Pleasant Bay Alliance

PLEASANT BAY COMPOSITE NITROGEN MANAGEMENT ANALYSIS

An Assessment of the Wastewater and Nitrogen Management Plans of Brewster, Chatham, Harwich and Orleans

March 2017

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EXECUTIVE SUMMARY

The primary threat to the health of Pleasant Bay is nitrogen enrichment from watershed sources. For close to two decades, the Pleasant Bay Alliance (Alliance) has coordinated action among the four towns sharing the watershed of Pleasant Bay to address this concern. The Alliance's contributions to understanding and managing nutrient loading include establishing and sustaining a water quality monitoring program, and coordinating the bay-wide approach to the MEP Technical Analysis and development of TMDLs. The Alliance also generated the analysis that led to Chatham's and Harwich's decision to construct the Muddy Creek bridge, which is the first nutrient management project implemented in the Pleasant Bay watershed, and will significantly reduce the amount of sewering needed in the sub-watershed. The Alliance convenes a monthly Watershed Work Group that brings together town, state and county personnel involved in nutrient management. In addition, the Alliance monitors tide levels and conducts research on the geomorphology of the barrier beach and inlet system, which influence system-wide hydrodynamics and ecological conditions.

The *Pleasant Bay Resource Management Plan Update* approved by Town Meetings in each member town, and by the state, directs the Alliance to continue this work concerning watershed-based nutrient management. The Alliance has developed this composite nutrient management analysis in response to that charge.

The purpose of this composite analysis is to show the combined effect of four towns' wastewater management plans on nutrient removal within the Pleasant Bay watershed. With the benefit of this information, Brewster, Chatham, Harwich and Orleans may choose to modify their individual plans, pursue joint projects or enter into negotiations with each other to take advantage of efficiencies. This analysis has been vetted by Town staff and technical consultants, and submitted to the Cape Cod Commission and MassDEP for comment. This analysis is now presented to the four towns' Boards of Selectmen for consideration.

The town plans are designed to remove enough nitrogen to achieve published standards and address other wastewater-related town needs. Those published standards take the form of Total Maximum Daily Loads (TMDLs). (TMDLs have been set for several water quality parameters, the most significant of which is nitrogen. When the term TMDL is used in this report, it refers to nitrogen-based TMDLs.) System-wide, the amount of attenuated nitrogen load to be removed in order to meet TMDLs is 17,717 kg/yr, or 36% of the total load bay-wide. There are nineteen separate TMDLs in Pleasant Bay and the amount of removal needed varies in different subembayments, ranging from 0% removal in Crows Pond and Chatham Harbor, to 75% removal in Lower Muddy Creek and 83% removal in Meetinghouse Pond. These removals pertain to existing watershed load. It is understood that 100% of any future load from added development also needs to be removed.

Each town has agreed to remove nitrogen in proportion to its share of the current attenuated load. This approach is common to all four of the town plans and is the basis of this analysis. It should be formalized in an inter-town memorandum of understanding. There are seven subembayments where one town is solely responsible for load removal. In the remaining subembayments, two or more towns share load removal requirements.

Nearly three quarters of the required load removal is focused in six subembayments. There are six subembayments for which an individual town's load removal requirement exceeds 5% of the system-wide load reduction requirement. Combined, these subembayments account for 71% of the total load reduction requirement. These subembayments are Round Cove, Lower Muddy Creek, Ryder's Cove, Meetinghouse Pond, Pochet and Pleasant Bay/Little Pleasant Bay.

On a subwatershed basis, gaps and overages in nitrogen removal create opportunities for exploring cost efficiencies through nutrient trading and shared facilities. In eight subwatersheds, existing plan removals are slightly below the amount required to meet TMDLs. These differences are not significant enough to warrant plan modification, and could be met through adaptive management. In eight other subembayments, the amount of nitrogen removal exceeds the amount required to meet TMDLs. However, the performance of the town plans in meeting TMDLs could be affected by variable performance of non-traditional technologies, or additional wastewater flow from new development in the watershed.

