cover within impaired watersheds through the use of stormwater BMPs that act to "disconnect" and reduce the effective impervious cover, promote ground water recharge and treat stormwater runoff associated with roadway areas. The goal is to reduce the effective impervious cover to 9 percent or less.

Implementation of MassDOT's Impaired Waters Program consists of the following four components:

1. **Programmed Projects Using the MassDOT Water Quality Data Form.** The Impaired Waters Program has been implemented statewide and has been facilitated using MassDOT's Water Quality Data Form. This interactive spreadsheet cross-references the water body receiving highway runoff with the Mass DEP 303(d) list of impaired waters. The Water Quality Data Form highlights the impairment status of the receiving water and provides recommendations regarding the installation of stormwater BMPs. This form also serves to track BMPS that were installed for any given project, thereby assisting with annual NPDES reporting requirements and eventually leading to a more efficient Operations and Maintenance schedule.

   A typical project requires the completion of various sections of the Data Form at different points of project development. The 25 percent design tab of the Water

Quality Data Form is submitted along with the other requirements of MassDOT's 25 percent Early Environmental Coordination Checklist. By completing this portion of the Data Form, the project designer can determine the impairment status of surface waters receiving stormwater discharges. If the receiving water is not meeting its attainable uses, the Data Form will prompt the designer to incorporate stormwater BMPs into the project design to mitigate the "pollutant(s) of concern." At that stage, the designer must assess the existing stormwater system on-site and determine its effectiveness in removing identified pollutants. If the existing system does not meet the target removal rates, then appropriate BMPs must be designed and incorporated into the project. To aid MassDOT in project tracking and annual NPDES compliance reporting, these pollutant removal achievements for each project are tracked using a part of the Water Quality Data Form known as the 75 percent Design Tab, which includes 75 percent design plans.

2. **Statewide Transportation Improvement Program (STIP) Aspects**. MassDOT has aggressively initiated the Impaired Waters Program into its road and bridge project development process. Examples of MassDOT's achievements thus far include more than 100 projects on the STIP that have been assessed for impacts to impaired waters utilizing the Water Quality Data Form. As a result of this analysis, additional stormwater BMPs have been added to many of these projects to reduce the impact of highway stormwater on impaired receiving waters. In addition, the entire 2011 Interstate Maintenance and National Highway System (IM/NHS) resurfacing projects have been assessed. BMPs are being designed and incorporated into final project plans, where appropriate.

3. **Retrofit Projects**. The stormwater retrofit component of the Impaired Waters Program entails mitigating stormwater discharges to impaired water bodies at locations where there is no future STIP related work planned. The first step in developing this approach involved compiling a list of impaired water segments that occur within close proximity and downstream of MassDOT highway outfalls. MassDOT has identified 255 outfalls of this type. MassDOT has committed to assessing 20 percent of these impaired segments every year for the next five years through its NPDES compliance contractor. These site assessments will generate recommendations for the installation of BMPs for stormwater mitigation.

   As described in the section above, assessments are being performed using an EPA approved methodology that uses impervious cover as a surrogate for stormwater related impairments. Using the "impervious cover method," any contributing watershed to an impaired segment comprised of more than 10 percent impervious cover is determined to be impaired by stormwater related pollutants. To mitigate for the effects of imperviousness, infiltration and detention BMPs are implemented to simulate pre-development "pervious" conditions. This percent reduction in watershed imperviousness is applied to all land uses in the watershed. MassDOT will develop retrofit projects to achieve our prescribed removal rates.

4. **Statewide Training**. Several statewide trainings have been conducted to familiarize in-house design, project, environmental, and maintenance staff with the requirements of the Impaired Waters Program. To date these trainings have

reached over 130 MassDOT staff at headquarters and in the district offices. Additional training sessions for design consultants reached 108 people, representing 63 different engineering and design firms.

In the first year (Federal Fiscal Year 2011) of implementation of the Impaired Waters Program, $60 million was earmarked for all MassDOT stormwater related projects. In mid- year 2012, MassDEP made contact with officials in MassDOT to determine their interests in contributing to the overall Massachusetts LIS NPS BMP assessment study. MassDOT currently owns and maintains approximately 5,000 miles of roadways in the Massachusetts LIS study area (MassDOT, 2012). The study area is made up of basically District 1, 2, and 3 areas (refer to Figures 10, 11, and 12 respectfully). The MassDOT Environmental and Operation and Maintenance (O & M) Program consists of a comprehensive effort in conjunction with ongoing upkeep of the roadways managed by MassDOT. Besides roadway resurfacing and bridge repair work, much effort is spent in BMP related work associated with road drainage both on the highways and areas just adjacent to them. This includes retrofitting and repairing catch basins and drainage pipes, catch basin and drainage pipe cleaning, detention basin and swale construction and maintenance, and other BMP projects to properly regulate stormwater drainage both on and off the roadways.

1. MassDOT BMP Implementation and TN Load Reduction Estimates

MassDOT officials in Boston contacted the Directors in each of the three District Offices. A survey process, similar to the one used for communities (see Section V) was sent to each MassDOT District office. Tables 9, 10, and 11 provide a summary of stormwater BMPs implemented by each District Office. Table 12 provides the estimated TN reductions for all three Districts. According to the MassDOT survey results, BMPs implemented have resulted in an estimated reduction of 78,627 lbs/yr TN.

