An Evaluation of Potential Nitrogen Load Reductions to Long Island Sound from the Connecticut River Basin

Submitted to:

New England Interstate Water Pollution Control Commission
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Table of Contents

1.0 INTRODUCTION

The Connecticut River Basin (CRB) is one of the largest basins draining into the Long Island Sound between the metropolitan New York City region and the southern coast of New England. A previously-completed study of conditions in the Sound has identified low dissolved oxygen (DO), or "hypoxia", as it's most pressing problem, and related research and computer modeling efforts have linked the low DO occurrences to excess loading of nitrogen to the system. In response to this situation, the Connecticut Department of Environmental Protection (CTDEP) and the New York State Department of Environmental Conservation (NYSDEC) completed a total maximum daily load (TMDL) analysis for DO in the Sound. The Long Island Sound (LIS) TMDL, approved by the U.S. Environmental Protection Agency in April 2001, identifies actions necessary to attain water quality standards (WQS) for DO in the Sound by 2014. Among other things, these actions include:

- A 25 percent reduction in point source loads of nitrogen from the upper part of the CRB (i.e., all areas above Connecticut).
- A 10 percent reduction in non-point source nitrogen loads from urban and agricultural areas within the entire CRB.
- An 18 percent reduction in nitrogen loads from atmospheric deposition within the entire CRB.

In support of these efforts, the study described in this document was initiated to quantify nitrogen loads from a variety of sources in the CRB. The primary objectives of this study were to: 1) estimate nitrogen loads transported to the Sound via the Connecticut River and its tributaries, 2) estimate potential load reductions that might be achieved via the implementation of various point and non-point source controls, and 3) estimate the costs associated with implementing these controls throughout the CRB. These objectives were addressed through the completion of various analyses conducted with a combination of water quality modeling and assessment tools.

Based on an evaluation of existing land use/cover data (ca. 2001), the CRB is primarily forested with pockets of agricultural and urban land interspersed throughout. Agricultural land is more or less distributed evenly throughout the basin, whereas the more heavily urbanized areas tend to be located towards the southern end of the basin (i.e., in Massachusetts and Connecticut). Point sources of pollution are also distributed across the basin. However, the larger wastewater treatment plants, due to the location of the larger urban areas, also tend to be found at the lower end of the CRB. A synopsis of the primary land use/cover categories found within the basin is provided in Table 1.

Table 1. Distribution of land use/cover within the CRB

Category	Quebec (%)	NH (%)	VT (%)	MA (%)	CT (%)	Total Basin Area (acres)	Percent of Total Basin
Open water	2.0	2.1	0.7	3.2	3.0	144,144	2.0
Forest/shrub land	82.9	86.4	84.1	71.7	60.7	5,672,052	78.7
Wetlands	0.0	1.2	2.3	6.2	1.1	201,801	2.8
Agricultural land	12.0	5.1	7.9	7.5	9.8	533,331	7.4
Urban land	1.6	4.9	4.9	11.2	25.3	641,439	8.9
Disturbed land	1.5	0.2	0.1	0.2	0.2	14,414	0.2
Total	100	100	100	100	100	7,207,182	100

2.0 ESTIMATION OF EXISTING LOADS

2.1 Overview of Modeling Approach

Estimation of current nitrogen loads discharged to Long Island Sound from the CRB was accomplished via an evaluation of existing in-stream water quality and flow data in combination with the use of a geographic information system (GIS)-based watershed model. The intent of this study was to quantify current loads and potential load reductions that might be achieved via the implementation of various point and non-point source controls for the entire CRB. Unfortunately, observed stream flow and water quality data were only available for a point on the Connecticut River located just below the Massachusetts state line. This point (the "Thompsonville station" shown in Figure 1) is where USGS stream gage 1184000 and a water quality monitoring station are co-located. To overcome the lack of observed data at the River's outlet on Long Island Sound, the watershed model was calibrated for the portion of the basin upstream of the Thompsonville site and subsequently extended to the entire basin.

Water quality monitoring data for the Thompsonville site for the period 10/2/2002 through 8/3/2005 were provided by the New England Interstate Water Pollution Control Commission (NEIWPCC). Using load/flow relationships established with these data, "observed" monthly nitrogen loads were then derived for the period 1999-2004. The loads for this period varied from a low of about 7,500 metric tons to a high of about 11,300 metric tons, with an average load of about 9,348 metric tons. This compares with 13,460 metric tons estimated by Boyer et al. (2002) for the period 1988-1993 and 12,786 metric tons estimated by Moore et al. (2004) using the New England SPARROW model for the period 1992-1993. The lower load estimate resulting from this current study are likely accounted for by: 1) decreased point source loads due to improvements in wastewater treatment plants and reduced output from pulp and paper mills within the basin over the last 10 years or so, 2) lower than average precipitation during the simulation period used for this analysis (i.e., 1999-2004), and 3) loss of agricultural land to other competing uses.

Once the observed load estimates were derived as described above, a GIS-based watershed model was used to simulate loads from 30 sub-basins comprising the larger CRB (see Figure 2). In this case, the watershed model used was AVGWLF, which is a GIS-based modeling system developed by researchers at Penn State University (Evans et al., 2002) that provides a link between ArcView GIS software and the Generalized Watershed Loading Function (GWLF) model developed originally by Haith and Shoemaker (1987). The GWLF model provides the ability to simulate runoff, sediment, and nutrient (N and P) loadings from a watershed given variable-size source areas (e.g., agricultural, forested, and developed land). It also has algorithms for calculating septic system loads, and allows for the inclusion of point source discharge data. It is a continuous simulation model which uses daily time steps for weather data and water balance calculations. Monthly calculations are made for sediment and nutrient loads, based on the daily water balance accumulated to monthly values. Since its' initial incorporation into AVGWLF (GWLF with an ArcView GIS interface), the GWLF model has undergone numerous upgrades, including the addition of a streambank erosion routine (Evans et al., 2003) and best management practice (BMP) assessment module (Evans, 2005). As a TMDL support tool, AVGWLF has been used by the Pennsylvania Department of Environmental Protection since 1998. It is presently being used to support lake TMDLs in New York, and a "regionalized" version of it has recently been developed for use in New England through an EPA-funded project with NEIWPCC (see http://www.neiwpcc2.org/AVGWLF/).

As described above, AVGWLF is a customized interface that is used to parameterize input data for the GWLF model. In utilizing this interface, the user is prompted to identify required GIS files describing key watershed characteristics (e.g., soils, land use/cover, topography, etc.) and to provide other information related to "non-spatial" model parameters (e.g., beginning and end of the growing season, the months during which manure is spread on agricultural land, etc.). This information is subsequently used to automatically derive values for required model input parameters which are then written to the various input files needed to execute the GWLF model. Also

accessed through the interface are Excel files that contain temperature and precipitation information used to create the necessary weather input file for a given watershed simulation. For this project, GIS and climate data sets developed previously as part of the EPA-funded project completed by NEIWPCC were utilized. For point source data, information on current effluent discharges (i.e., flow and nitrogen concentration) for wastewater treatment plants distributed throughout the basin were compiled by participating state agencies. For this project, discharge data (ca. 2005-2007) were compiled for a total of 142 treatment plants, which were predominantly municipal plants as well as a handful of paper mills and other activities.

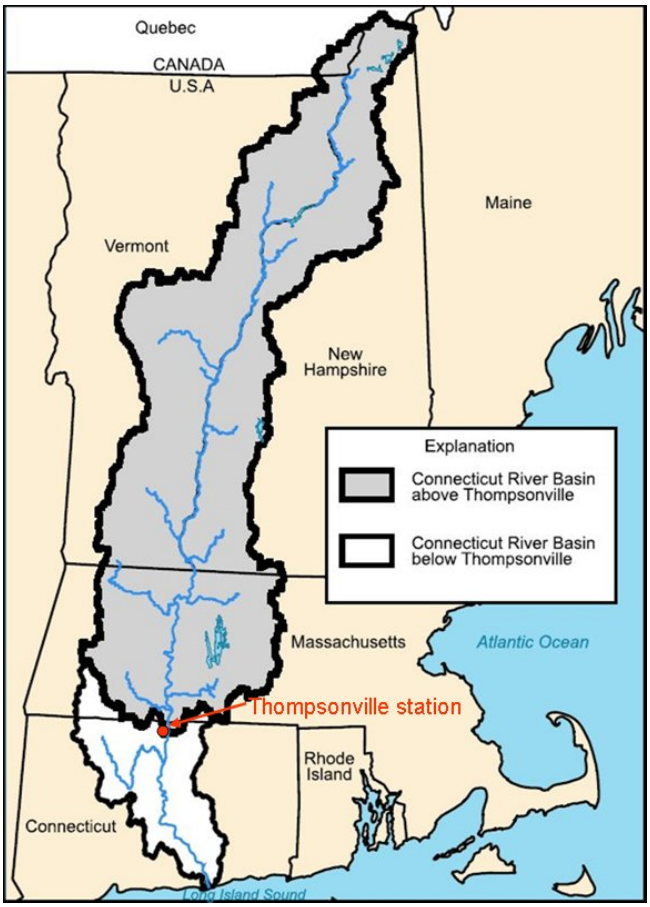


Figure 1. Location of Thompsonville station

For the first step of the modeling exercise, the AVGWLF watershed model was used to estimate nitrogen loads generated within each of 25 sub-basins draining to the Thompsonville site. With no attempt to account for in-stream losses, AVGWLF estimated that an average of 15,098 metric tons per year of nitrogen were produced within this particular drainage area during the 1999-2004 time frame. It was assumed that the difference between the observed loads (i.e., 9,348 metric tons/year) and modeled loads could be attributed to losses occurring between the source areas of nitrogen loads located throughout the larger basin and the outlet at Thompsonville. These losses would presumably be due to nitrogen retention by smaller streams, lakes, ponds and wetlands within each of the sub-basins. Some additional loss is also assumed to occur once these loads are delivered to the Connecticut River. It was assumed that any losses in the Connecticut River would increase linearly with distance to the basin outlet. Based on these assumptions, nitrogen losses from source areas to the outlet at Thompsonville were estimated to be on the order of 38 percent across the basin as a whole.

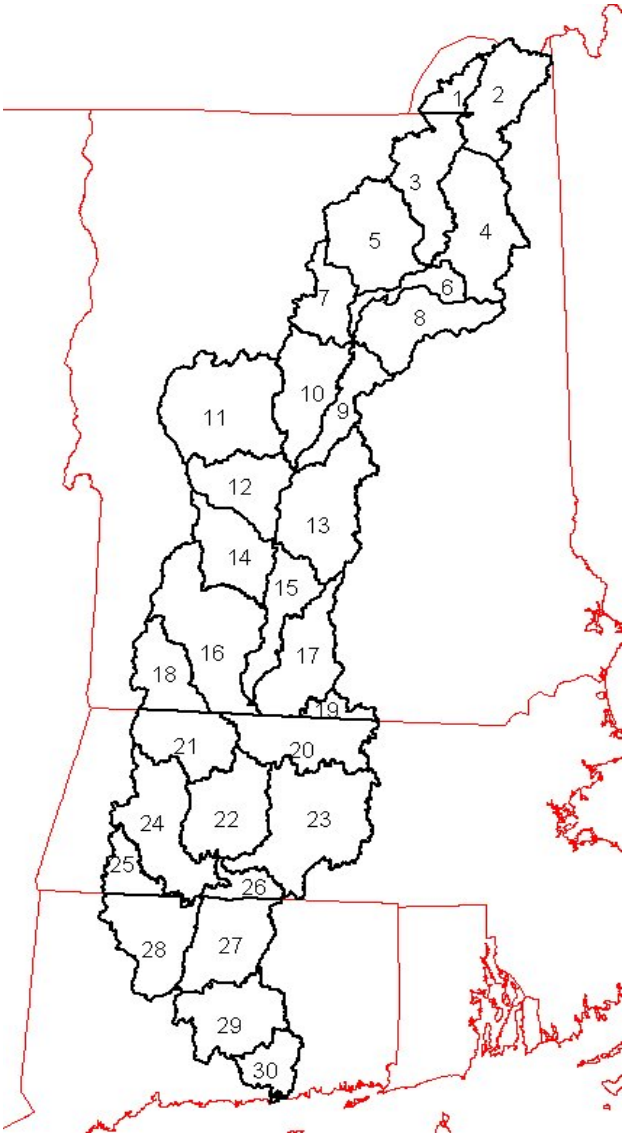


Figure 2. Sub-basins within Connecticut River Basin.

Based on previous work completed by Paul Stacey at CTDEP (pers. com.), it was assumed that approximately 31 percent of the point source load delivered to the Connecticut River at the northernmost point of the basin was lost by the time it reached the outlet on Long Island Sound. Consequently, in-stream loss rates for the Connecticut River (i.e., "point source" attenuation factors) were estimated based on distance from the center of each sub-basin to the outlet on Long Island Sound. As shown in Table 2, these values ranged from 31 percent to about 1 percent. For initial model calibration purposes, these factors were adjusted downward based on the distance from the top of the basin to the monitoring station at Thompsonville (see values shown in parentheses). Using the observed load calculated for the Thompsonville station, a mean "non-point source attenuation factor" for each sub-basin delivering loads to the main stem was then estimated as part of the calibration process in calculating the load delivered to the gage at Thompsonville. Once this latter value was established, it was then applied, along with the previously-calculated Connecticut River attenuation factors, to the estimation of loads from each sub-basin to the outlet on Long Island Sound.

Table 2. Attenuation factors by sub-basin.

SB	CAF	PSAF	SB	CAF	PSAF
1	0.61 (0.56)	0.30 (0.24)	16	0.46 (0.41)	0.15 (0.09)
2	0.63 (0.57)	0.31 (0.25)	17	0.46 (0.40)	0.14 (0.08)
3	0.60 (0.54)	0.28 (0.22)	18	0.44 (0.38)	0.12 (0.07)
4	0.59 (0.53)	0.27 (0.21)	19	0.45 (0.40)	0.14 (0.08)
5	0.57 (0.51)	0.25 (0.19)	20	0.44 (0.38)	0.12 (0.07)
6	0.56 (0.51)	0.25 (0.19)	21	0.44 (0.38)	0.12 (0.06)
7	0.55 (0.49)	0.23 (0.18)	22	0.41 (0.35)	0.09 (0.03)
8	0.56 (0.50)	0.24 (0.18)	23	0.41 (0.36)	0.10 (0.04)
9	0.53 (0.47)	0.21 (0.15)	24	0.40 (0.35)	0.09 (0.03)
10	0.53 (0.47)	0.21 (0.15)	25	0.42	0.10
11	0.53 (0.48)	0.22 (0.16)	26	0.38 (0.33)	0.07 (0.01)
12	0.51 (0.45)	0.19 (0.14)	27	0.37	0.05
13	0.50 (0.45)	0.19 (0.13)	28	0.39	0.07
14	0.49 (0.43)	0.17 (0.11)	29	0.34	0.02
15	0.47 (0.41)	0.15 (0.09)	30	0.32	0.01

SB = Sub-basin
CAF = Combined attenuation factor (including point and non-point sources)
PSAF = In-stream attenuation factor for point sources
Note: Attenuation factors for the monitoring station at Thompsonville, CT are shown in parentheses.

Shown in Table 2 are the "combined" attenuations factors that represent the combined loss of nitrogen from both point and non-point sources as it moves from source areas via smaller streams to the Connecticut River and then on to the outlet. As shown in this table, the combined (i.e., load-weighted) attenuation factors were estimated to range from about 0.63 in the northernmost reaches of the basin to 0.32 for sub-basin 30 at the southern end of the basin.

Based on the calculations made as described above, it was estimated that the average loss of non-point source nitrogen between the source areas in each sub-basin and the Connecticut River is about 31.7 percent. In the northeast part of the U.S., average velocities of small streams are around 2.5 miles per hour (Reed and Stuckey, 2002; Moore et al., 2004). This means that in a 24-hour period, a theoretical "stream particle" could travel a distance of about 60 miles (24 * 2.5 = 60). For the sub-basins shown in Figure 2, the average distance from the headwater areas to the outlet is about 33 miles, which equates to average stream travel times of 0.55 days. Given this average travel time to the Connecticut River, the estimated loss rate of 31.7 percent seems reasonable based on the results of the New England SPARROW study recently completed by USGS (Moore et al., 2004). In this study, it was suggested that about 50% of the nitrogen is lost in smaller streams and sub-basins for each 0.9 days of travel time. If re-calculated out to an average travel time of 0.9 days, the average loss rate used in this study would be equal to about 51.9 percent (0.9 / 0.55 * 31.7 = 51.9).

After establishing the attenuation factors as described above, a comparison was made between observed and simulated mean annual loads for a selected number of sub-areas, in addition to the Thompsonville site, for which stream monitoring data were available for the same time period (i.e., 1999-2004). Three of these sub-areas (including the Thompsonville site) represent loads in the Connecticut River, whereas three additional sub-areas represented tributary loads. The corresponding sub-basins for each of these sites (depicted in Figure 2), along with the observed and simulated loads, are shown in Table 3. Based upon the

relatively close agreement between observed and simulated loads for these test sites (average % difference of 3.9% and R^2 = 0.9973), it was assumed that the attenuation factors given in Table 2 provided reasonably accurate rates of nitrogen loss throughout the CRB.

Table 3. Load comparison for CRB test sites.

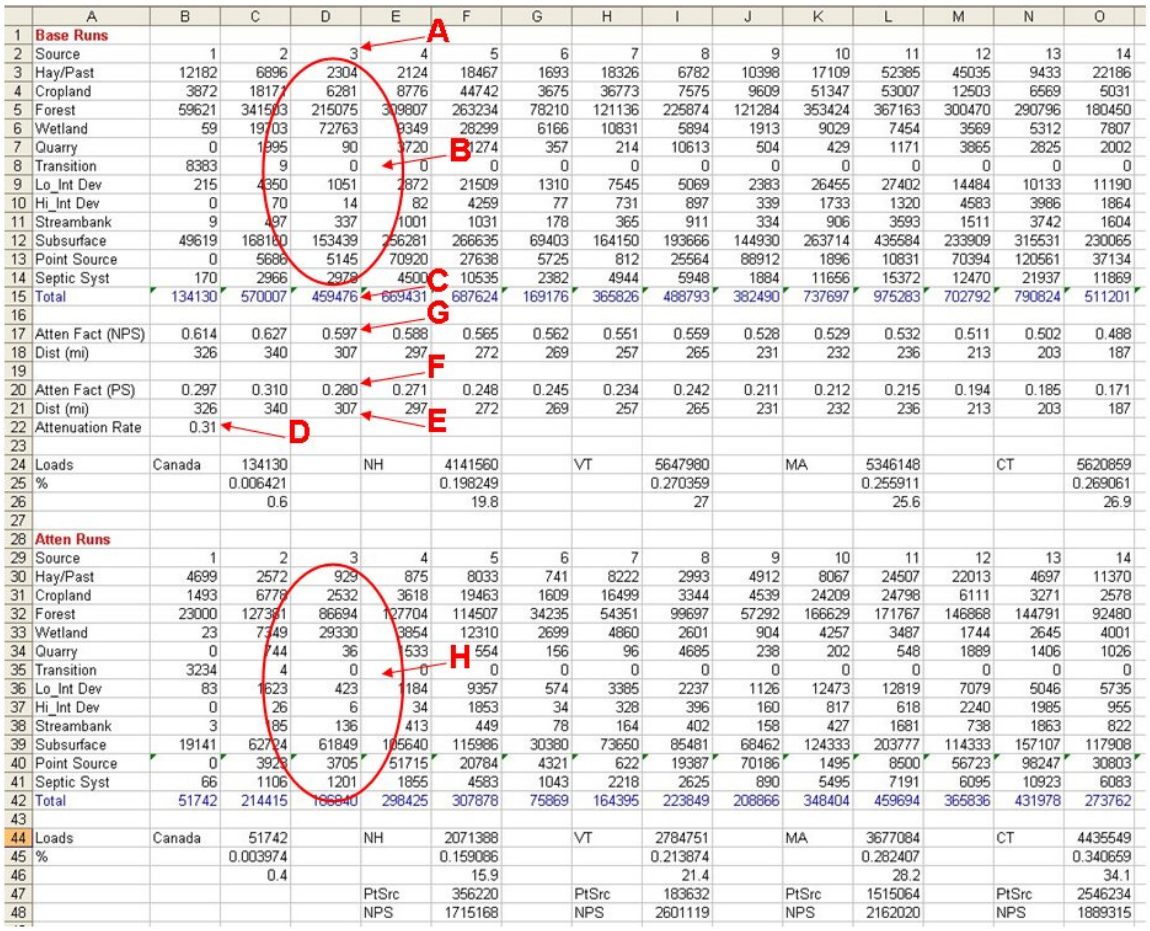
Site Name	Site Type[1]	Sub-Basins Represented	Observed (kg/yr)	Simulated[2] (kg/yr)	% Difference
CT River at Wells River, VT	1	1 through 8	2,228,445	2,276,404	2.1
CT River at N. Walpole, NH	1	1 through 14	4,247,288	4,643,545	8.5
CT River at Thompsonville	1	1 through 26	9,348,048	9,352,624	0.0
Passumpsic River	2	5	392,859	399,200	1.6
White River	2	11	612,652	666,118	8.0
Farmington River	2	25 and 28	837,705	865,499	3.2
					Avg. 3.9

[1] 1 = Connecticut River load, 2 = tributary load
[2] Based on use of AVGWLF and attenuation factors

Subsequent to model calibration, AVGWLF was run on the remaining sub-basins. To facilitate calculation of "delivered" loads, the initial AVGWLF-predicted loads (i.e., the "generated" loads) for each basin were put into an Excel spreadsheet along with equations for calculating the loads delivered to Long Island Sound based on estimated attenuation factors. A screen capture of a portion of this spreadsheet is shown in Figure 3. In this example, "A" signifies the sub-basin number, the values in area "B" are the loads (in kg/yr) for different pollution sources simulated by AVGWLF, "C" is the total load for this sub-basin, "D" is the maximum "point source" attenuation (31%) that would occur from the uppermost portion of the entire basin to the outlet on Long Island Sound, "E" is the distance (in miles) from the middle of the sub-basin to the outlet, "F" is the area-specific point source (in-stream) attenuation factor based on the maximum value ("D") and distance to the outlet ("E"), "G" is the combined attenuation factor for each sub-basin which includes the estimated "non-point source" attenuation (31.7% as discussed earlier) and the "point source" value based on distance to the outlet, and the values represented by "H" are the re-calculated (i.e., "delivered") loads based on the basin-specific attenuation factors.

2.2 Summary of Model Results

Using the modeling approach discussed above, nitrogen loads delivered to Long Island Sound by the entire basin were estimated to be on the order of 13,020,514 kg/yr (or 13,021 metric tons per year). This converts to about 28,710,233 lbs/yr or 78,658 lbs/day. As shown in Table 4, this estimate falls within the range of values reported by other studies for various time periods. As described previously, this estimate is lower than the SPARROW study probably due to the fact that higher estimates for point source loads and land area under cultivation would have been used in the earlier study. This new estimate, however, is very similar to that developed in a study done by AquaTerra Consultants and HydroQual, Inc. (2001) for CTDEP , which is the basis for the Long Island Sound TMDL.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Base Runs**														
2	Source	1	2	3	4	5	6	7	8	9	10	11	12	13	14
3	Hay/Past	12182	6896	2304	2124	18467	1693	18326	6782	10398	17109	52385	45035	9433	22186
4	Cropland	3872	18171	6281	8776	44742	3675	36773	7575	9609	51347	53007	12503	6569	5031
5	Forest	59621	341503	215075	309807	263234	78210	121136	225874	121284	353424	367163	300470	290796	180450
6	Wetland	59	19703	72763	9349	28299	6166	10831	5894	1913	9029	7454	3569	5312	7807
7	Quarry	0	1995	90	3720	1274	357	214	10613	504	429	1171	3865	2825	2002
8	Transition	8383	9	0	0	0	0	0	0	0	0	0	0	0	0
9	Lo_Int Dev	215	4350	1051	2872	21509	1310	7545	5069	2383	26455	27402	14484	10133	11190
10	Hi_Int Dev	0	70	14	82	4259	77	731	897	339	1733	1320	4583	3986	1864
11	Streambank	9	497	337	1001	1031	178	365	911	334	906	3593	1511	3742	1604
12	Subsurface	49619	168160	153439	256281	266635	69403	164150	193666	144930	263714	435584	233909	315531	230065
13	Point Source	0	5686	5145	70920	27638	5725	812	25564	88912	1896	10831	70394	120561	37134
14	Septic Syst	170	2966	2978	4500	10535	2382	4944	5948	1884	11656	15372	12470	21937	11869
15	Total	134130	570007	459476	669431	687624	169176	365826	488793	382490	737697	975283	702792	790824	511201
16															
17	Atten Fact (NPS)	0.614	0.627	0.597	0.588	0.565	0.562	0.551	0.559	0.528	0.529	0.532	0.511	0.502	0.488
18	Dist (mi)	326	340	307	297	272	269	257	265	231	232	236	213	203	187
19															
20	Atten Fact (PS)	0.297	0.310	0.280	0.271	0.248	0.245	0.234	0.242	0.211	0.212	0.215	0.194	0.185	0.171
21	Dist (mi)	326	340	307	297	272	269	257	265	231	232	236	213	203	187
22	Attenuation Rate	0.31													
23															
24	Loads	Canada	134130		NH	4141560		VT	5647980		MA	5346148		CT	5620859
25	%		0.006421			0.198249			0.270359			0.255911			0.269061
26			0.6			19.8			27			25.6			26.9
27															
28	**Atten Runs**														
29	Source	1	2	3	4	5	6	7	8	9	10	11	12	13	14
30	Hay/Past	4699	2572	929	875	8033	741	8222	2993	4912	8067	24507	22013	4697	11370
31	Cropland	1493	6778	2532	3618	19463	1609	16499	3344	4539	24209	24798	6111	3271	2578
32	Forest	23000	127381	86694	127704	114507	34235	54351	99697	57292	166629	171767	146868	144791	92480
33	Wetland	23	7349	29330	3854	12310	2699	4860	2601	904	4257	3487	1744	2645	4001
34	Quarry	0	744	36	1533	554	156	96	4685	238	202	548	1889	1406	1026
35	Transition	3234	4	0	0	0	0	0	0	0	0	0	0	0	0
36	Lo_Int Dev	83	1623	423	1184	9357	574	3385	2237	1126	12473	12819	7079	5046	5735
37	Hi_Int Dev	0	26	6	34	1853	34	328	396	160	817	618	2240	1985	955
38	Streambank	3	85	136	413	449	78	164	402	158	427	1681	738	1863	822
39	Subsurface	19141	62794	61849	105640	115986	30380	73650	85481	68462	124333	203777	114333	157107	117908
40	Point Source	0	3923	3705	51715	20784	4321	622	19387	70186	1495	8500	56723	98247	30803
41	Septic Syst	66	1106	1201	1855	4583	1043	2218	2625	890	5495	7191	6095	10923	6083
42	Total	51742	214415	186840	298425	307878	75869	164395	223849	208866	348404	459694	365836	431978	273762
43															
44	Loads	Canada	51742		NH	2071388		VT	2784751		MA	3677084		CT	4435549
45	%		0.003974			0.159086			0.213874			0.282407			0.340659
46			0.4			15.9			21.4			28.2			34.1
47					PtSrc	356220		PtSrc	183632		PtSrc	1515064		PtSrc	2546234
48					NPS	1715168		NPS	2601119		NPS	2162020		NPS	1889315

Figure 3. Example loads and attenuation calculations.

Table 4. Nitrogen load estimates (in metric tons) for the entire CRB from other studies.