Watershed wide, the four town plans provide a combination of traditional and non-traditional technologies (a so-called "hybrid approach'), with non-traditional technologies accounting for about 25% of the estimated removal system-wide. Individually, the plans differ in the degree to which they utilize traditional and non-traditional technologies. Non-traditional approaches make greater use of natural processes and their performance will vary due to environmental factors. For this reason, non-traditional approaches are subject to a regulatory requirement for a back-up traditional system in the event that the non-traditional approach does not function as predicted. Back-up is planned in some, but not all, subwatersheds in which non-traditional approaches are proposed.

In those subembayments where the nitrogen loads from more than one town must be reduced, costs savings may be realized through nitrogen trading. A watershed-wide approach may identify locations and technologies where one town removes more than its requirement and another town removes less, with payment of a negotiated amount to equal the costs. Such opportunities exist in the northerly headwaters subembayments shared by Brewster and Orleans, and in the Muddy Creek and Pleasant Bay subembayments shared by Chatham and Harwich.

The implementation of town plans will occur over several decades. Implementation has started with the Muddy Creek bridge and some non-traditional pilot projects. Sewering or further

measures are not scheduled to begin in the near future. In their implementation timelines, the towns have given relatively high priority to four of the six high-load sub-watersheds: Meetinghouse Pond, Muddy Creek Upper and Lower (Harwich) and Round Cove. The Pleasant Bay subembayment is designated as a high priority by Brewster and Harwich. It will be addressed in a later phases of the Chatham and the Orleans plans (although nitrogen removals in the headwaters embayments will have an indirect positive impact on Pleasant Bay). However, Pochet, which accounts for nearly 9% of the total load reduction requirement, is not scheduled for early implementation by Orleans.

Appropriate next steps are identified at the end of this report. They are aimed at taking advantage of cost efficiencies, ensuring enhanced funding, developing a Targeted Watershed Management Plan, undertaking confirmatory estuary modeling, preparing for inter-municipal agreements, ensuring consistency with the 208 Plan Update, and preparing for a possible Watershed Permit.

1.0 PURPOSE

Water quality in Pleasant Bay is impacted by watershed inputs form activities in four towns: Brewster, Chatham, Harwich and Orleans. Each town has formulated a plan for reducing the nitrogen loads that are the primary cause for water quality problems. Each town plan addresses multiple watersheds and accounts for a variety of town-wide needs and priorities. It is the purpose of this composite analysis to:

- compile the portions of the four town plans that deal specifically with the Pleasant Bay watershed,
- compare the proposed town-by-town nitrogen removals against the Total Maximum Daily Loads (TMDLs) for Pleasant Bay,
- identify gaps and overlaps in the collective plans for nitrogen removal,
- identify actions that may be helpful in improving the cost-effectiveness of the combined plans, and
- provide the foundation for developing a Targeted Watershed Management Plan for Pleasant Bay consistent with the 208 Plan Update and subsequent guidance prepared by the Cape Cod Commission, and for determining the applicability of watershed permitting.

This analysis is presented to the four towns' Boards of Selectmen for consideration. With the benefit of this information, each town may choose to modify its plan, pursue joint projects or enter into negotiations with one or more towns to take advantage of efficiencies. Such actions can easily be accommodated within the long implementation periods associated with each town plan.

2.0 DATA SOURCES AND METHODS

This analysis incorporates information from the Pleasant Bay portion of each town's wastewater management plan as of November 2016. The nutrient loading and load reduction information is based on the analyses generated by the Massachusetts Estuaries Project (MEP), as modified by engineering analyses provided in the individual town plans and vetted by each member community. Drafts of this report have been reviewed by each towns' representative on the Pleasant Bay Alliance's Watershed Work Group and by each town's wastewater consultant. Drafts of this report were also submitted to the Cape Cod Commission and MassDEP for comment.

As watershed-based analysis of the four town plans continues, use of watershed decision support tools available through the Cape Cod Commission may be advisable to facilitate consideration of updated land use information and nitrogen load estimates.

Numerous reports have been published related to the nature and extent of the nitrogen loading problem and proposals to reduce that loading. The most pertinent documents are listed in Table A-1 In Appendix A.