Figure 10 – MassDOT District 1 Territory

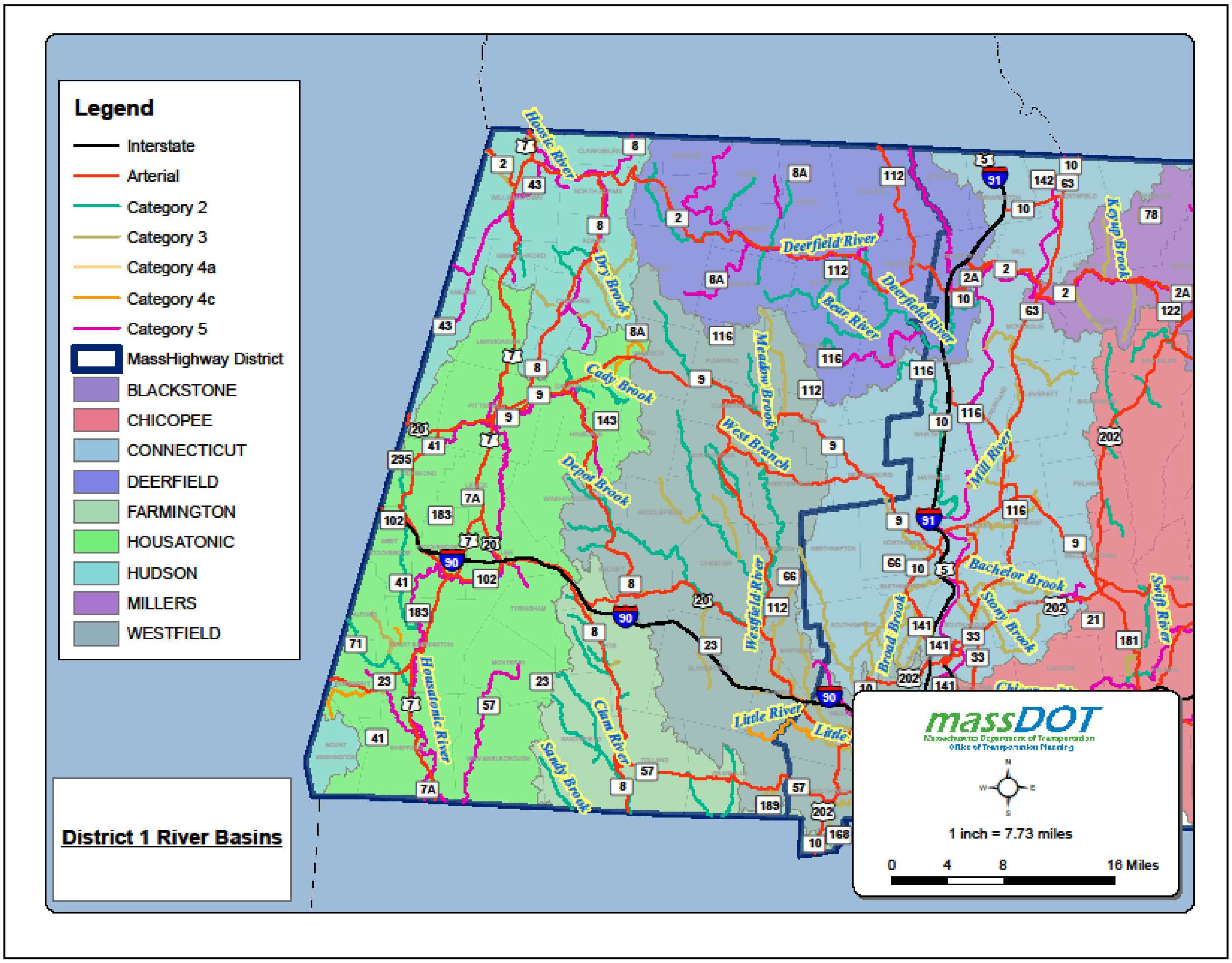


Table 9 - District 1- Stormwater Related BMP Projects*

Housatonic River Watershed			
Town	**Route**	**Project**	**Urban BMPs Implemented**
Chester-Huntington	20	602314	Catch Basin (15 cu/yds) and Pipe Cleaning (400 m)*
Lee	20	603548	Catch Basin (75 cu/yds) and Pipe Cleaning (200 m)*
Lenox	7 & 20	606261	Pipe Cleaning (24 ft)
	7A-Kemble St.	601886	5 Drop Inlets; 9 Catch basins-Catch Basin Retrofits, Deep Sump,etc.
	7A-Kemble St.	601886	Grass swales 731 M X 6' wide; Filter strips 126 M X 20'wide*
	Intersect. 7 & 20	603655	Grass swales 720M X 6' wide(.3 acre); Filter strips 2150' M X 20'wide (1 acre)*
	Intersect. 7 & 20	603855	Wetlands Replication, 4040 sq ft (.1 acre); sediment trap, 350 sq ft*
	7A-Kemble St.	601866	Sediment Forebays, 2 each, 91 sq M total (.02 acres)*
Adams	Route 166	603550	Catch Basin (25 cu/yds) and Pipe Cleaning (650')*
	Route 166	603550	Filter Strips 1372' X 20'(.6 acres)*
Districtwide- Housatonic, Westfield, Farmington, Conn. Mainstem, Deerfield Watersheds			
Town	**Route**	**Project**	**Urban BMPs**
All towns	All routes	Dist-wide	Street Sweeping detritus collected- 3,852 cubic yards, or 5,778 tons of detritus collected per year*
All towns	All routes	Dist-wide	Catch Basin cleaning detritus collected- 3,500 cubic yards or 5,250 tons per year*

* Represents BMPs where TN reductions can be estimated.