Annual load	Study Period	Study
16,215	1992-93	NE SPARROW[1]
16,243	1991-95	LIS Study
13,307	1991-95	Connecticut HSPF[2]
11,051	1988-98	Mullaney[3]
13,021	1999-2005	Current study

[1] Moore et al., 2004.
[2] AquaTerra Consultants and HydroQual, Inc., 2001
[3] Mullaney et al., 2002.

In terms of load distribution, the estimated annual loads associated with each of the primary sources in the basin are shown in Table 5. Estimates of loading rates (both generated and delivered) for the three principal non-point sources of nitrogen are given in Table 6. More detailed information on loads from all sources and sub-basins can be found in Appendix A.

Table 5. Distribution of delivered annual loads by primary source for the entire CRB.

Source	Annual Load	% of Total Load
Point Sources	4,601,149 kg (10,145,534 lb)	35.3%
Agricultural Areas[1]	1,753,724 kg (3,866,961 lb)	13.5%
Urban Areas[2]	1,381,668 kg (3,046,577 lb)	10.6%
Remaining Sources[3]	5,283,973 kg (11,651,160 lb)	40.6%
Total	13,020,514 kg (28,710,233 lb)	100

[1]Includes both surface and sub-surface loads
[2]Includes both surface and sub-surface loads, as well as septic systems
[3]Includes loads from all remaining non-point sources such as forests, wetlands, disturbed areas, etc.

Table 6. Estimated loading rates for agricultural and urban sources within the entire CRB

	Area (ha)	Generated Load	Kg/ha	Delivered Load	Kg/ha
Agriculture	213,879	3,242,526 kg (7,149,770 lb)	15.16	1,753,724 kg (3,866,961 lb)	8.20
Urban	259,582	2,339,386 kg (5,158,346 lb)	9.01	1,381,668 kg (3,046,577 lb)	5.32
Other NPS	2,443,194	10,312,144 kg (22,738,728 lb)	4.22	5,283,973 kg (11,651,160 lb)	2.16

Note: "Generated" loads refer to "in-situ" loads prior to attenuation. "Other NPS" refers to all other loads in the basin except for point source loads.

As part of the modeling exercise, the total nitrogen loads (both generated and delivered) were also estimated for each geographic region within the entire Connecticut River basin. As shown in Table 7, the loads delivered by each region as a percentage of the total load become modified (.i.e., attenuated) as a function of distance and travel time to the mouth of the river. Table 8 provides a breakdown of the distribution between point and non-point source loads delivered annually to the Long Island Sound by each of these geographic regions. Additional details on state-by-state load distributions are also provided in Section 4.5.

Table 7. Load contributions by geographic region.

Region	Percent Generated[1]	Percent Delivered[2]
Quebec	0.6	0.4
NH	19.8	15.9
VT	27.0	21.4
MA	25.6	28.2
CT	26.9	34.1

[1] Total load produced not accounting for losses due to travel time and distance
[2] Total load delivered to Long Island Sound after losses

Table 8. Mean annual delivered load contributions by geographic region.

Region	Point Sources	% of Total	Non-Point Sources	% of Total	Total
Quebec	---	0	51,742 kg (114,092 lb)	0.6	51,742 kg (114,092 lb)
NH	356,220 kg (785,464 lb)	7.7	1,715,168 kg (3,781,946 lb)	20.4	2,071,388 kg (4,567,410 lb)
VT	183,632 kg (404,908 lb)	4.0	2,601,119 kg (5,735,467 lb)	30.9	2,784,751 kg (6,140,375 lb)
MA	1,515,064 kg (3,340,716 lb)	32.9	2,162,020 kg (4,767,254 lb)	25.7	3,677,084 kg (8,107,970 lb)
CT	2,546,234 kg (5,614,445 lb)	55.3	1,889,315 kg (4,165,941 lb)	22.4	4,435,549 kg (9,780,386 lb)
Total	4,601,149 kg (10,145,534 lb)	100	8,419,365(18,564,699 lb)	100	13,020,514 kg (28,710,333 lb)

3.0 POTENTIAL LOAD REDUCTIONS AND ASSOCIATED COSTS

Once the base loads were established for different areas of the Connecticut River basin, the next step in the modeling exercise was to evaluate potential load reductions that might be achieved via the implementation of both point and non-point source controls throughout the basin. A primary objective of this study was to estimate costs associated with achieving incremental reductions in nitrogen loading that could be subsequently used to develop point and non-point "cost curves" similar to the example shown in Figure 4. The purpose of such cost curves is to depict varying levels of nitrogen reduction versus money spent in implementing assorted reduction strategies.

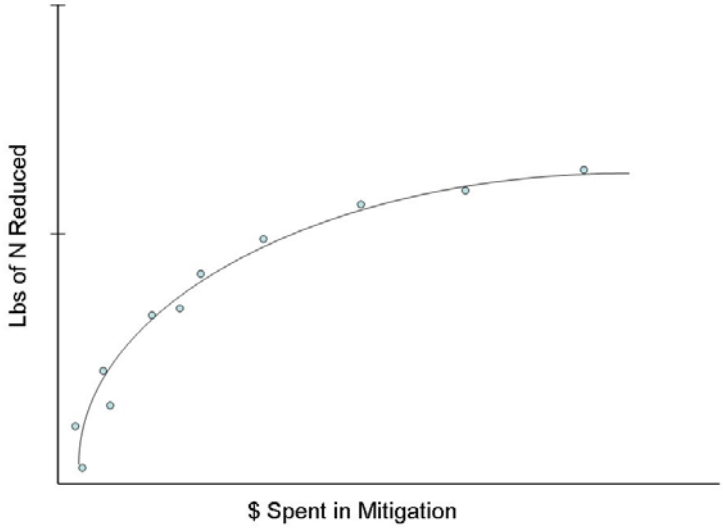


Figure 4. Example nitrogen reduction cost curve.

The load reduction evaluation was essentially accomplished in two steps. First, future reductions associated with proposed wastewater treatment plant upgrades were estimated using information provided by the participating states. During the second step of the evaluation process, the implementation of various non-point source controls (e.g., agricultural BMPs, stream protection activities, etc.) were iteratively simulated to

estimate additional load reductions and associated costs that could be used to derive additional cost curves. For the purposes of this study, potential point source reductions were only estimated for treatment plants in the upper part of the CRB (i.e., north of Connecticut). This was done to provide states in this area with sufficient information to adequately frame their options in terms of point source versus non-point source controls.

For this study, the PRedICT tool that has been incorporated into AVGWLF (Evans, 2003) was used to simulate the effects of various non-point source controls. This tool allows the user to create various "scenarios" in which current landscape conditions and pollutant loads (both point and non-point) can be compared against "future" conditions that reflect the use of different pollution reduction strategies. The tool includes pollutant reduction coefficients for nitrogen, phosphorus and sediment, and also has built-in cost information for an assortment of pollution mitigation techniques. For this particular analysis, representative "agricultural" and "urban" BMPs were used to evaluate potential reductions. It was felt that in this case it was not necessary to simulate specific BMPs; rather, it was only necessary to "treat" agricultural or urban land in each basin using representative or composite BMPs that reflect the average reduction efficiency and unit cost for any number of cost-effective measures that might be used in each situation.

3.1 Point Source Reductions

As described earlier, data were compiled on current wastewater characteristics (i.e., discharge flows and concentrations) for 142 treatment plants located throughout the basin. (These plant data are presented in Appendix B). For the purposes of this particular analysis, estimates were made of the potential nitrogen reductions that could be achieved by bringing all treatment plants outside of Connecticut to three specific "levels" or target concentrations (i.e., 8 mg/l, 5 mg/l, and 3 mg/l). For the first level (Level 1), an estimate was made of the reduction that could be achieved by bringing all plants with current discharge concentrations above 8 mg/l to a concentration of 8 mg/l. For the next two levels, similar calculations were made of potential reductions that would be obtained by upgrading plants from 8 to 5 mg/l, and then from 5 to 3 mg/l. The estimated basin-wide load reductions based on this approach are shown in Table 9. Potential load reductions by treatment level are summarized for each plant in Appendix C.

Table 9. Estimated point source load reductions.

	Kg/Yr	Lb/Yr
Level 1 (8 mg/l)	940,947	2,074,788
Level 2 (5 mg/l)	306,885	676,682
Level 3 (3 mg/l)	287,742	634,471
Total	1,535,574	3,385,941

As given previously, the current estimated point source load delivered to Long Island Sound is 4,601,149 kg/yr (or 10,145,534 lb/yr). Given the values in Table 9, the current point source load from the entire basin could be reduced by about 33.4% (1,535,574 / 4,601,149) if all treatment plants above Connecticut were brought to a discharge concentration of 3 mg/l of total nitrogen. If only the point sources outside of Connecticut are considered (which contribute an annual load of about 2,054,916 kg), then the maximum potential load reduction would be about 74.7% (1,535,574 / 2,054,916).

The costs associated with upgrading treatment plants for each of the treatment levels described above was accomplished using an approach previously developed as part of a study to estimate the cost of plant upgrades in the Chesapeake Bay Basin (Chesapeake Bay Program, 2002). In the latter study, various regression equations were developed to estimate total capital costs and yearly overhead and maintenance (O&M) costs associated with treatment plants of different sizes (i.e., design discharge flows). More specifically, different equations were developed for each of the same three treatment levels used in this current study (i.e., existing effluent concentration to 8 mg/l, 8 mg/l to 5 mg/l, and 5 mg/l to 3 mg/l). Additional descriptions of the Chesapeake Bay study regressions as also applied in this study are provided below.

(Note that the regression equations described below are based on costs in 2000 and only consider the cost of upgrading from one level to the next, and do not include the costs incurred for achieving the previous treatment level).

For all treatment plants independent of size, the following equation was used to estimate total capital costs associated with Level 1 plant upgrades:

Cost (in dollars) = $2023829 + 704350.8039Q - 5986.733Q^2$
where Q = design flow rate (mgd)

In the Chesapeake Bay study (as well as this one), annual O&M costs were assumed to be equal to 2% of the estimated total capital cost for each plant.

In the case of Level 2 upgrades, two different sets of cost equations were used depending on the design flow (in mgd) for each plant. The corresponding total capital cost and O&M equations for plants with design flows of 1 mgd or less are as follows:

Capital Cost (in thousands of dollars) = 967.06Q + 144.4

Annual O&M Costs (in dollars) = 24636Q + 4582.1

For plants with design flows greater than 1 mgd, the following equations were used:

Capital Cost (in thousands of dollars) = 386.01Q + 864.83

Annual O&M Costs (in dollars) = 13383Q + 19021

For Level 3 upgrades, the equations used were:

For plants with design flows of 1 mgd or less:

Capital Cost (in thousands of dollars) = 1061.7Q + 205.83

Annual O&M Costs (in dollars) = 24636Q + 4582.1

For plants with design flows greater than 1 mgd, the following equations were used:

Capital Cost (in thousands of dollars) = 386.01Q + 864.83

Annual O&M Costs (in dollars) = 13383Q + 19021

Since the Chesapeake Bay study used as a basis for cost estimation was completed using construction data representative of the year 2000, all costs computed for the current study were increased by a factor of 18.1% to represent estimated construction cost increases from 2000 to 2007. (This estimated cost factor was obtained from information available on the Engineering News Record web site (http://enr.construction.com/features/coneco/recentindexes.asp)). The updated total capital costs and annual O&M costs associated with each level of treatment are summarized in Table 10. Estimated costs for each individual plant are provided in Appendix D. Those wishing to know more about the specific data and methodologies used to develop the initial regression equations are referred to the original Chesapeake Bay study report (Chesapeake Bay Program, 2002).

Table 10. Estimated costs for upgrading all treatment plants outside of Connecticut.

	Total Capital Costs*	Annual O&M Costs*
Level 1	$362,050,073	$7,241,001
Level 2	$119,692,574	$3,515,469
Level 3	$264,191,429	$10,534,318
Total	$745,934,076	$21,290,788

* Updated to reflect 2007 dollars

3.2 Reductions in Agricultural Areas

With respect to agricultural areas, two measures that have been shown to be effective in terms of reducing nitrogen loads are nutrient management and cover crops (Chesapeake Bay Commission, 2004). Both of these have similar per-acre implementation costs (about $25-$40 per acre). However, since the reduction efficiency for cover crops has historically been better documented, this was used as the representative crop-related BMP in this study. Two good sources of BMP data (the Chesapeake Bay Program and the Maryland Department of the Environment) suggest that the efficiency value for this BMP ranges from about 15% to 65% depending upon cover crop type and planting date. Based on the recommendation of the advisory group, a median efficiency value of 20% and an annual cost of $35/acre were used.

In addition to cover crops, the effects of implementing stream (riparian) buffers was also simulated in agricultural areas. The Chesapeake Bay Program has established a range of efficiency values for both forested and grass buffers depending upon physiographic location. For forested buffers, the range is 25% - 70%, with a median value of 50%. For grass buffers, the range is 17% - 57%, with a median value of 34%. For the purposes of this study, an average value of 39% was used under the assumption that future implementation of this measure would likely involve a mixture of the two types. With respect to cost, the New York Department of Environmental Conservation has established an average per-acre annual cost of $76.49 for grassed buffers and $165.50 for forested buffers, for an average annual cost of $121 per acre. *(Note: These costs included annualized capital costs, as well as annual O&M and land rental costs. They are also for "constructed" acres versus "treated" acres as with cover crops).* This estimate of $121 per acre for stream buffers was assumed to be sufficiently representative of the region for use in this study.

As discussed earlier, the *PRedICT* tool within *AVGWLF* was used to estimate potential load reductions from agricultural BMPs. In estimating reductions, both "surface" and "sub-surface" loads were considered. With respect to surface loads, potential reductions associated with cover crop implementation are estimated first within *PRedICT*, and then the remaining load is reduced via the simulation of stream buffer implementation. With sub-surface nitrogen, all sub-surface loads associated with agricultural areas were reduced uniformly using the reduction efficiency coefficient for stream buffers (i.e., 39%). Additionally, in this study it was assumed that 5% of all agricultural areas throughout the entire basin were currently being "treated" with agricultural BMPs. Therefore, only the remaining 95% was addressed in terms of future reductions. While this 95% implementation assumption may be somewhat unrealistic in terms of future expectations, this value was useful for establishing an upper limit on estimated future reductions.

Using the methodology described above, it was estimated that a maximum of 595,765 kg/yr (or 1,313,636 lb/yr) could be reduced within the entire Connecticut River Basin via the implementation of various mitigation strategies in agricultural areas at an estimated annual cost of $6.48 million. Given a current estimated agricultural load of 3,886,961 lb/yr, this would equate to a maximum potential reduction of about 34.1% (1,313,636 / 3,886,961 = 0.341) within the Basin at a unit cost of about $4.93 per pound of nitrogen reduced.

3.3 Reductions in Urban Areas

As part of this study, a representative urban BMP was also evaluated to estimate potential load reductions throughout the entire basin. As shown in previous work done in New Hampshire (Greg Comstock, per. com.), the two most cost-effective urban BMPs appear to be wet ponds and submerged gravel wetlands. The average per acre-drained construction costs for these BMPs are $7,000 and $11,500, respectively; and the associated nitrogen removal efficiencies are 55% and 85%, respectively. If it is assumed that a mix of these two BMPs would be implemented as part of future restoration activities, representative urban BMP values can then be developed as follows:

Average per acre-drained construction cost:

($7,000 + $11,500) / 2 = $9,250

Average removal efficiency:

(55% + 85%) / 2 = 70%

(Note: The removal efficiency value for urban BMPs only applies to "surface" loads and does not affect septic system loads or other subsurface fractions which are considered to be part of the total urban loads).

In addition to the actual construction costs, the cost of land acquisition was also considered in this analysis. Such costs are usually difficult to obtain, but based on input from the study advisory group, average costs for urban and rural land were used in this study to approximate land acquisition costs for the two urban land categories utilized by the AVGWLF model (i.e., "high-density" developed and "low-density" developed). These costs are shown in Table 11.

For the urban BMP example given earlier, the per acre-drained construction costs are based on the assumption that a wet pond or constructed wetland measuring 0.3 acres in size can treat approximately 5 acres of developed land that is 75% impervious. This is the same as saying that 1 acre of this type of system can treat approximately 16.666 acres of developed land (i.e., 5 / 0.3 = 16.666). Given that, it was assumed that the per-acre costs for drained ("treated") urban land in any given area could be assumed to be equal to the per-acre land acquisition cost divided by 16.666. The estimated per acre-drained urban BMP costs used in this study are given in Table 12.

Table 11. Estimated land acquisition costs ($/acre) by state.

State	Urban Areas	Rural Areas
NH	100,000	4,000
VT	100,000	4,000
MA	150,000	8,000
CT	200,000	12,000

Table 12. Estimated urban BMP costs ($/acre of drained developed land) by state.

State	Urban Areas	Rural Areas
NH	15,250	9,490
VT	15,250	9,490
MA	18,250	9,730
CT	21,250	9,970

As an example of how these costs were derived, the following illustrates how the total urban land BMP cost was calculated for the state of Massachusetts.

Urban BMP construction cost per drained developed acre: $9,250 as calculated above

Land acquisition cost per drained developed acre in urban areas: $150,000 / 16.666 = $9,000

Land acquisition cost per drained developed acre in rural areas: $8,000 / 16.666 = $480

Total urban BMP cost per drained developed acre in urban areas: $9,000 + $9,250 = $18,250

Total urban BMP cost per drained developed acre in rural areas: $480 + $9,250 = $9,730

As with agricultural BMPs, it was assumed that 5% of the urban areas within the entire CRB were currently being treated, leaving 95% of the urban areas available for estimating potential reductions. The total cost for full urban BMP implementation within all of the sub-basins was estimated to be $2,753,607,287. Although full urban BMP implementation may be an unrealistic expectation, this assumption is nevertheless useful for establishing an upper limit on possible future reductions.

Using the methodology outlined above, the maximum nitrogen reduction that might be obtained via full implementation of urban BMPs in the entire Connecticut River Basin was estimated to be about 469,456 kg/yr (or 1,035,150 lb/yr). When considering the total load delivered via all urban sources to the Sound (i.e., about 1,381,668 kg/yr (or 3,046,577 lb/yr)), this would equate to a maximum potential reduction of approximately 34% (1,035,150 lbs / 3,046,577 lb = 0.340).

4.0 DEVELOPMENT OF COST CURVES

Based upon the work described in previous sections, existing nitrogen loads and potential load reductions that might be obtained via the implementation of various point and non-point source control strategies were estimated. The costs associated with these control strategies were also estimated. Using both sets of results, a number of cost curves similar to the example shown earlier in Figure 4 were subsequently developed with the intent of demonstrating the cost/benefit advantages of various strategy combinations. As noted earlier, potential point source reductions were only estimated for the states north of Connecticut. Consequently, the cost curves discussed below only apply to those states as well.

4.1 Point Source Controls

As part of this study, potential reductions that might be achieved via controls associated with three different discharge concentrations (i.e., 8 mg/l, 5 mg/l, and 3 mg/l) for treatment plants in New Hampshire, Vermont and Massachusetts were calculated (see Table 9). The total capital costs and O&M costs associated with each level of treatment were also estimated (see Table 10). For the purposes of this study, it was recommended by the study advisory group that annualized rather than total capital costs be used to facilitate more direct comparison with non-point source mitigation costs. Consequently, the capital costs shown in Table 10 were subsequently divided by 20 to annualize these costs over a 20-year period. The newly-calculated total annual costs used for the cost curves discussed below for point sources are given in Table 13.

Table 13. Estimated total annual costs for point source reductions.

	Total Annual Cost*
Level 1 (8 mg/l)	$25,343,505
Level 2 (5 mg/l)	$9,500,098
Level 3 (3 mg/l)	$23,743,889
Total	$58,587,492

* Includes annualized capital cost and annual O&M cost

(Note: The load reduction values depicted by the "Y" axis on each of the "point source" cost curves shown in this section represent reductions in delivered loads to Long Island Sound and not reductions at the plant location. In other words, the effects of distance to the CRB outlet (i.e., in-stream attenuation) have been considered).

A number of different cost curves were developed for point sources using the estimated mean annual nitrogen reduction and the total annual cost information reflected in Table 13. Figure 5, for example, depicts one in which the points on the graph are ordered on the basis "most" to "least" effective sub-basin. In this case, each point represents the accumulated total annual cost of bringing all treatment plants within a given sub-basin to "Level 3" implementation (i.e., effluent concentration of 3 mg/l). Points closest to the origin (0,0) typically depict sub-basins that have one or more plants with effluent concentrations that at present are significantly above 8 mg/l; therefore, the cost/benefit of upgrading these plants is fairly high. Conversely, points at the other end of the curve (i.e., in the upper-right portion of the plot) represent basins with combined plant effluents closer to the 3 mg/l target). In these cases, the relative cost benefits are fairly low.

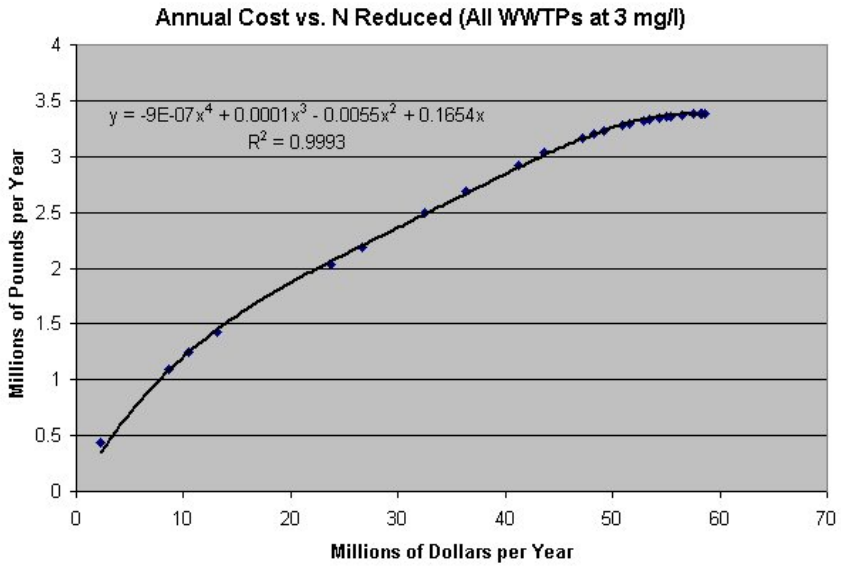


Figure 5. Costs ordered on basis of most to least cost-effective sub-basins.

Figure 5 is shown primarily to illustrate the concept of decreasing cost-effectiveness in terms of "entire-area" plant upgrades with increasing distance of the corresponding sub-basin from the outlet. Implementation of plant upgrades on a sub-basin by sub-basin basis, however, is somewhat unrealistic. Consequently, information presented in the following cost curves would probably be more useful for implementing future plant upgrades on a "case-by-case" basis.

Figure 6 shows the cost information arranged by treatment plant instead of sub-basin. In this case, the points are ordered on the basis of cost-effectiveness for each level of plant upgrade. So, for treatment level 1 (bringing all plants to 8 mg/l), the total reduction would be about 2.1 million pounds/year at an annual cost of around 25 million dollars. The points on the plot are ordered from most to least cost-effective, and for each step, the plants closest to the origin (0,0) would be more cost-effective in terms of future upgrades than those to the right. (Note: it should be evident from the discussion that each plant is plotted a total of three times to represent each sequential technology step).

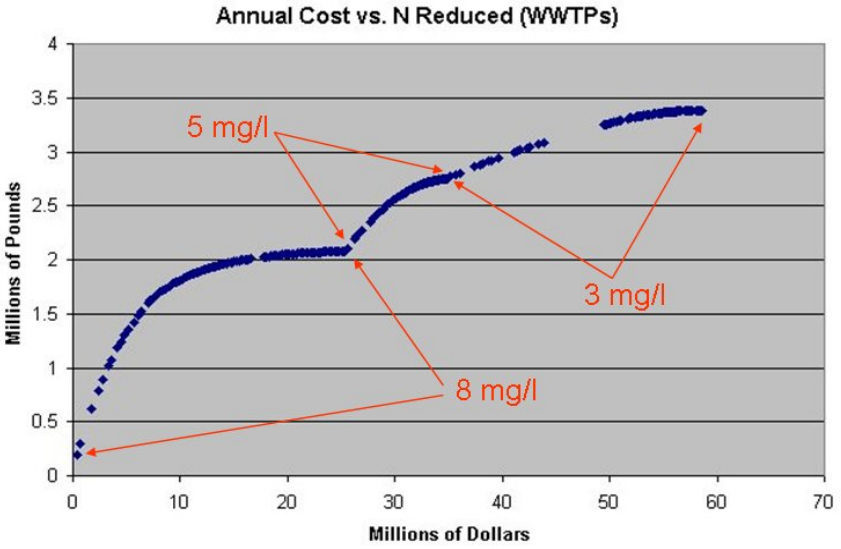


Figure 6. Costs ordered on basis of cost-effective technology implementation.

The cost curve presented in Figure 7 is similar to the one in the previous figure. However, in this case, the average per unit costs associated with each plant upgrade level (i.e., average cost per pound of nitrogen eliminated from delivery to Long Island Sound) was calculated, and these average values were used to re-compute the total cost of sequential upgrades for each plant. As can be seen from Figure 7, the per unit costs for Level 3 (3 mg/l) implementation are much higher than the other two levels. The actual average per unit costs calculated are $12.21/lb (Level 1), $14.04/lb (Level 2), and $37.42/lb (Level 3).

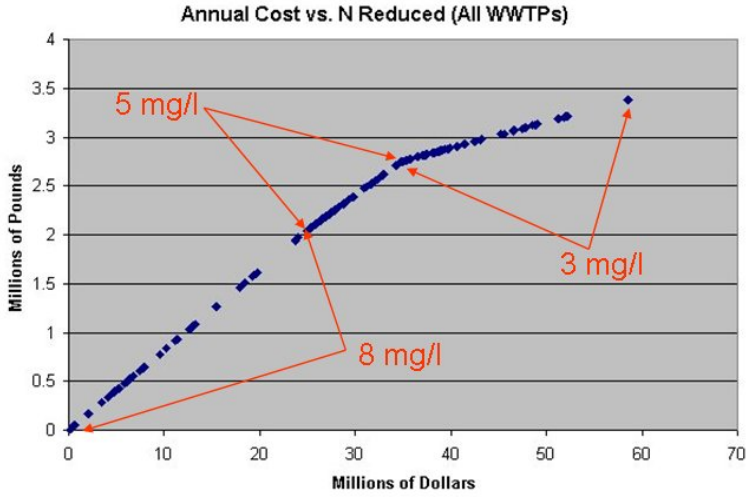


Figure 7. Costs ordered by cost-effective technology implementation using average per unit implementation costs.

