VIII. CRITICAL NUTRIENT THRESHOLD DETERMINATION AND DEVELOPMENT OF WATER QUALITY TARGETS

VIII.1. ASSESSMENT OF NITROGEN RELATED HABITAT QUALITY

Determination of site specific nitrogen thresholds for an embayment requires the integration of key habitat parameters (infauna and eelgrass), sediment characteristic data, and nutrient related water quality information, (particularly dissolved oxygen and chlorophyll a). Additional information on temporal changes within each sub-embayment and its watershed further strengthen the analysis. These data were all collected to support threshold development in the Stage Harbor, Bassing Harbor, Muddy Creek, Sulphur Springs and Taylor Pond Systems by the MEP Team and were discussed in Section VII. Nitrogen threshold development builds on these data and links habitat quality to summer water column nitrogen levels from long-term baseline water quality monitoring (Chatham Water Watchers, Pleasant Bay Alliance, and MEP Team; Table VIII-1).

The five embayment systems in this study displayed a range of habitat quality, both between systems and along the longitudinal axis of the larger systems. In general, sub-embayments show decline in habitat quality moving from the inlet to the inland-most tidal reach. This trend is seen in both the nitrogen levels (highest inland), eelgrass distribution, infaunal community stress indicators and community properties, as well as summer dissolved oxygen and chlorophyll a records. The following is a brief synopsis of the present habitat quality within each of the five embayment systems. The underlying quantitative data is presented on nitrogen (Section VI), oxygen and chlorophyll a (Section VII-1), eelgrass (Section VII-2), and benthic infauna (Section VII-3).

Stage Harbor System – Little Mill Pond, Mill Pond, and Oyster Pond have elevated nitrogen levels and have lost historic eelgrass beds which once covered most of their respective basins. Oxygen depletion is observed during summer in each system with Mill Pond (and presumably Little Mill Pond) having ecologically significant declines (<3 mg L^{-1}). Oyster Pond had less oxygen depletion possibly due to its greater fetch for ventilation with the atmosphere. Chlorophyll a levels were consistent with the observed oxygen depletion. The lower reaches of the Oyster River and Upper Stage Harbor show good habitat quality as evidenced by their persistent eelgrass beds, infaunal community structure and oxygen and chlorophyll a levels. The inner-most high quality habitat is found in the lower Mitchell River/upper Stage Harbor.

Sulphur Springs System – Cockle Cove consists primarily of a salt marsh and central tidal creek. This system contains little water at low tide and has a high assimilative capacity for nitrogen as do other New England salt marshes. The Cockle Cove tidal creek and its associated marsh area are functioning well as a salt marsh ecosystem. The nitrogen threshold established for the open water areas of the Sulphur Springs system is not applicable to the Cockle Cove salt marsh area. Additionally, data is not currently available to justify increasing the nitrogen load to the Cockle Cove marsh system. Sulphur Springs is a shallow basin containing significant macroalgal accumulations, no eelgrass, and appears to be transitioning to salt marsh. However, Sulphur Springs basin is still functioning as an embayment, but a eutrophic one. Nitrogen levels are high (Section VI), oxygen levels become significantly depleted (6% of time <3 mg L^{-1}) and phytoplankton blooms are common and large (chlorophyll a levels >20 ug L^{-1}). Eelgrass has not been observed for over a decade.

Table VIII-1. Assessment of nitrogen related habitat quality within the embayments of the Town of Chatham. Water quality stations and benthic stations were in the same basin, but not in the exact same locations. Data for this comparison is from 2000, when the eelgrass mapping and benthic infauna were assayed. Note that the 1998-2002 water quality data was used in the validation of the water quality model and that the moored instrumentation captured a greater range of dissolved oxygen and chlorophyll a than the water quality sampling programs. Ecological Assessment Classification (SMAST) attempts to integrate water quality and habitat indicators, as well as any temporal trends which have been identified. No data is represented by "-- --".

Embayment System	Depth m	Salinity ppt	Minimum D.O. Mg/L	Secchi depth m	Nitrogen DIN mg N/L	Nitrogen TN mgN/L	Phytoplankton Tot-Pig ug/L	Sediment Type	Sediment Carbon mgC/cc	MacroAlgae Abundance	Eelgrass* Cover/Density/Status	Infaunal** Community Classification	Ecological*** Assessment Class/Status
Stage Harbor System:													
Oyster Pond	2.85	29.8	7.06	2.13	0.05	0.79	5.18	Mud/Sand	737	Low	Sparse/Low/Decline	Intermediate	Mod-Fair/Decline
Oyster River	1	30.1	6.23	2.13	0.04	0.46	4.43	Sand	236	-- --	Mod/Mod/Decline	-- --	Mod-High/Decline
Stage Harbor	1.6	30.2	7.09	1.84	0.04	0.66	5.63	Sand	546	-- --	Mod/Mod/Decline	-- --	Mod-High/Decline
Stage Harbor - Upper	1.6	30	7.45	2.22	0.04	0.46	4.2	Sand/mud	950	-- --	Mod/High/Decline	Intermed/Healthy	Mod-High/Decline
Mitchell River								Sand	294	-- --	Low/Low/Decline	Intermediate	Mod/Decline
Mill Pond	4.46	30	6.57	2.12	0.04	0.50	5.2	Mud	815	-- --	0	Stressed	Poor
Little Mill Pond	4.15	29.8	5.63	2.34	0.09	0.69	6.74	Mud	1334	-- --	0	Stressed	Poor
Taylors Pond System:													
Taylors Pond	2.18	28.3	5.85	1.76	0.06	0.51	7.03	Mud	1624	Moderate	0	Stressed	Poor
Mill Creek	1.01	28.3	5.26	1	0.06	0.49	6.35	Sand	702	Moderate	-- --	-- --	-- --
Cockle Cove System:													
Sulphur Springs	1.03	28.6	4.8	1.03	0.04	0.36	5.56	Mud/Sand	1246	High	0	-- --	Poor
Bucks Creek	0.82	28.1	5.86	0.8	0.05	0.40	4.66	Sand	853	Moderate	0	-- --	Moderate
Cockle Cove Cr Mid	NA	0	NA	-- --	0.25	1.49	-- --	-- --	-- --	-- --	-- --	-- --	N/A****
Cockle Cove Cr Low	0.31	24.5	2.78	0.31	0.20	0.89	6.35	Sand	300	-- --	-- --	-- --	N/A****
Bassing Harbor System													
Bassing Harbor	1.8	28.7	6.78	1.42	0.05	0.54	5.63	Sand/mud	1186	-- --	High/Mod/Stable-Incr.	Intermediate	Mod-High
Crows Pond	4.98	29.2	6.58	1.97	0.11	0.76	5.92	Sand/mud	1292	-- --	Mod/Mod/Decline	Intermediate	Moderate
Ryder Cove - Inner	2.34	29.1	6.04	2	0.06	0.47	6.29	Mud/Sand	899	-- --	Mod/High/Decline.	Intermediate	Moderate
Ryder Cove - Outer	3.5	28.2	6.55	2.35	0.04	0.44	6.45	Mud/Sand	1210	-- --	High/Low/Stable	-- --	Moderate
Frost Fish Outer	1.1	28.5	5.48	1.1	0.16	1.24	11.02	-- --	-- --	-- --	0	-- --	Poor
Frost Fish Inner	0.6	15.3	NA	-- --	0.30	0.92	-- --	Mud	792	-- --	0	Stressed	N/A****
Muddy Creek System:													
Upper	-- --	-- --	-- --	-- --	-- --	-- --	-- --	Mud	940	-- --	0	Stressed	Poor
Lower	1.37	25.6	6.33	1.18	0.04	0.57	9.99	Mud	1447	-- --	Sparse Patch	Stressed	Poor