3.0 BACKGROUND

Pleasant Bay is the largest coastal embayment on Cape Cod. The Pleasant Bay system is state-designated as Outstanding Resource Waters and an Area of Critical Environmental Concern. According to the Cape Cod Commission, the water surface of the Bay covers nearly 6,200 acres and approximately 11,800 acres of land surface are within the watershed.

For modeling purposes, the system as a whole consists of 19 separate subembayments (e.g., Round Cove, Meetinghouse Pond, Crows Pond, etc.), each of which has a TMDL for total nitrogen. The land area contributing groundwater and, thus, nitrogen load to each subembayment is delineated as a separate subwatershed.

MEP studies have determined that the water quality in most Pleasant Bay subembayments is moderately or significantly impaired. Nitrogen has been identified as the principal contaminant, from the following controllable sources:

- Septic systems 75%
- Stormwater runoff 9%
- Lawn and golf course fertilization 16%

The MEP has determined that 36% of the current attenuated watershed nitrogen load bay-wide must be removed to restore water quality. Individual subembayments have nitrogen removal needs

ranging from 0% to 83%. Each of the four towns in the Pleasant Bay watershed has developed plans for nitrogen removal, and those plans are in varying stages of implementation.

4.0 NITROGEN LOADS AND REMOVAL REQUIREMENTS

Groundwater modeling performed as part of the MEP studies allows the Pleasant Bay watershed and individual subwatersheds to be delineated. The TMDLs were set for 19 individual subembayments and for the system as a whole. The watersheds to those 19 subembayments have been aggregated to 18 for this report, as shown in Figure 1. (That aggregation was necessary because the 2007 town-by-town allocation of existing loads was conducted for all individual subembayments except for the Pleasant Bay and Little Pleasant Bay subembayments. For the purposes of this report, these two subembayments were combined into one subembayment called "Pleasant Bay.")

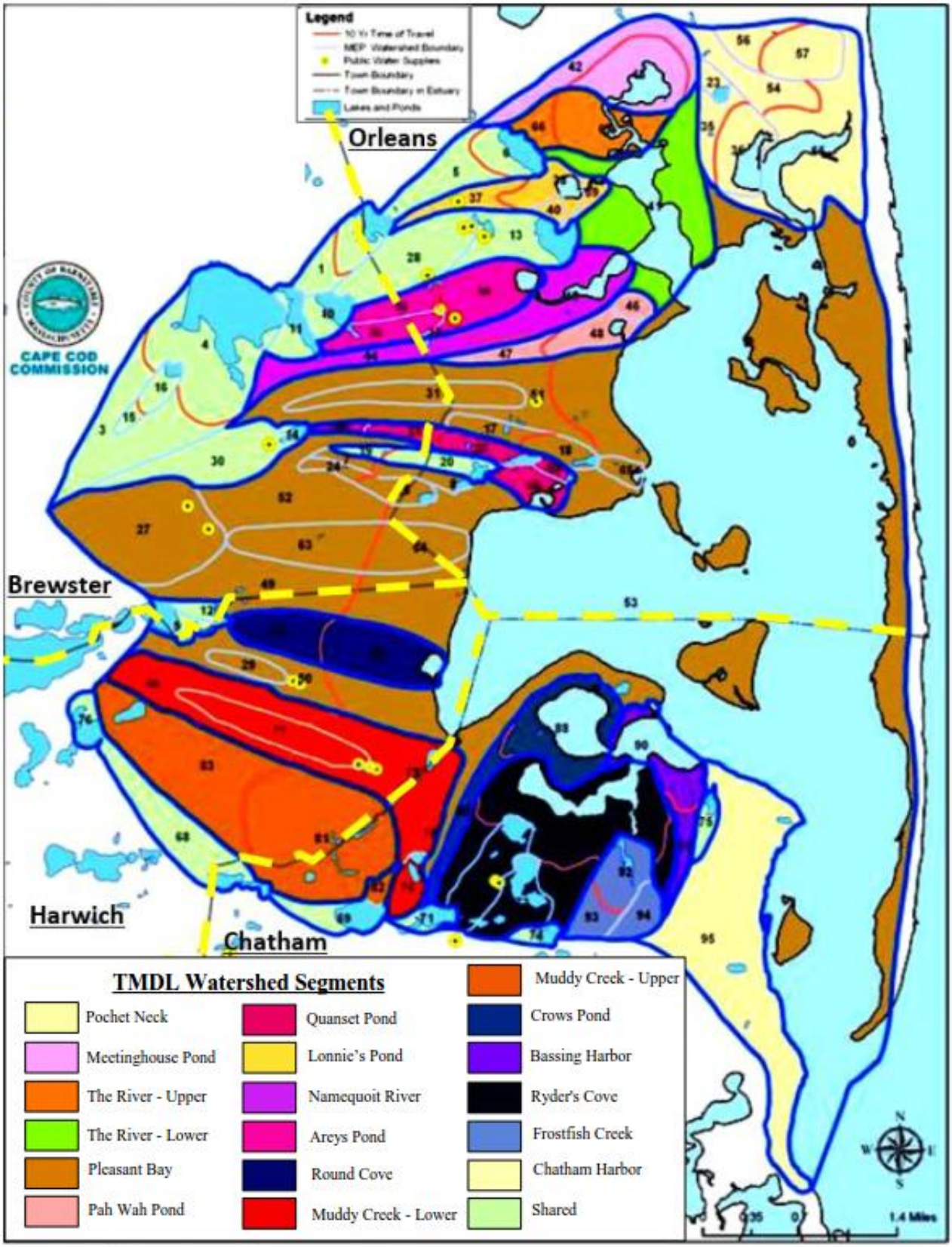
The MEP Technical Report presents estimates of nitrogen loads originating both within the watershed, as well as within the embayment. The "watershed loads" generally include nitrogen from septic systems; lawn, golf course and cranberry bog fertilization; and stormwater runoff. The watershed loads are considered "locally controllable" and it is those loads that are addressed in town plans and reported here. Loads that occur in the embayment, including atmospheric deposition and benthic release, are not considered to be locally controllable and, therefore, are not addressed in town plans or in this analysis.