Finally, Figure 8 shows a cost curve in which the cumulative costs of treatment plant upgrades are ordered solely on the basis of calculated per unit cost-effectiveness (i.e., cost per pound of nitrogen eliminated from delivery to the Sound). This curve differs from the previous two in that the plants are "inter-mixed" in terms of upgrade level. For example, Figure 9 illustrates the spreadsheet used to produce the plot in Figure 8. As shown in the figure, data are ordered by per unit cost (see column "F"), and the highlighted area illustrates the plants for which upgrades could be implemented to obtain the indicated results (i.e., a total reduction of 1.9 million pounds at a total cost of 9.9 million). Note that in this case, the implication is that it may be more cost-effective to upgrade some plants to a higher level before upgrading other plants to a lower level

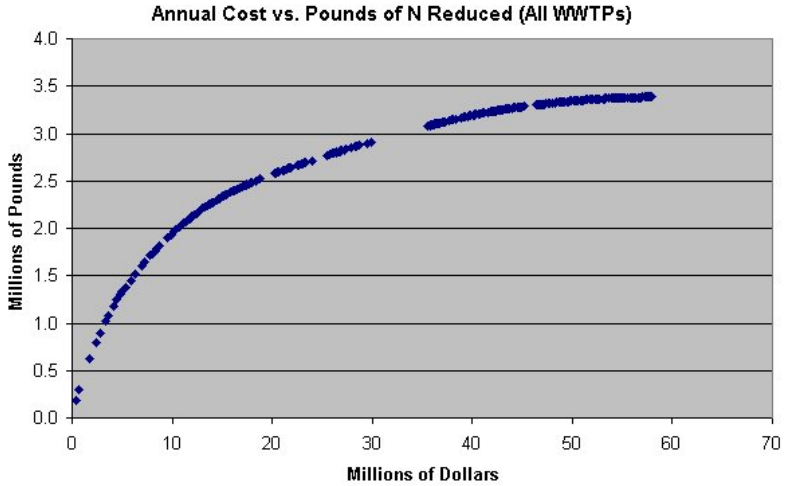
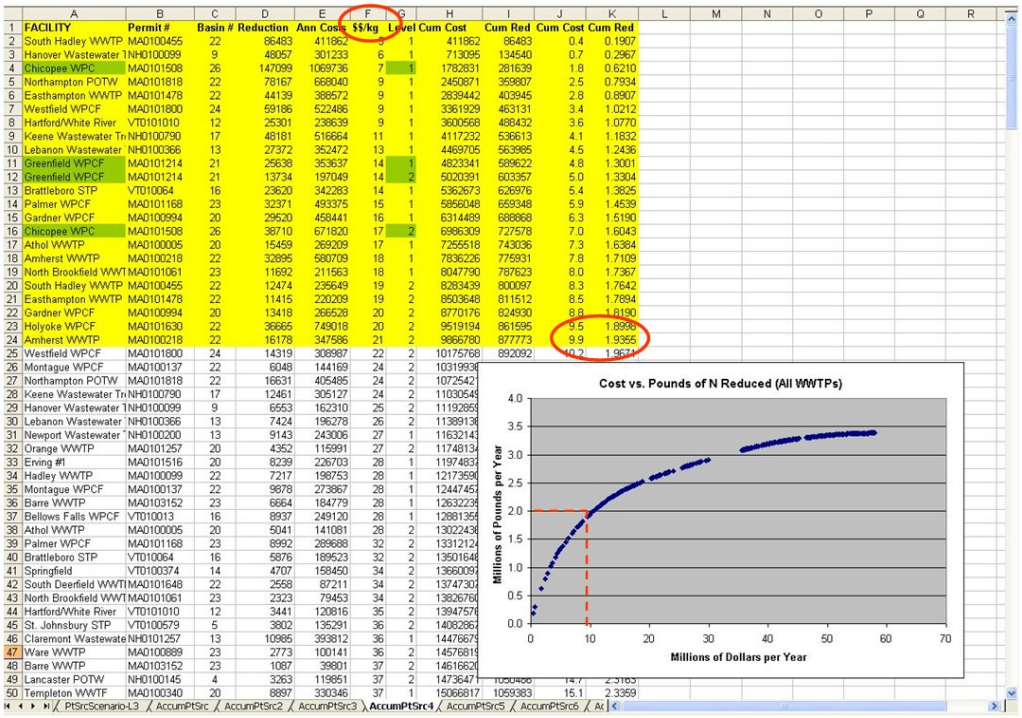


Figure 8. Costs ordered on basis of cost-effective technology implementation.



	FACILITY	Permit #	Basin #	Reduction	Ann Costs	$/kg	Level	Cum Cost	Cum Red	Cum Cost	Cum Red
2	South Hadley WWTP	MA0100455	22	86483	411862	5	1	411862	86483	0.4	0.1907
3	Hanover Wastewater Tr	NH0100099	9	48057	301233	6	1	713095	134540	0.7	0.2967
4	Chicopee WPC	MA0101508	26	147099	1069736	7	1	1782831	281639	1.8	0.6210
5	Northampton POTW	MA0101818	22	78167	668040	9	1	2450871	359807	2.5	0.7934
6	Easthampton WWTP	MA0101478	22	44139	388572	9	1	2839442	403945	2.8	0.8907
7	Westfield WPCF	MA0101800	24	59186	522486	9	1	3361929	463131	3.4	1.0212
8	Hartford/White River	VT0101010	12	25301	238639	9	1	3600568	488432	3.6	1.0770
9	Keene Wastewater Tr	NH0100790	17	48181	516664	11	1	4117232	536613	4.1	1.1832
10	Lebanon Wastewater	NH0100366	13	27372	352472	13	1	4469705	563985	4.5	1.2436
11	Greenfield WPCF	MA0101214	21	25638	353637	14	1	4823341	589622	4.8	1.3001
12	Greenfield WPCF	MA0101214	21	13734	197049	14	2	5020391	603357	5.0	1.3304
13	Brattleboro STP	VT010064	16	23620	342283	14	1	5362673	626976	5.4	1.3825
14	Palmer WPCF	MA0101168	23	32371	493375	15	1	5856048	659348	5.9	1.4539
15	Gardner WPCF	MA0100994	20	29520	458441	16	1	6314489	688868	6.3	1.5190
16	Chicopee WPC	MA0101508	26	38710	671820	17	2	6986309	727578	7.0	1.6043
17	Athol WWTP	MA0100005	20	15459	269209	17	1	7255518	743036	7.3	1.6384
18	Amherst WWTP	MA0100218	22	32895	680709	18	1	7836226	775931	7.8	1.7109
19	North Brookfield WWT	MA0101061	23	11692	211563	18	1	8047790	787623	8.0	1.7367
20	South Hadley WWTP	MA0100455	22	12474	235649	19	2	8283439	800097	8.3	1.7642
21	Easthampton WWTP	MA0101478	22	11415	220209	19	2	8503648	811512	8.5	1.7894
22	Gardner WPCF	MA0100994	20	13418	266528	20	2	8770176	824930	8.8	1.8190
23	Holyoke WPCF	MA0101630	22	36665	749018	20	2	9519194	861595	9.5	1.8996
24	Amherst WWTP	MA0100218	22	16178	347586	21	2	9866780	877773	9.9	1.9355
25	Westfield WPCF	MA0101800	24	14319	308987	22	2	10175768	892092	10.2	1.9674
26	Montague WPCF	MA0100137	22	6048	144169	24	2	1031993			
27	Northampton POTW	MA0101818	22	16631	405485	24	2	1072542			
28	Keene Wastewater Tr	NH0100790	17	12461	305127	24	2	1103054			
29	Hanover Wastewater T	NH0100099	9	6553	162310	25	2	1119286			
30	Lebanon Wastewater	NH0100366	13	7424	196278	26	2	1138913			
31	Newport Wastewater	NH0100200	13	9143	243006	27	1	1163214			
32	Orange WWTP	MA0101257	20	4352	115991	27	2	1174813			
33	Erving #1	MA0101516	20	8239	226703	28	1	1197483			
34	Hadley WWTP	MA0100099	22	7217	198753	28	1	1217359			
35	Montague WPCF	MA0100137	22	9878	273867	28	1	1244745			
36	Barre WWTP	MA0103152	23	6664	184779	28	1	1263223			
37	Bellows Falls WPCF	VT010013	16	8937	249120	28	1	1288135			
38	Athol WWTP	MA0100005	20	5041	141081	28	2	1302243			
39	Palmer WPCF	MA0101168	23	8992	269688	32	2	1331212			
40	Brattleboro STP	VT010064	16	5876	189523	32	2	1350164			
41	Springfield	VT0100374	14	4707	158450	34	2	1366009			
42	South Deerfield WWTI	MA0101648	22	2558	87211	34	2	1374730			
43	North Brookfield WWT	MA0101061	23	2323	79453	34	2	1382676			
44	Hartford/White River	VT0101010	12	3441	120816	35	2	1394757			
45	St. Johnsbury STP	VT0100579	5	3802	135291	36	2	1408286			
46	Claremont Wastewate	NH0101257	13	10985	393812	36	1	1447667			
47	Ware WWTP	MA0100889	23	2773	100141	36	2	1457681			
48	Barre WWTP	MA0103152	23	1087	39801	37	2	1461662			
49	Lancaster POTW	NH0100145	4	3263	119851	37	2	1473647	1050466	14.7	2.3165
50	Templeton WWTF	MA0100340	20	8897	330346	37	1	15066817	1059383	15.1	2.3359

Figure 9. Data used for cost curve in Figure 8.

In using the results presented above, the reader is cautioned about relying too heavily on them for developing detailed budgets for localized plant upgrade scenarios. As described earlier, all cost estimates for treatment plant upgrades were derived using the costing methodology developed as part of a pollution mitigation study for the Chesapeake Bay. While it is believed that the methodology does provide one with useful budget information for planning purposes, it is not based on actual construction costs that have been developed for specific plants located in the Connecticut River Basin. In the event such costs are developed in the future, it is likely that the total costs will differ somewhat from those estimated as part of the current study, and that the ordering of plants in terms of their upgrade cost-effectiveness will vary from the example illustrated in Figure 9.

4.2 Controls in Agricultural Areas

As described previously, for the purposes of this study, the two agricultural controls for which potential nitrogen reductions and annual costs were estimated include the use of cover crops and riparian buffers. It was estimated that the use of such controls would result in a maximum nitrogen load reduction of 595,765 kg/yr (or 1,313,636 lb/yr) for the entire Connecticut River Basin at an estimated annual cost of $6.48 million.

In the cost curve shown in Figure 10, each point represents the cumulative cost and corresponding reduction associated with treating 100% of the agricultural areas within a given sub-basin with the two control measures identified. The points (sub-basins) are ordered on the basis of total per unit cost-effectiveness (i.e., cost per pound of nitrogen eliminated from delivery to the Sound). As one moves from left to right, basin-wide implementation of agricultural mitigation efforts becomes less cost-effective. In general, this decreasing cost-effectiveness mirrors increasing distance of a given sub-basin from the Sound. Due to lower attenuation factors, a pound of nitrogen reduced in a sub-basin close to the Sound will result in a greater portion of that amount being removed before it reaches the Sound in comparison to a sub-basin farther away.

Estimates of costs for less than 100% agricultural BMP implementation can be derived more or less via a process of simple interpolation. For example, a 50% implementation rate would yield a load reduction of about 656,818 lb/yr (i.e., 0.50 x maximum load reduction of 1,313,636 lb/yr). The corresponding cost on the "x" axis in Figure 10 for a "y" value of 0.657 is approximately $1.8 million dollars per year. This approach assumes, of course, that BMP implementation is fairly uniform across all sub-basins.

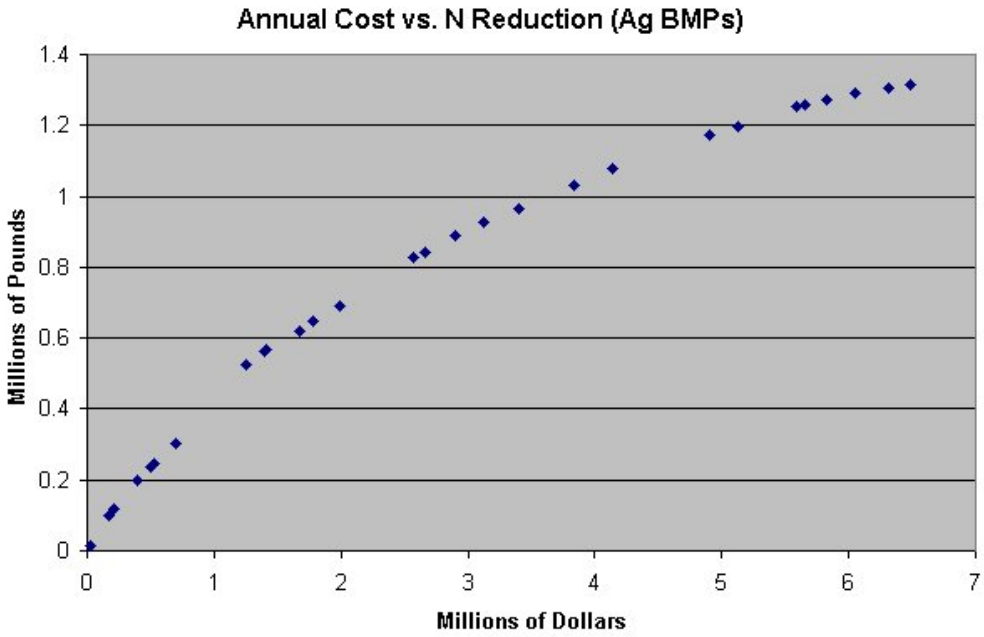


Figure 10. Cost curve for agricultural control assuming 100% implementation.

4.3 Controls in Urban Areas

The total cost for full urban BMP implementation within the entire CRB was estimated to be about $2.75 billion dollars, and the total potential reduction was estimated to be about 469,456 kg/yr (or 1,035,150 lb/yr) as previously discussed in section 3.3. To allow for better comparison with the other mitigation measures, however, this total cost was divided by 20 years (similar to the point source costs) to derive an estimated annual cost of $137,680,064. When ordered on the basis of most to least cost-effective sub-basin (as was done with agricultural controls in Figure 5), the resulting cost curve looks like the one shown in Figure 11. Similar to agricultural controls, as one moves from left to right, basin-wide implementation of urban mitigation efforts becomes less cost-effective. In a very general sense, basins with urban areas closer to the outlet are more cost-effective to treat than those farther away. However, due to the fact that land acquisition cost are more expensive as one moves from the northern end of the basin to the southern end, this cost relationship is far less linear than it is for agricultural BMPs. Also, as with agricultural BMPs, costs associated with less than 100% urban BMP implementation can be estimated using the interpolation approach described for agricultural BMPs in the previous section.

As can be seen by comparing the urban costs with the other two types of mitigation activities, urban controls are generally much more expensive. The average per unit costs of all point source controls combined are about $17.30 per pound of nitrogen eliminated from the Sound per year (i.e., $58.59 million per year / 3,385,941 lb/yr), and the per unit cost for agricultural controls is about $4.93 per pound of nitrogen eliminated. In comparison, the per unit cost for urban controls is about $133 per pound of nitrogen eliminated ($137,680,064 / 1,035,150 lb).

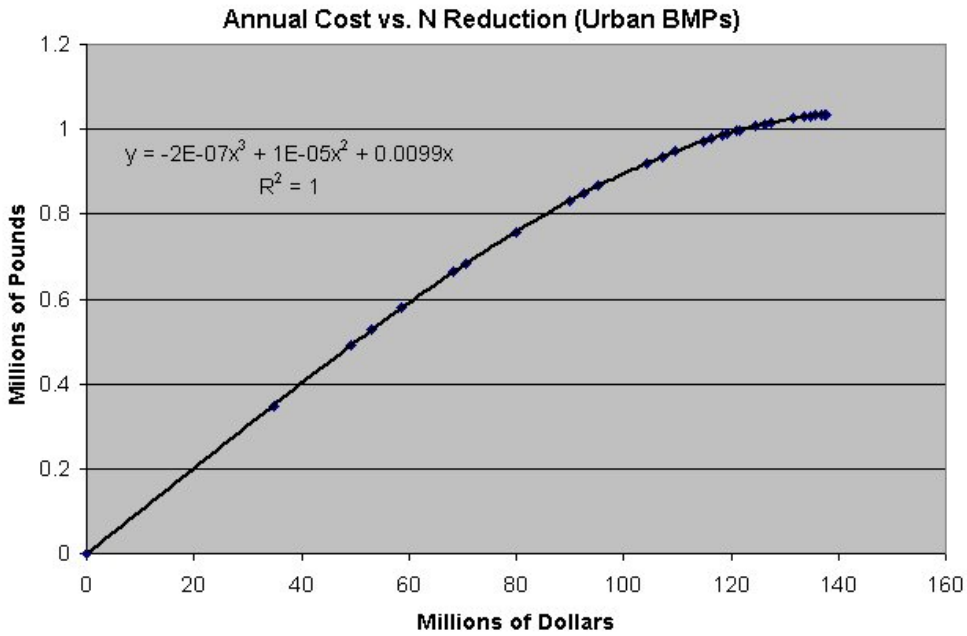


Figure 11. Cost curve for urban control assuming 100% implementation.

4.4 All Control Activities Combined

In the preceding sections, various cost curves were developed for each of the separate control activities. However, the cost and pollution reduction results can also be combined into one cost curve reflecting the cumulative costs and reductions associated with implementing both point and non-point source controls. Summarized in Table 14 are the estimated implementation costs and corresponding nitrogen reductions related to each type of control measure. Again, these costs and reductions assume that all treatment plants above Connecticut are brought to nitrogen discharge levels of 3 mg/l, as well as 100% implementation of urban and agricultural BMPs throughout the entire CRB (including Connecticut). Shown in Figure 12 is a cost curve that combines the cumulative costs and reductions for all of these measures. In this case, the points on the curve include results for both sub-basins (for agricultural and urban BMP implementation) and individual point sources (similar to that depicted in Figures 8 and 9).

Table 14. Summary of potential costs and reductions associated with all point and non-point source control measures.

Measure	Estimated Maximum Annual Nitrogen Reduction	Estimated Maximum Annual Cost ($)
Point Source Controls	1,535,574 kg (3,385,036 lb)	58,587,492
Agricultural Control	595,765 kg (1,313,663 lb)	6,480,613
Urban Controls	469,456 kg (1,035,151 lb)	137,680,364
Totals	2,600,385 kg (5,733,850 lb)	202,748,470

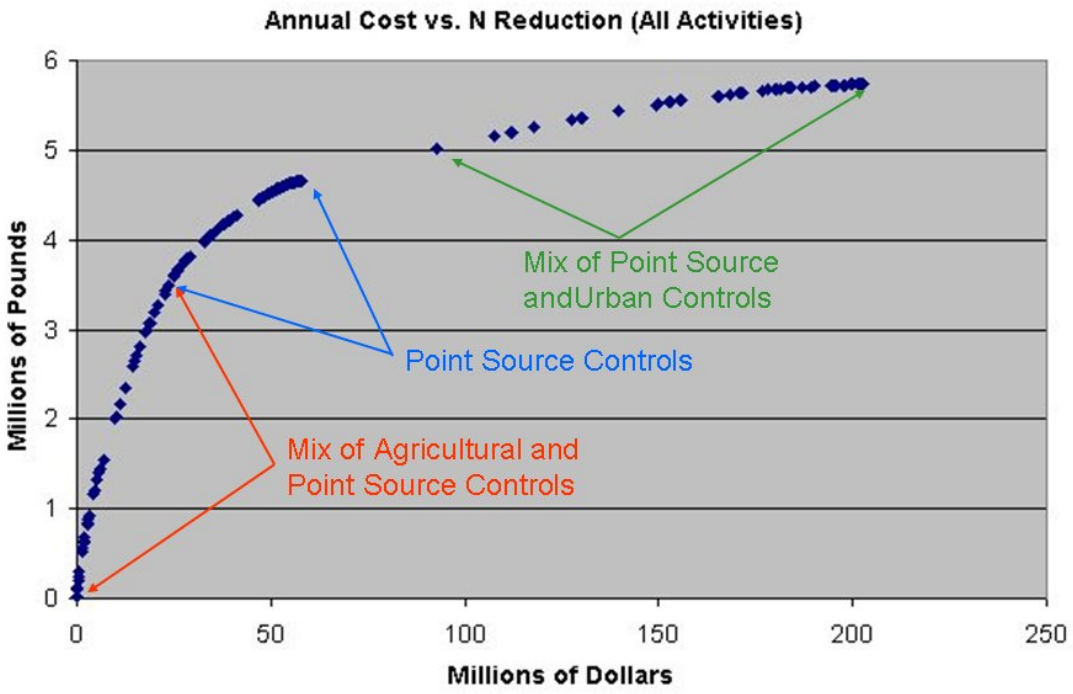


Figure 12. Combined cost curve for implementation of all control strategies.

As can be seen from Figure 12, a mix of agricultural BMPs and the more cost-effective point source controls would result in an estimated nitrogen reduction of about 3.7 million pounds per year at an approximate annual cost of about $27 million. Beyond that, further reductions would be made primarily using point source controls. With full implementation of agricultural BMPs and various nitrogen controls implemented on the majority of treatment plants, approximately 4.7 million pounds per year of nitrogen could be eliminated from the Sound at an annual cost of about $58 million. An additional 1 million pounds could be eliminated as well, but only through the implementation of more costly urban BMPs and more controls on the remaining treatment plants. This additional reduction would come at an additional annual cost of about $145 million.

A portion of some of the data used to derive the cost curve in Figure 12 is shown in Figure 13. High-lighted in this figure are specific activities that would need to be implemented (i.e., basin-wide agricultural measures and plant-specific upgrades) to achieve the reduction indicated by the dashed, red line in the inset cost curve (in this case, a reduction of about 3.6 million pounds at an annual cost of about $25.2 million). At the other end of the spectrum, as shown in Figure 14, an annual investment of about $149.4 million would be needed to eliminate the delivery of approximately 5.5 million pounds per year to the Sound. At this stage, it is assumed that all of the agricultural BMPs, most of the point source upgrades, and some relatively expensive urban BMPs would need to be implemented to obtain this level of reduction. A complete listing of all of the data shown in these figures can be found in Appendix E.

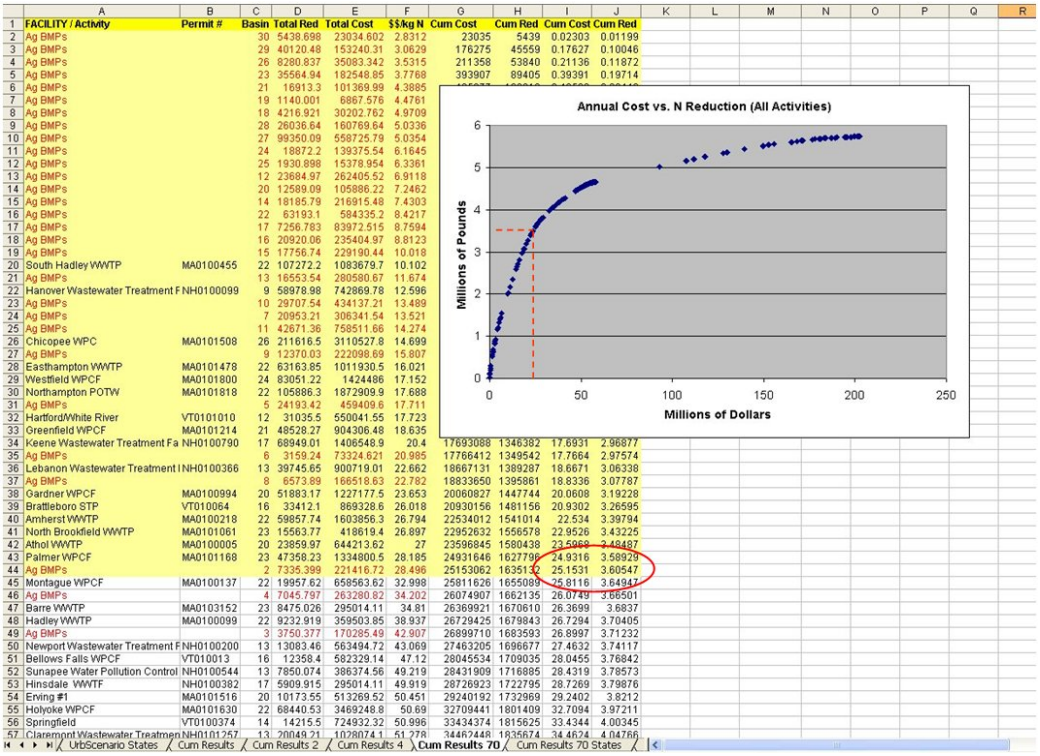


Figure 13. Example reduction scenario based on the cost curve data.

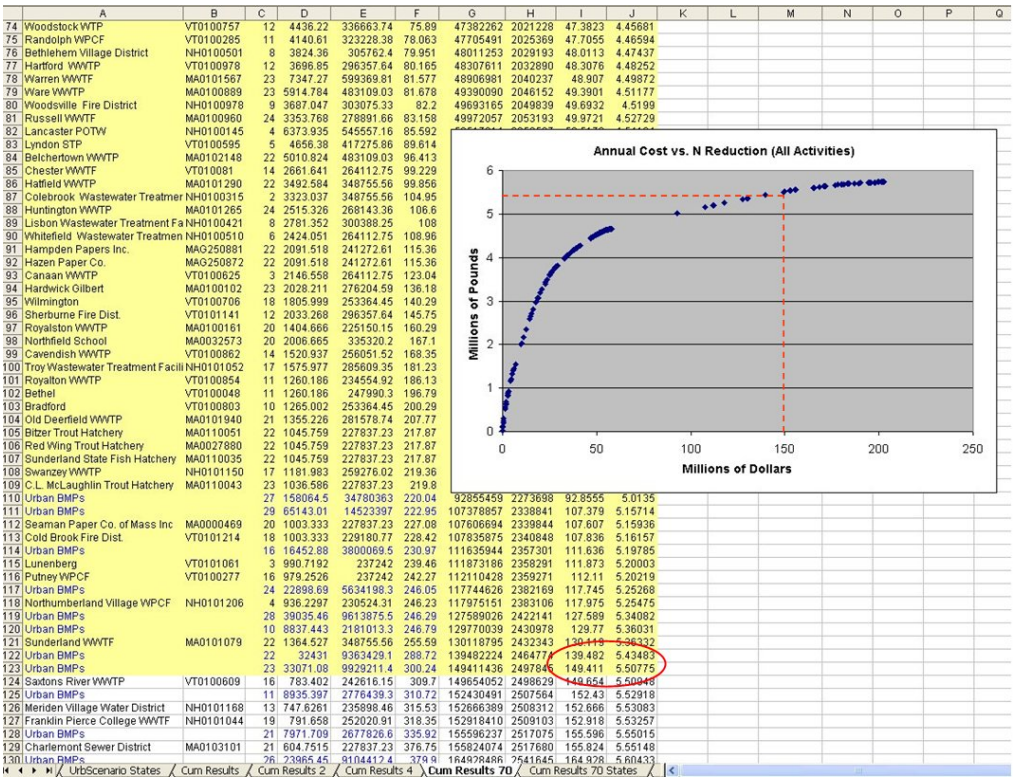


Figure 14. Another example of estimated costs and associated nitrogen reduction.

4.5 State-Based Cost Curves

Individual cost curves similar to the one shown in Figure 12 have also been developed for each geographic region in the Connecticut River Basin (excluding Quebec). These curves are shown in Figures 15 through 18 in the following sub-sections. Note that the cost curves for New Hampshire, Vermont and Massachusetts include results for both point source and non-point source reductions, whereas the curve for Connecticut only includes the results for non-point source reductions since, for the purposes of this study, future point source reductions in this state were not considered. Also presented in the following sub-sections are summaries of different types of estimated loads, potential reductions, and costs for each state. The complete data sets used to develop these curves are provided in Appendix F. A summary of the potential maximum costs and reductions by state are provided in Table 14.