* Eelgrass coverage was classified as High, Moderate (Mod), Low and Absent (0); the stability of the beds was based upon areal changes since the DEP survey of 1994 (Costello).
** Infaunal communities classification is based upon the composition and number of species representative of "healthy", "Intermediate", and "stressed" conditions.
*** Classification is based upon High - low nutrient stress & high habitat quality; Moderate - moderate to fair nutrient stress & moderate habitat quality; Low - high nutrient related stress and poor habitat quality.
**** Infaunal communities reflective of salt marsh conditions.

Taylors Pond System – Taylors Pond represents the inland-most sub-embayment and is a drowned kettle pond. The lower portion of this system is comprised of a tidal salt marsh, Mill Creek. Like the Sulphur Springs System, the inner basin functions as an embayment and the tidal creek as a salt marsh with low sensitivity to nitrogen inputs. Taylors Pond is currently showing poor habitat quality. There is currently no eelgrass community and no record of eelgrass for over a decade. Watercolumn nitrogen levels are enriched over incoming tidal waters (Section VI) and dissolved oxygen depletion to ~4 mg L^{-1} is common. Chlorophyll a levels of 10-15 ug L^{-1} are common during summer. The benthic infaunal community is impoverished, with only a mean of 43 individuals collected in the grab samples, compared to several hundred in the high quality sub-embayments.

Bassing Harbor System – The inner-most sub-embayments to this system contain high quality habitat that is currently becoming impaired by nitrogen enrichment. Ryder Cove receives the greatest watershed nitrogen load of the Bassing Harbor sub-systems. This sub-embayment has been losing its eelgrass over at least the last decade. In 1951 the full basin appears to have supported eelgrass beds many of which do not exist today. Infaunal communities indicate a moderate quality system with relatively low diversity and evenness. This is consistent with a system whose habitat is in transition from high to moderate level of quality. Upper Ryder Cove is currently showing bottom water oxygen depletion, frequently to <4 mg L^{-1} and occasionally to < 3 mg L^{-1}. The periodic oxygen declines, loss of eelgrass, and watershed nitrogen loading is consistent with the observed phytoplankton blooms, which generally (>40% of time) are >15 ug L^{-1} and frequently >20 ug L^{-1}. In contrast, the outer reach of Ryder Cove still supports relatively high habitat quality with dissolved oxygen levels almost always above 5 mg L^{-1} (99%) and moderate chlorophyll a levels (<15 ug L^{-1}). These watercolumn parameters are consistent with the high eelgrass coverage. Crows Pond is the other inland-most sub-embayment in this bifurcated estuary. However, Crows Pond has a significantly lower watershed nitrogen load than that to Ryder Cove. Crows Pond currently supports a high level of habitat quality, with eelgrass beds surrounding the central basin and sparse coverage throughout. Infaunal diversity and evenness is consistent with a high quality habitat. Oxygen levels are consistently above 5 mg L^{-1} and chlorophyll a levels also are moderate (generally 10-15 ug L^{-1}). However, it appears that habitat quality is currently declining. Eelgrass coverage is less than in the 1951 and 1995 records. At present it appears the Crows Pond is slightly beyond its threshold nitrogen level and is beginning to decline in habitat quality. In addition, Frost Fish Creek is a tributary system to outer Ryder Cove which functions primarily as a salt marsh with a central basin (Section IV, Section VI). As discussed above for Cockle Cove, Frost Fish Creek (inner) functions as a salt marsh. As such, the nitrogen threshold developed for the open water portions of the Bassing Harbor system is not specifically applicable to Frost Fish Creek (inner). The outer-most basin is Bassing Harbor which receives tidal exchanges with Pleasant Bay. Bassing Harbor currently supports high habitat quality and based upon the eelgrass records has been relatively constant since 1951. The infaunal community is consistent with high habitat quality as is the maintenance of oxygen levels and moderate to low chlorophyll a levels (typically 5-10 ug L^{-1}. The Bassing Harbor sub-embayments appears to be a relatively stable high habitat quality system, with demonstrated good eelgrass and infaunal communities.