The MEP studies also quantify the natural attenuation that reduces watershed loads once they reach the groundwater and flow toward the embayment. When nitrogen loads pass through multiple attenuation sites (bogs, streams, ponds), significant natural nitrogen removal can occur that must be accounted for. Over the entire Pleasant Bay system, natural processes reduce the unattenuated load by about 11%:

Overall unattenuated watershed load	54,500 kg/yr
Less natural attenuation	-6,000 kg/yr
Attenuated load	48,500 kg/yr

Table A-2 summarizes the unattenuated and attenuated loads coming from each town to each of the 18 subembayments in the Pleasant Bay system. On a percent-of-unattenuated-load basis, the greatest natural attenuation occurs in Brewster in the watersheds it shares with Orleans, and in the Muddy Creek watershed shared by Chatham and Harwich.

Figure 1. Location of Pleasant Bay Subembayments



Based on the ecological health of each subembayment, specifically the degree of water quality impairment, the MEP estimated the threshold loads (TMDLs) of nitrogen above which ecological impairment occurs. The difference between the actual load and the threshold load or TMDL is the amount of nitrogen that must be removed to restore water quality. Table A-3 summarizes the amount of nitrogen that must be removed in each of the 18 subembayments. The aggregate attenuated nitrogen load to be removed in order to meet TMDLs is 17,717 kg/yr.

5.0 ALLOCATION OF RESPONSIBILITY FOR NITROGEN LOAD REMOVALS

There needs to be some equitable assignment of responsibility for removal of the excess nitrogen loads in the watershed. Each of the four towns has developed its nitrogen management plan on the premise that its responsibility for nitrogen removal is proportional to its current attenuated nitrogen load. For example, 79% of the current attenuated nitrogen load to the Areys Pond subembayment comes from Orleans, so Orleans has assumed that it should remove 79% of the nitrogen over the threshold load. This approach is the one now recommended by the Cape Cod Commission in the 208 Plan Update and this approach is endorsed by DEP.