In Table 14, as well as on the following pages, "maximum potential" loads, load reductions and costs refer to the upper limits of the estimates based on the assorted point and non-point source scenarios evaluated as part of this study (i.e., 100% implementation of agricultural and urban BMPs in all states and "Level 3" implementation for all treatment plants above Connecticut). These values are meant to serve as estimates of future reductions and associated costs, and are not meant to imply that further reductions or additional costs might not be possible as part of other activities undertaken in the future. The values of "0" for point source loads and costs in the case of Connecticut are not meant to suggest that there are no costs associated with current wastewater treatment plant upgrades in this state. Rather, it is meant to indicate that no further upgrades beyond ongoing efforts were evaluated as part of this study. For use in better establishing potential costs associated with different mitigation activities, separate cost curves similar to those shown earlier in Figures 8 through 11 have also been developed for each state. These are included in Appendix G.

Table 14. State-by-state summaries of estimated nitrogen reductions and costs.

	NH	VT	MA	CT
Maximum annual cost (millions of dollars)	$28.81	$32.49	$79.62	$61.83
Maximum annual reduction (millions of lb)	0.82	0.88	3.08	0.96
$/lb based on maximum reductions	$35.13	$36.92	$25.85	$64.41

New Hampshire

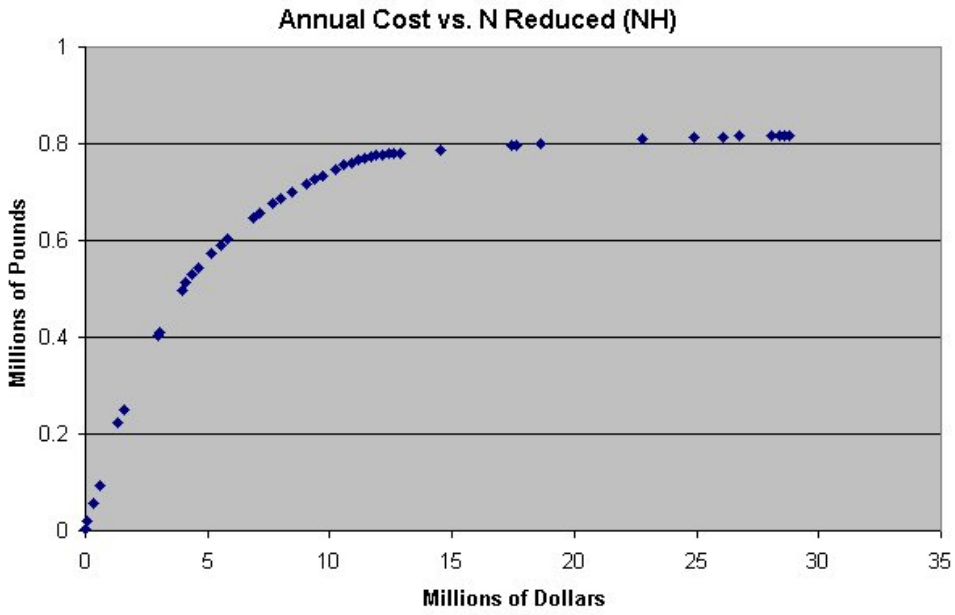


Figure 15. Combined cost curve for New Hampshire.

State Summary

Maximum potential total annual cost: $28.81 million per year
Current delivered N load to LIS: 4,567,410 lb/yr (12,513 lb/day)
Maximum potential N reduction: 818,234 lb/yr (2,242 lb/day)
Maximum potential delivered N load to LIS: 3,749,176 lb/yr (10,272 lb/day)
Maximum potential reduction in total N: 17.9%
Current point source N load delivered to LIS: 785,464 lb/yr (2,152 lb/day)
Maximum potential point source N reduction: 607,175 lb/yr (1,663 lb/day)
Maximum potential point source N delivered to LIS: 178,289 lb/yr (488 lb/day)
Maximum potential reduction in point source N: 77.3%
Maximum potential annual cost for point source controls: $11.96 million per year
Current total non-point source N load delivered to LIS: 3,781,946 lb/yr (10,361 lb/day)
Maximum potential total non-point source N reduction: 211,060 lb/yr (578 lb/day)
Maximum potential total non-point source N delivered to LIS: 3,570,886 lb/yr (9,783 lb/day)
Maximum potential reduction in total non-point source N: 5.6%
Maximum potential annual cost for non-point source controls: $16.60 million per year
Current agricultural non-point source N load delivered to LIS: 504,376 lb/yr (1,382 lb/day)
Maximum potential agricultural non-point source N reduction: 174,616 lb/yr (478 lb/day)
Maximum potential agricultural non-point source N delivered to LIS: 329,760 lb/yr (903 lb/day)
Maximum potential reduction in agricultural non-point source N: 34.6%
Maximum potential annual cost for agricultural controls: $1.55 million per year
Current urban non-point source N load delivered to LIS: 199,786 lb/yr (547 lb/day)
Maximum potential urban non-point source N reduction: 36,442 lb/yr (100 lb/day)
Maximum potential urban non-point source N delivered to LIS: 163,344 lb/yr (448 lb/day)
Maximum potential reduction in urban non-point source N: 18.2%
Maximum potential annual cost for urban controls: $15.30 million per year

Vermont

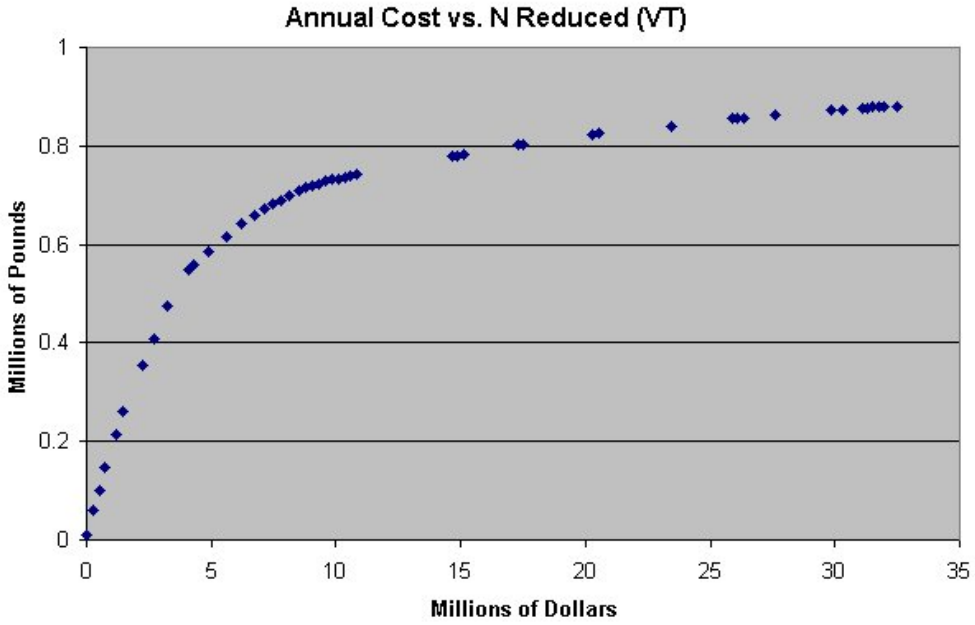


Figure 16. Combined cost curve for Vermont.

State Summary

Maximum potential total annual cost: $32.49 million per year
Current delivered N load to LIS: 6,140,375 lb/yr (16,823 lb/day)
Maximum potential N reduction: 879,509 lb/yr (2,410 lb/day)
Maximum potential delivered N load to LIS: 5,260,866 lb/yr (14,413 lb/day)
Maximum potential reduction in total N: 14.3%
Current point source N load delivered to LIS: 404,908 lb/yr (1,109 lb/day)
Maximum potential point source N reduction: 339,765 lb/day (931 lb/day)
Maximum potential point source N delivered to LIS: 65,143 lb/yr (178 lb/day)
Maximum potential reduction in point source N: 83.9%
Maximum potential annual cost for point source controls: $10.67 million per year
Current total non-point source N load delivered to LIS: 5,735,467 lb/yr (15,714 lb/day)
Maximum potential total non-point source N reduction: 539,744 lb/yr (1,479 lb/day)
Maximum potential total non-point source N delivered to LIS: 5,195,723 lb/yr (14,235 lb/day)
Maximum potential reduction in total non-point source N: 9.4%
Maximum potential annual cost for non-point source controls: $21.33 million per year
Current agricultural non-point source N load delivered to LIS: 1,238,037 lb/yr (3,392 lb/day)
Maximum potential agricultural non-point source N reduction: 415,166 lb/yr (1,137 lb/day)
Maximum potential agricultural non-point source N delivered to LIS: 822,871 lb/yr (2,254 lb/day)
Maximum potential annual cost for agricultural controls: $2.87 million per year
Maximum potential reduction in agricultural non-point source N: 33.5%
Current urban non-point source N load delivered to LIS: 390,766 lb/yr (1,071 lb/day)
Maximum potential urban non-point source N reduction: 124,578 lb/yr (341 lb/day)
Maximum potential urban non-point source N delivered to LIS: 266,188 lb/yr (729 lb/day)
Maximum potential reduction in urban non-point source N: 31.9%
Maximum potential annual cost for urban controls: $18.94 million per year

Massachusetts

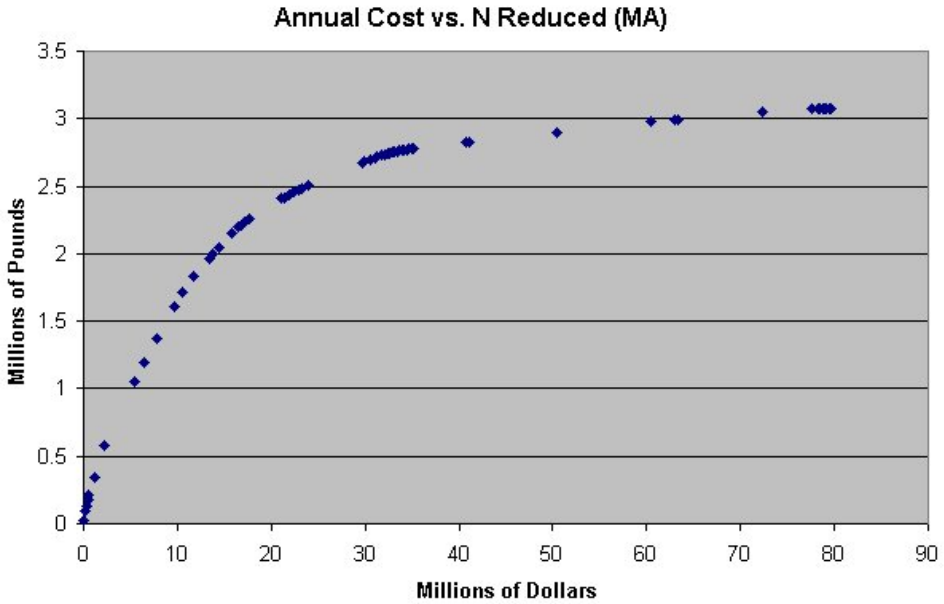


Figure 17. Combined cost curve for Massachusetts.

State Summary

Maximum potential total annual cost: $79.64 million per year
Current delivered N load to LIS: 8,107,970 lb/yr (22,214 lb/day)
Maximum potential N reduction: 3,075,410 lb/yr (8,426 lb/day)
Maximum potential delivered N load to LIS: 5,032,560 (13,788 lb/day)
Maximum potential reduction in total N: 37.9%
Current point source N load delivered to LIS: 3,340,716 lb/yr (9,153 lb/day)
Maximum potential point source N reduction: 2,438,096 lb/yr (6,680 lb/day)
Maximum potential point source N delivered to LIS: 902,620 (2,473 lb/day)
Maximum potential reduction in point source N: 73.0%
Maximum potential annual cost for point source controls: $35.95 million per year
Current total non-point source N load delivered to LIS: 4,767,254 lb/yr (13,061 lb/day)
Maximum potential total non-point source N reduction: 637,313 lb/yr (1,746 lb/day)
Maximum potential total non-point source N delivered to LIS: 4,129,941 lb/yr (11,315 lb/day)
Maximum potential reduction in total non-point source N: 13.4%
Maximum potential annual cost for non-point source controls: $43.49 million per year
Current agricultural non-point source N load delivered to LIS: 1,020,408 lb/yr (2,796 lb/day)
Maximum potential agricultural non-point source N reduction: 346,944 lb/yr (951 lb/day)
Maximum potential agricultural non-point source N delivered to LIS: 673,464 lb/yr (1,845 lb/day)
Maximum potential reduction in agricultural non-point source N: 34.0%
Maximum potential annual cost for agricultural controls: $1.16 million per year
Current urban non-point source N load delivered to LIS: 848,572 lb/yr (2,325 lb/day)
Maximum potential urban non-point source N reduction: 290,370 lb/yr (796 lb/day)
Maximum potential urban non-point source N delivered to LIS: 558,202 lb/yr (1,529 lb/day)
Maximum potential reduction in urban non-point source N: 34.2%
Maximum potential annual cost for urban controls: $42.50 million per year

Connecticut

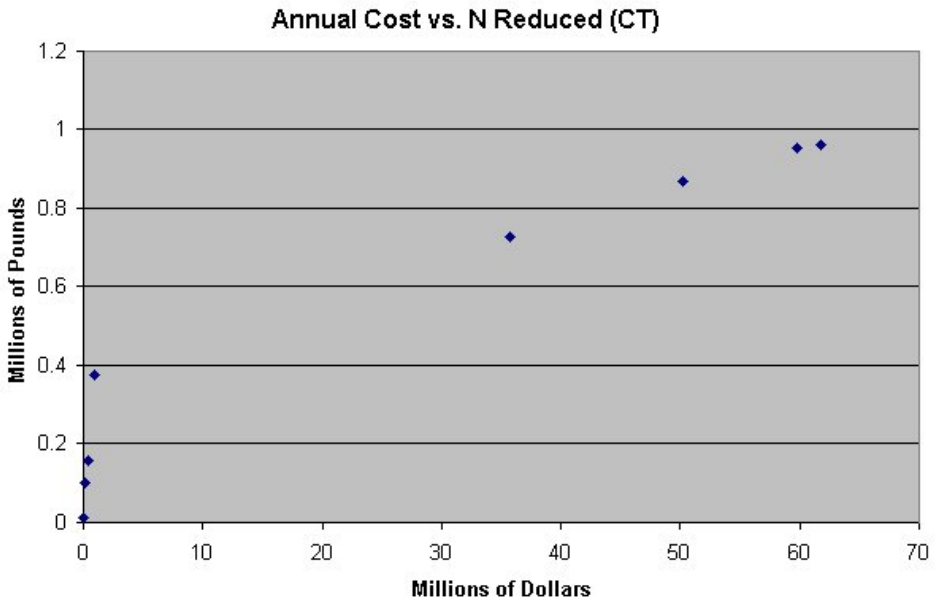


Figure 18. Combined cost curve for Connecticut.

State Summary

Maximum potential annual cost: $61.83 million per year
Current delivered N load to LIS: 9,780,386 lb/yr (26,796 lb/day)
Maximum potential N reduction: 960,696 lb/yr (2,632 lb/day)
Maximum potential delivered N load to LIS: 8,819,690 lb/yr (24,164 lb/day)
Maximum potential reduction in total N: 9.8%
Current point source N load delivered to LIS: 5,614,445 lb/yr (15,382 lb/day)
Maximum potential point source N reduction: 0
Maximum potential point source N delivered to LIS: 5,614,445 lb/yr (15,382 lb/day)
Maximum potential reduction in point source N: 0%
Maximum potential annual cost for point source controls: 0
Current total non-point source N load delivered to LIS: 4,165,941 lb/yr (11,414 lb/day)
Maximum potential total non-point source N reduction: 960,696 lb/yr (2,632 lb/day)
Maximum potential total non-point source N delivered to LIS: 3,205,245 lb/yr (8,781 lb/day)
Maximum potential reduction in total non-point source N: 23.1%
Maximum potential annual cost for non-point source controls: $61.70 million per year
Current agricultural non-point source N load delivered to LIS: 1,069,718 lb/yr (2,931 lb/day)
Maximum potential agricultural non-point source N reduction: 376,936 lb/yr (1,033 lb/day)
Maximum potential agricultural non-point source N delivered to LIS: 692,782 lb/yr (1,898 lb/day)
Maximum potential reduction in agricultural non-point source N: 35.2%
Maximum potential annual cost for agricultural controls: $ 0.90 million per year
Current urban non-point source N load delivered to LIS: 1,602,171 lb/yr (4,390 lb/day)
Maximum potential urban non-point source N reduction: 583,761 kg/yr (1,599 lb/day)
Maximum potential urban non-point source N delivered to LIS: 1,018,410 lb/yr (2,790 lb/day)
Maximum potential reduction in urban non-point source N: 36.4%
Maximum potential annual cost for urban controls: $60.93 million per year.

5.0 SUMMARY AND CONCLUSIONS

Based on the work completed, it was determined that the current nitrogen load delivered to Long Island Sound via the entire CRB is about 13,020,514 kg (or 28,710,233 lb) per year. Of this amount, approximately 35.3% originates from point sources (primarily municipal wastewater treatment plants), with the remainder (64.7%) coming from non-point sources. Of the total mean annual load, approximately 13.5% (about 3,866,961 lb/yr) is from agricultural sources, and about 10.6% (about 3,046,577 lb/yr) is from urban sources. The remaining 40.6% of the non-point source load (about 11,651,160 lb/yr) originates from theoretically "uncontrollable" sources such as forested areas and wetlands principally located in the upper reaches of the Connecticut River Basin.

Based upon the analyses presented in sections 3.2 and 3.3, it appears that the maximum potential reductions in agricultural and urban loads (under the assumption of full BMP implementation) are about 34.1% (1,313,636 lb/yr) and 34.0% (1,035,150 lbs/yr), respectively. Similarly, the results presented in section 3.1 suggest that the point source loads in the upper part of the CRB (i.e., in areas above Connecticut) could be reduced by approximately 3,385,941 lb/yr if all plants were upgraded to discharge no more than 3 mg/l of nitrogen. This would equate to a reduction of about 74.7% when considering the current point source load delivered by sources upstream of Connecticut (4,531,090 lb/yr).

As described earlier, the recommended nitrogen reductions outlined in the LIS TMDL include:

- A 25 percent reduction in point source loads of nitrogen from the upper part of the CRB (i.e., all areas above Connecticut).
- A 10 percent reduction in nitrogen loads from urban and agricultural areas within the entire CRB.
- An 18 percent reduction in nitrogen loads from atmospheric deposition within the entire CRB.

Given the potential maximum load reductions cited in the previous paragraph, it appears that the 10% reduction target for both agricultural and urban loads within the entire CRB can be technologically achieved. Due to the relatively much higher cost of implementing urban BMPs, it may be that the combined nitrogen load from these two sources can be reduced more cost-effectively via the use of much cheaper agricultural control measures. Similarly, it should be technologically achievable to meet the stated goals for point source reductions in the upper CRB.

For illustrative purposes, a summary of potential annual costs for each state to meet the recommended nitrogen reductions given above for point and non-point sources are presented in Table 15 and 16, respectively. These cost estimates were derived using the separate point and non-point source cost curves for each state included in Appendix G. For the case of 10 percent reductions in agricultural and urban loads, this reduction was assumed to be a 10 percent reduction in the combined load rather than in the load associated with each category. Given the relatively lower cost of agricultural BMPs, it was assumed that agricultural areas would be fully addressed prior to implementing urban BMPs in order to meet the 10 percent reduction target. Consequently, these estimated annual costs should probably be viewed as the lowest potential costs as future state-based control plans may include a limited amount of urban BMP implementation as well. With respect to the point source costs given in Table 15, it should be recognized that the cost curves from which they were obtained were developed using simplified cost estimation routines (i.e., the Chesapeake Bay regression equations) and not actual site-specific cost information. Consequently, these cost estimates would likely vary somewhat if site-specific cost information was used.

As can be seen from Table 16, the potential annual costs associated with reducing non-point source loads in all states are fairly low. This is due primarily to the fact that the 10% reduction goal can technically be met in all states by solely addressing agricultural loads without the need to use less cost-effective measures in urban areas.

Table 15. Potential state-by-state annual costs for point source controls with a 25% reduction goal.

State	Current Load[1]	Reduction Target[2]	Annual Cost[3] (million $ / year)
New Hampshire	785,464 lb/yr (2,152 lb/day)	196,366 lb/yr (538 lb/day)	1.9
Vermont	404,908 lb/yr (1,109 lb/day)	101,227 lb/yr (277 lb/day)	1.0
Massachusetts	3,340,716 lb/yr (9,153 lb/day)	835,179 lb/yr (2,288 lb/day)	5.1
Connecticut	5,614,445 lb/yr (15,382 lb/day)	----	----
Totals	10,145,534 lb/yr (27,796 lb/day)	1,132,772 lb/yr (3,103 lb/day)	8.0

[1] Represents annual loads delivered to Long Island Sound
[2] Represents 25% of current annual load
[3] Represents annualized capital costs plus annual O& M costs

Table 16. Potential state-by-state annual costs for non-point source controls with a 10% reduction goal.

State	Current Load[1]	Reduction Target[2]	Annual Cost[3] (million $ / year)
New Hampshire	704,162 lb/yr (1,929 lb/day)	70,416 lb/yr (193 lb/day)	0.39
Vermont	1,628,803 lb/yr (4,462 lb/day)	162,880 lb/yr (446 lb/day)	0.82
Massachusetts	1,868,980 lb/yr (5,121 lb/day)	186,898 lb/yr (512 lb/day)	0.49
Connecticut	2,671,889 lb/yr (7,320 lb/day)	267,189 lb/yr (732 lb/day)	0.57
Totals	6,873,834 lb/yr (18,832 lb/day)	687,383 lb/yr (1,883 lb/day)	2.3

[1] Represents annual loads delivered to Long Island Sound from agricultural and urban areas only
[2] Represents 10% of current annual load from agricultural and urban areas
[3] Represents annualized construction costs plus annual maintenance costs

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APPENDICES

Appendix A – Nitrogen Loads by Sub-Basin

Included on the following pages is an extended table that provides a listing of the "generated" and "delivered" nitrogen loads (in kg/yr) estimated by source for each of the 30 sub-basins used in this study. The generated loads are the loads simulated via use of the AVGWLF model. The delivered loads are those delivered to the outlet on Long Island Sound. These loads were re-calculated using both point and non-point source attenuation factors as described in section 2.1. The sub-basins pertaining to each geographic area in the CRB are as follows:

Quebec: 1
New Hampshire: 2,4,6,8,9,13,15,17 and 19
Vermont: 3,5,7,10,11,12,14,16 and 18
Massachusetts: 20 through 26
Connecticut: 27 through 30

Annual Nitrogen Loads (kg/yr) by Source and Sub-Basin

Sub-basin	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Generated																
Hay/past	12182	6896	2304	2124	18467	1693	18326	6782	10398	17109	52385	45035	9433	22186	17040	31675
Row crop	3872	18171	6281	8776	44742	3675	36773	7575	9609	51347	53007	12503	6569	5031	6250	10071
Forest	59621	341503	215075	309807	263234	78210	121136	225874	121284	353424	367163	300470	290796	180450	144469	375577
Wetland	59	19703	72763	9349	28299	6166	10831	5894	1913	9029	7454	3569	5312	7807	2774	17344
Quarry	0	1995	90	3702	1274	357	214	10613	504	429	1171	3865	2825	2002	1543	5109
Transition	8383	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LD Devel	215	4350	1051	2872	21509	1310	7545	5069	2383	26455	27402	14484	10133	11190	6965	34092
HD Devel	0	70	14	82	4259	77	731	897	339	1733	1320	4583	3986	1864	698	11971
Streambank	9	497	337	1001	1031	178	365	911	334	906	3593	1511	3742	1604	993	1947
Subsurface	49619	168160	153439	256281	266635	69403	164150	193666	144930	263714	435584	233909	315531	230065	193008	325424
Pt Source	0	5686	5145	70920	27638	5725	812	25564	88912	1896	10831	70394	120561	37134	11644	65316
Septic Sys	170	2966	2978	4500	10535	2382	4944	5948	1884	11656	15372	12470	21937	11869	10985	23126
Total kg	134130	570007	459476	669431	687624	169176	365826	488793	382490	737697	975283	702792	790824	511201	396368	899652
(lbs/day)	810	3443	2776	4044	4154	1022	2210	2953	2311	4456	5892	4246	4777	3088	2394	5435
Comb AF	0.614	0.627	0.597	0.588	0.565	0.562	0.551	0.559	0.528	0.529	0.532	0.511	0.502	0.488	0.465	0.463
PS AF	0.297	0.310	0.280	0.271	0.248	0.245	0.234	0.242	0.211	0.212	0.215	0.194	0.185	0.171	0.148	0.146
Delivered																
Hay/past	4699	2572	929	875	8033	741	8222	2993	4912	8067	24507	22013	4697	11370	9121	17013
Row crop	1493	6778	2532	3618	19463	1609	16499	3344	4539	24209	24798	6111	3271	2578	3345	5410
Forest	23000	127381	86694	127704	114507	34235	54351	99697	57292	166629	171767	146868	144791	92480	77334	200655
Wetland	23	7349	29330	3854	12310	2699	4860	2601	904	4257	3487	1744	2645	4001	1485	9316
Quarry	0	744	36	1533	554	156	96	4685	238	202	548	1889	1406	1026	826	2744
Transition	3234	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LD Devel	83	1623	423	1184	9357	574	3385	2237	1126	12473	12819	7079	5046	5735	3728	18311
HD Devel	0	26	6	34	1853	34	328	396	160	817	618	2240	1985	955	374	6430
Streambank	3	185	136	413	449	78	164	402	158	427	1681	738	1863	822	532	1046
Subsurface	19141	62724	61849	105640	115986	30380	73650	85481	68462	124333	203777	114333	157107	117908	103316	174791
Pt Source	0	3923	3705	51715	20784	4321	622	19387	70186	1495	8500	56723	98247	30803	9924	55788
Septic Sys	66	1106	1201	1855	4583	1043	2218	2625	890	5495	7191	6095	10923	6083	5880	12421
Total kg	51742	214415	186840	298425	307878	75869	164395	223849	208866	348404	459694	365836	431978	273762	215865	503924
(lbs/day)	313	1295	1129	1803	1860	458	993	1352	1262	2105	2777	2210	2610	1654	1304	3044

Comb AF = combined non-point source and point source attenuation factor (includes 0.317 factor for loss prior to reaching Connecticut River)
PS AF = point source attenuation factor (used for transport in Connecticut River)

Annual Nitrogen Loads (kg/yr) by Source and Sub-Basin (cont.)