Muddy Creek – Muddy Creek like Bassing Harbor exchanges tidal waters with the greater Pleasant Bay System. However, unlike Bassing Harbor, Muddy Creek is a highly eutrophic embayment. Muddy Creek does not support significant eelgrass beds; however, a small sparse bed has persisted adjacent to the inlet. Muddy Creek is divided into an upper and lower portion by a dike whose weir has been removed or washed away. Both portions are highly eutrophic with frequent bottomwater anoxia and large algal blooms (chlorophyll a frequently >50 ug L^{-1}). The upper portion has a lower habitat quality than the lower portion, most likely as a result of access to the higher quality waters entering from Pleasant Bay. An infaunal community persists but it is dominated by species tolerant of organic enrichment. Species diversity and evenness are low. The whole of Muddy Creek currently supports nitrogen impaired habitat of poor quality.

VIII.2. THRESHOLD NITROGEN CONCENTRATIONS

The threshold nitrogen level for an embayment represents the average watercolumn concentration of nitrogen that will support the habitat quality being sought. The watercolumn nitrogen level is ultimately controlled by the watershed nitrogen load and the nitrogen concentration in the inflowing tidal waters (boundary condition). The watercolumn nitrogen concentration is modified by the extent of sediment regeneration.

Threshold nitrogen levels for each of the five embayment systems in this study were developed to restore or maintain SA waters or high habitat quality. In these five systems, high habitat quality was defined as supportive of eelgrass and infaunal communities. Dissolved oxygen and chlorophyll a were considered in the assessment.

The approach developed by the MEP has been to select a sentinel sub-embayment within each embayment system. First, a sentinel sub-embayment is selected based upon its location within the system. The sentinel should be close to the inland-most reach as this is typically where water quality is lowest in an embayment system. Therefore, restoration or protection of the sentinel sub-embayment will necessarily create high quality habitat throughout the estuary. Second, a sentinel sub-embayment should be sufficiently large to prevent steep horizontal water quality gradients, such as would be found in the region of entry of a stream or river or in the upper most region of a narrow, shallow estuary. This second criteria relates to the ability to accurately determine the baseline nitrogen level and to conduct the predictive modeling runs. Finally, the sentinel system should be able to obtain the minimum level of habitat quality acceptable for the greater system (unless a multiple classification is to be used).

After the sentinel sub-system (or systems) is selected, the nitrogen level associated with high and stable habitat quality typically derived from a lower reach of the same system or an adjacent embayment is used as the nitrogen concentration target. Finally, the watershed nitrogen loading rate is manipulated in the calibrated water quality model to determine the watershed nitrogen load which will produce the target nitrogen level within the sentinel system. Differences between the required modeled nitrogen load to achieve the target nitrogen level and the present watershed nitrogen load represent nitrogen management goals for restoration or protection of the embayment system as a whole.

The threshold nitrogen levels for the each embayment system was determined as follows:

Stage Harbor System – This embayment system has two upper reaches. Therefore, two sentinel sub-embayments were selected, mid-Oyster Pond and Mill Pond. Little Mill Pond could not be used because it is small and has steep horizontal nitrogen gradients (see Section VI). Within the Stage Harbor System, the uppermost sub-embayment supportive of high quality habitat was upper Stage Harbor (Section VII, VIII-1). Watercolumn total nitrogen levels within this embayment region vary with the tidal stage due to high nitrogen outflowing waters and low nitrogen inflowing waters (Section VI). The calibrated water quality model for this system indicates an average total nitrogen level in the upper Stage Harbor of about 0.40 mg N L^{-1} is most representative of the conditions within this sub-embayment. However, upper Stage Harbor does not appear to be stable based upon changes in eelgrass distribution. Therefore, a nitrogen level reflective of conditions closer to the inlet should achieve the stability required.

The lower nitrogen level is equivalent to the tidally averaged total nitrogen concentration mid-way between upper Stage Harbor and Stage Harbor or 0.38 mg N L^{-1}. This threshold selection is supported by the fact that the high quality and stable habitat near the mouth of the Oyster River is also at a tidally averaged total nitrogen concentration of 0.37 mg N L^{-1}. The 0.38 mg N L^{-1} was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in each sentinel system to this level. Tidal waters inflowing from Nantucket Sound have an average concentration of total nitrogen of 0.285 mg N L^{-1}.

Sulphur Springs System – The Sulphur Springs basin is both the inland-most sub-embayment and also represents the largest component of the Sulphur Springs System (which also includes Mill Creek and Bucks Creek). Since this System exchanges tidal waters with Nantucket Sound (0.285 mg N L^{-1}), as does Stage Harbor, and since there is currently no high quality habitat within this system, Stage Harbor habitat quality information was used to support the Sulphur Springs thresholds analysis. The tidally averaged nitrogen threshold concentration for this system was determined to be the same as for the sentinel sub-embayments to the Stage Harbor System or 0.38 mg N L^{-1}. The 0.38 mg N L^{-1} was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in the Sulphur Springs sentinel system to this level. This 0.38 mg N L^{-1} threshold concentration was developed for the open water portions of the system and as previously mentioned above is not applicable to the Cockle Cove subsystem as it is functioning well as a salt marsh.

Taylors Pond System – This system was approached in a similar manner to the Sulphur Springs System and for the same reasons. Taylors Pond represents the innermost and functional embayment within this system. This system also exchanges tidal waters with Nantucket Sound (0.285 mg N L^{-1}), as does the Stage Harbor System and there is no high quality stable embayment habitat within this system. Therefore, the tidally averaged nitrogen threshold concentration for this system was determined to be the same as for the sentinel sub-embayments to the Stage Harbor System or 0.38 mg N L^{-1}. The 0.38 mg N L^{-1} was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in Taylors Pond to this level.

Bassing Harbor System – Although this system has two inland-most sub-embayments, Ryder Cove and Crows Pond, only Ryder Cove was selected as the sentinel system. This resulted from the fact that Crows Pond has a relatively low nitrogen load from its watershed and appears to currently support higher quality habitat than Ryder Cove. Ryder Cove currently shows a gradient in habitat quality with lower quality habitat in the upper reach and higher quality in the lower reach. Ryder Cove represents a system capable of fully supporting eelgrass beds and stable high quality habitat. At present, this basin is transitioning from high to low habitat quality in response to increased nitrogen loading. Restoration of nitrogen levels in upper Ryder Cove to levels supportive of high quality habitat should also result in the restoration and protection of the whole of the Bassing Harbor System.