Figure 11– MassDOT District 2 Territory

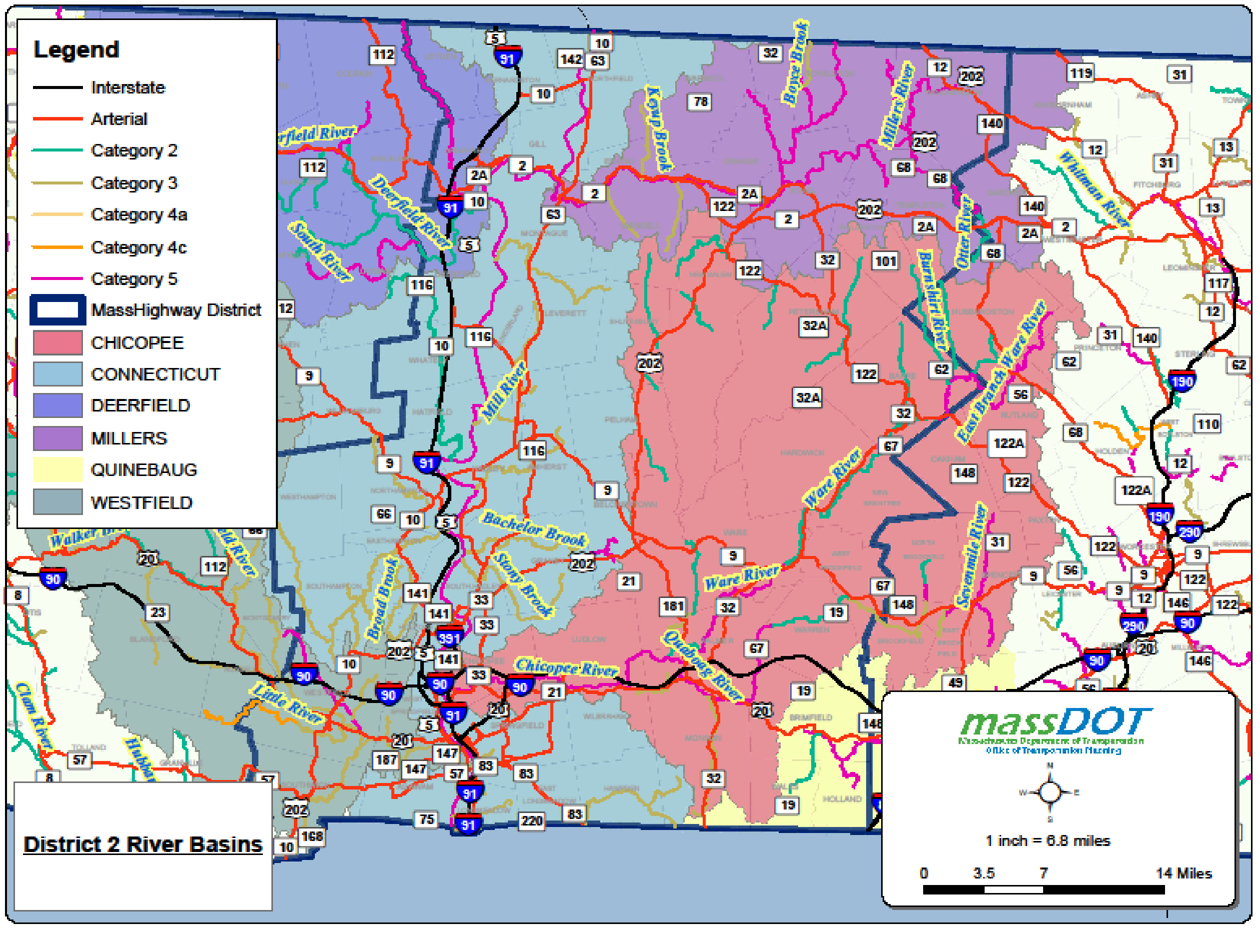


Table 10 - District 2-Stormwater Related BMP Projects *

Chicopee River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Barre	32 over Ware River	60511	Vegetative Swale; Deep Sump Pump Catch Basins
	122 over Prince River	605084	Clean pipe sediment; Deep Sump Pump Catch Basins
	Vernon Ave/Ware River	603566	DSCBs(removal of pipe sediments)
Brimfield-Palmer	Kings Br over Quaboag River	603705	RDDPS-removal and disposal of Pipe Sediments
Granby-Ware	Ware Depot	605751	Removal of Drainage Pipe Sed.; Sedimentation basin construction
Ludlow	East & Chapin Sts.	604437	Deep Sump Catch Basins; Removal/Disposal Pipe Sediments
Monson	Lower Hampden Road	601502	DSCBs and Stone for Pipe Ends
Orange	Route 2	602942	RDDPS; Plunge Pool; Detention Basin w. Forebay
Palmer	Springfield St. Reconstruction	602575	Vegetative Swales; Sediment Traps; RDDSS
	State St. over Ware River.	604030	Deep sump catch basins; SFPE
	67 Bridge reconstruction	605529	Remove Drainage Structure & Pipe Sediments
Petersham	32 and 12 intersection	603794	RDDPS; 2 Vegetated Swales; Stone for Pipe Ends
Shutesbury	Prescott & Cooleyville Rd.	601561	Deep sump catch basins; RDDPS; Bio-retention basins
Greater Springfield Area	I-91 & I-291	605810	RDDPS throughout roadways; Deep sump catch basins
West Brookfield	9	602662	Clean Drain Structures/Pipes; stone for pipe ends; hardening shoulders to prevent erosion
Wilbraham	Post Office Park	604205	Deep sump catch basins; infiltration trenches construction (75' X 150'); street sweeping*
Connecticut River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Amherst	116,Country Corners Rd to Hampshire College	604043	RDDPS; 54 Deep sump catch basins; Porous Pavement; 12,325 sq ft Wetland Replication; .85 acres Veg. Swales*
	Routes to Wildwood Elementary, &Amherst Regional Middle Schools.	606229	RDDPS; 4 Deep sump catch basins
	Meadow St., over Swamp Brook	603585	2 Deep sump catch basins; 45 sq ft grassy swale*
Bernardston	Rtes 5 & 12 intersection reconstruction	602241	29 Deep sump catch basins
	116 (Center St)	603996	38 Deep sump catch basins; Stone for Pipe Ends

Connecticut River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Chicopee- South Hadley	33 Resurfacing and Repairs	605620	2 Deep sump catch basins; 6 Standard catch basins to deep sump
Chicopee-Holyoke	116, over Connecticut River	082611	RDDPS(removal drainage structure pipe discharge)
Deerfield-Whatley	Intersection & Signal improvements	606217	2 Deep sump catch basin; redirect discharge from 2 catch basins currently going into resource area to grass infield between I-91 main line & off ramp
East Longmeadow	Red stone Trail- Construction of a Bike path	602338	Grass ditches; Drainage to grass shoulders
Easthampton	Hendrix St over Broad Brook	604464	RDDSS-Removal-disposal of drainage system sediments; SFPE
Gill- Montague	Avenue ‘A’ over Conn. River	601585	100’ long drainage pad to outlet area
Granby	Aldrich St. over Bachelor Brook	603797	2 Vegetative Swales;
	202, Resurfacing	604520	Stone Swale
Greenfield	Traffic signal improvements@ 8 intersections	604062	13 Deep sump catch basins; RDDSS-Removal-disposal of drainage system sediments
Hadley	Mt.Warner Rd over Mill River	600754	7 Deep sump catch basins; 2 Grass Swales
Hampden	Chapin Rd over Scantic River	604442	2 Deep sump catch basins;
Holyoke	202 over B&MRR Bridge	603735	RDDSS-Removal-disposal of drainage system sediments; 5 Hooded deep sump catch basins
	Pleasant St/YaleSt/Northampton St	602295	RDDSS-Removal-disposal of drainage system sediments; 23 Deep sump catch basins w. inlet sediment control devices
Leverett	63 over NECRR	603689	RDDSS-Removal-disposal of drainage system sediments; 2 Deep sump catch basins; Clean drainage pipes
Monson	Lower Hampden Rd reconstruction	601502	Deep sump catch basins;Rip rap slopes; Settling basin; Grass ditches
Northampton	Earl St intersection improvements	604451	RDDSS-Removal-disposal of drainage system sediments; Deep sump catch basins; Modified rock filled slopes
Shutesbury	Leverett Prescott & Cooleyville Rd reconstruction	601561	RDDSS-Removal-disposal of drainage system sediments; Deep sump catch basins; Water Quality swale; Bio-retention basin
South Hadley	47 over Batchelor Brook	603260	Deep sump catch basins; SFPE
Springfield	Amtrack Overpass to Osgood St Infrastructure Improve.	604449	RDDSS-Removal-disposal of drainage system sediments; 17 Deep sump catch basins; Clean drainage pipes
	Parker St. Reconstruction	600551	Install sedimentation chamber/plunge pool @Loon Pond; 2 Deep sump catch basins