Sub-basin	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total (kg)	Total (lb)
Generated																
Hay/past	11020	8772	1868	6309	23973	27445	34293	20972	2700	2080	30382	19585	24470	5731	493635	1088466
Row crop	2597	2026	310	4512	6465	33447	7444	8454	1484	1223	18066	4671	4094	749	379793	837444
Forest	227412	153242	41631	70693	173460	180142	117693	250258	81528	29676	101611	189826	164749	82402	5610416	12370968
Wetland	5749	14356	3767	35040	27581	60399	97840	47665	13436	11957	4394	6717	8472	107760	556401	1226865
Quarry	1789	5026	19	3077	1234	1483	2711	3399	436	166	2112	2118	2465	712	62456	137716
Transition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8383	18506
LD Devel	10494	3750	468	18330	18319	49165	61464	51130	2294	15983	98428	76354	98062	5296	686563	1513870
HD Devel	709	70	6	9863	3021	32734	23218	6520	3	42393	276078	19409	50111	262	497020	1095930
Streambank	1362	290	58	1045	786	2204	3100	1737	154	823	4494	2032	2380	391	39814	87789
Subsurface	194294	107870	36477	241523	194032	429262	486425	283843	64129	128348	606847	343433	408863	100357	7089218	15631726
Pt Source	113642	5957	1083	182277	79341	617334	127501	114385	271	537717	1677826	414505	570386	6217	4996620	11017547
Septic Sys	16011	7069	3704	12700	6152	22823	42500	24915	5151	10557	89837	16967	65749	2489	470346	1037114
Total kg	585079	308428	89391	585370	534364	1456437	1004189	813279	171586	780923	2910076	1095616	1399800	215366	20890676	46063941
(lbs/day)	3535	1863	540	3536	3228	8798	6066	4913	1037	4718	17580	6619	8456	1301		126203
Comb AF	0.458	0.422	0.454	0.442	0.438	0.405	0.413	0.403	0.420	0.383	0.365	0.387	0.339	0.323		
PS AF	0.141	0.125	0.137	0.125	0.125	0.088	0.096	0.086	0.103	0.066	0.048	0.070	0.022	0.006		
Delivered																
Hay/past	5969	4895	1020	3521	13466	16343	20139	12527	1566	1284	19283	12002	16177	3878	262836	579554
Row crop	1407	1131	169	2518	3631	19917	4371	5049	861	755	11466	2862	2707	507	186947	412219
Forest	123184	85523	22740	39453	97439	107269	69117	149478	47284	18321	64490	116324	108919	55755	2830679	6241647
Wetland	3114	8-12	2058	19556	15493	35966	57458	28470	7793	7382	2789	4116	5601	7280	295953	652576
Quarry	969	2805	10	1717	693	883	1592	2030	253	103	1341	1298	1629	482	32489	71639
Transition	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3237	7139
LD Devel	5684	2093	256	10230	10290	29276	36096	30540	1330	9867	62470	46789	64831	3583	398518	878733
HD Devel	384	39	3	5504	1697	19492	13635	3894	2	26172	175220	11894	33130	178	307497	678032
Streambank	738	162	31	583	441	1313	1821	1037	89	508	2852	1245	1573	264	21755	47970
Subsurface	105245	60201	19925	134791	108994	255613	285660	169538	37193	79236	385152	210453	270306	67903	3809089	8399042
Pt Source	97582	5213	935	159508	69720	563299	115295	104582	243	502417	1596748	385404	557905	6177	4601149	10145534
Septic Sys	8673	3945	2023	7088	3456	13590	24959	14882	2987	6517	57018	10397	43468	1684	270362	596149
Total kg	352948	174018	49172	384470	325322	1062960	630143	522027	99601	652561	2378828	802785	1106245	147691	13020514	28710233
(lbs/day)	2132	1051	297	2323	1965	6421	3807	3154	602	3942	14371	4850	6683	892		78658

Comb AF = Combined non-point source and point source attenuation factor (includes 0.317 factor for loss prior to reaching Connecticut River)
PS AF = point source attenuation factor (used for transport in Connecticut River

Appendix B – Current Discharge Characteristics of Wastewater Treatment Plants in the CRB

FACILITY	State	Permit No.	Design Flow MGD	Avg. Flow MGD	Total N (mgl)	Total N kg/day	Total N (lb/day)
American Tissue/Atalntic Paper Mills	NH	NH0001180	0.16	0.11	3	1.2	2.8
Bethlehem Village District	NH	NH0100501	0.34	0.22	19.6	16.3	36.0
Charlestown WWTF	NH	NH0100765	1.1	0.4	19.6	29.7	65.4
Cheshire County Home	NH	NH0100391	0.04	0.03	19.6	2.2	4.9
Chesire Medical Center	NH	NH0021539	NA	0	19.6	0.0	0.0
Claremont Wastewater Treat. Facility	NH	NH0101257	3.89	1.61	14.06	85.7	188.9
Colebrook Wastewater Treat. Facility	NH	NH0100315	0.5	0.21	19.6	15.6	34.4
Coy Paper Company	NH	NH0001261	NA	0	19.6	0.0	0.0
Fish Hatchery-Berlin	NH	NH0000621	7.1	7.1	2	53.7	118.5
Fish Hatchery - Twin Mountain	NH	NH0000744	0.7	0.7	2	5.3	11.7
Franklin Pierce College WWTF	NH	NH0101044	0.14	0.04	19.6	3.0	6.5
Glencliff Home for the Elderly	NH	NH0101371	NA	0	19.6	0.0	0.0
Groveton Wastewater Treat. Facility	NH	NH0100226	0.37	0.27	19.6	20.0	44.2
Hanover Wastewater Treatment Facility	NH	NH0100099	2.3	2.004	30	227.6	501.8
Hinsdale WWTF	NH	NH0100382	0.3	0.3	19.6	22.3	49.1
Keene Wastewater Treatment Facility	NH	NH0100790	6	3.5	19.6	259.7	572.5
Lancaster Grange POTW	NH	NH0101249	0.004	0.004	19.6	0.3	0.7
Lancaster POTW	NH	NH0100145	1.2	1.08	8.86	36.2	79.9
Lebanon Wastewater Treatment Facility	NH	NH0100366	3.18	2.198	19.06	158.6	349.6
Lisbon Wastewater Treatment Facility	NH	NH0100421	0.32	0.16	19.6	11.9	26.2
Littleton Wastewater Treatment Facility	NH	NH0100153	1.5	1.099	10.06	41.8	92.3
Meriden Village Water District	NH	NH0101168	0.08	0.04	19.6	3.0	6.5
Newport Wastewater Treatment Plant	NH	NH0100200	1.3	0.7	19.6	51.9	114.5
Northumberland Village WPCF	NH	NH0101206	0.06	0.056	19.6	4.2	9.2
Paper Service Limited	NH	NH0000311	NA	0	19.6	0.0	0.0
Piermont Wastewater Treatment	NH	NH0101231	0.007	0.004	19.6	0.3	0.7
Stratford Mill House System WWTF	NH	NH0101214	0.024	0.017	19.6	1.3	2.8
Stratford Village System WWTF	NH	NH0100536	0.056	0.029	19.6	2.2	4.7
Sullivan County Home	NH	NH0100684	NA	0	19.6	0.0	0.0
Sunapee Water Pollution Cont. Facility	NH	NH0100544	0.64	0.42	19.6	31.2	68.7
Swanzey WWTP	NH	NH0101150	0.167	0.06	19.6	4.5	9.8
Troy Mills, Inc.	NH	NH0000523	NA	0	19.6	0.0	0.0
Troy Wastewater Treatment Facility	NH	NH0101052	0.265	0.08	19.6	5.9	13.1
US Army Cold Regions Research	NH	NH0001619	NA	0	19.6	0.0	0.0
Wasau Paper	NH	NH0001562	NA	4.59	4.4	76.4	168.6
Whitefield Wastewater Treat. Facility	NH	NH0100510	0.185	0.14	19.6	10.4	22.9
Winchester Wastewater Treat. Plant	NH	NH0100404	0.28	0.24	19.6	17.8	39.3
Woodsville Fire District	NH	NH0100978	0.33	0.259	16.06	15.7	34.7
Tillotson Health Care Corp	NH	NH0023175	NA	0	19.6	0.0	0.0
Bellows Falls WPCF	VT	VT010013	1.405	0.58	21.06	46.2	101.9
Bethel	VT	VT0100048	0.125	0.07	19.6	5.2	11.5
Bradford	VT	VT0100803	0.145	0.07	19.6	5.2	11.5
Brattleboro STP	VT	VT010064	3.005	1.66	20.06	126.0	277.9
Bridgewater	VT	VT0100846	0.045	0.01	19.6	0.7	1.6
Canaan WWTP	VT	VT0100625	0.185	0.13	19.6	9.6	21.3
Cavendish WWTP	VT	VT0100862	0.155	0.08	19.6	5.9	13.1

FACILITY	State	Permit No.	Design Flow MGD	Avg. Flow MGD	Total N (mgl)	Total N kg/day	Total N (lb/day)
Chelsea WWTP	VT	VT0100943	0.065	0.03	19.6	2.2	4.9
Chester WWTF	VT	VT010081	0.185	0.14	19.6	10.4	22.9
Danville	VT	VT0100633	0.065	0.03	19.6	2.2	4.9
Lunenberg	VT	VT0101061	0.085	0.06	19.6	4.5	9.8
Hartford WWTP	VT	VT0100978	0.305	0.2	19.6	14.8	32.7
Ludlow WWTF	VT	VT0100145	0.705	0.39	15.5	22.9	50.5
Lyndon STP	VT	VT0100595	0.755	0.27	19.6	20.0	44.2
Putney WPCF	VT	VT0100277	0.085	0.05	19.6	3.7	8.2
Randolph WPCF	VT	VT0100285	0.405	0.23	19.6	17.1	37.6
Readsboro WPC	VT	VT0100731	0.755	0.04	19.6	3.0	6.5
Royalton WWTP	VT	VT0100854	0.075	0.07	19.6	5.2	11.5
St. Johnsbury STP	VT	VT0100579	1.6	1.22	12.06	55.7	122.8
Saxtons River WWTP	VT	VT0100609	0.105	0.04	19.6	3.0	6.5
Sherburne Fire Dist.	VT	VT0101141	0.305	0.11	19.6	8.2	18.0
South Woodstock WWTP	VT	VT0100749	0.055	0.01	19.6	0.7	1.6
Springfield	VT	VT0100374	2.2	1.37	12.06	62.5	137.9
Hartford/White River	VT	VT0101010	1.225	1.03	30.06	117.2	258.4
Whitingham	VT	VT0101109	0.015	0.01	19.6	0.7	1.6
Whitingham Jacksonville	VT	VT0101044	0.055	0.03	19.6	2.2	4.9
Cold Brook Fire Dist.	VT	VT0101214	0.055	0.05	19.6	3.7	8.2
Wilmington	VT	VT0100706	0.145	0.09	19.6	6.7	14.7
Windsor	VT	VT0100919	1.135	0.44	19.6	32.6	72.0
Windsor-Weston	VT	VT0100447	0.025	0.01	19.6	0.7	1.6
Woodstock WTP	VT	VT0100757	0.455	0.24	19.6	17.8	39.3
Woodstock-Taftsville	VT	VT0100765	0.015	0	19.6	0.0	0.0
Huntington WWTP	MA	MA0101265	0.2	0.12	19.6	8.9	19.6
Russell WWTF	MA	MA0100960	0.24	0.16	19.6	11.9	26.2
Westfield WPCF	MA	MA0101800	6.1	3.78	20.4	291.9	643.6
Woronoco Village WWTF	MA	MA0103233	0.02	0.01	19.6	0.7	1.6
Charlemont Sewer District	MA	MA0103101	0.05	0.03	19.6	2.2	4.9
Greenfield WPCF	MA	MA0101214	3.2	3.77	13.6	194.1	427.9
Monroe WWTF	MA	MA0100188	0.02	0.01	19.6	0.7	1.6
Old Deerfield WWTP	MA	MA0101940	0.25	0.18	9.2	6.3	13.8
Shelburne Falls WWTF	MA	MA0101044	0.25	0.22	16.9	14.1	31.0
Amherst WWTP	MA	MA0100218	7.1	4.28	14.1	228.4	503.7
Barre WWTP	MA	MA0103152	0.3	0.29	26.4	29.0	63.9
Belchertown WWTP	MA	MA0102148	1	0.41	12.7	19.7	43.5
Easthampton WWTP	MA	MA0101478	3.8	3.02	19.6	224.0	494.0
Hadley WWTP	MA	MA0100099	0.54	0.32	25.9	31.4	69.2
Hatfield WWTP	MA	MA0101290	0.5	0.22	15.6	13.0	28.6
Holyoke WPCF	MA	MA0101630	17.5	9.7	8.6	315.7	696.2
Montague WPCF	MA	MA0100137	1.83	1.6	12.9	78.1	172.3
Northampton POTW	MA	MA0101818	8.6	4.4	22.1	368.1	811.6
Northfield School	MA	MA0032573	0.45	0.1	19.6	7.4	16.4
Northfield WWTF	MA	MA0100200	0.28	0.24	16.8	15.3	33.7
South Deerfield WWTP	MA	MA0101648	0.85	0.7	7.9	20.9	46.2

FACILITY	State	Permit No.	Design Flow MGD	Avg. Flow MGD	Total N (mgl)	Total N kg/day	Total N (lb/day)
South Hadley WWTP	MA	MA0100455	4.2	3.3	28.8	359.7	793.2
Sunderland WWTF	MA	MA0101079	0.5	0.19	8.7	6.3	13.8
Athol WWTP	MA	MA0100005	1.75	1.39	17.2	90.5	199.5
Erving Center WWTP	MA	MA0101052	2.7	1.8	3.2	21.8	48.1
Erving #1	MA	MA0101516	1.02	0.32	29.3	35.5	78.3
Erving #3	MA	MA0102776	0.01	0.01	19.6	0.7	1.6
Gardner WPCF	MA	MA0100994	5	3.7	14.6	204.5	450.8
Orange WWTP	MA	MA0101257	1.1	1.2	8.6	39.1	86.1
Royalston WWTP	MA	MA0100161	0.04	0.07	19.6	5.2	11.5
Templeton WWTF	MA	MA0100340	2.8	0.4	26.4	40.0	88.1
Winchendon WPCF	MA	MA0100862	1.1	0.61	15.5	35.8	78.9
Chicopee WPC	MA	MA0101508	15.5	10	19.4	734.3	1619.1
Hardwick Wheelwright	MA	MA0102431	0.04	0.01	12.3	0.5	1.0
Hardwick Gilbert	MA	MA0100102	0.23	0.14	14.6	7.7	17.1
North Brookfield WWTP	MA	MA0101061	0.76	0.62	23.1	54.2	119.5
Palmer WPCF	MA	MA0101168	5.6	2.4	18.8	170.8	376.6
Spencer WWTP	MA	MA0100919	1.08	0.56	13.6	28.8	63.6
Ware WWTP	MA	MA0100889	1	0.74	9.4	26.3	58.1
Warren WWTF	MA	MA0101567	1.5	0.53	14.1	28.3	62.4
Springfield WWTP	MA	MA0101613	67	45.4	4.3	738.9	1629.3
Bitzer Trout Hatchery	MA	MA0110051	NA	0.05	19.6	3.7	8.2
C.L. McLaughlin Trout Hatchery	MA	MA0110043	NA	0.05	19.6	3.7	8.2
Hampden Papers Inc.	MA	MAG250881	NA	0.1	19.6	7.4	16.4
Hazen Paper Co.	MA	MAG250872	NA	0.1	19.6	7.4	16.4
Red Wing Trout Hatchery	MA	MA0027880	NA	0.05	19.6	3.7	8.2
Seaman Paper Co. of Mass Inc	MA	MA0000469	NA	0.05	19.6	3.7	8.2
Sunderland State Fish Hatchery	MA	MA0110035	NA	0.05	19.6	3.7	8.2
Tolland State Forest WWTP	MA	MA0027359	NA	0.01	19.6	0.7	1.6
BRISTOL WPCF	CT	CT0100374	NA	10.63	12.9	519.0	1144.5
CANTON WPCF	CT	CT0100072	NA	0.63	16.8	40.1	88.3
EAST HAMPTON WPCF	CT	CT0024694	NA	1.39	10.3	54.2	119.5
EAST HARTFORD WPCF	CT	CT0100170	NA	7.64	12	347.0	765.2
EAST WINDSOR WPCF	CT	CT0100196	NA	1.51	2.8	16.0	35.3
ENFIELD WPCF	CT	CT0100200	NA	6.03	16.9	385.7	850.5
FARMINGTON WPCF	CT	CT0100218	NA	4.48	9.7	164.5	362.7
GLASTONBURY WPCF	CT	CT0100226	NA	2.44	15.1	139.5	307.5
HARTFORD WPCF	CT	CT0100251	NA	56.06	13.1	2779.7	6129.1
MANCHESTER WPCF	CT	CT0100293	NA	6.49	14.1	346.4	763.7
MATTABASSETT WPCF	CT	CT0100307	NA	20.27	10.5	805.6	1776.3
MIDDLETOWN WPCF	CT	CT0100323	NA	4.96	9.6	180.2	397.4
PLAINVILLE WPCF	CT	CT0100455	NA	2.3	16	139.3	307.1
PLYMOUTH WPCF	CT	CT0100463	NA	1.17	7.2	31.9	70.3
PORTLAND WPCF	CT	CT0101150	NA	0.51	6.5	12.5	27.7
ROCKY HILL WPCF	CT	CT0100480	NA	8.08	12	367.0	809.2
SIMSBURY WCPF	CT	CT0100919	NA	2.47	15.5	144.9	319.5
SOUTH WINDSOR WPCF	CT	CT0100510	NA	2.11	18.7	149.3	329.3

FACILITY	State	Permit No.	Design Flow MGD	Avg. Flow MGD	Total N (mgl)	Total N kg/day	Total N (lb/day)
SUFFIELD WPCF	CT	CT0100552	NA	1.41	3.2	17.1	37.7
VERNON WPCF	CT	CT0100609	NA	4.86	16.4	301.7	665.2
WINDSOR LOCKS WPCF	CT	CT0101591	NA	1.63	8.5	52.4	115.6
WINDSOR POQUONOCK	CT	CT0100994	NA	2.32	22.3	195.8	431.8
WINSTED WPCF	CT	CT0101222	NA	1.67	13.9	87.9	193.7
Somers WPCF	CT	CT0101605	NA	0.1	15	5.7	12.5
New Hartford MTP	CT	CT0100331	NA	0.09	17.21	5.9	12.9
Avon Old School	CT	CT0100005	NA	0.03	19.6	2.2	4.9
CT Valley Hospital	CT	CT0100137	NA	0.05	19.6	3.7	8.2
East Haddam WPCF	CT	CT0101761	NA	0.1	15	5.7	12.5
Deep River WPCF	CT	CT0101745	NA	0.2	15	11.4	25.0
AGC Industries	CT	CT0025275	NA	0.03	0.17	0.0	0.0
Alpha Plating	CT	CT0021831	NA	0.01	0.34	0.0	0.0

Appendix C – Comparison of Wastewater Treatment Plant Loads by Treatment Level

FACILITY	State	Permit No.	Current Total N (mg/l)	Current Total N (lb/day)	Level 1 Total N (lb/day)	Level 2 Total N (lb/day)	Level 3 Total N (lb/day)
American Tissue/Atalntic Paper Mills	NH	NH0001180	3.0	2.75	2.75	2.75	2.75
Bethlehem Village District	NH	NH0100501	19.6	35.99	14.69	9.18	5.51
Charlestown WWTF	NH	NH0100765	19.6	65.43	26.71	16.69	10.02
Cheshire County Home	NH	NH0100391	19.6	4.91	2.00	1.25	0.75
Claremont Wastewater Treat. Facility	NH	NH0101257	14.1	188.92	107.50	67.18	40.31
Colebrook Wastewater Treat. Facility	NH	NH0100315	19.6	34.35	14.02	8.76	5.26
Fish Hatchery-Berlin	NH	NH0000621	2.0	118.51	118.51	118.51	118.51
Fish Hatchery - Twin Mountain	NH	NH0000744	2.0	11.68	11.68	11.68	11.68
Franklin Pierce College WWTF	NH	NH0101044	19.6	6.54	2.67	1.67	1.00
Groveton Wastewater Treatment Facility	NH	NH0100226	19.6	44.17	18.03	11.27	6.76
Hanover Wastewater Treatment Facility	NH	NH0100099	30.0	501.76	133.80	83.63	50.18
Hinsdale WWTF	NH	NH0100382	19.6	49.07	20.03	12.52	7.51
Keene Wastewater Treatment Facility	NH	NH0100790	19.6	572.53	233.69	146.05	87.63
Lancaster Grange POTW	NH	NH0101249	19.6	0.65	0.27	0.17	0.10
Lancaster POTW	NH	NH0100145	8.9	79.86	72.11	45.07	27.04
Lebanon Wastewater Treatment Facility	NH	NH0100366	19.1	349.64	146.75	91.72	55.03
Lisbon Wastewater Treatment Facility	NH	NH0100421	19.6	26.17	10.68	6.68	4.01
Littleton Wastewater Treatment Facility	NH	NH0100153	10.1	92.27	73.38	45.86	27.52
Meriden Village Water District	NH	NH0101168	19.6	6.54	2.67	1.67	1.00
Newport Wastewater Treatment Plant	NH	NH0100200	19.6	114.51	46.74	29.21	17.53
Northumberland Village WPCF	NH	NH0101206	19.6	9.16	3.74	2.34	1.40
Piermont Wastewater Treatment	NH	NH0101231	19.6	0.65	0.27	0.17	0.10
Stratford Mill House System WWTF	NH	NH0101214	19.6	2.78	1.14	0.71	0.43
Stratford Village System WWTF	NH	NH0100536	19.6	4.74	1.94	1.21	0.73
Sunapee Water Pollution Control Facility	NH	NH0100544	19.6	68.70	28.04	17.53	10.52
Swanzey WWTP	NH	NH0101150	19.6	9.81	4.01	2.50	1.50
Troy Wastewater Treatment Facility	NH	NH0101052	19.6	13.09	5.34	3.34	2.00
Wasau Paper	NH	NH0001562	4.4	168.55	168.55	168.55	114.92
Whitefield Wastewater Treat. Facility	NH	NH0100510	19.6	22.90	9.35	5.84	3.51
Winchester Wastewater Treatment Plant	NH	NH0100404	19.6	39.26	16.02	10.02	6.01
Woodsville Fire District	NH	NH0100978	16.1	34.72	17.29	10.81	6.48
Bellows Falls WPCF	VT	VT010013	21.1	101.94	38.73	24.20	14.52
Bethel	VT	VT0100048	19.6	11.45	4.67	2.92	1.75
Bradford	VT	VT0100803	19.6	11.45	4.67	2.92	1.75
Brattleboro STP	VT	VT010064	20.1	277.92	110.83	69.27	41.56
Bridgewater	VT	VT0100846	19.6	1.64	0.67	0.42	0.25
Canaan WWTP	VT	VT0100625	19.6	21.27	8.68	5.42	3.25
Cavendish WWTP	VT	VT0100862	19.6	13.09	5.34	3.34	2.00
Chelsea WWTP	VT	VT0100943	19.6	4.91	2.00	1.25	0.75
Chester WWTF	VT	VT010081	19.6	22.90	9.35	5.84	3.51
Danville	VT	VT0100633	19.6	4.91	2.00	1.25	0.75
Lunenberg	VT	VT0101061	19.6	9.81	4.01	2.50	1.50
Hartford WWTP	VT	VT0100978	19.6	32.72	13.35	8.35	5.01
Ludlow WWTF	VT	VT0100145	15.5	50.45	26.04	16.27	9.76
Lyndon STP	VT	VT0100595	19.6	44.17	18.03	11.27	6.76
Putney WPCF	VT	VT0100277	19.6	8.18	3.34	2.09	1.25
Randolph WPCF	VT	VT0100285	19.6	37.62	15.36	9.60	5.76
Readsboro WPC	VT	VT0100731	19.6	6.54	2.67	1.67	1.00

FACILITY	State	Permit No.	Current Total N (mg/l)	Current Total N (lb/day)	Level 1 Total N (lb/day)	Level 2 Total N (lb/day)	Level 3 Total N (lb/day)
Royalton WWTP	VT	VT0100854	19.6	11.45	4.67	2.92	1.75
St. Johnsbury STP	VT	VT0100579	12.1	122.80	81.46	50.91	30.55
Saxtons River WWTP	VT	VT0100609	19.6	6.54	2.67	1.67	1.00
Sherburne Fire Dist.	VT	VT0101141	19.6	17.99	7.34	4.59	2.75
South Woodstock WWTP	VT	VT0100749	19.6	1.64	0.67	0.42	0.25
Springfield	VT	VT0100374	12.1	137.89	91.47	57.17	34.30
Hartford/White River	VT	VT0101010	30.1	258.40	68.77	42.98	25.79
Whitingham	VT	VT0101109	19.6	1.64	0.67	0.42	0.25
Whitingham Jacksonville	VT	VT0101044	19.6	4.91	2.00	1.25	0.75
Cold Brook Fire Dist.	VT	VT0101214	19.6	8.18	3.34	2.09	1.25
Wilmington	VT	VT0100706	19.6	14.72	6.01	3.76	2.25
Windsor	VT	VT0100919	19.6	71.98	29.38	18.36	11.02
Windsor-Weston	VT	VT0100447	19.6	1.64	0.67	0.42	0.25
Woodstock WTP	VT	VT0100757	19.6	39.26	16.02	10.02	6.01
Huntington WWTP	MA	MA0101265	19.6	19.63	8.01	5.01	3.00
Russell WWTF	MA	MA0100960	19.6	26.17	10.68	6.68	4.01
Westfield WPCF	MA	MA0101800	20.4	643.57	252.38	157.74	94.64
Woronoco Village WWTF	MA	MA0103233	19.6	1.64	0.67	0.42	0.25
Charlemont Sewer District	MA	MA0103101	19.6	4.91	2.00	1.25	0.75
Greenfield WPCF	MA	MA0101214	13.6	427.91	251.71	157.32	94.39
Monroe WWTF	MA	MA0100188	19.6	1.64	0.67	0.42	0.25
Old Deerfield WWTP	MA	MA0101940	9.2	13.82	12.02	7.51	4.51
Shelburne Falls WWTF	MA	MA0101044	16.9	31.03	14.69	9.18	5.51
Amherst WWTP	MA	MA0100218	14.1	503.66	285.76	178.60	107.16
Barre WWTP	MA	MA0103152	26.4	63.90	19.36	12.10	7.26
Belchertown WWTP	MA	MA0102148	12.7	43.46	27.37	17.11	10.27
Easthampton WWTP	MA	MA0101478	19.6	494.01	201.64	126.02	75.61
Hadley WWTP	MA	MA0100099	25.9	69.17	21.37	13.35	8.01
Hatfield WWTP	MA	MA0101290	15.6	28.64	14.69	9.18	5.51
Holyoke WPCF	MA	MA0101630	8.6	696.22	647.64	404.78	242.87
Montague WPCF	MA	MA0100137	12.9	172.26	106.83	66.77	40.06
Northampton POTW	MA	MA0101818	22.1	811.56	293.78	183.61	110.17
Northfield School	MA	MA0032573	19.6	16.36	6.68	4.17	2.50
Northfield WWTF	MA	MA0100200	16.8	33.65	16.02	10.02	6.01
South Deerfield WWTP	MA	MA0101648	7.9	46.15	46.15	29.21	17.53
South Hadley WWTP	MA	MA0100455	28.8	793.20	220.33	137.71	82.62
Sunderland WWTF	MA	MA0101079	8.7	13.80	12.69	7.93	4.76
Athol WWTP	MA	MA0100005	17.2	199.53	92.81	58.00	34.80
Erving Center WWTP	MA	MA0101052	3.2	48.07	48.07	48.07	45.07
Erving #1	MA	MA0101516	29.3	78.25	21.37	13.35	8.01
Erving #3	MA	MA0102776	19.6	1.64	0.67	0.42	0.25
Gardner WPCF	MA	MA0100994	14.6	450.85	247.04	154.40	92.64
Orange WWTP	MA	MA0101257	8.6	86.13	80.12	50.08	30.05
Royalston WWTP	MA	MA0100161	19.6	11.45	4.67	2.92	1.75
Templeton WWTF	MA	MA0100340	26.4	88.13	26.71	16.69	10.02
Winchendon WPCF	MA	MA0100862	15.5	78.91	40.73	25.46	15.27
Chicopee WPC	MA	MA0101508	19.4	1619.11	667.67	417.30	250.38
Hardwick Wheelwright	MA	MA0102431	12.3	1.03	0.67	0.42	0.25