Table A-3 applies that approach to load removal to the 18 Pleasant Bay subembayments. In the aggregate, the town responsibilities for removal of attenuated nitrogen load are:

Brewster	2,262 kg/yr (13% of total removal responsibility)
Chatham	4,076 kg/yr (23% of total removal responsibility)
Harwich	4,399 kg/yr (25% of total removal responsibility)
Orleans	6,980 kg/yr (39% of total removal responsibility)
Total	17,717 kg/yr (100% of total removal responsibility)

Orleans has the largest load removal responsibility because the subembayments it impacts are the most impaired, overall. Chatham has the largest attenuated nitrogen load, but significant portions of that load are tributary to subembayments with no impairment (such as Chatham Harbor).

Table 1 presents the annual nitrogen load removals allocated to each town and to each subembayment. The blue-shaded cells in Table 1 are those where the nitrogen removal requirement exceeds 5% of the overall 17,717 kg/yr (886 kg/yr). Those eight shaded cells cover six subembayments and represent 71% of the total removal requirement Bay-wide. They are:

Meetinghouse Pond—Orleans
Round Cove—Harwich
Lower Muddy Creek—Harwich
Ryder's Cove—Chatham

Table 1. Nitrogen Removal Requirements by Town and by Subembayment (kg/yr)

Subembayment	Brewster	Chatham	Harwich	Orleans	Total
Meetinghouse Pond				1,876	1,876
Town Percent of Total Removal				100%	100%
Lonnies Pond	14			284	298
Town Percent of Total Removal	5%			95%	100%
Areys Pond	29			113	142
Town Percent of Total Removal	20%			80%	100%
The River - Upper	3			375	378
Town Percent of Total Removal	1%			99%	100%
The River - Lower	6			518	524
Town Percent of Total Removal	1%			99%	100%
Namequoit River	19			348	367
Town Percent of Total Removal	5%			95%	100%
Paw Wah Pond				413	413
Town Percent of Total Removal				100%	100%
Quanset Pond	29			227	256
Town Percent of Total Removal	11%			89%	100%
Round Cove	1		1,209		1,210
Town Percent of Total Removal	0.1%		99.9%		100%
Muddy Creek Upper		193	584		777
Town Percent of Total Removal		25%	75%		100%
Muddy Creek Lower		584	986		1,570
Town Percent of Total Removal		37%	63%		100%
Ryder's Cove		1,954			1,954
Town Percent of Total Removal		100%			100%
Crows Pond		0			0
Town Percent of Total Removal		-			-
Bassing Harbor		0			0
Town Percent of Total Removal		-			-
Frost Fish Creek		803			803
Town Percent of Total Removal		100%			100%
Pochet				1,569	1,569
Town Percent of Total Removal				100%	100%
Pleasant Bay (including Little Pleasant Bay)	2,161	542	1,620	1,257	5,580
Town Percent of Total Removal	39%	10%	29%	22%	100%
Chatham Harbor		0			0
Town Percent of Total Removal		-			-
Total (All Subembayments)	2,262	4,076	4,399	6,980	17,717
Town Percent of Total Removal	13%	23%	25%	39%	100%

Notes:

1. Blue shading denotes entries that are greater than 5% of total (more than 886 kg/yr).
2. Blue shaded entries account for 71% of overall requirement.
3. See Table A-2 and A-3 in Appendix A for derivation of load removal requirements.

Pochet—Orleans
Pleasant Bay (Main and Little Pleasant Bay)—Brewster, Harwich and Orleans

These high-load areas represent 48% (Chatham) to 96% (Brewster) of the individual town's overall responsibility.

6.0 DESCRIPTION OF TOWN PLANS FOR PLEASANT BAY

The town plans all provide significant details on the planning approaches taken and related findings and recommendations. Town-provided summaries of each plan, as they relate to Pleasant Bay, are presented in Appendix B.