Connecticut River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Springfield-Wilbraham	20 reconstruction	605213	Catch basins with hooded sediment sumps
Ware	Maint.depot resurfacing, etc	605751	RDDSS-Removal-disposal of drainage system sediments; Sedimentation basin w. outlet structure
West Springfield	5 Reconsrtuct. From I-95 to Monterey Drive	604210	RDDSS-Removal-disposal of drainage system and pipe sediments; 2 Deep sump catch basins
	Off I-91 extend north over Conn. River(maint.resurfacing)	605587	RDDSS-Removal-disposal of drainage system and pipe sediments; 12 Deep sump catch basins; Clean paved waterways
Whatley	Park and Ride	604222	Detention Basin w/Forebay; Porous pavement
Deerfield River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Deerfield	5 & 10 Culvert replacement	602795	Clean sediment from unnamed intermit. Stream bottom/install reinforced turf mats in channel
Greenfield	Traffic signal improvements @ 8 intersections; 2/2A rotary improvements	604062	RDDSS-Removal-disposal of drainage system and pipe sediments; 13 Deep sump catch basins; other Deep sump catch basin installations @ 2/2A
Millers River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Athol-Phillipston	2 Safety Improvements	602943	Deep sump catch basins; Detention basins incl forebays (1.17 acres);stone/grass swales, incl 1.46 acres vegetated swales;0.26 acres rock/riprap swales*; RDDSS
Athol	2A (South Main St.) Improvement	602151	RDDSS-Removal-disposal of drainage system and pipe sediments; Deep sump catch basins installation
Erving	Relocation of Rte 2@ Erving Paper Mill/Reconstr/Improvements	602941	2 Detention basins w. forebays; Vegetated swales; Stone for pipe ends; Deep sump catch basins
			Dry detention ponds; 5 Wet Ponds* totaling 8.39 acres*
Orange	2, Reconstruction	602942	Deep sump catch basins;TRM lined ditches; Grassy Swales;3 Detention basins w. plunge pools; RDDSS; Wildlife passage area
Templeton	No.Main St.,over E Templeton Pond	604366	2 Deep sump catch basins
	202 Reconstruction/resurfacing	600259	Deep sump catch basins; RDDSS-Removal-disposal of drainage system sediments; annual street sweeping

Millers River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
	101 (Dudley Rd.) reconstruction	600721	Deep sump catch basins; RDDSS-Removal-disposal of drainage system sediments; vegetative swales installed
	2 Resurfacing & related	604509	Removal-disposal of drainage system sediments; Cleaning paved waterways
Winchendon	202 over No. Branch, Millers River	602853	Deep sump catch basins outlet to leaching basins;
	202(Glen Allen St.) over Millers R.	602853	Deep sump catch basins; 2 Leaching catch basins; Removal-disposal of drainage system sediments
Westfield River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Southwick	202 Reconstruction	605154	0.6 acre Detention basin w. riser/overflow structure; 0.23 acre Detention basin w. forebay*; 83 Deep sump catch basins; Stone for Pipe ends
West Springfield	20 (Westfield St.)	604737	43 Deep sump catch basins; RDDSS-Removal-disposal of drainage system sediments
Westfield	Reconstruction 20 (Main St) & 10/202 (Broad St.)	603318	88 Deep sump catch basins; RDDSS-Removal-disposal of drainage system sediments
OVERALL DISTRICT HOUSEKEEPING ACTIVITIES			
Town	**Route**	**Project**	**Urban BMPs**
ALL TOWNS	ALL ROUTES (See Map Dist 2 above)	General	**Street Sweeping detritus collected- 3,000 cubic yards, or 4,500 tons per year***
ALL TOWNS	ALL ROUTES (See Map Dist 2 above)	General	**Catch Basin cleaning detritus collected- 2,100 cubic yards or 3,150 tons per year***

* Represents BMPs where TN reductions can be estimated.

Figure 12- MassDOT District 3 Territory

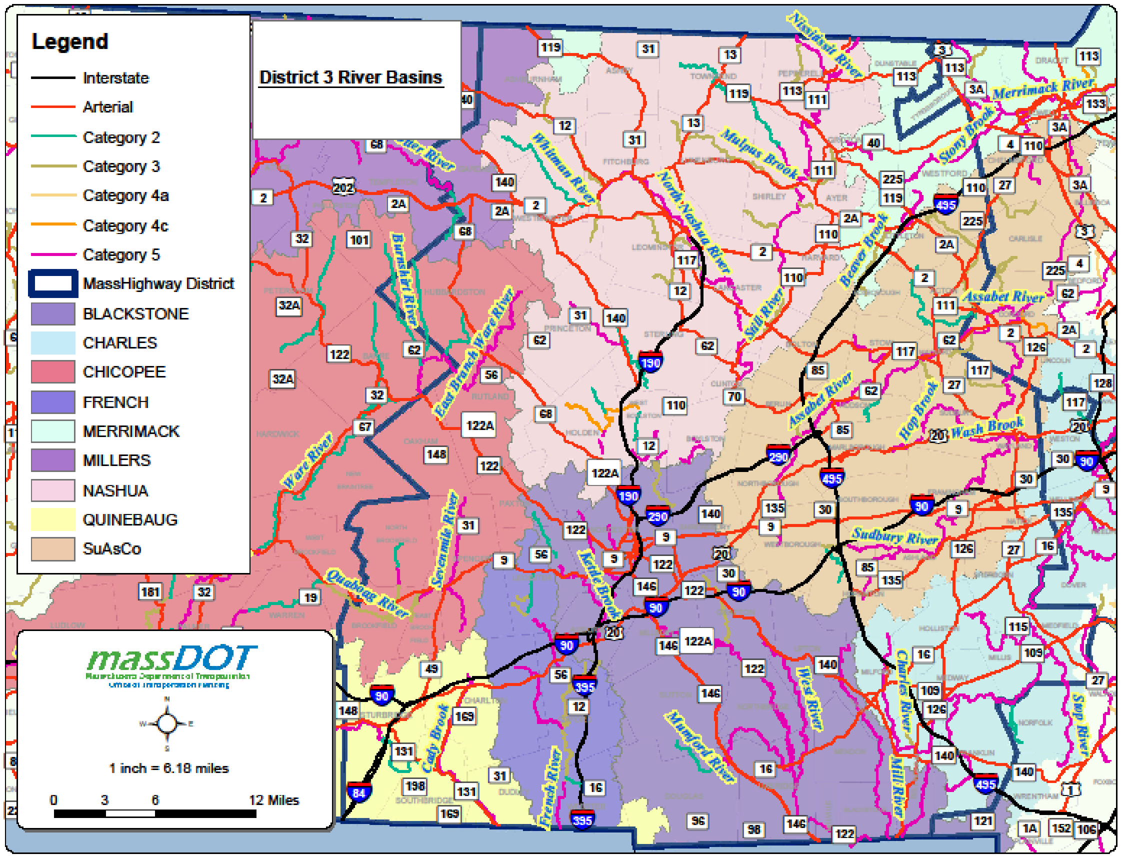


Table 11 - District 3 Stormwater Related BMP Projects*

Chicopee River Watershed			
Town	**Route**	**Project**	**Urban BMPs**
Hubbardston	62	601960	Deep sump catch basins
			Swales (constructed)
			Dry detention ponds
			Erosion and sedimentation controls during construction
Rutland	68	603485	Deep sump catch basins
			Swales (constructed)
			Erosion and sedimentation controls during construction
Spencer	49	606451	Deep sump catch basins
			Swales (constructed)
			Erosion and sedimentation controls during construction
French River Watershed			
Town	Route	Project	Urban BMPs
Oxford	I-395	605759	Deep sump catch basins
			Swales (constructed)
			Dry detention ponds; 5 Wet Ponds totaling 8.39 acres*
			Infiltration practices without sand, vegetation
			Erosion and sedimentation controls during construction
Quinebaug River Watershed			
Town	Route	Project	Urban BMPs
Dudley	31	604374	Deep sump catch basins
			Erosion and sedimentation controls during construction
Southbridge/ Sturbridge	131	601223	Deep sump catch basins
			Swales (constructed)
			4 Wet Detention/Retention Basins totaling 5.47 acres*
			Erosion and sedimentation controls during construction
Southbridge	169	602961	Deep sump catch basins
			Erosion and sedimentation controls during construction