Following the approach used for the Stage Harbor System, a region of stable high quality habitat was selected within the Bassing Harbor System. The region selected was Bassing Harbor which has both high quality eelgrass and benthic animal communities, which appear to be stable. Unfortunately, total nitrogen within this system appears to be very high. In fact, the whole of lower Pleasant Bay appears to contain very high levels of total nitrogen. Analysis of the composition of the watercolumn nitrogen pool within these embayments revealed that the concentrations of dissolved inorganic nitrogen (DIN) and particulate organic nitrogen (PON) were the same as for the Stage Harbor System. In fact, the level of these combined pools (DIN+PON) was lower in Bassing Harbor (0.133 mg N L^{-1}) than in the Stage Harbor (0.158 mg

N L^{-1}) and the mouth of Oyster River (0.160 mg N L^{-1}). It appears that the reason for the higher total nitrogen levels in the Pleasant Bay waters results from the accumulation of dissolved organic nitrogen. The bulk of dissolved organic nitrogen (DON) is relatively non-supportive of phytoplankton production in shallow estuaries, although some fraction is actively cycling. It is likely that the high background DON results from the relatively long residence time of Pleasant Bay waters relative to the smaller systems. This allows the accumulation of the less biologically active nitrogen forms, hence the higher background. Decomposition of phytoplankton, macroalgae and eelgrass release DON to estuarine waters as do salt marshes and surface freshwater inflows.

Based upon these site-specific observations, an adjusted nitrogen threshold could be developed for the Bassing Harbor System. The approach was to determine the baseline dissolved organic nitrogen level for the region (average of inner and outer Ryder Cove, Bassing Harbor, Frost Fish Creek, Tern Island, and Pleasant Bay), which was determined to be 0.394 mg N L^{-1}. Note, the threshold developed for Bassing Harbor system is not applicable to Frost Fish Creek (inner) since it functions as a salt marsh system. A threshold range was then developed using a conservative DIN+PON level from the Bassing Harbor sub-embayment plus the dissolved organic nitrogen background and an upper threshold based upon the Stage Harbor DIN and PON values discussed above. The threshold range for this system was set as 0.527 mg N L^{-1} to 0.552 mg N L^{-1} and the higher threshold was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in upper Ryder Cove to this level. The nitrogen boundary condition (the concentration of nitrogen in inflowing tidal waters from Pleasant Bay) for the Bassing Harbor System is 0.48 mg N L^{-1}.

Muddy Creek System – This system is highly eutrophic. Given the long narrow basin and the hydrodynamic evaluation (Section V), it was decided to make lower Muddy Creek the sentinel system. This is also based upon the fact that the upper portion was historically a freshwater system. Following the approach for the Bassing Harbor System, the MEP Team considered the Ryder Cove Threshold appropriate for application to lower Muddy Creek. Note that lower Muddy Creek recently supported a sparse eelgrass bed. The threshold was used to develop watershed nitrogen loads required to reduce the average nitrogen concentrations in lower Muddy Creek to this level. However, threshold relates to The nitrogen boundary condition (the concentration of nitrogen in inflowing tidal waters from Pleasant Bay) for the Muddy Creek System is 0.50 mg N L^{-1}.

VIII.3. DEVELOPMENT OF TARGET NITROGEN LOADS

The tidally averaged total nitrogen thresholds derived in Section VIII-2 were used to adjust the calibrated constituent transport model developed in Section V. Watershed nitrogen loads were sequentially lowered, using reductions in septic effluent discharges only, until the nitrogen levels reached the threshold levels in each sentinel system.

As shown in Table VIII-2, the nitrogen load reductions within the Stage Harbor system necessary to achieve the threshold nitrogen concentrations were relatively high, with more than 90% removal of septic load required within three sub-embayments (Oyster Pond, Oyster River, and Stage Harbor). For the other south coastal embayments (Sulphur Springs and Taylors Pond systems), between 50% and 60% of the septic load would need to be removed to achieve the nitrogen concentration targets. The distribution of tidally-averaged nitrogen concentrations associated with the above thresholds analysis are shown in Figures VIII-1 through VIII-6.

As shown in Table VIII-3, the nitrogen load reductions within the Bassing Harbor system necessary to achieve the threshold nitrogen concentrations were relatively low, with between 30% and 50% removal of septic load required within the sub-embayments. For Muddy Creek, between 50% and 60% of the septic load would need to be removed to achieve the nitrogen concentration targets for Lower Muddy Creek. Modeling to attain this target for upper Muddy Creek indicated that most of the load would have to be removed. This resulted in a variety of modeling scenarios, which are presented in Chapter IX, and the development of a possible dike scenario (which would require additional modeling for full consideration). The distribution of tidally-averaged nitrogen concentrations associated with the above thresholds analysis are shown in Figures VIII-7 through VIII-10.

Tables VIII-4 and VIII-5, show the total nitrogen load associated with the threshold scenarios for the south coastal and Pleasant Bay embayments, respectively. Due to the high fraction of septic load relative to the total nitrogen load to each sub-embayment, the percent of total load that needs to be removed to achieve the threshold targets is only slightly lower than the percent of septic load that needs to be removed. A more complete breakdown of the nitrogen loads for each of the threshold scenarios modeled is shown in Tables VIII-6 and VIII-7.

Although the above modeling results provide one manner of achieving the selected threshold levels for the sentinel sub-embayments within each estuarine system, the specific examples do not represent the only method for achieving this goal. However, the thresholds analysis provides general guidelines needed for the nitrogen management of these systems. Future water quality modeling scenarios can be run based on other nitrogen removal strategies.

Table VIII-2. Comparison of sub-embayment watershed septic loads used for modeling of present and threshold loading scenarios of the South Coastal embayments and Stage Harbor systems. These loads represent groundwater load contribution from septic systems only, and do not include runoff, fertilizer, atmospheric deposition and benthic flux loading terms.