FACILITY	State	Permit No.	Current Total N (mg/l)	Current Total N (lb/day)	Level 1 Total N (lb/day)	Level 2 Total N (lb/day)	Level 3 Total N (lb/day)
Hardwick Gilbert	MA	MA0100102	14.6	17.06	9.35	5.84	3.51
North Brookfield WWTP	MA	MA0101061	23.1	119.53	41.40	25.87	15.52
Palmer WPCF	MA	MA0101168	18.8	376.57	160.24	100.15	60.09
Spencer WWTP	MA	MA0100919	13.6	63.56	37.39	23.37	14.02
Ware WWTP	MA	MA0100889	9.4	58.05	49.41	30.88	18.53
Warren WWTF	MA	MA0101567	14.1	62.37	35.39	22.12	13.27
Springfield WWTP	MA	MA0101613	4.3	1629.29	1629.29	1629.29	1136.71
Bitzer Trout Hatchery	MA	MA0110051	19.6	8.18	3.34	2.09	1.25
C.L. McLaughlin Trout Hatchery	MA	MA0110043	19.6	8.18	3.34	2.09	1.25
Hampden Papers Inc.	MA	MAG250881	19.6	16.36	6.68	4.17	2.50
Hazen Paper Co.	MA	MAG250872	19.6	16.36	6.68	4.17	2.50
Red Wing Trout Hatchery	MA	MA0027880	19.6	8.18	3.34	2.09	1.25
Seaman Paper Co. of Mass Inc	MA	MA0000469	19.6	8.18	3.34	2.09	1.25
Sunderland State Fish Hatchery	MA	MA0110035	19.6	8.18	3.34	2.09	1.25
Tolland State Forest WWTP	MA	MA0027359	19.6	1.64	0.67	0.42	0.25
BRISTOL WPCF	CT	CT0100374	12.9	1144.45	1144.45	1144.45	1144.45
CANTON WPCF	CT	CT0100072	16.8	88.33	88.33	88.33	88.33
EAST HAMPTON WPCF	CT	CT0024694	10.3	119.49	119.49	119.49	119.49
EAST HARTFORD WPCF	CT	CT0100170	12.0	765.15	765.15	765.15	765.15
EAST WINDSOR WPCF	CT	CT0100196	2.8	35.29	35.29	35.29	35.29
ENFIELD WPCF	CT	CT0100200	16.9	850.51	850.51	850.51	850.51
FARMINGTON WPCF	CT	CT0100218	9.7	362.68	362.68	362.68	362.68
GLASTONBURY WPCF	CT	CT0100226	15.1	307.50	307.50	307.50	307.50
HARTFORD WPCF	CT	CT0100251	13.1	6129.13	6129.13	6129.13	6129.13
MANCHESTER WPCF	CT	CT0100293	14.1	763.73	763.73	763.73	763.73
MATTABASSETT WPCF	CT	CT0100307	10.5	1776.30	1776.30	1776.30	1776.30
MIDDLETOWN WPCF	CT	CT0100323	9.6	397.40	397.40	397.40	397.40
PLAINVILLE WPCF	CT	CT0100455	16.0	307.13	307.13	307.13	307.13
PLYMOUTH WPCF	CT	CT0100463	7.2	70.31	70.31	70.31	70.31
PORTLAND WPCF	CT	CT0101150	6.5	27.67	27.67	27.67	27.67
ROCKY HILL WPCF	CT	CT0100480	12.0	809.22	809.22	809.22	809.22
SIMSBURY WCPF	CT	CT0100919	15.5	319.52	319.52	319.52	319.52
SOUTH WINDSOR WPCF	CT	CT0100510	18.7	329.31	329.31	329.31	329.31
SUFFIELD WPCF	CT	CT0100552	3.2	37.66	37.66	37.66	37.66
VERNON WPCF	CT	CT0100609	16.4	665.20	665.20	665.20	665.20
WINDSOR LOCKS WPCF	CT	CT0101591	8.5	115.63	115.63	115.63	115.63
WINDSOR POQUONOCK	CT	CT0100994	22.3	431.78	431.78	431.78	431.78
WINSTED WPCF	CT	CT0101222	13.9	193.73	193.73	193.73	193.73
Somers WPCF	CT	CT0101605	15.0	12.52	12.52	12.52	12.52
New Hartford MTP	CT	CT0100331	17.2	12.93	12.93	12.93	12.93
Avon Old School	CT	CT0100005	19.6	4.91	4.91	4.91	4.91
CT Valley Hospital	CT	CT0100137	19.6	8.18	8.18	8.18	8.18
East Haddam WPCF	CT	CT0101761	15.0	12.52	12.52	12.52	12.52
Deep River WPCF	CT	CT0101745	15.0	25.04	25.04	25.04	25.04
AGC Industries	CT	CT0025275	0.2	0.04	0.04	0.04	0.04
Alpha Plating	CT	CT0021831	0.3	0.03	0.03	0.03	0.03

Appendix D – Estimated Capital and O&M Costs by Plant (All costs in 2007 dollars)

Level 1 Costs

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
American Tissue/Atalntic Paper Mills	NH	NH0001180	0.16	3	0	0	0
Bethlehem Village District	NH	NH0100501	0.34	8	2672966	53459	187108
Charlestown WWTF	NH	NH0100765	1.1	8	3305156	66103	231361
Cheshire County Home	NH	NH0100391	0.04	8	2423416	48468	169639
Chesire Medical Center	NH	NH0021539	NA	0	0	0	0
Claremont Wastewater Treatment Facility	NH	NH0101257	3.89	8	5625886	112518	393812
Colebrook Wastewater Treatment Facility	NH	NH0100315	0.5	8	2806059	56121	196424
Coy Paper Company	NH	NH0001261	NA	0	0	0	0
Fish Hatchery-Berlin	NH	NH0000621	7.1	2	0	0	0
Fish Hatchery - Twin Mountain	NH	NH0000744	0.7	2	0	0	0
Franklin Pierce College WWTF	NH	NH0101044	0.14	8	2506599	50132	175462
Glencliff Home for the Elderly	NH	NH0101371	NA	0	0	0	0
Groveton Wastewater Treatment Facility	NH	NH0100226	0.37	8	2697921	53958	188854
Hanover Wastewater Treatment Facility	NH	NH0100099	2.3	8	4303333	86067	301233
Hinsdale WWTF	NH	NH0100382	0.3	8	2639693	52794	184779
Keene Wastewater Treatment Facility	NH	NH0100790	6	8	7380917	147618	516664
Lancaster Grange POTW	NH	NH0101249	0.004	8	2393469	47869	167543
Lancaster POTW	NH	NH0100145	1.2	8	3388338	67767	237184
Lebanon Wastewater Treatment Facility	NH	NH0100366	3.18	8	5035316	100706	352472
Lisbon Wastewater Treatment Facility	NH	NH0100421	0.32	8	2656330	53127	185943
Littleton Wastewater Treatment Facility	NH	NH0100153	1.5	8	3637884	72758	254652
Meriden Village Water District	NH	NH0101168	0.08	8	2456689	49134	171968
Newport Wastewater Treatment Plant	NH	NH0100200	1.3	8	3471520	69430	243006
Northumberland Village WPCF	NH	NH0101206	0.06	8	2440052	48801	170804
Paper Service Limited	NH	NH0000311	NA	0	0	0	0
Piermont Wastewater Treatment	NH	NH0101231	0.007	8	2395965	47919	167718
Stratford Mill House System WWTF	NH	NH0101214	0.024	8	2410106	48202	168707
Stratford Village System WWTF	NH	NH0100536	0.056	8	2436725	48734	170571
Sullivan County Home	NH	NH0100684	NA	0	0	0	0
Sunapee Water Pollution Control Facility	NH	NH0100544	0.64	8	2922516	58450	204576
Swanzey WWTP	NH	NH0101150	0.167	8	2529059	50581	177034
Troy Mills, Inc.	NH	NH0000523	NA	0	0	0	0
Troy Wastewater Treatment Facility	NH	NH0101052	0.265	8	2610579	52212	182741
US Army Cold Regions Research	NH	NH0001619	NA	8	0	0	0
Wasau Paper	NH	NH0001562	NA	4.4	0	0	0
Whitefield Wastewater Treatment Facility	NH	NH0100510	0.185	8	2544032	50881	178082
Winchester Wastewater Treatment Plant	NH	NH0100404	0.28	8	2623056	52461	183614
Woodsville Fire District	NH	NH0100978	0.33	8	2664648	53293	186525
Tillotson Health Care Corp	NH	NH0023175	NA	0	0	0	0
Bellows Falls WPCF	VT	VT010013	1.405	8	3558861	71177	249120
Bethel	VT	VT0100048	0.125	8	2494122	49882	174589
Bradford	VT	VT0100803	0.145	8	2510758	50215	175753
Brattleboro STP	VT	VT010064	3.005	8	4889752	97795	342283
Bridgewater	VT	VT0100846	0.045	8	2427575	48551	169930
Canaan WWTP	VT	VT0100625	0.185	8	2544032	50881	178082

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
Cavendish WWTP	VT	VT0100862	0.155	8	2519077	50382	176335
Chelsea WWTP	VT	VT0100943	0.065	8	2444212	48884	171095
Chester WWTF	VT	VT010081	0.185	8	2544032	50881	178082
Danville	VT	VT0100633	0.065	8	2444212	48884	171095
Lunenberg	VT	VT0101061	0.085	8	2460848	49217	172259
Hartford WWTP	VT	VT0100978	0.305	8	2643852	52877	185070
Ludlow WWTF	VT	VT0100145	0.705	8	2976585	59532	208361
Lyndon STP	VT	VT0100595	0.755	8	3018176	60364	211272
Putney WPCF	VT	VT0100277	0.085	8	2460848	49217	172259
Randolph WPCF	VT	VT0100285	0.405	8	2727035	54541	190892
Readsboro WPC	VT	VT0100731	0.755	8	3018176	60364	211272
Royalton WWTP	VT	VT0100854	0.075	8	2452530	49051	171677
St. Johnsbury STP	VT	VT0100579	1.6	8	3721065	74421	260475
Saxtons River WWTP	VT	VT0100609	0.105	8	2477485	49550	173424
Sherburne Fire Dist.	VT	VT0101141	0.305	8	2643852	52877	185070
South Woodstock WWTP	VT	VT0100749	0.055	8	2435893	48718	170513
Springfield	VT	VT0100374	2.2	8	4220152	84403	295411
Hartford/White River	VT	VT0101010	1.225	8	3409133	68183	238639
Whitingham	VT	VT0101109	0.015	8	2402620	48052	168183
Whitingham Jacksonville	VT	VT0101044	0.055	8	2435893	48718	170513
Cold Brook Fire Dist.	VT	VT0101214	0.055	8	2435893	48718	170513
Wilmington	VT	VT0100706	0.145	8	2510758	50215	175753
Windsor	VT	VT0100919	1.135	8	3334269	66685	233399
Windsor-Weston	VT	VT0100447	0.025	8	2410938	48219	168766
Woodstock WTP	VT	VT0100757	0.455	8	2768627	55373	193804
Woodstock-Taftsville	VT	VT0100765	0	8	0	0	0
Huntington WWTP	MA	MA0101265	0.2	8	2556509	51130	178956
Russell WWTF	MA	MA0100960	0.24	8	2589783	51796	181285
Westfield WPCF	MA	MA0101800	6.1	8	7464093	149282	522486
Woronoco Village WWTF	MA	MA0103233	0.02	8	2406779	48136	168475
Charlemont Sewer District	MA	MA0103101	0.05	8	2431734	48635	170221
Greenfield WPCF	MA	MA0101214	3.2	8	5051952	101039	353637
Monroe WWTF	MA	MA0100188	0.02	8	2406779	48136	168475
Old Deerfield WWTP	MA	MA0101940	0.25	8	2598101	51962	181867
Shelburne Falls WWTF	MA	MA0101044	0.25	8	2598101	51962	181867
Amherst WWTP	MA	MA0100218	7.1	8	8295838	165917	580709
Barre WWTP	MA	MA0103152	0.3	8	2639693	52794	184779
Belchertown WWTP	MA	MA0102148	1	8	3221973	64439	225538
Easthampton WWTP	MA	MA0101478	3.8	8	5551025	111021	388572
Hadley WWTP	MA	MA0100099	0.54	8	2839333	56787	198753
Hatfield WWTP	MA	MA0101290	0.5	8	2806059	56121	196424
Holyoke WPCF	MA	MA0101630	17.5	8	16945147	338903	1186160
Montague WPCF	MA	MA0100137	1.83	8	3912382	78248	273867
Northampton POTW	MA	MA0101818	8.6	8	9543429	190869	668040
Northfield School	MA	MA0032573	0.45	8	2764468	55289	193513
Northfield WWTF	MA	MA0100200	0.28	8	2623056	52461	183614
South Deerfield WWTP	MA	MA0101648	0.85	7.9	0	0	0

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
South Hadley WWTP	MA	MA0100455	4.2	8	5883738	117675	411862
Sunderland WWTF	MA	MA0101079	0.5	8	2806059	56121	196424
Athol WWTP	MA	MA0100005	1.75	8	3845837	76917	269209
Erving Center WWTP	MA	MA0101052	2.7	3.2	0	0	0
Erving #1	MA	MA0101516	1.02	8	3238610	64772	226703
Erving #3	MA	MA0102776	0.01	8	2398460	47969	167892
Gardner WPCF	MA	MA0100994	5	8	6549157	130983	458441
Orange WWTP	MA	MA0101257	1.1	8	3305156	66103	231361
Royalston WWTP	MA	MA0100161	0.04	8	2423416	48468	169639
Templeton WWTF	MA	MA0100340	2.8	8	4719234	94385	330346
Winchendon WPCF	MA	MA0100862	1.1	8	3305156	66103	231361
Chicopee WPC	MA	MA0101508	15.5	8	15281937	305639	1069736
Hardwick Wheelwright	MA	MA0102431	0.04	8	2423416	48468	169639
Hardwick Gilbert	MA	MA0100102	0.23	8	2581464	51629	180703
North Brookfield WWTP	MA	MA0101061	0.76	8	3022335	60447	211563
Palmer WPCF	MA	MA0101168	5.6	8	7048215	140964	493375
Spencer WWTP	MA	MA0100919	1.08	8	3288519	65770	230196
Ware WWTP	MA	MA0100889	1	8	3221973	64439	225538
Warren WWTF	MA	MA0101567	1.5	8	3637884	72758	254652
Springfield WWTP	MA	MA0101613	67	4.3	0	0	0
Bitzer Trout Hatchery	MA	MA0110051	NA	8	2431734	48635	170221
C.L. McLaughlin Trout Hatchery	MA	MA0110043	NA	8	2431734	48635	170221
Hampden Papers Inc.	MA	MAG250881	NA	8	2473326	49467	173133
Hazen Paper Co.	MA	MAG250872	NA	8	2473326	49467	173133
Red Wing Trout Hatchery	MA	MA0027880	NA	8	2431734	48635	170221
Seaman Paper Co. of Mass Inc	MA	MA0000469	NA	8	2431734	48635	170221
Sunderland State Fish Hatchery	MA	MA0110035	NA	8	2431734	48635	170221
Tolland State Forest WWTP	MA	MA0027359	NA	8	2398460	47969	167892

Level 2 Costs

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
American Tissue/Atalntic Paper Mills	NH	NH0001180	0.16	3	0	0	0
Bethlehem Village District	NH	NH0100501	0.34	5	558897	15304	43249
Charlestown WWTF	NH	NH0100765	1.1	5	1522830	39850	115991
Cheshire County Home	NH	NH0100391	0.04	5	216268	6575	17389
Chesire Medical Center	NH	NH0021539	NA	0	0	0	0
Claremont Wastewater Treatment Facility	NH	NH0101257	3.89	5	2794729	83947	223683
Colebrook Wastewater Treatment Facility	NH	NH0100315	0.5	5	741633	19959	57041
Coy Paper Company	NH	NH0001261	NA	0	0	0	0
Fish Hatchery-Berlin	NH	NH0000621	7.1	2	0	0	0
Fish Hatchery - Twin Mountain	NH	NH0000744	0.7	2	0	0	0
Franklin Pierce College WWTF	NH	NH0101044	0.14	5	330477	9485	26009
Glencliff Home for the Elderly	NH	NH0101371	NA	0	0	0	0
Groveton Wastewater Treatment Facility	NH	NH0100226	0.37	5	593160	16177	45835

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
Hanover Wastewater Treatment Facility	NH	NH0100099	2.3	5	2069883	58816	162310
Hinsdale WWTF	NH	NH0100382	0.3	5	513213	14140	39801
Keene Wastewater Treatment Facility	NH	NH0100790	6	5	3756631	117296	305127
Lancaster Grange POTW	NH	NH0101249	0.004	5	175152	5528	14285
Lancaster POTW	NH	NH0100145	1.2	5	1568418	41430	119851
Lebanon Wastewater Treatment Facility	NH	NH0100366	3.18	5	2471056	72725	196278
Lisbon Wastewater Treatment Facility	NH	NH0100421	0.32	5	536055	14722	41525
Littleton Wastewater Treatment Facility	NH	NH0100153	1.5	5	1705181	46172	131431
Meriden Village Water District	NH	NH0101168	0.08	5	261951	7739	20837
Newport Wastewater Treatment Plant	NH	NH0100200	1.3	5	1614005	43011	123711
Northumberland Village WPCF	NH	NH0101206	0.06	5	239110	7157	19113
Paper Service Limited	NH	NH0000311	NA	0	0	0	0
Piermont Wastewater Treatment	NH	NH0101231	0.007	5	178578	5615	14544
Stratford Mill House System WWTF	NH	NH0101214	0.024	5	197994	6110	16009
Stratford Village System WWTF	NH	NH0100536	0.056	5	234541	7041	18768
Sullivan County Home	NH	NH0100684	NA	0	0	0	0
Sunapee Water Pollution Control Facility	NH	NH0100544	0.64	5	901526	24032	69109
Swanzey WWTP	NH	NH0101150	0.167	5	361314	10270	28336
Troy Mills, Inc.	NH	NH0000523	NA	0	0	0	0
Troy Wastewater Treatment Facility	NH	NH0101052	0.265	5	473240	13122	36784
US Army Cold Regions Research	NH	NH0001619	NA	0	0	0	0
Wasau Paper	NH	NH0001562	NA	4.4	0	0	0
Whitefield Wastewater Treatment Facility	NH	NH0100510	0.185	5	381872	10794	29888
Winchester Wastewater Treatment Plant	NH	NH0100404	0.28	5	490371	13558	38077
Woodsville Fire District	NH	NH0100978	0.33	5	547476	15013	42387
Tillotson Health Care Corp	NH	NH0023175	NA	0	0	0	0
Bellows Falls WPCF	VT	VT010013	1.405	5	1661873	44670	127764
Bethel	VT	VT0100048	0.125	5	313346	9048	24716
Bradford	VT	VT0100803	0.145	5	336188	9630	26440
Brattleboro STP	VT	VT010064	3.005	5	2391277	69959	189523
Bridgewater	VT	VT0100846	0.045	5	221978	6721	17820
Canaan WWTP	VT	VT0100625	0.185	5	381872	10794	29888
Cavendish WWTP	VT	VT0100862	0.155	5	347609	9921	27302
Chelsea WWTP	VT	VT0100943	0.065	5	244820	7303	19544
Chester WWTF	VT	VT010081	0.185	5	381872	10794	29888
Danville	VT	VT0100633	0.065	5	244820	7303	19544
Lunenberg	VT	VT0101061	0.085	5	267662	7885	21268
Hartford WWTP	VT	VT0100978	0.305	5	518923	14285	40232
Ludlow WWTF	VT	VT0100145	0.705	5	975763	25924	74712
Lyndon STP	VT	VT0100595	0.755	5	1032868	27378	79022
Putney WPCF	VT	VT0100277	0.085	5	267662	7885	21268
Randolph WPCF	VT	VT0100285	0.405	5	633133	17195	48852
Readsboro WPC	VT	VT0100731	0.755	5	1032868	27378	79022
Royalton WWTP	VT	VT0100854	0.075	5	256241	7594	20406
St. Johnsbury STP	VT	VT0100579	1.6	5	1750769	47752	135291
Saxtons River WWTP	VT	VT0100609	0.105	5	290504	8466	22992
Sherburne Fire Dist.	VT	VT0101141	0.305	5	518923	14285	40232

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
South Woodstock WWTP	VT	VT0100749	0.055	5	233399	7012	18682
Springfield	VT	VT0100374	2.2	5	2024295	57236	158450
Hartford/White River	VT	VT0101010	1.225	5	1579815	41825	120816
Whitingham	VT	VT0101109	0.015	5	187715	5848	15234
Whitingham Jacksonville	VT	VT0101044	0.055	5	233399	7012	18682
Cold Brook Fire Dist.	VT	VT0101214	0.055	5	233399	7012	18682
Wilmington	VT	VT0100706	0.145	5	336188	9630	26440
Windsor	VT	VT0100919	1.135	5	1538786	40403	117342
Windsor-Weston	VT	VT0100447	0.025	5	199136	6139	16096
Woodstock WTP	VT	VT0100757	0.455	5	690238	18650	53162
Woodstock-Taftsville	VT	VT0100765	0	5	0	0	0
Huntington WWTP	MA	MA0101265	0.2	5	399003	11230	31181
Russell WWTF	MA	MA0100960	0.24	5	444687	12394	34629
Westfield WPCF	MA	MA0101800	6.1	5	3802219	118876	308987
Woronoco Village WWTF	MA	MA0103233	0.02	5	193426	5993	15665
Charlemont Sewer District	MA	MA0103101	0.05	5	227689	6866	18251
Greenfield WPCF	MA	MA0101214	3.2	5	2480173	73041	197049
Monroe WWTF	MA	MA0100188	0.02	5	193426	5993	15665
Old Deerfield WWTP	MA	MA0101940	0.25	5	456108	12685	35491
Shelburne Falls WWTF	MA	MA0101044	0.25	5	456108	12685	35491
Amherst WWTP	MA	MA0100218	7.1	5	4258097	134682	347586
Barre WWTP	MA	MA0103152	0.3	5	513213	14140	39801
Belchertown WWTP	MA	MA0102148	1	5	1312682	34507	100141
Easthampton WWTP	MA	MA0101478	3.8	5	2753700	82524	220209
Hadley WWTP	MA	MA0100099	0.54	5	787316	21123	60489
Hatfield WWTP	MA	MA0101290	0.5	5	741633	19959	57041
Holyoke WPCF	MA	MA0101630	17.5	5	8999226	299057	749018
Montague WPCF	MA	MA0100137	1.83	5	1855621	51388	144169
Northampton POTW	MA	MA0101818	8.6	5	4941913	158390	405485
Northfield School	MA	MA0032573	0.45	5	684528	18504	52731
Northfield WWTF	MA	MA0100200	0.28	5	490371	13558	38077
South Deerfield WWTP	MA	MA0101648	0.85	5	1141367	30142	87211
South Hadley WWTP	MA	MA0100455	4.2	5	2936051	88846	235649
Sunderland WWTF	MA	MA0101079	0.5	5	741633	19959	57041
Athol WWTP	MA	MA0100005	1.75	5	1819150	50123	141081
Erving Center WWTP	MA	MA0101052	2.7	3.2	0	0	0
Erving #1	MA	MA0101516	1.02	5	1486360	38585	112903
Erving #3	MA	MA0102776	0.01	5	182005	5702	14803
Gardner WPCF	MA	MA0100994	5	5	3300753	101490	266528
Orange WWTP	MA	MA0101257	1.1	5	1522830	39850	115991
Royalston WWTP	MA	MA0100161	0.04	5	216268	6575	17389
Templeton WWTF	MA	MA0100340	2.8	5	2297822	66719	181610
Winchendon WPCF	MA	MA0100862	1.1	5	1522830	39850	115991
Chicopee WPC	MA	MA0101508	15.5	5	8087470	267446	671820
Hardwick Wheelwright	MA	MA0102431	0.04	5	216268	6575	17389
Hardwick Gilbert	MA	MA0100102	0.23	5	433266	12103	33767
North Brookfield WWTP	MA	MA0101061	0.76	5	1038578	27524	79453

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
Palmer WPCF	MA	MA0101168	5.6	5	3574280	110974	289688
Spencer WWTP	MA	MA0100919	1.08	5	1513712	39534	115219
Ware WWTP	MA	MA0100889	1	5	1312682	34507	100141
Warren WWTF	MA	MA0101567	1.5	5	1705181	46172	131431
Springfield WWTP	MA	MA0101613	67	4.3	0	0	0
Bitzer Trout Hatchery	MA	MA0110051	NA	5	227689	6866	18251
C.L. McLaughlin Trout Hatchery	MA	MA0110043	NA	5	227689	6866	18251
Hampden Papers Inc.	MA	MAG250881	NA	5	284793	8321	22561
Hazen Paper Co.	MA	MAG250872	NA	5	284793	8321	22561
Red Wing Trout Hatchery	MA	MA0027880	NA	5	227689	6866	18251
Seaman Paper Co. of Mass Inc	MA	MA0000469	NA	5	227689	6866	18251
Sunderland State Fish Hatchery	MA	MA0110035	NA	5	227689	6866	18251
Tolland State Forest WWTP	MA	MA0027359	NA	5	182005	5702	14803

Level 3 Costs

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
American Tissue/Atalntic Paper Mills	NH	NH0001180	0.16	3			
Bethlehem Village District	NH	NH0100501	0.34	3	669400	41936	75406
Charlestown WWTF	NH	NH0100765	1.1	3	1866369	86949	180268
Cheshire County Home	NH	NH0100391	0.04	3	293240	23460	38122
Chesire Medical Center	NH	NH0021539	NA	0	0	0	0
Claremont Wastewater Treatment Facility	NH	NH0101257	3.89	3	4721444	174507	410579
Colebrook Wastewater Treatment Facility	NH	NH0100315	0.5	3	870019	51790	95291
Coy Paper Company	NH	NH0001261	NA	0	0	0	0
Fish Hatchery-Berlin	NH	NH0000621	7.1	2	0	0	0
Fish Hatchery - Twin Mountain	NH	NH0000744	0.7	2	0	0	0
Franklin Pierce College WWTF	NH	NH0101044	0.14	3	418627	29619	50550
Glencliff Home for the Elderly	NH	NH0101371	NA	0	0	0	0
Groveton Wastewater Treatment Facility	NH	NH0100226	0.37	3	707016	43784	79134
Hanover Wastewater Treatment Facility	NH	NH0100099	2.3	3	3094358	124608	279326
Hinsdale WWTF	NH	NH0100382	0.3	3	619246	39473	70435
Keene Wastewater Treatment Facility	NH	NH0100790	6	3	6880660	240724	584757
Lancaster Grange POTW	NH	NH0101249	0.004	3	248101	21243	33648
Lancaster POTW	NH	NH0100145	1.2	3	1968701	90087	188522
Lebanon Wastewater Treatment Facility	NH	NH0100366	3.18	3	3994884	152225	351969
Lisbon Wastewater Treatment Facility	NH	NH0100421	0.32	3	644323	40704	72921
Littleton Wastewater Treatment Facility	NH	NH0100153	1.5	3	2275698	99502	213287
Meriden Village Water District	NH	NH0101168	0.08	3	343395	25924	43094
Newport Wastewater Treatment Plant	NH	NH0100200	1.3	3	2071033	93226	196777
Northumberland Village WPCF	NH	NH0101206	0.06	3	318317	24692	40608
Paper Service Limited	NH	NH0000311	NA	0	0	0	0
Piermont Wastewater Treatment	NH	NH0101231	0.007	3	251862	21428	34021
Stratford Mill House System WWTF	NH	NH0101214	0.024	3	273178	22475	36134
Stratford Village System WWTF	NH	NH0100536	0.056	3	313302	24446	40111