OVERALL DISTRICT HOUSEKEEPING ACTIVITIES			
Town	**Route**	**Project**	**Urban BMPs**
ALL TOWNS	ALL ROUTES (See Map Dist 3 above)	General	**Street Sweeping detritus collected- 1,250 cubic yards, or 1,870 tons per year***
ALL TOWNS	ALL ROUTES (See Map Dist 3 above)	General	**Catch Basin cleaning detritus collected- 70 cubic yards or 103 tons per year***

* Represents BMPs where TN reductions can be estimated.

Table 12 - Total Nitrogen (TN) Loading Reductions for Districts 1, 2, 3

Roadway BMP Type/Description	Total Acreage,# of Units, or lbs (Tons) Detritus Removed	TN Reduction Calculation (Reference for Determining TN Reduction)	Total TN Reductions in lbs/Year
Catch Basin Cleaning	7,202 cu.yds. (10,798 tons)	conv. 1.5 tons/cu yd X tons X 5.83 lbs TN/ton X 0.7 dry wt. factor (Appendix 2)	44,067
Street Sweeping	6,570 cu.yds. (9,853 tons)	conv. 1.5 tons/cu yd X tons X 5 lbs TN/ton X 0.7 dry wt. factor (Appendix 4, pp52)	34,486
Grassy Swales, Bioswales	.501 acres	(Grass channel) .10+.45/2 + bioswale (.7)/2 X 11.9 X.501 acre (Appendix 4, pp 31)	4
Filter Strips	1.8 acres	.5 X 11.9 X 1.8 (Appendix 4, pp 30)	11
Wetland Replication- Wet Ponds	8.49 acres	.2 X 11.9 X 8.49 (Appendix 4, pp 30)	20
Erosion Control- Sediment Forebays	0.02 acres	.25 X 11.9 X .02 (Appendix 1, pp 2)	0.06
Infiltration Trench (Ditch)	.13 acres	.80 X 11.9 X .13 (Appendix 1, pp 2)	1
Vegetated Conveyance Channels	.3 acres	.45 X 11.9 X .3 (Appendix 1, pp 2)	2
Vegetated Swales	2.54 acres	Bioswale: .70 (efficiency) X 11.9 X 2.54 (Appendix 4, pp 31)	21
Detention Basins (Wet)	5.47 acres	Wet Ponds: .20 X 11.9 X 5.47 (Appendix 4, pp 31)	13
Detention Basins (Dry)	2 acres	.05 X 11.9 X 2 (Appendix4, pp 31)	1
Total MassDOT TN Reductions			78,627

X. Assessment of Section 319 Grants for BMP Implementation

The majority of Massachusetts Section 319 funds are directed to implementation projects that address the prevention, control, and abatement of NPS pollution. MassDEP's grant program favors work that will result in meeting water quality standards and restoring beneficial uses, (i.e., in removal of the waterbody from the 303(d) list). Projects that will implement measures which have been recommended in lake diagnostic/feasibility studies or other evaluations that address water quality problems are also encouraged for funding under the 319 program. Work in stormwater regulated areas is generally not eligible to receive 319 funding.

Besides implementation projects, the Massachusetts 319 program considers proposals for demonstration projects, including projects that will evaluate new and innovative BMPs, technologies, or institutional approaches; and accelerate the transfer and adoption of these new and innovative BMPs, technology or institutional approaches. Preference is given to technologies that will directly lead to measurable water quality improvements.

EPA developed and instituted a management tracking system, known as the Grants Reporting Tracking System (GRTS), to track Section 319 grant projects, including nutrient reduction statistics for BMPs put in place. An Excel spreadsheet, with relevant nutrient removal information derived from the GRTS database, is available to states. For the purposes of this assessment, MassDEP used the GRTS database to look at Section 319 funded projects since 2001 that were implemented within the Massachusetts LIS watershed. MassDEP primarily looked at projects that included a BMP installation resulting in TN reductions (see Table 13). States have only recently been required to enter nutrient reductions and the geographic location for projects, so this information may not be available for all projects.

1. 319 Program BMP Implementation and TN Load Reduction Estimates

Table 13 provides a summary of NPS BMPs implemented with 319 funding in the Massachusetts LIS watershed. Included at the bottom of the table is the estimated TN reduction for all projects. According to the information pulled from the GRTS database, 319 funded BMPs implemented have resulted in an estimated reduction of 499 lbs/yr TN.

Table 13 - Massachusetts LIS Watershed 319 Projects with Estimated TN Reductions

319 Grant Project Title	Award Year	Brief Project overview/objectives	BMP type	# of Units	Estimated TN Reduction lbs/yr
Oak Hill Tributary Improvement Project	2004	To install Riparian Buffers and other flow retarding BMPs to prevent downstream flooding	Catchbasins; Constr.wetland; Sediment Forebay& Control basin	16	297
Orange Riverfront Park LID Techniques	2004	LID Techniques in lieu of traditional stormwater BMPs	Raingarden/bio-retention basins; Vegetated swales	7	2
River Street BMP Implementation Project	2004	Install LID Techniques in lieu of traditional Stormwater BMPs	Catch basin(Leaching); Infiltration /Leaching Basins	11	171
Windsor Reservoir restoration Project	2004	Stabilize roadways(sidings) by installing stormwater and flood preventing BMPs	Sediment Forebay; Vegetated Swales; Sediment Control Basin	3	14
Congamond Lakes Restoration Projects	2004, 2009	Sediment loading & associated pollutants reduced; invasive weeds decrease; targeted outfalls clear of debris	Sediment Forebay; Vegetated Swales(3); Sediment Control Basins(3)	7	3.7 acres total; 15 lbs/yr
Total TN Loading Reductions for 319 projects					499

XI. CSO Progress—Lower Chicopee Basin

The LIS TMDL workgroup determined that for the LIS TMDL, CSO discharges will be considered NPS. The elimination and control of CSO discharges have been a MassDEP and community priority for over a decade. This activity has, and continues to occur in communities in the lower parts of the Chicopee and Westfield basins (along with their tributaries) and portions of the Connecticut River mainstem and its immediate tributaries in the vicinity of Springfield, Massachusetts. In addition to the City of Springfield communities that have been involved include Palmer, Ludlow, South Hadley, West Springfield, Agawam, Chicopee, and Holyoke. Over $100 million in combined federal, state, and local community monies have been spent on these efforts. Four major milestones reached as of the end of Calendar 2010 included (Boisjolie, 2011) the following.