Sub-embayment	Present Septic Load g/day)	New Septic Load (kg/day)	Threshold % Change
Stage Harbor			
Oyster Pond	11.16	0.11	-99%
Oyster River	9.69	0.79	-92%
Stage Harbor	2.32	0.00	-100%
Mitchell River	5.57	2.66	-52%
Mill Pond	1.55	0.59	-62%
Little Mill Pond	1.35	0.65	-52%
Sulphur Springs			
Sulphur Springs	13.74	6.67	-52%
Bucks Creek	3.51	1.62	-54%
Cockle Cove Creek	2.72	2.72	0%
Waste Water TF	3.03	3.03	0%
Taylors Pond			
Mill Creek	5.33	2.14	-60%
Taylors Pond	7.11	2.91	-59%

Table VIII-3. Comparison of sub-embayment watershed septic loads used for modeling of present and threshold loading scenarios of the Pleasant Bay embayment systems. These loads represent groundwater load contribution from septic systems only, and do not include runoff, fertilizer, atmospheric deposition and benthic flux loading terms.

Sub-embayment	Present Septic Load (kg/day)	New Septic Load (kg/day)	Threshold % Change
Bassing Harbor			
Crows Pond	5.12	3.32	-35%
Ryder Cove	11.14	5.71	-49%
Frost Fish Creek	3.09	2.17	-30%
Bassing Harbor	2.41	1.48	-39%
Muddy Creek			
Muddy Creek -lower	11.49	4.71	-59%
Muddy Creek - upper	16.69	7.07	-58%

Table VIII-4. Comparison of sub-embayment watershed loads (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the South Coastal embayments and Stage Harbor systems. These loads do not include atmospheric deposition and benthic flux loading terms. Note that this is but one of many approaches for reaching the “target” N value.

Sub-embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Threshold % Change
Stage Harbor			
Oyster Pond	13.03	1.98	-85%
Oyster River	11.47	2.76	-76%
Stage Harbor	2.76	0.44	-84%
Mitchell River	6.38	3.47	-46%
Mill Pond	1.78	0.81	-54%
Little Mill Pond	1.64	0.93	-43%
Sulphur Springs			
Sulphur Springs	15.33	8.26	-46%
Bucks Creek	4.08	2.18	-46%
Cockle Cove Creek	6.66	6.66	0%
Waste Water TF	3.03	3.03	0%
Taylors Pond			
Mill Creek	6.22	3.03	-51%
Taylors Pond	8.21	4.01	-51%

Table VIII-5. Comparison of sub-embayment watershed loads (including septic, runoff, and fertilizer) used for modeling of present and threshold loading scenarios of the Pleasant Bay embayment systems. These loads do not include atmospheric deposition and benthic flux loading terms.

Sub-embayment	Present Total Load (kg/day)	Threshold Total Load (kg/day)	Threshold % Change
Bassing Harbor			
Crows Pond	5.79	4.01	-30.6%
Ryder Cove	12.35	6.92	-44.0%
Frost Fish Creek	3.59	2.67	-25.7%
Bassing Harbor	2.66	1.73	-35.1%
Muddy Creek			
Muddy Creek -lower	13.36	6.58	-50.8%
Muddy Creek - upper	19.05	9.43	-50.5%

Table VIII-6. Sub-embayment loads used for nitrogen threshold scenarios run for the Stage Harbor and South Coastal embayment systems, with total watershed N loads, atmospheric N loads, and benthic flux.

Sub-embayment	Watershed Load (kg/day)	Atmospheric Deposition (kg/day)	Benthic Flux (kg/day)
Stage Harbor			
Oyster Pond	1.98	0.29	10.2
Oyster River	2.76	1.05	0.3
Stage Harbor	0.44	3.25	4.9
Mitchell River	3.47	0.88	-1.3
Mill Pond	0.81	0.63	1.4
Little Mill Pond	0.93	0.12	0.8
Sulphur Springs			
Sulphur Springs	8.26	0.38	-2.3
Bucks Creek	2.18	0.13	1.9
Cockle Cove Creek	6.66	0.06	-0.6
Waste Water TF	3.03	-	
Taylors Pond			
Mill Creek	3.03	0.17	-0.2
Taylors Pond	4.01	0.19	-0.9

Table VIII-7. Sub-embayment loads used for nitrogen threshold scenarios run for the Bassing Harbor and Muddy Creek systems of Pleasant Bay, with total watershed N loads, atmospheric N loads, and benthic flux.

Sub-embayment	Watershed Load (kg/day)	Atmospheric Deposition (kg/day)	Benthic Flux (kg/day)
Bassing Harbor			
Crows Pond	4.01	1.39	2.6
Ryder Cove	6.92	1.30	5.6
Frost Fish Creek	2.67	0.10	-0.1
Bassing Harbor	1.73	1.08	-0.1
Muddy Creek			
Muddy Creek –lower	6.58	0.21	-0.9
Muddy Creek - upper	9.43	0.20	2.3

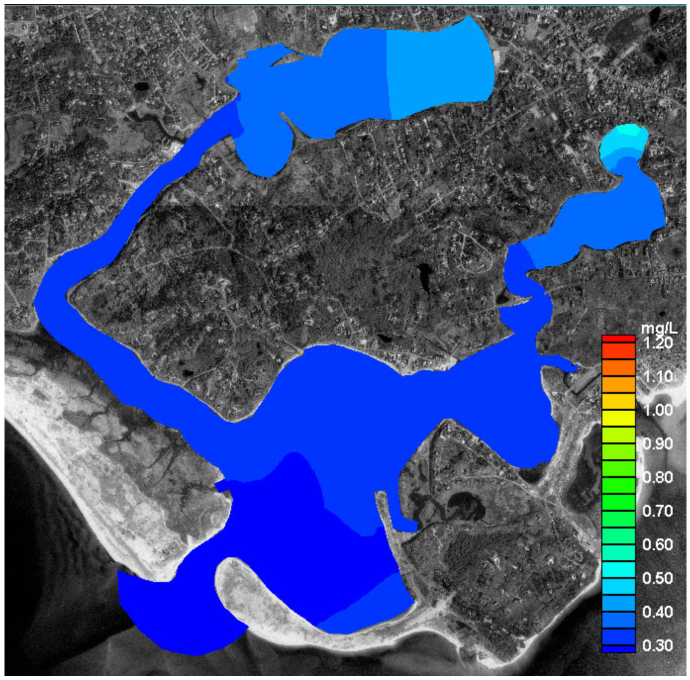

Figure VIII-1. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Stage Harbor system, for threshold loading conditions (0.38 mg/L in both Mill Pond and Oyster Pond).