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
Sullivan County Home	NH	NH0100684	NA	0	0	0	0
Sunapee Water Pollution Control Facility	NH	NH0100544	0.64	3	1045561	60412	112690
Swanzey WWTP	NH	NH0101150	0.167	3	452481	31282	53906
Troy Mills, Inc.	NH	NH0000523	NA	0	0	0	0
Troy Wastewater Treatment Facility	NH	NH0101052	0.265	3	575360	37317	66085
US Army Cold Regions Research	NH	NH0001619	NA	3	0	0	0
Wasau Paper	NH	NH0001562	NA	3	5437772	196475	468363
Whitefield Wastewater Treatment Facility	NH	NH0100510	0.185	3	475051	32390	56143
Winchester Wastewater Treatment Plant	NH	NH0100404	0.28	3	594168	38241	67949
Woodsville Fire District	NH	NH0100978	0.33	3	656862	41320	74163
Tillotson Health Care Corp	NH	NH0023175	NA	0	0	0	0
Bellows Falls WPCF	VT	VT010013	1.405	3	2178483	96521	205445
Bethel	VT	VT0100048	0.125	3	399819	28695	48686
Bradford	VT	VT0100803	0.145	3	424896	29927	51172
Brattleboro STP	VT	VT010064	3.005	3	3815802	146733	337523
Bridgewater	VT	VT0100846	0.045	3	299509	23768	38744
Canaan WWTP	VT	VT0100625	0.185	3	475051	32390	56143
Cavendish WWTP	VT	VT0100862	0.155	3	437435	30543	52415
Chelsea WWTP	VT	VT0100943	0.065	3	324587	25000	41229
Chester WWTF	VT	VT010081	0.185	3	475051	32390	56143
Danville	VT	VT0100633	0.065	3	324587	25000	41229
Lunenberg	VT	VT0101061	0.085	3	349664	26232	43715
Hartford WWTP	VT	VT0100978	0.305	3	625515	39781	71056
Ludlow WWTF	VT	VT0100145	0.705	3	1127062	64415	120768
Lyndon STP	VT	VT0100595	0.755	3	1189755	67494	126982
Putney WPCF	VT	VT0100277	0.085	3	349664	26232	43715
Randolph WPCF	VT	VT0100285	0.405	3	750902	45939	83484
Readsboro WPC	VT	VT0100731	0.755	3	1189755	67494	126982
Royalton WWTP	VT	VT0100854	0.075	3	337125	25616	42472
St. Johnsbury STP	VT	VT0100579	1.6	3	2378031	102640	221542
Saxtons River WWTP	VT	VT0100609	0.105	3	374741	27463	46201
Sherburne Fire Dist.	VT	VT0101141	0.305	3	625515	39781	71056
South Woodstock WWTP	VT	VT0100749	0.055	3	312048	24384	39987
Springfield	VT	VT0100374	2.2	3	2992026	121470	271071
Hartford/White River	VT	VT0101010	1.225	3	1994284	90872	190586
Whitingham	VT	VT0101109	0.015	3	261893	21921	35015
Whitingham Jacksonville	VT	VT0101044	0.055	3	312048	24384	39987
Cold Brook Fire Dist.	VT	VT0101214	0.055	3	312048	24384	39987
Wilmington	VT	VT0100706	0.145	3	424896	29927	51172
Windsor	VT	VT0100919	1.135	3	1902185	88048	183157
Windsor-Weston	VT	VT0100447	0.025	3	274432	22537	36258
Woodstock WTP	VT	VT0100757	0.455	3	813595	49018	89698
Woodstock-Taftsville	VT	VT0100765	0	3	0	0	0
Huntington WWTP	MA	MA0101265	0.2	3	493859	33314	58007
Russell WWTF	MA	MA0100960	0.24	3	544013	35778	62978
Westfield WPCF	MA	MA0101800	6.1	3	6982992	243863	593012
Woronoco Village WWTF	MA	MA0103233	0.02	3	268163	22229	35637

FACILITY	State	Permit No.	Design Flow MGD	TOTAL N (mgl)	Costs Capital	Costs O&M/yr	Annual Costs
Charlemont Sewer District	MA	MA0103101	0.05	3	305779	24076	39365
Greenfield WPCF	MA	MA0101214	3.2	3	4015350	152853	353620
Monroe WWTF	MA	MA0100188	0.02	3	268163	22229	35637
Old Deerfield WWTP	MA	MA0101940	0.25	3	556552	36393	64221
Shelburne Falls WWTF	MA	MA0101044	0.25	3	556552	36393	64221
Amherst WWTP	MA	MA0100218	7.1	3	8006317	275245	675561
Barre WWTP	MA	MA0103152	0.3	3	619246	39473	70435
Belchertown WWTP	MA	MA0102148	1	3	1496953	82583	157430
Easthampton WWTP	MA	MA0101478	3.8	3	4629345	171682	403150
Hadley WWTP	MA	MA0100099	0.54	3	920174	54253	100262
Hatfield WWTP	MA	MA0101290	0.5	3	870019	51790	95291
Holyoke WPCF	MA	MA0101630	17.5	3	18648893	601626	1534070
Montague WPCF	MA	MA0100137	1.83	3	2613396	109858	240528
Northampton POTW	MA	MA0101818	8.6	3	9541304	322319	799385
Northfield School	MA	MA0032573	0.45	3	807326	48711	89077
Northfield WWTF	MA	MA0100200	0.28	3	594168	38241	67949
South Deerfield WWTP	MA	MA0101648	0.85	3	1308873	73345	138788
South Hadley WWTP	MA	MA0100455	4.2	3	5038675	184236	436169
Sunderland WWTF	MA	MA0101079	0.5	3	870019	51790	95291
Athol WWTP	MA	MA0100005	1.75	3	2531530	107348	233924
Erving Center WWTP	MA	MA0101052	2.7	3	3503688	137161	312346
Erving #1	MA	MA0101516	1.02	3	1784503	84439	173664
Erving #3	MA	MA0102776	0.01	3	255624	21613	34394
Gardner WPCF	MA	MA0100994	5	3	5857335	209342	502208
Orange WWTP	MA	MA0101257	1.1	3	1866369	86949	180268
Royalston WWTP	MA	MA0100161	0.04	3	293240	23460	38122
Templeton WWTF	MA	MA0100340	2.8	3	3606021	140300	320601
Winchendon WPCF	MA	MA0100862	1.1	3	1866369	86949	180268
Chicopee WPC	MA	MA0101508	15.5	3	16602244	538860	1368972
Hardwick Wheelwright	MA	MA0102431	0.04	3	293240	23460	38122
Hardwick Gilbert	MA	MA0100102	0.23	3	531475	35162	61735
North Brookfield WWTP	MA	MA0101061	0.76	3	1196025	67802	127603
Palmer WPCF	MA	MA0101168	5.6	3	6471330	228171	551738
Spencer WWTP	MA	MA0100919	1.08	3	1845902	86321	178617
Ware WWTP	MA	MA0100889	1	3	1496953	82583	157430
Warren WWTF	MA	MA0101567	1.5	3	2275698	99502	213287
Springfield WWTP	MA	MA0101613	67	3	69303466	2155070	5620243
Bitzer Trout Hatchery	MA	MA0110051	NA	3	305779	24076	39365
C.L. McLaughlin Trout Hatchery	MA	MA0110043	NA	3	305779	24076	39365
Hampden Papers Inc.	MA	MAG250881	NA	3	368472	27156	45579
Hazen Paper Co.	MA	MAG250872	NA	3	368472	27156	45579
Red Wing Trout Hatchery	MA	MA0027880	NA	3	305779	24076	39365
Seaman Paper Co. of Mass Inc	MA	MA0000469	NA	3	305779	24076	39365
Sunderland State Fish Hatchery	MA	MA0110035	NA	3	305779	24076	39365
Tolland State Forest WWTP	MA	MA0027359	NA	3	255624	21613	34394

Appendix E – Cost Curve Data for All Mitigation Activities

The next few pages include the cost and load reduction data for all pollution mitigation activities used to create the cost curves shown in Figures 12 through 14. These cumulative costs (Cum Cost) and reductions (Cum Red) have been ordered on the basis of cost per unit of nitrogen (kg or lb) eliminated from delivery to Long Island Sound as described in section 4.4. Reductions for agricultural and urban BMPs assume 100% implementation of the BMP type in the corresponding basin, and reductions for wastewater treatment plants assume a "Level 3" nitrogen concentration (i.e., 3.0 mg/l).

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		30	5438.7	23034.6	2.8	0.02	0.01	32.9
Ag BMPs		29	40120.5	153240.3	3.1	0.18	0.10	275.2
Ag BMPs		26	8280.8	35083.3	3.5	0.21	0.12	325.3
Ag BMPs		23	35564.9	182548.8	3.8	0.39	0.20	540.1
Ag BMPs		21	16913.3	101370.0	4.4	0.50	0.23	642.3
Ag BMPs		19	1140.0	6867.6	4.5	0.50	0.24	649.2
Ag BMPs		18	4216.9	30202.8	5.0	0.53	0.25	674.6
Ag BMPs		28	26036.6	160769.6	5.0	0.69	0.30	831.9
Ag BMPs		27	99350.1	558725.8	5.0	1.25	0.52	1432.1
Ag BMPs		24	18872.2	139375.5	6.2	1.39	0.56	1546.1
Ag BMPs		25	1930.9	15379.0	6.3	1.41	0.57	1557.8
Ag BMPs		12	23685.0	262405.5	6.9	1.67	0.62	1700.9
Ag BMPs		20	12589.1	105886.2	7.2	1.77	0.65	1776.9
Ag BMPs		14	18185.8	216915.5	7.4	1.99	0.69	1886.8
Ag BMPs		22	63193.1	584335.2	8.4	2.58	0.83	2268.5
Ag BMPs		17	7256.8	83972.5	8.8	2.66	0.84	2312.4
Ag BMPs		16	20920.1	235405.0	8.8	2.90	0.89	2438.8
Ag BMPs		15	17756.7	229190.4	10.0	3.12	0.93	2546.0
South Hadley WWTP	MA0100455	22	107272.2	1083679.7	10.1	4.21	1.17	3194.1
Ag BMPs		13	16553.5	280580.7	11.7	4.49	1.20	3294.1
Hanover WWTF	NH0100099	9	58979.0	742869.8	12.6	5.23	1.33	3650.4
Ag BMPs		10	29707.5	434137.2	13.5	5.67	1.40	3829.8
Ag BMPs		7	20953.2	306341.5	13.5	5.97	1.44	3956.4
Ag BMPs		11	42671.4	758511.7	14.3	6.73	1.54	4214.2
Chicopee WPC	MA0101508	26	211616.5	3110527.8	14.7	9.84	2.00	5492.6
Ag BMPs		9	12370.0	222098.7	15.8	10.06	2.03	5567.3
Easthampton WWTP	MA0101478	22	63163.9	1011930.5	16.0	11.08	2.17	5948.9
Westfield WPCF	MA0101800	24	83051.2	1424486.0	17.2	12.50	2.35	6450.6
Northampton POTW	MA0101818	22	105886.3	1872909.9	17.7	14.37	2.59	7090.3
Ag BMPs		5	24193.4	459409.6	17.7	14.83	2.64	7236.4
Hartford/White River	VT0101010	12	31035.5	550041.5	17.7	15.38	2.71	7423.9
Greenfield WPCF	MA0101214	21	48528.3	904306.5	18.6	16.29	2.82	7717.1
Keene WWTF	NH0100790	17	68949.0	1406548.9	20.4	17.69	2.97	8133.6
Ag BMPs		6	3159.2	73324.6	21.0	17.77	2.98	8152.7
Lebanon WWTF	NH0100366	13	39745.6	900719.0	22.7	18.67	3.06	8392.8
Ag BMPs		8	6573.9	166518.6	22.8	18.83	3.08	8432.5
Gardner WPCF	MA0100994	20	51883.2	1227177.5	23.7	20.06	3.19	8746.0
Brattleboro STP	VT010064	16	33412.1	869328.6	26.0	20.93	3.27	8947.8
Amherst WWTP	MA0100218	22	59857.7	1603856.3	26.8	22.53	3.40	9309.4
North Brookfield WWTP	MA0101061	23	15563.8	418619.4	26.9	22.95	3.43	9403.4
Athol WWTP	MA0100005	20	23860.0	644213.6	27.0	23.60	3.48	9547.6
Palmer WPCF	MA0101168	23	47358.2	1334800.5	28.2	24.93	3.59	9833.7
Ag BMPs		2	7335.4	221416.7	28.5	25.15	3.61	9878.0
Montague WPCF	MA0100137	22	19957.6	658563.6	33.0	25.81	3.65	9998.6
Ag BMPs		4	7045.8	263280.8	34.2	26.07	3.67	10041.1
Barre WWTP	MA0103152	23	8475.0	295014.1	34.8	26.37	3.68	10092.3
Hadley WWTP	MA0100099	22	9232.9	359503.8	38.9	26.73	3.70	10148.1

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		3	3750.4	170285.5	42.9	26.90	3.71	10170.7
Newport WWTP	NH0100200	13	13083.5	563494.7	43.1	27.46	3.74	10249.8
Bellows Falls WPCF	VT010013	16	12358.4	582329.1	47.1	28.05	3.77	10324.4
Sunapee WPCF	NH0100544	13	7850.1	386374.6	49.2	28.43	3.79	10371.9
Hinsdale WWTF	NH0100382	17	5909.9	295014.1	49.9	28.73	3.80	10407.6
Erving #1	MA0101516	20	10173.6	513269.5	50.5	29.24	3.82	10469.0
Holyoke WPCF	MA0101630	22	68440.5	3469248.8	50.7	32.71	3.97	10882.5
Springfield	VT0100374	14	14215.5	724932.3	51.0	33.43	4.00	10968.4
Claremont WWTF	NH0101257	13	20049.2	1028074.1	51.3	34.46	4.05	11089.5
South Deerfield WWTP	MA0101648	22	4321.6	225999.1	52.3	34.69	4.06	11115.6
St. Johnsbury STP	VT0100579	5	11483.2	617307.3	53.8	35.31	4.08	11185.0
Winchendon WPCF	MA0100862	20	9217.4	527619.6	57.2	35.83	4.10	11240.6
Winchester WWTP	NH0100404	17	4727.9	289640.0	61.3	36.12	4.11	11269.2
Orange WWTP	MA0101257	20	8123.4	527619.6	65.0	36.65	4.13	11318.3
Windsor	VT0100919	12	8133.1	533897.7	65.6	37.18	4.15	11367.4
Charlestown WWTF	NH0100765	15	7815.7	527619.6	67.5	37.71	4.17	11414.6
Groveton WWTF	NH0100226	4	4514.0	313823.6	69.5	38.03	4.18	11441.9
Spencer WWTP	MA0100919	23	7413.5	524032.1	70.7	38.55	4.19	11486.7
Ludlow WWTF	VT0100145	14	5583.3	403840.5	72.3	38.95	4.20	11520.4
Northfield WWTF	MA0100200	20	4003.7	289640.0	72.3	39.24	4.21	11544.6
Wasau Paper	NH0001562	4	6471.8	468363.4	72.4	39.71	4.23	11583.7
Templeton WWTF	MA0100340	20	11314.7	832556.9	73.6	40.54	4.25	11652.0
Littleton WWTF	NH0100153	8	8125.1	599369.8	73.8	41.14	4.27	11701.1
Springfield WWTP	MA0101613	26	76156.1	5620243.2	73.8	46.76	4.44	12161.2
Shelburne Falls WWTF	MA0101044	21	3713.5	281578.7	75.8	47.05	4.45	12183.6
Woodstock WTP	VT0100757	12	4436.2	336663.7	75.9	47.38	4.46	12210.4
Randolph WPCF	VT0100285	11	4140.6	323228.4	78.1	47.71	4.47	12235.4
Bethlehem Village District	NH0100501	8	3824.4	305762.4	80.0	48.01	4.47	12258.5
Hartford WWTP	VT0100978	12	3696.9	296357.6	80.2	48.31	4.48	12280.9
Warren WWTF	MA0101567	23	7347.3	599369.8	81.6	48.91	4.50	12325.3
Ware WWTP	MA0100889	23	5914.8	483109.0	81.7	49.39	4.51	12361.0
Woodsville Fire District	NH0100978	9	3687.0	303075.3	82.2	49.69	4.52	12383.3
Russell WWTF	MA0100960	24	3353.8	278891.7	83.2	49.97	4.53	12403.5
Lancaster POTW	NH0100145	4	6373.9	545557.2	85.6	50.52	4.54	12442.0
Lyndon STP	VT0100595	5	4656.4	417275.9	89.6	50.93	4.55	12470.2
Belchertown WWTP	MA0102148	22	5010.8	483109.0	96.4	51.42	4.56	12500.4
Chester WWTF	VT010081	14	2661.6	264112.8	99.2	51.68	4.57	12516.5
Hatfield WWTP	MA0101290	22	3492.6	348755.6	99.9	52.03	4.58	12537.6
Colebrook WWTF	NH0100315	2	3323.0	348755.6	105.0	52.38	4.58	12557.7
Huntington WWTP	MA0101265	24	2515.3	268143.4	106.6	52.65	4.59	12572.9
Lisbon WWTF	NH0100421	8	2781.4	300388.3	108.0	52.95	4.60	12589.7
Whitefield WWTF	NH0100510	6	2424.1	264112.8	109.0	53.21	4.60	12604.3
Hampden Papers Inc.	MAG250881	22	2091.5	241272.6	115.4	53.45	4.61	12617.0
Hazen Paper Co.	MAG250872	22	2091.5	241272.6	115.4	53.69	4.61	12629.6
Canaan WWTP	VT0100625	3	2146.6	264112.8	123.0	53.96	4.61	12642.6
Hardwick Gilbert	MA0100102	23	2028.2	276204.6	136.2	54.24	4.62	12654.8
Wilmington	VT0100706	18	1806.0	253364.4	140.3	54.49	4.62	12665.7

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Sherburne Fire Dist.	VT0101141	12	2033.3	296357.6	145.8	54.78	4.63	12678.0
Royalston WWTP	MA0100161	20	1404.7	225150.2	160.3	55.01	4.63	12686.5
Northfield School	MA0032573	20	2006.7	335320.2	167.1	55.35	4.63	12698.6
Cavendish WWTP	VT0100862	14	1520.9	256051.5	168.4	55.60	4.64	12707.8
Troy WWTF	NH0101052	17	1576.0	285609.3	181.2	55.89	4.64	12717.3
Royalton WWTP	VT0100854	11	1260.2	234554.9	186.1	56.12	4.64	12724.9
Bethel	VT0100048	11	1260.2	247990.3	196.8	56.37	4.65	12732.6
Bradford	VT0100803	10	1265.0	253364.4	200.3	56.62	4.65	12740.2
Old Deerfield WWTP	MA0101940	21	1355.2	281578.7	207.8	56.90	4.65	12748.4
Bitzer Trout Hatchery	MA0110051	22	1045.8	227837.2	217.9	57.13	4.66	12754.7
Red Wing Trout Hatchery	MA0027880	22	1045.8	227837.2	217.9	57.36	4.66	12761.0
Sunderland Fish Hatchery	MA0110035	22	1045.8	227837.2	217.9	57.59	4.66	12767.3
Swanzey WWTP	NH0101150	17	1182.0	259276.0	219.4	57.85	4.66	12774.5
C.L. McLaughlin Hatchery	MA0110043	23	1036.6	227837.2	219.8	58.08	4.66	12780.7
Urban BMPs		27	158064.5	34780363.2	220.0	92.86	5.01	13735.6
Urban BMPs		29	65143.0	14523397.4	222.9	107.38	5.16	14129.2
Seaman Paper Co.	MA0000469	20	1003.3	227837.2	227.1	107.61	5.16	14135.2
Cold Brook Fire Dist.	VT0101214	18	1003.3	229180.8	228.4	107.84	5.16	14141.3
Urban BMPs		16	16452.9	3800069.5	231.0	111.64	5.20	14240.7
Lunenberg	VT0101061	3	990.7	237242.0	239.5	111.87	5.20	14246.7
Putney WPCF	VT0100277	16	979.3	237242.0	242.3	112.11	5.20	14252.6
Urban BMPs		24	22898.7	5634198.3	246.0	117.74	5.25	14390.9
Northumberland Vill WPCF	NH0101206	4	936.2	230524.3	246.2	117.98	5.25	14396.6
Urban BMPs		28	39035.5	9613875.5	246.3	127.59	5.34	14632.4
Urban BMPs		10	8837.4	2181013.3	246.8	129.77	5.36	14685.8
Sunderland WWTF	MA0101079	22	1364.5	348755.6	255.6	130.12	5.36	14694.0
Urban BMPs		22	32431.0	9363429.1	288.7	139.48	5.43	14889.9
Urban BMPs		23	33071.1	9929211.4	300.2	149.41	5.51	15089.7
Saxtons River WWTP	VT0100609	16	783.4	242616.1	309.7	149.65	5.51	15094.5
Urban BMPs		11	8935.4	2776439.3	310.7	152.43	5.53	15148.4
Meriden Village Water Dist.	NH0101168	13	747.6	235898.5	315.5	152.67	5.53	15153.0
Franklin Pierce Coll. WWTF	NH0101044	19	791.7	252020.9	318.3	152.92	5.53	15157.7
Urban BMPs		21	7971.7	2677826.6	335.9	155.60	5.55	15205.9
Charlemont Sewer District	MA0103101	21	604.8	227837.2	376.7	155.82	5.55	15209.5
Urban BMPs		26	23965.4	9104412.4	379.9	164.93	5.60	15354.3
Whitingham Jacksonville	VT0101044	18	602.0	229180.8	380.7	165.16	5.61	15358.0
Cheshire County Home	NH0100391	15	586.2	225150.2	384.1	165.38	5.61	15361.5
Urban BMPs		5	7454.0	2908251.8	390.2	168.29	5.62	15406.5
Urban BMPs		12	6197.4	2425343.1	391.4	170.72	5.64	15444.0
Chelsea WWTP	VT0100943	11	540.1	231867.8	429.3	170.95	5.64	15447.2
Danville	VT0100633	7	527.0	231867.8	440.0	171.18	5.64	15450.4
Stratford Village WWTF	NH0100536	4	484.8	229449.5	473.3	171.41	5.64	15453.3
Urban BMPs		20	10462.8	5225166.9	499.4	176.63	5.66	15516.6
Urban BMPs		7	2468.9	1257499.2	509.3	177.89	5.67	15531.5
Urban BMPs		14	4449.0	2278837.9	512.2	180.17	5.68	15558.3
Readsboro WPC	VT0100731	18	802.7	417275.9	519.9	180.59	5.68	15563.2
Urban BMPs		18	1418.0	805532.8	568.1	181.39	5.68	15571.8

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Urban BMPs		15	2727.7	1678141.1	615.2	183.07	5.69	15588.2
Urban BMPs		25	886.1	569247.6	642.4	183.64	5.69	15593.6
Erving Center WWTP	MA0101052	20	435.2	312345.9	717.7	183.95	5.69	15596.2
Urban BMPs		17	4035.7	2897280.1	717.9	186.85	5.70	15620.6
Stratford Mill House WWTF	NH0101214	4	284.2	220850.8	777.1	187.07	5.70	15622.3
Urban BMPs		30	2501.0	2016440.9	806.3	189.09	5.71	15637.4
Urban BMPs		2	1096.5	960961.4	876.4	190.05	5.71	15644.0
Urban BMPs		13	4675.0	4166046.7	891.1	194.22	5.72	15672.3
Woronoco Village WWTF	MA0103233	24	209.6	219776.0	1048.5	194.44	5.72	15673.6
Tolland State Forest WWTP	MA0027359	25	205.7	217088.9	1055.3	194.65	5.72	15674.8
Erving #3	MA0102776	20	200.7	217088.9	1081.8	194.87	5.72	15676.0
Whitingham	VT0101109	18	200.7	218432.5	1088.5	195.09	5.72	15677.2
Monroe WWTF	MA0100188	21	201.6	219776.0	1090.2	195.31	5.72	15678.4
Windsor-Weston	VT0100447	12	184.8	221119.5	1196.3	195.53	5.72	15679.6
Urban BMPs		8	1751.3	2142868.5	1223.6	197.67	5.73	15690.1
Bridgewater	VT0100846	12	184.8	226493.7	1225.3	197.90	5.73	15691.3
South Woodstock WWTP	VT0100749	12	184.8	229180.8	1239.9	198.13	5.73	15692.4
Urban BMPs		9	855.0	1192277.3	1394.5	199.32	5.73	15697.5
Urban BMPs		6	403.6	634188.6	1571.4	199.95	5.73	15700.0
Urban BMPs		4	810.0	1288912.3	1591.2	201.24	5.73	15704.9
Urban BMPs		3	285.1	507287.6	1779.6	201.75	5.73	15706.6
Hardwick Wheelwright	MA0102431	23	116.1	225150.2	1938.5	201.97	5.73	15707.3
Urban BMPs		19	172.3	341845.4	1983.6	202.32	5.73	15708.3
Piermont WWTF	NH0101231	9	72.4	216282.8	2988.3	202.53	5.73	15708.8
Lancaster Grange POTW	NH0101249	4	66.9	215476.7	3222.2	202.75	5.73	15709.2

Summary under assumption of full implementation of point and non-point source mitigation activities:

Annual cost: $202.75 million per year
Potential N reduction: 5,733,849 lb/year (15,709 lb/day)
Current N load delivered to LIS: 28,710,233 lb/year (78,658 lb/day)
Reduced N load delivered to LIS: 22,976,384 (62,949 lb/day)
Potential percent reduction of total load: 20.0%

Appendix F – Cost Curve Data for All Mitigation Activities by State

Contained in this appendix are cost and load reduction similar to that provided in Appendix E; except that in this case, the data are organized by state. These are the detailed data sets used to develop the cost curves presented in section 4.5. As with Appendix E, reductions for agricultural and urban BMPs assume 100% implementation of the BMP type in the corresponding basin, and reductions for wastewater treatment plants assume a "Level 3" nitrogen concentration (i.e., 3.0 mg/l).