1. The cumulative annual volume of untreated CSO discharge in the Massachusetts LIS watershed has been reduced by approximately 1 billion gallons/year, from approximately 1.742 billion gallons/year in 2000 to 741 million gallons/year in 2010.
2. Eighteen miles of the Chicopee River and its tributaries, running west from the Palmer/Warren town line to Springfield's CSO # 37, (Cedar Street, Indian Orchard), no longer have CSO's. An additional five miles of Chicopee River running west from Springfield's CSO #37 to Chicopee's CSO #37 (East Main Street, Chicopee Falls), have been reduced to four discharges per year as a result of projects completed in 2009 and 2010 in Springfield, Ludlow, and Palmer. The remaining three miles of Chicopee River, running west from Chicopee CSO #37 to the confluence with the Connecticut River, will have CSO's eliminated by 2029 as identified in Chicopee's 2009 Final Long Term Control Plan (FLTCP).
3. The number of CSO regulators has been reduced from approximately 149 to 70. Of the 70 remaining active CSO regulators, there are plans to eliminated 30 by 2029, 20 additional CSOs have a planned level of control of no more than four untreated discharges per year. The remaining 20 CSO regulators do not currently presently have an identified intended level of control.
4. As a result, five former CSO communities, (Ludlow, Palmer, South Hadley, West Springfield, and Agawam), have eliminated CSO discharge in Western Massachusetts since 2000.

Table 14 below summarizes CSO related- work plus other CSO accomplishments and planned activities within the region (Boisjolie, 2011).

Table 14 – Massachusetts LIS Watershed CSO Status, as of June 24, 2011

CSO Cities in the Massachusetts portion of the LIS Study Area	Receiving Water	Number of CSO Regulators		Volume of Untreated CSO: Million Gallons/yr (MG/yr) (estimated)		Intended Community CSO Level of Control (LOC)[1] and Status[2] (see footnotes below)	Comments
		Former	Existing Dec 2010	Former	Existing 2010		
Palmer	Chicopee River, tributaries	29	*0*	32.3	*0*	*A - 1*	Elimination of Last Remaining CSO Regulator in Dec 2010
Ludlow	Chicopee River	9	*0*	11.5	*0*	*A - 1*	Elimination of Last Remaining CSO Regulator in July 2010
South Hadley	CT River & small tributaries	11	*0*	16.9	*0*	*A - 1*	Elimination of Last Remaining CSO Regulator in Dec 2007
West Springfield	CT River & Westfield River	8	*0*	36.1	*0*	*A - 1*	Elimination of Last Remaining CSO Regulator in 2000
Agawam	CT River & Westfield River	14	*0*	5.5	*0*	*A - 1*	Elimination of Last Remaining CSO Regulator in 2000 [monitor CSO # 011]
Remaining CSO Communities, 2010 (See Individual Tables, attached)		(From DLTCP's[3])			(from CY 2010 CSO Reports)		
Montague	CT River	3	3	7.0	0.5	B - 2	2006 FLTCP[4], LOC of 4 untreated discharges/yr, or less, per regulator
Holyoke	CT River	15	14	516.6	84.4	U	FLTCP yet to be required
Chicopee	CT River & Chicopee River	33	29	484.9[5]	166.1[6]	B - 3	2009 FLTCP elimination of all CSO's to *Chicopee* River and CT River except for one remaining CSO (#07.1) to CT River, by 2029. CSO #07.1 LOC 4 untreated discharges/yr.
Springfield	Connecticut River, Chicopee River, & Mill River	27	24 (& WWTP Bypass # 42)	631.3[7]	490.0[8]	U	FLTCP required by May 2012, Springfield in process of developing FLTCP and proposed LOC

CSO Cities in the Massachusetts portion of the LIS Study Area	Receiving Water	Number of CSO Regulators		Volume of Untreated CSO: Million Gallons/yr (MG/yr) (estimated)		Intended Community CSO Level of Control (LOC)[1] and Status[2] (see footnotes below)	Comments
		Former	Existing Dec 2010	Former	Existing 2010		
Cumulative		**149**	**70**	**1,742.1 MG/yr**	**741.0 MG/yr (2010)**	Of 70 remaining CSO Regulators, 50 have intended LOC of "A" (eventual elimination) or "B" (4 untreated discharges) identified. 16 are "B -1" LOC & Status (completed), 4 are "B -2" (designed/under construction), 2 are "A-2"and 28 are "A-3". The 20 CSO regulators without identified LOC's to date are in Springfield and Holyoke	
Cumulative Reduction		**79 Regulators Eliminated**		**1,001.1 MG/yr (approx One Billion Gal/yr) Eliminated**			

[1] Intended CSO: **A**: Elimination of CSO discharge, **B:** Four Untreated discharges per year, or less (Class B-CSO),
Level of Control **(LOC) codes** **C:** More than Four untreated discharges per year (Class C),
U: Unknown, not identified at present
[2] LOC *Status* codes: **1:** LOC *Construction* Completed **2**: LOC *Design* Completed, **3**: LOC proposed in CSO Final Long Term Control Plan
[3] Draft Long Term Control Plan
[4] Final Long Term Control Plan
[5] (341.7 CT River; 142.6 Chicopee River; 0.6 Williamansett Brook)
[6] (91.4 CT River; 74.1 Chicopee River; 0.6 Williamansett Brook)
[7] (547.6 CT River; 22.5 Chicopee River; 61.2 Mill River)
[8] (480.2 CT River; 1.6 Chicopee River; 8.2 Mill River)

Of the 1 billion gallons of CSO discharges that have been abated annually, approximately 500 million gallons (MG) have been totally eliminated, 100 MG are captured and returned to a wastewater treatment plant (WWTP) for full treatment, and 300 MG is treated effluent from CSO treatment facilities are is subsequently discharged to the river. To estimate TN reductions from these CSO discharge reductions, MassDEP looked at monitoring records that indicated an average TN concentration in CSO discharges is 10 mg/L. A TN concentration of 5 mg/l was used for the portion of the CSO discharge that was sent to the WWTP for processing.