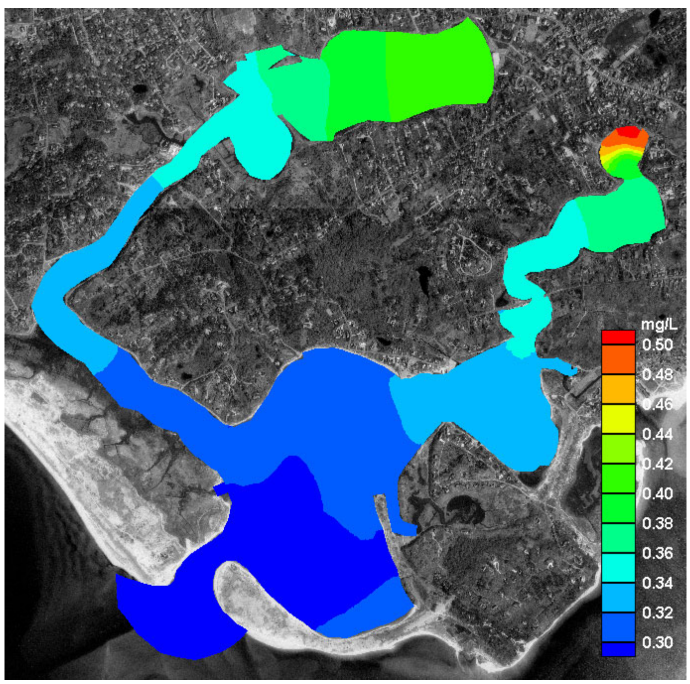

Figure VIII-2. Same results as for figure above, but shown with finer contour increments for emphasis. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Stage Harbor system, for threshold loading conditions (0.38 mg/L in both Mill Pond and Oyster Pond).

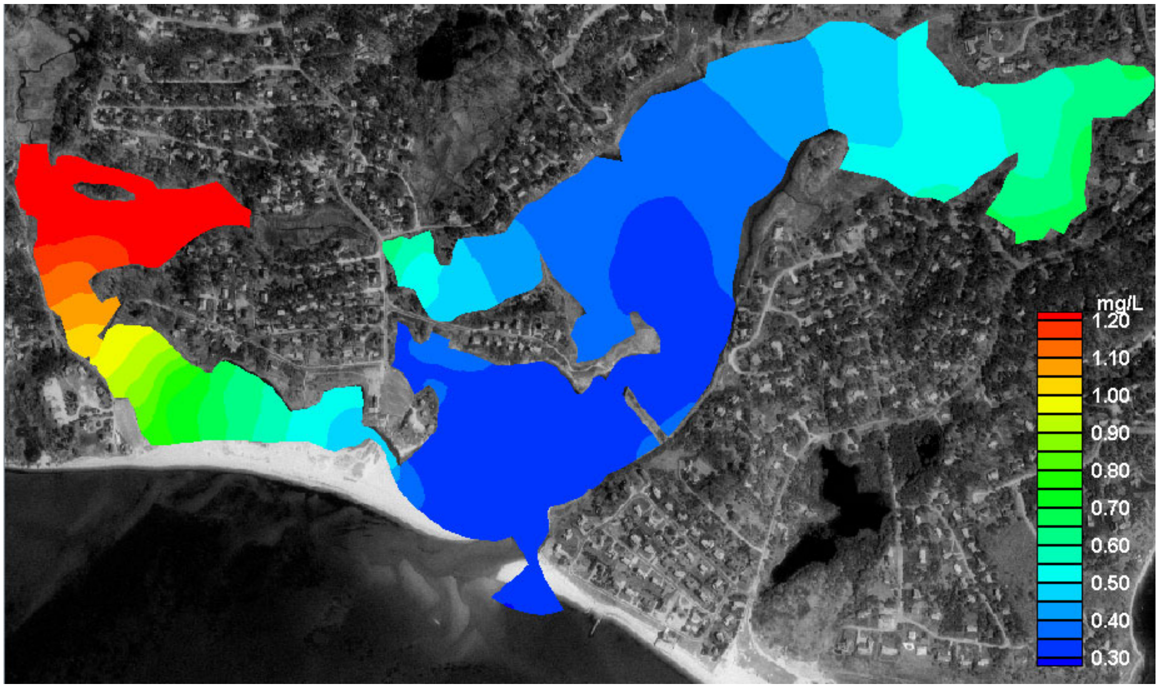

Figure VIII-3. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Sulphur Springs/Cockle Cove Creek system, for threshold loading conditions (0.38 mg/L in Sulphur Springs).