New Hampshire

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		19	1140.0	6867.6	4.5	0.01	0.00	6.9
Ag BMPs		17	7256.8	83972.5	8.8	0.09	0.02	50.7
Ag BMPs		15	17756.7	229190.4	10.0	0.32	0.06	158.0
Ag BMPs		13	16553.5	280580.7	11.7	0.60	0.09	258.0
Hanover WWTF	NH0100099	9	58979.0	742869.8	12.6	1.34	0.22	614.3
Ag BMPs		9	12370.0	222098.7	15.8	1.57	0.25	689.0
Keene WWTF	NH0100790	17	68949.0	1406548.9	20.4	2.97	0.40	1105.6
Ag BMPs		6	3159.2	73324.6	21.0	3.05	0.41	1124.6
Lebanon WWTF	NH0100366	13	39745.6	900719.0	22.7	3.95	0.50	1364.7
Ag BMPs		8	6573.9	166518.6	22.8	4.11	0.51	1404.5
Ag BMPs		2	7335.4	221416.7	28.5	4.33	0.53	1448.8
Ag BMPs		4	7045.8	263280.8	34.2	4.60	0.54	1491.3
Newport WWTP	NH0100200	13	13083.5	563494.7	43.1	5.16	0.57	1570.4
Sunapee WPCF	NH0100544	13	7850.1	386374.6	49.2	5.55	0.59	1617.8
Hinsdale WWTF	NH0100382	17	5909.9	295014.1	49.9	5.84	0.60	1653.5
Claremont WWTF	NH0101257	13	20049.2	1028074.1	51.3	6.87	0.65	1774.6
Winchester WWTP	NH0100404	17	4727.9	289640.0	61.3	7.16	0.66	1803.2
Charlestown WWTF	NH0100765	15	7815.7	527619.6	67.5	7.69	0.68	1850.4
Groveton WWTF	NH0100226	4	4514.0	313823.6	69.5	8.00	0.69	1877.7
Wasau Paper	NH0001562	4	6471.8	468363.4	72.4	8.47	0.70	1916.8
Littleton WWTF	NH0100153	8	8125.1	599369.8	73.8	9.07	0.72	1965.8
Bethlehem Village District	NH0100501	8	3824.4	305762.4	80.0	9.37	0.73	1988.9
Woodsville Fire District	NH0100978	9	3687.0	303075.3	82.2	9.68	0.73	2011.2
Lancaster POTW	NH0100145	4	6373.9	545557.2	85.6	10.22	0.75	2049.7
Colebrook WWTF	NH0100315	2	3323.0	348755.6	105.0	10.57	0.76	2069.8
Lisbon WWTF	NH0100421	8	2781.4	300388.3	108.0	10.87	0.76	2086.6
Whitefield WWTF	NH0100510	6	2424.1	264112.8	109.0	11.14	0.77	2101.3
Troy WWTF	NH0101052	17	1576.0	285609.3	181.2	11.42	0.77	2110.8
Swanzey WWTP	NH0101150	17	1182.0	259276.0	219.4	11.68	0.77	2117.9
Northumberland Vill. WPCF	NH0101206	4	936.2	230524.3	246.2	11.91	0.78	2123.6
Meriden Village Water Dist.	NH0101168	13	747.6	235898.5	315.5	12.15	0.78	2128.1
Franklin Pierce Coll. WWTF	NH0101044	19	791.7	252020.9	318.3	12.40	0.78	2132.9
Cheshire County Home	NH0100391	15	586.2	225150.2	384.1	12.63	0.78	2136.4
Stratford Village WWTF	NH0100536	4	484.8	229449.5	473.3	12.85	0.78	2139.3
Urban BMPs		15	2727.7	1678141.1	615.2	14.53	0.79	2155.8
Urban BMPs		17	4035.7	2897280.1	717.9	17.43	0.80	2180.2
Stratford Mill WWTF	NH0101214	4	284.2	220850.8	777.1	17.65	0.80	2181.9
Urban BMPs		2	1096.5	960961.4	876.4	18.61	0.80	2188.5
Urban BMPs		13	4675.0	4166046.7	891.1	22.78	0.81	2216.8
Urban BMPs		8	1751.3	2142868.5	1223.6	24.92	0.81	2227.4
Urban BMPs		9	855.0	1192277.3	1394.5	26.11	0.81	2232.5
Urban BMPs		6	403.6	634188.6	1571.4	26.75	0.82	2235.0
Urban BMPs		4	810.0	1288912.3	1591.2	28.04	0.82	2239.9
Urban BMPs		19	172.3	341845.4	1983.6	28.38	0.82	2240.9
Piermont WWTP	NH0101231	9	72.4	216282.8	2988.3	28.59	0.82	2241.3
Lancaster Grange POTW	NH0101249	4	66.9	215476.7	3222.2	28.81	0.82	2241.7

Vermont

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		18	4216.9	30202.8	5.0	0.03	0.01	25.5
Ag BMPs		12	23685.0	262405.5	6.9	0.29	0.06	168.6
Ag BMPs		14	18185.8	216915.5	7.4	0.51	0.10	278.4
Ag BMPs		16	20920.1	235405.0	8.8	0.74	0.15	404.8
Ag BMPs		10	29707.5	434137.2	13.5	1.18	0.21	584.3
Ag BMPs		7	20953.2	306341.5	13.5	1.49	0.26	710.8
Ag BMPs		11	42671.4	758511.7	14.3	2.24	0.35	968.6
Ag BMPs		5	24193.4	459409.6	17.7	2.70	0.41	1114.8
Hartford/White River	VT0101010	12	31035.5	550041.5	17.7	3.25	0.48	1302.3
Brattleboro STP	VT010064	16	33412.1	869328.6	26.0	4.12	0.55	1504.1
Ag BMPs		3	3750.4	170285.5	42.9	4.29	0.56	1526.8
Bellows Falls WPCF	VT010013	16	12358.4	582329.1	47.1	4.88	0.58	1601.4
Springfield	VT0100374	14	14215.5	724932.3	51.0	5.60	0.62	1687.3
St. Johnsbury STP	VT0100579	5	11483.2	617307.3	53.8	6.22	0.64	1756.7
Windsor	VT0100919	12	8133.1	533897.7	65.6	6.75	0.66	1805.8
Ludlow WWTF	VT0100145	14	5583.3	403840.5	72.3	7.16	0.67	1839.5
Woodstock WTP	VT0100757	12	4436.2	336663.7	75.9	7.49	0.68	1866.3
Randolph WPCF	VT0100285	11	4140.6	323228.4	78.1	7.82	0.69	1891.4
Hartford WWTP	VT0100978	12	3696.9	296357.6	80.2	8.11	0.70	1913.7
Lyndon STP	VT0100595	5	4656.4	417275.9	89.6	8.53	0.71	1941.8
Chester WWTF	VT010081	14	2661.6	264112.8	99.2	8.79	0.71	1957.9
Canaan WWTP	VT0100625	3	2146.6	264112.8	123.0	9.06	0.72	1970.9
Wilmington	VT0100706	18	1806.0	253364.4	140.3	9.31	0.72	1981.8
Sherburne Fire Dist.	VT0101141	12	2033.3	296357.6	145.8	9.61	0.73	1994.1
Cavendish WWTP	VT0100862	14	1520.9	256051.5	168.4	9.86	0.73	2003.2
Royalton WWTP	VT0100854	11	1260.2	234554.9	186.1	10.10	0.73	2010.9
Bethel	VT0100048	11	1260.2	247990.3	196.8	10.35	0.74	2018.5
Bradford	VT0100803	10	1265.0	253364.4	200.3	10.60	0.74	2026.1
Cold Brook Fire Dist.	VT0101214	18	1003.3	229180.8	228.4	10.83	0.74	2032.2
Urban BMPs		16	16452.9	3800069.5	231.0	14.63	0.78	2131.6
Lunenberg	VT0101061	3	990.7	237242.0	239.5	14.87	0.78	2137.6
Putney WPCF	VT0100277	16	979.3	237242.0	242.3	15.10	0.78	2143.5
Urban BMPs		10	8837.4	2181013.3	246.8	17.28	0.80	2196.9
Saxtons River WWTP	VT0100609	16	783.4	242616.1	309.7	17.53	0.80	2201.6
Urban BMPs		11	8935.4	2776439.3	310.7	20.30	0.82	2255.6
Whitingham Jacksonville	VT0101044	18	602.0	229180.8	380.7	20.53	0.82	2259.2
Urban BMPs		5	7454.0	2908251.8	390.2	23.44	0.84	2304.2
Urban BMPs		12	6197.4	2425343.1	391.4	25.87	0.85	2341.7
Chelsea WWTP	VT0100943	11	540.1	231867.8	429.3	26.10	0.86	2344.9
Danville	VT0100633	7	527.0	231867.8	440.0	26.33	0.86	2348.1
Urban BMPs		7	2468.9	1257499.2	509.3	27.59	0.86	2363.0
Urban BMPs		14	4449.0	2278837.9	512.2	29.87	0.87	2389.9
Readsboro WPC	VT0100731	18	802.7	417275.9	519.9	30.28	0.87	2394.8
Urban BMPs		18	1418.0	805532.8	568.1	31.09	0.88	2403.3
Whitingham	VT0101109	18	200.7	218432.5	1088.5	31.31	0.88	2404.5
Windsor-Weston	VT0100447	12	184.8	221119.5	1196.3	31.53	0.88	2405.7

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Bridgewater	VT0100846	12	184.8	226493.7	1225.3	31.75	0.88	2406.8
South Woodstock WWTP	VT0100749	12	184.8	229180.8	1239.9	31.98	0.88	2407.9
Urban BMPs		3	285.1	507287.6	1779.6	32.49	0.88	2409.6

Massachusetts

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		26	8280.8	35083.3	3.5	0.04	0.02	50.0
Ag BMPs		23	35564.9	182548.8	3.8	0.22	0.10	264.9
Ag BMPs		21	16913.3	101370.0	4.4	0.32	0.13	367.1
Ag BMPs		24	18872.2	139375.5	6.2	0.46	0.18	481.1
Ag BMPs		25	1930.9	15379.0	6.3	0.47	0.18	492.7
Ag BMPs		20	12589.1	105886.2	7.2	0.58	0.21	568.8
Ag BMPs		22	63193.1	584335.2	8.4	1.16	0.35	950.5
South Hadley WWTP	MA0100455	22	107272.2	1083679.7	10.1	2.25	0.58	1598.6
Chicopee WPC	MA0101508	26	211616.5	3110527.8	14.7	5.36	1.05	2877.0
Easthampton WWTP	MA0101478	22	63163.9	1011930.5	16.0	6.37	1.19	3258.5
Westfield WPCF	MA0101800	24	83051.2	1424486.0	17.2	7.79	1.37	3760.3
Northampton POTW	MA0101818	22	105886.3	1872909.9	17.7	9.67	1.61	4399.9
Greenfield WPCF	MA0101214	21	48528.3	904306.5	18.6	10.57	1.71	4693.1
Gardner WPCF	MA0100994	20	51883.2	1227177.5	23.7	11.80	1.83	5006.5
Amherst WWTP	MA0100218	22	59857.7	1603856.3	26.8	13.40	1.96	5368.1
North Brookfield WWTP	MA0101061	23	15563.8	418619.4	26.9	13.82	1.99	5462.2
Athol WWTP	MA0100005	20	23860.0	644213.6	27.0	14.47	2.05	5606.3
Palmer WPCF	MA0101168	23	47358.2	1334800.5	28.2	15.80	2.15	5892.4
Montague WPCF	MA0100137	22	19957.6	658563.6	33.0	16.46	2.19	6013.0
Barre WWTP	MA0103152	23	8475.0	295014.1	34.8	16.75	2.21	6064.2
Hadley WWTP	MA0100099	22	9232.9	359503.8	38.9	17.11	2.23	6119.9
Erving #1	MA0101516	20	10173.6	513269.5	50.5	17.63	2.26	6181.4
Holyoke WPCF	MA0101630	22	68440.5	3469248.8	50.7	21.10	2.41	6594.9
South Deerfield WWTP	MA0101648	22	4321.6	225999.1	52.3	21.32	2.42	6621.0
Winchendon WPCF	MA0100862	20	9217.4	527619.6	57.2	21.85	2.44	6676.6
Orange WWTP	MA0101257	20	8123.4	527619.6	65.0	22.38	2.45	6725.7
Spencer WWTP	MA0100919	23	7413.5	524032.1	70.7	22.90	2.47	6770.5
Northfield WWTF	MA0100200	20	4003.7	289640.0	72.3	23.19	2.48	6794.7
Templeton WWTF	MA0100340	20	11314.7	832556.9	73.6	24.02	2.51	6863.0
Springfield WWTP	MA0101613	26	76156.1	5620243.2	73.8	29.64	2.67	7323.1
Shelburne Falls WWTF	MA0101044	21	3713.5	281578.7	75.8	29.93	2.68	7345.5
Warren WWTF	MA0101567	23	7347.3	599369.8	81.6	30.52	2.70	7389.9
Ware WWTP	MA0100889	23	5914.8	483109.0	81.7	31.01	2.71	7425.7
Russell WWTF	MA0100960	24	3353.8	278891.7	83.2	31.29	2.72	7445.9
Belchertown WWTP	MA0102148	22	5010.8	483109.0	96.4	31.77	2.73	7476.2
Hatfield WWTP	MA0101290	22	3492.6	348755.6	99.9	32.12	2.74	7497.3
Huntington WWTP	MA0101265	24	2515.3	268143.4	106.6	32.39	2.74	7512.5
Hampden Papers Inc.	MAG250881	22	2091.5	241272.6	115.4	32.63	2.75	7525.1
Hazen Paper Co.	MAG250872	22	2091.5	241272.6	115.4	32.87	2.75	7537.8

FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Hardwick Gilbert	MA0100102	23	2028.2	276204.6	136.2	33.15	2.76	7550.0
Royalston WWTP	MA0100161	20	1404.7	225150.2	160.3	33.37	2.76	7558.5
Northfield School	MA0032573	20	2006.7	335320.2	167.1	33.71	2.76	7570.6
Old Deerfield WWTP	MA0101940	21	1355.2	281578.7	207.8	33.99	2.77	7578.8
Bitzer Trout Hatchery	MA0110051	22	1045.8	227837.2	217.9	34.22	2.77	7585.1
Red Wing Trout Hatchery	MA0027880	22	1045.8	227837.2	217.9	34.44	2.77	7591.4
Sunderland St. Fish Hatchery	MA0110035	22	1045.8	227837.2	217.9	34.67	2.77	7597.8
McLaughlin Trout Hatchery	MA0110043	23	1036.6	227837.2	219.8	34.90	2.78	7604.0
Seaman Paper Co. of Mass	MA0000469	20	1003.3	227837.2	227.1	35.13	2.78	7610.1
Urban BMPs		24	22898.7	5634198.3	246.0	40.76	2.83	7748.4
Sunderland WWTF	MA0101079	22	1364.5	348755.6	255.6	41.11	2.83	7756.7
Urban BMPs		22	32431.0	9363429.1	288.7	50.47	2.90	7952.6
Urban BMPs		23	33071.1	9929211.4	300.2	60.40	2.98	8152.4
Urban BMPs		21	7971.7	2677826.6	335.9	63.08	2.99	8200.5
Charlemont Sewer District	MA0103101	21	604.8	227837.2	376.7	63.31	2.99	8204.2
Urban BMPs		26	23965.4	9104412.4	379.9	72.41	3.05	8349.0
Urban BMPs		20	10462.8	5225166.9	499.4	77.64	3.07	8412.2
Urban BMPs		25	886.1	569247.6	642.4	78.21	3.07	8417.5
Erving Center WWTP	MA0101052	20	435.2	312345.9	717.7	78.52	3.07	8420.1
Woronoco Village WWTF	MA0103233	24	209.6	219776.0	1048.5	78.74	3.07	8421.4
Tolland State Forest WWTP	MA0027359	25	205.7	217088.9	1055.3	78.96	3.07	8422.6
Erving #3	MA0102776	20	200.7	217088.9	1081.8	79.17	3.07	8423.9
Monroe WWTF	MA0100188	21	201.6	219776.0	1090.2	79.39	3.08	8425.1
Hardwick Wheelwright	MA0102431	23	116.1	225150.2	1938.5	79.62	3.08	8425.8

Connecticut

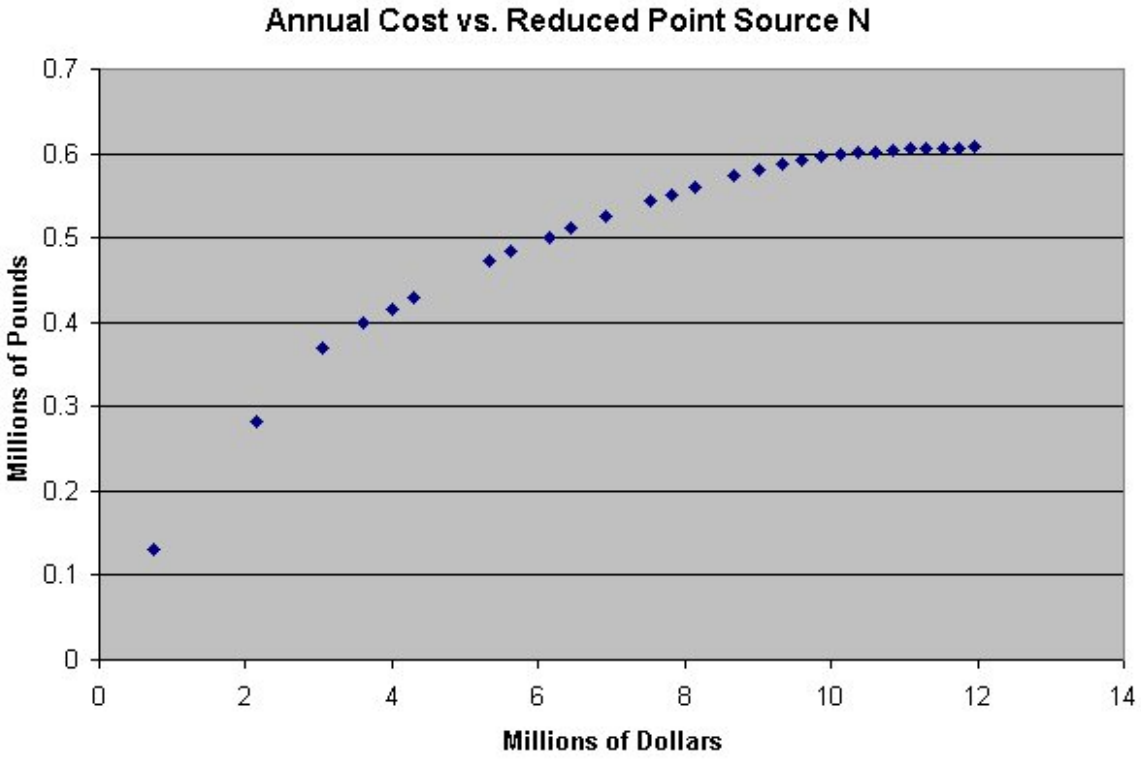
FACILITY / Activity	Permit #	Basin	N Reduced (kg / yr)	Total Cost (dollars / yr)	$ / kg N	Cum Cost (million $ / yr)	Cum Red (million lb/yr)	Cum Red (lb / day)
Ag BMPs		30	5438.7	23034.6	2.8	0.02	0.01	32.9
Ag BMPs		29	40120.5	153240.3	3.1	0.18	0.10	275.2
Ag BMPs		28	26036.6	160769.6	5.0	0.34	0.16	432.5
Ag BMPs		27	99350.1	558725.8	5.0	0.90	0.38	1032.7
Urban BMPs		27	158064.5	34780363.2	220.0	35.68	0.73	1987.6
Urban BMPs		29	65143.0	14523397.4	222.9	50.20	0.87	2381.1
Urban BMPs		28	39035.5	9613875.5	246.3	59.81	0.96	2616.9
Urban BMPs		30	2501.0	2016440.9	806.3	61.83	0.96	2632.0

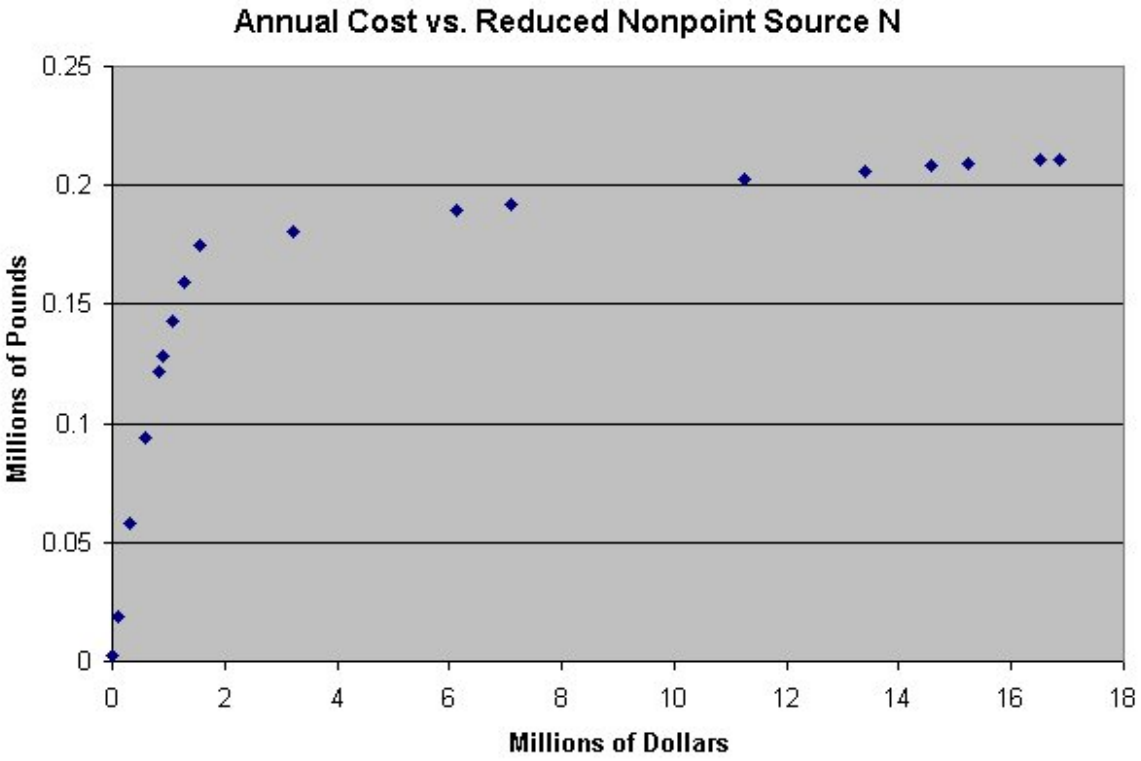
Note: Further point source reductions were not considered in Connecticut

Appendix G – Additional Cost Curve Data by State for Point and Non-Point Source Controls

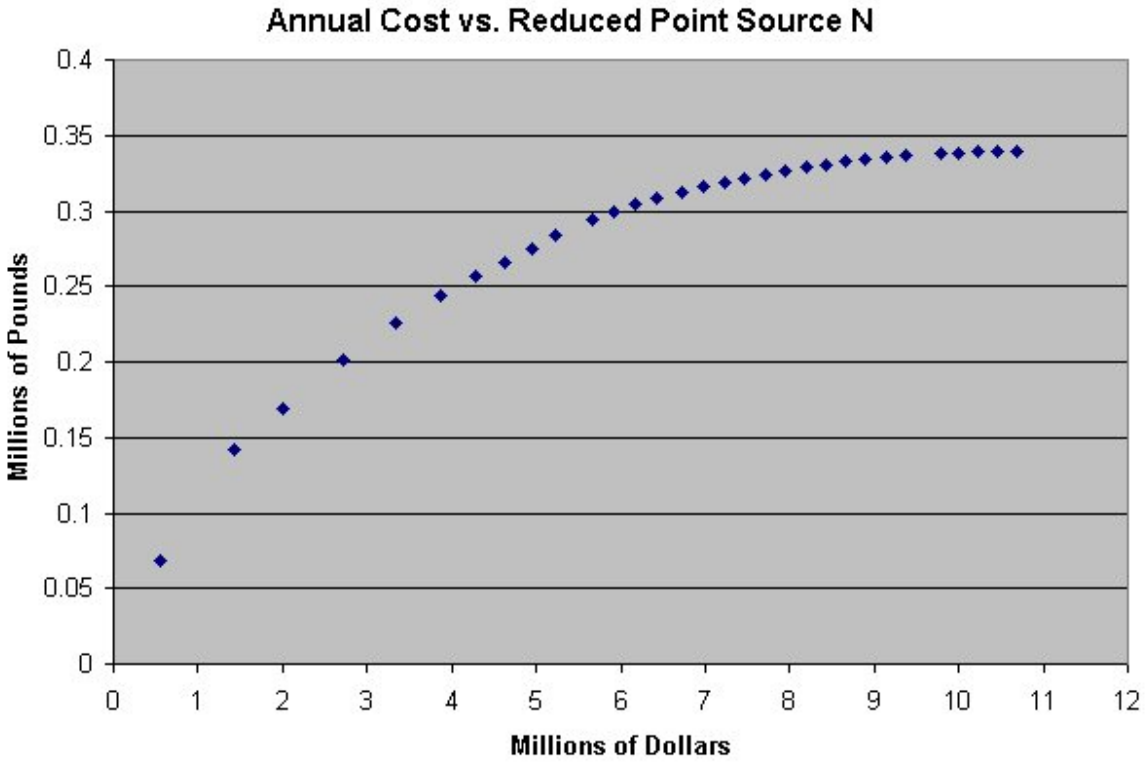
Contained in this appendix are additional cost curves for each state similar to those shown in Section 4.5. In this case, however, separate cost curves are shown for wastewater treatment plant upgrades and the implementation of non-points source controls (i.e., agricultural and urban BMPs). The non-point source cost curve for Connecticut is not shown here as it is the same as that shown in section 4.5.

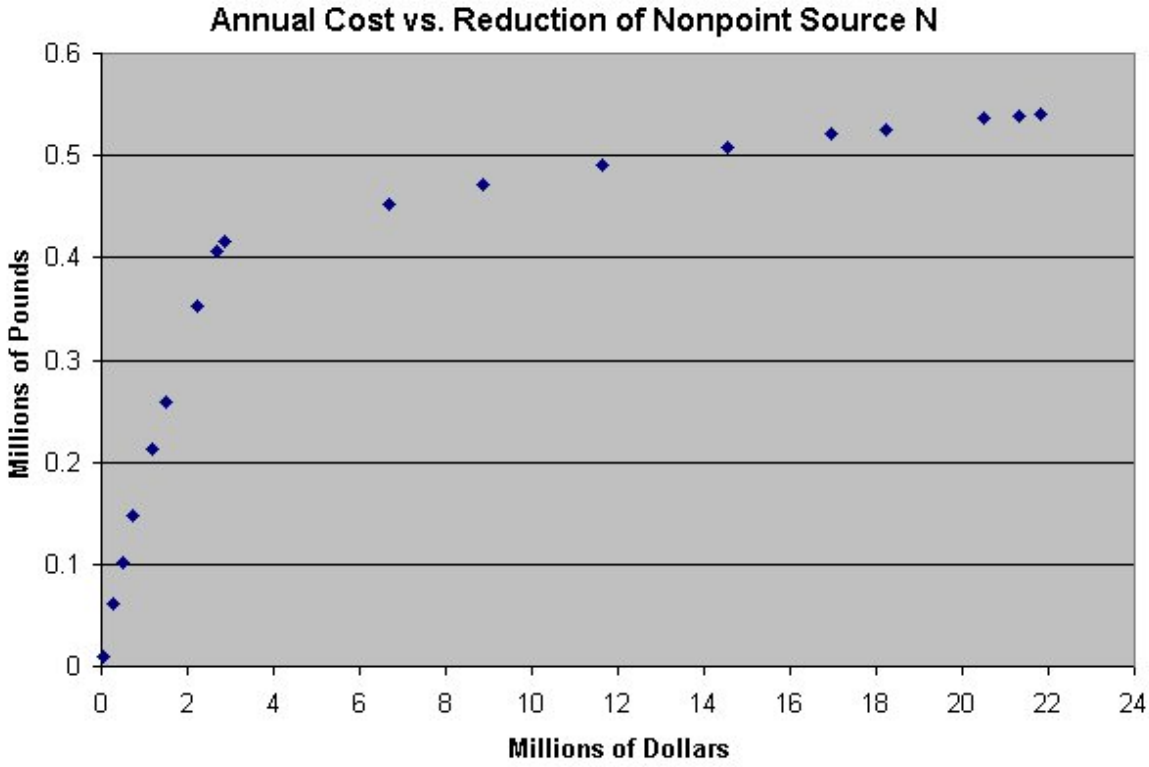
New Hampshire





Vermont


Annual Cost vs. Reduced Point Source N
Millions of Pounds
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 1 2 3 4 5 6 7 8 9 10 11 12
Millions of Dollars


Annual Cost vs. Reduction of Nonpoint Source N
Millions of Pounds
0.6
0.5
0.4
0.3
0.2
0.1
0
0 2 4 6 8 10 12 14 16 18 20 22 24
Millions of Dollars

Massachusetts