MassDEP used the following calculation to determine TN reductions from the CSO abatement efforts:

- Baseline CSO Load: 1,800 MG/yr x 8.34 lbs/G x10 mg/L = 150,120 lbs/yr (75.1 tons/yr)
- Existing CSO Load: (900 MG/year x 8.34 lbs/G x 10 mg/L) +(100 MG/year x 8.34 lbs/G x 5 mg/L) + (300 MG/yr x 8.34 lbs/G x 10 mg/L) = 104,250 lbs/yr (52.1 tons/yr)
- Total removed: 150,120 lbs/yr - 104,250lbs/yr = 45,870 lbs/yr (22.9 tons/yr)

XII. Summary of TN Loading Reductions for the Massachusetts LIS Watershed

Based on MassDEP's assessment of BMP implementation throughout the Massachusetts LIS watershed, Massachusetts estimates that it has exceeded (by three-fold) it's LIS TMDL NPS load reduction targets. Table 15 summarizes MassDEP's estimated TN load reductions, based on BMP implementation throughout the state, the

LIS TMDL 10 percent reduction targets and the difference between the estimated load reduction and the TMDL target.

Table 15 - Summary of Estimated TN Reductions as Compared to the LIS TMDL 10 Percent NPS Load Reduction Target

Source	Estimated Reductions Achieved (lbs/yr)	10 percent target (lbs/yr)	Difference Between Estimated Reductions and LIS TMDL Target (lbs/yr)
Urban BMPs	701,422	180,460	599,589
MassDOT BMPs	78,627		
Agriculture BMPs	42,371	72,900	(30,529)
319 Program BMPs	499	---	499
CSO Abatement	45,870	---	45,870
Total	868,789	253,360	615,429

XIII. Data Gaps

This section summarizes the observed data shortfalls found in the process of gathering the NPS BMP information in Massachusetts. Where possible, it also attempts to identify why the shortfall may exist. Finally, it provides specific actions that MassDEP could consider to help make gathering information on the implementation of NPS BMPs easier and more straightforward in the future.

Comparisons Between 1990 Baseline Year and Present

During 2012 the LIS TMDL Workgroup discussed the feasibility of comparing: (1) land-use data, circa 1990, with present land-use data; and, (2) the relative effectiveness of TN reductions from BMPs in place in 1990 versus the present (2012). To address this issue, MassDEP attempted to compare land-use changes between the two eras and found a number of difficulties in making such comparisons. GIS technologies were in their infancy in 1990; they are now very sophisticated. Methodologies for developing and assimilating land-use information to create the GIS data layers for each of the two time frames is also very different, therefore, MassDEP has deemed that landuse maps from the two time periods are incompatible.

Making additional comparisons of TN reductions resulting from BMPs implemented between the 1990 and 2012 eras in the Massachusetts LIS watershed, also proved to be very difficult. BMP technologies have changed a great deal between the two period times and therefore may result in very different TN removal rates. State and federal programs have also evolved a great deal during the 1990's and early 2000's. Many of the programs that exist today and drive NPS BMPs implementation did not exist or were just coming together in 1990. Data collection requirements associated with these new programs and the installation of BMPs has increased significantly in complexity and volume since 1990. Finally, the demand for information related to TN reduction capabilities for BMPs is reasonably new.

The following is a brief summary of identified problems and issues associated with trying to compare BMP implementation efforts between 1990 and 2012. For ease of discussion, observations are categorized into different land-use types and correspond to their associated sections of this report.

1. Section VI: Assessment of Stormwater BMPs

In 1990 the City of Springfield was the only community covered under the NPDES Stormwater Program within the Massachusetts LIS watershed. In 1994, Phase II of that program began coverage for an additional 37 remaining MS4 communities within the Massachusetts LIS watershed. Any comparisons between 1990 and 2012 would, thereby, be very difficult due to the incompatibility of permit coverage between the two time periods. In addition, retrieval of relevant information on BMPs used by the cities and towns back in 1990 is difficult at best. Record keeping of BMPs implemented by Springfield in the early 1990s was either not tracked or is no longer available. Many other MS4 communities didn't keep any records on BMP implementation until after the year 2000 when annual reporting for each MS4 became a requirement by EPA. Many non-MS4 communities still do not track stormwater BMP implementation.

2. Section VII: Assessment of Agricultural BMPs

In 1990 NRCS's EQIP Grant Program, in its present operating and program auditing sense, did not exist. In addition, the present conservation planning software used by NRCS did not exist. Although project assistance to farmers in Massachusetts was provided, the overall program was much smaller and emphasized general education efforts. There was no BMP classification program, the defining primary emphasis of the current NRCS Grant Program. MDAR's did not provide any BMP project information for the 1990 timeframe.

3. Section VIII: Assessment of Roadway BMPs

MassDOT coverage under the stormwater program did not begin until 2005, and there are no BMP implementation records prior to that time.

4. Section IX: Assessment of the 319 Program BMPs

The NPS 319 Grant Program began in the late 1980's, and has changed a great deal over recent years. The management tracking system, GRTS is used to track various technical aspects of the Region's 319 Grant Projects, including nutrient reduction statistics for relevant BMPs. There is no nutrient reduction data available for 319 grant projects from the early 1990s time period to compare with the more recent period.

Urban BMP Data Shortfalls

The primary source of data and information associated with urban NPS BMPs is from the cities and towns, as well as EPA Region 1. The principal regulatory vehicle for generating this information is MS4 NPDES permit program. Urban BMPs are also installed to control stormwater runoff and resultant erosion associated with compliance with several programs including: (1) the Federal Construction General Permit, which regulates all construction-period activities that disturb an acre or more of land; (2) the Massachusetts State Wetlands

Protection Regulations, which require projects within a "wetlands jurisdictional area" to meet the 10 Massachusetts Stormwater Standard requirements; and (3) Massachusetts State Law allowing Massachusetts towns to adopt additional stormwater rules for local purposes. The various programs requiring the installation of urban NPS BMPs makes collecting BMP information complicated.

Communities covered under the Phase II MS4 permit program are required to submit annual progress reports to EPA Region 1. These are submitted on forms provided by EPA. The annual reports are available through EPA at: http://www.epa.gov/region1/npdes/stormwater/2003-permit-archives.html. Before MassDEP developed its BMP survey to collect information for this effort, MassDEP reviewed and evaluated several years of these annual reports from the 38 MS4 communities to determine the extent of usable information related to BMPs, and to determine what extent that information could be used to track TN loading reductions. That effort indicated that, except for the reporting of street sweeping and catch basin detritus (by weight) by some communities, other BMP information, particularly certain data needed for estimating load reduction were largely incomplete or absent. As a result additional follow-up became necessary. The data and other information received back from MassDEP's surveys helped to fill this data gap. Tables 5 and 6 in Section VI summarize BMP information reported by the communities. The following is an overview of the information provided by the communities through this survey vehicle.