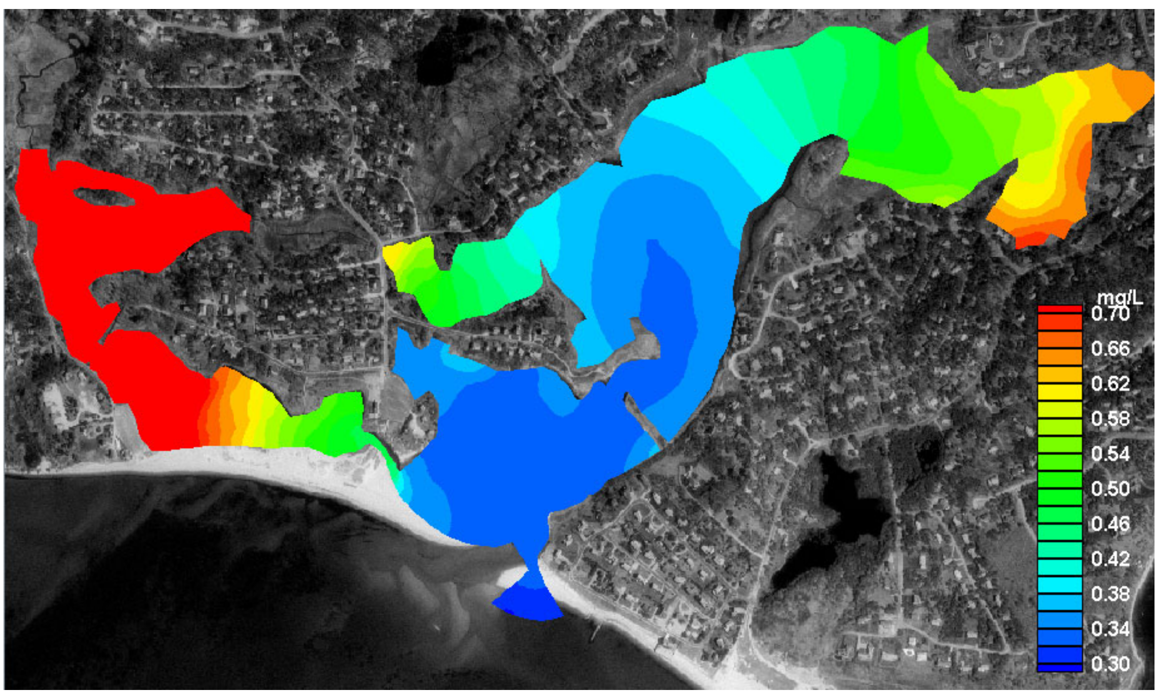

Figure VIII-4. Same results as for figure above, but shown with finer contour increments for emphasis. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Sulphur Springs/Cockle Cove Creek system, for threshold loading conditions (0.38 mg/L in Sulphur Springs).

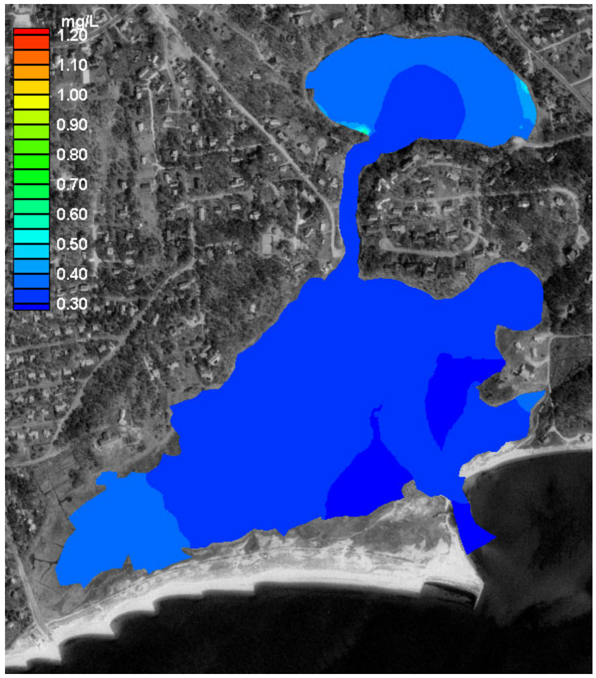

Figure VIII-5. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Taylors Pond/Mill Creek system, for threshold loading conditions (0.38 mg/L in Taylors Pond).

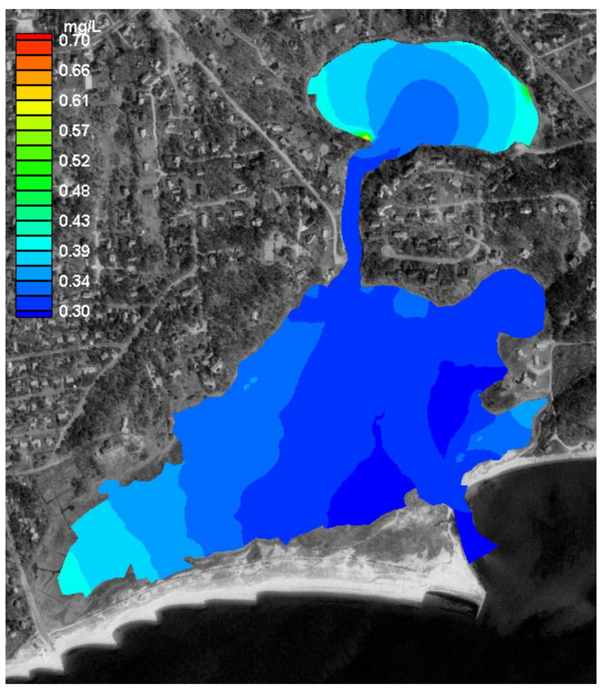

Figure VIII-6. Same results as for figure above, but shown with finer contour increments for emphasis. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Taylors Pond/Mill Creek system, for threshold loading conditions (0.38 mg/L in Taylors Pond).

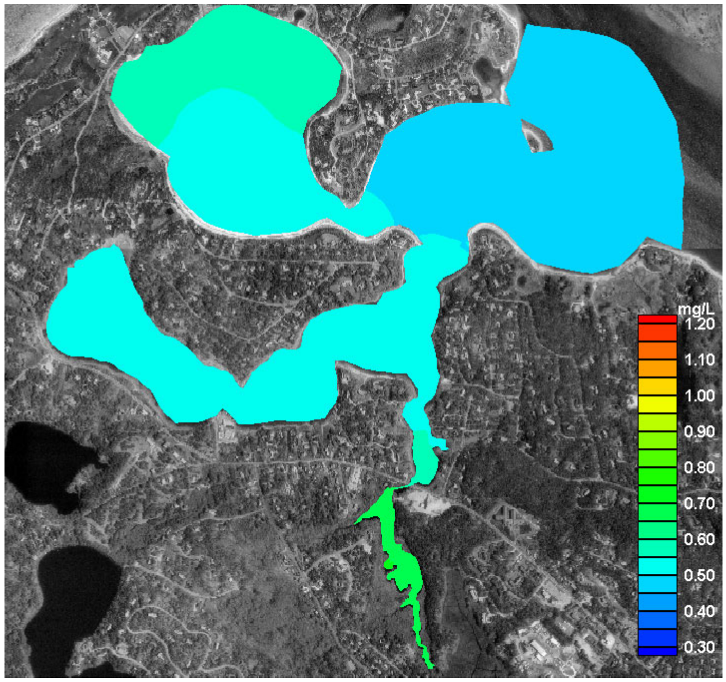

Figure VIII-7. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Bassing Harbor system, for threshold loading conditions (0.55 mg/L in Ryder Cove), and present background N concentration at the entrance to Pleasant Bay (0.48 mg/L).

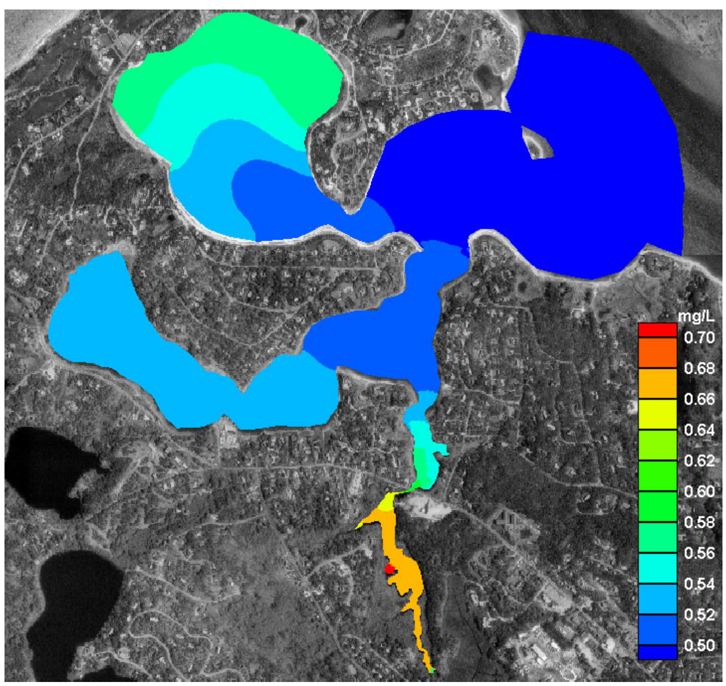

Figure VIII-8. Same results as for figure above, but shown with finer contour increments for emphasis. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Bassing Harbor system, for threshold loading conditions (0.55 mg/L in Ryder Cove), and present background N concentration at the entrance to Pleasant Bay (0.48 mg/L).

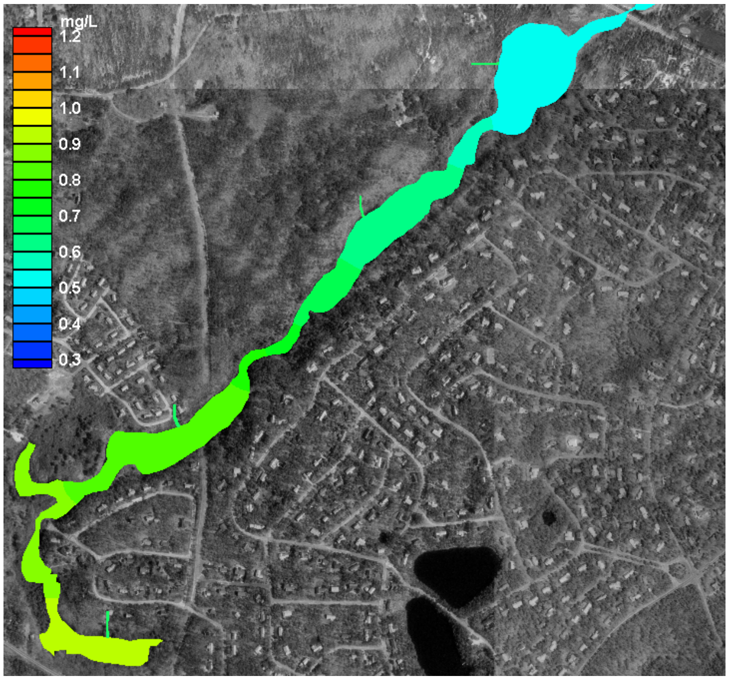

Figure VIII-9. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Muddy Creek system, for threshold loading conditions (0.55 mg/L in lower Muddy Creek), and present background N concentration at the entrance to Pleasant Bay (0.50 mg/L).

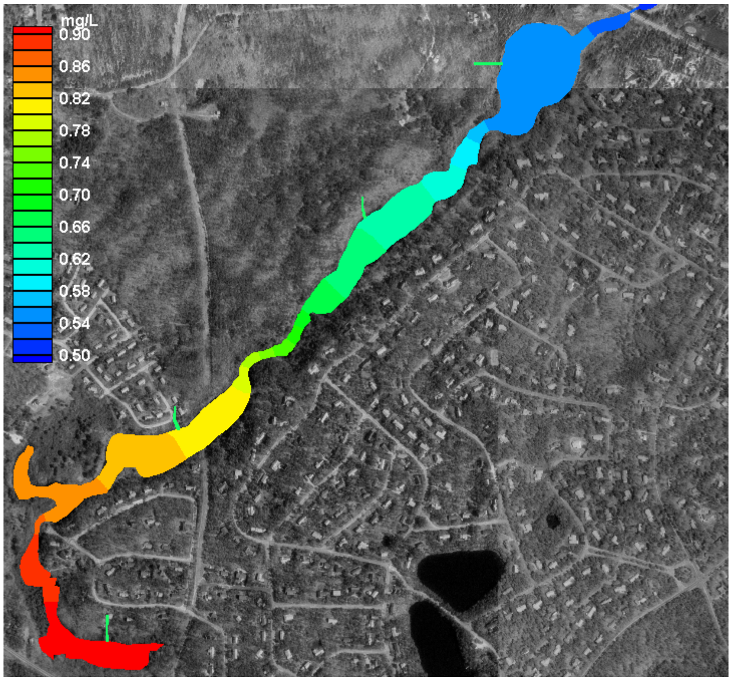

Figure VIII-10. Same results as for figure above, but shown with finer contour increments for emphasis. Contour Plot of modeled total nitrogen concentrations (mg/L) in the Muddy Creek system, for threshold loading conditions (0.55 mg/L in lower Muddy Creek), and present background N concentration at the entrance to Pleasant Bay (0.50 mg/L).