1. Most Commonly Reported BMP Data

The three most commonly reported BMPs were of the housekeeping variety, i.e., street sweeping, catch basin cleaning, and yard waste pickup by communities. A large percentage of communities reported tonnages or cubic yards collected for these. The second most common BMP type reported were those related to illicit connections discovered/fixed, and septic system pumping/ tie-ins to sewer. The third category of BMP, which included nearly half of the total 34 BMPs listed on the survey, necessitated the collection of BMP acreage data from the community in order to estimate TN reductions (from Appendix 1). These included BMPs such as swales, bioswales, grassy swales, dry or wet detention ponds, infiltration basins, rain gardens, tree planting/forestation, filtering practices, erosion and sediment controls, vegetated borders, impervious surfaces reduction, and permeable pavement. Based on survey responses, very few communities track and record acreage data for the BMP practices listed in the previous sentence.

Although many communities eventually provided some information, there were over 125 BMPs reported with no useable data (acreages or weight) in which to determine TN reductions. As a result, a sub-set of potential TN reductions estimates could not be estimated for Massachusetts.

2. BMPs Where Data Was Generally Not Available

There were several other types or groups of BMPs reported by communities for which TN reduction calculations could not be made due to a lack of data and other information. These included lawn fertilization education programs, nutrient management programs, and cluster zoning implementation. In addition, data was lacking relative to implementation of innovative and alternative technologies to reduce nutrients from Title 5 Wastewater Systems, and Groundwater Discharges implemented to replace Title 5 systems. For these BMPs, MassDEP could not identify literature values for TN reductions for these types of BMPs. The Chesapeake Stormwater Network (CSN) indicated that a Stormwater Committee at CSN ad recently been considering nutrient credits for BMPs such as lawn fertilization education programs and nutrient management, but had not made any final determinations.

Other types of BMPs reported by communities included: (1) groundwater overlay districts, which protect drinking water sources and (2) catch basin retrofits with deep sump/hood installation. Even though several communities reported acreages for groundwater overlay districts, MassDEP could not identify potential nutrient reduction credits for these types of BMPs. As for catch basin retrofits, MassDEP surmised that this particular BMP probably resulted in increased detritus collections, thereby reducing TN loadings to the watershed. However, no nutrient reduction credits were given for these activities.

One additional BMP reported by 3 communities was Stormceptor^{tm} Systems. Contact with the consulting firm that manages many of the installations in the Western Massachusetts area indicated that there are many more communities where these systems have been installed within the LIS watershed; however, data related to nitrogen removal capabilities for these systems is not readily available.

3. Review of MS4 Annual Reports

MassDEP conducted a detailed review of many MS4 annual reports submitted by communities to EPA. EPA provides communities designed to compile statistics such as pounds/tonnages collected for housekeeping BMPs, and acreages for other type of BMPs such as swales, wet/dry ponds, infiltration basins, etc. However, this information is most often incomplete or blank. MassDEP recommends that EPA emphasize the importance of completing these data sheets as part of the report. Non-MS4 communities followed the same pattern as MS4 communities with respect to reporting BMPs in their responses to MassDEP's survey. Statistics for housekeeping type BMPs periodically included weight statistics, but other BMPs (requiring acreages or numbers) typically lacked useable data and other relevant information.

BMP information provided by MassDOT also followed similar patterns to that provided Massachusetts communities. Housekeeping data (e.g., street sweeping, catch basin cleans), weight or tonnage information was periodically available, but acreage information, e.g., for swales, infiltration basins, etc., was missing.

4. Suggested Actions to Address Data Gaps for Urban BMPs

1. EPA, through its MS4 permit program, should work with permitted communities to improve their recordkeeping (i.e., acreages, or weight, or numbers) for BMPs applied and include this information in their annual reports.
2. LISS, EPA Region 1, MassDEP and/or Regional Planning Agencies could also encourage communities to keep better records of BMPs implemented so they can receive credit for the good work they are doing.
3. MassDEP should work with MassDOT to facilitate better communication between the two agencies regarding BMP implementation in the future.
4. LISS should work with CSN's Stormwater Committee on their development of nutrient credits for lawn fertilization education programs and nutrient management programs in communities.
5. LISS should promote additional research to help determine guidelines for nutrient reduction capabilities for: (1) Title 5 Advanced Waste Treatment Systems; (2) Groundwater Discharge Plants to replace Title 5; and (3) Groundwater Overlay Districts that protect Drinking Water Supplies.

Agricultural BMPs Data Gaps

Section VII of this report covers the assessment of documented agricultural BMPs that have been implemented within the Massachusetts LIS watershed. For agricultural land use, the principal agency charged with BMP implementation in Massachusetts is the NRCS. At the state level MDAR, and the UMass, Extension Program also work with the agricultural community. NRCS provided MassDEP with a list of approximately 5,500 separate NRCS farm and grant projects initiated since 2001 where NPS BMPs had been implemented. Nine principal BMPs were identified as the most commonly utilized by NRCS within the Massachusetts LIS watershed. NRCS staff clearly indicated that the agency actively follows-up on its projects, and related BMPs put in place, for at least the first 3 years following BMP implementation, after which time farm owners are largely left 'on their own' as they continue presumably maintain the BMPs on their property. NRCS has not conducted any follow-up with grantees to determine the rates of continued BMP maintenance for their projects beyond that initial 3 year time period following implementation.

MDAR provided NPS BMP information for projects they sponsored which was comprised of 20 recent NPS BMP projects, (Table 8 in Section VII above), within the LIS watershed. However, quite a number of these projects have received some sort of NRCS staffing or grant support. MassDEP was concerned about "double counting" BMP projects. The UMass extension program did not provide and BMP information.

1. Suggested Actions to Address Agricultural BMP Data Gaps

1. NRCS should consider establishing a monitoring program for nutrient reduction projects funded through EQIP. The monitoring period for projects should begin prior to BMP implementation and continue for some period beyond the typical 3 year NRCS oversight window to determine if, and for how long, BMPs are typically being maintained by farmers.

2. Grant opportunities should be indentified and pursued to develop an inventory of farming operations, including BMPs in place, above a minimum acreage size within the LIS watershed. MDAR, UMass, NRCS, Regional Planning agency(s), or another entity (public or private) might be identified to conduct and maintain the inventory. NRCS, MDAR, or LISS could be targeted for funding this effort.
3. The five states location in the LIS watershed should discuss and possibly consider legislation including a funding program similar to that being implemented in Pennsylvania, which would mandate the development of nutrient management plans as part of Federal and State requirements under the Clean Water Act specifically related to implementation of the TMDL.

   Pennsylvania has a legislatively mandated Nutrients Management Program, with an accompanying grant support program, for 'high density farms' involving animals with a certain total weight per acre. Regulated farms are required to have approved nutrient management plans. State funding programs that have been made available include: (a) grants for nutrient management plans, (i.e., 75 percent cost share, up to $1,500); (b) grants for plan implementation (i.e., 80 percent cost share, up to $75,000); (c) grants for alternative manure technologies; and (d) cover crops during for fall applications on bare fields. Similar activities or programs might be considered for the LIS watershed states where high density farms are identified.

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