7.0 COMPARISON OF TOWN PLANS WITH REMOVAL REQUIREMENTS

The four town plans were analyzed to determine the nitrogen load removals that should occur once those plans are implemented. Tables A-4 and A-5 compare the town-planned removals with the removal requirements derived from the TMDLs for each subembayment. Table 2 summarizes those tables for the entire Pleasant Bay system. The orange-shaded cells are those locations where the planned nitrogen removal is less than the TMDL requirements. The green-shaded cells are those locations where the town plans will remove more nitrogen than required by the TMDLs. Figure 2 graphically compares the planned removals with the TMDL requirements. Table 2 leads to the following key findings:

- In 10 subembayments, the town plans collectively achieve removals that are very close to those dictated by the TMDLs. In these places, all planned removals are within 5% of the removal need. Such minor differences are easily addressed through adaptive management.

- In six subembayments impacted by Chatham, the removals will be significantly in excess of the need. This reflects the fact that Chatman plans to install sewers town-wide, for multiple reasons beyond just nitrogen removal. Chatham will remove significant nitrogen loads in the watersheds of Crows Pond, Bassing Harbor and Chatham Harbor, where no removal is needed, and removals will exceed the TMDL requirements in Muddy Creek, Ryder's Cove and the Pleasant Bay subembayment.

Although no nitrogen removal is required in the Crows Pond, Bassing Harbor and Chatham Harbor subembayments, the proposed removals will have a positive impact on the system as a whole.

Table 2. Comparison of Town Plans with Watershed Load Removal Requirements

	Brewster	Chatham	Harwich	Orleans	TOTAL
Nitrogen Load Removal Requirement, kg/yr	2,262	4,076	4,399	6,980	17,717
Nitrogen Removal Included in Town Plan, kg/yr	1,871	13,058	4,540	6,974	26,442
Load Removal in Excess of TMDL, kg/yr	-	8,982	141	-	9,123
Load Removal Below TMDL, kg/yr	390	-	-	7	397
Load Removal Compared with TMDL	-17%	220%	3%	-0.1%	49%

Figure 2. Comparison of Nitrogen Removal Requirements and Town Plans

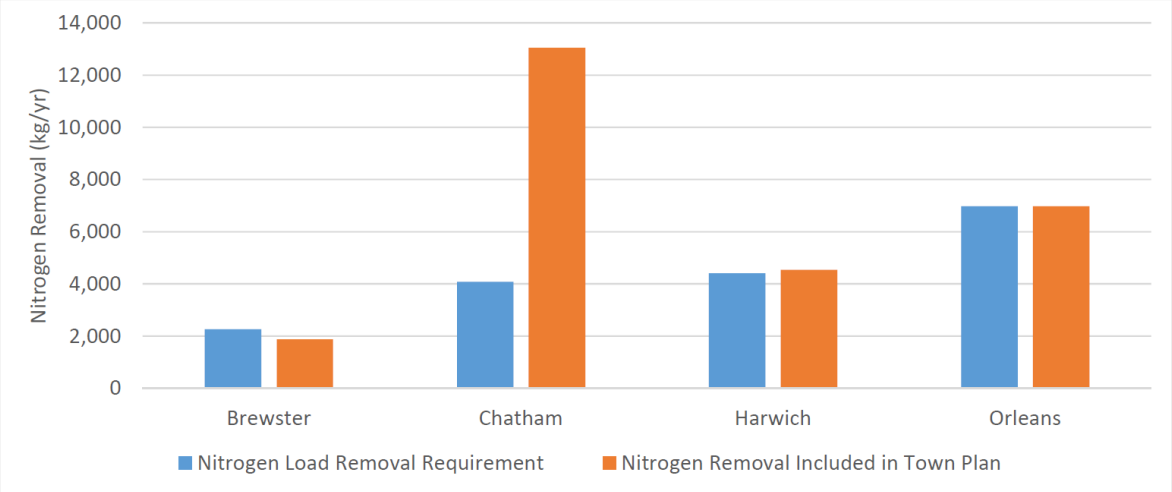


Table 2 shows that Brewster's plan will remove 390 kg/yr less than required by the TMDLs. A significant portion of that "shortfall" is a result of the construction of the Muddy Creek bridge which has shifted nitrogen load downstream into the main Pleasant Bay subembayment, where Brewster is responsible for a certain share of its removal. This anomaly could be addressed in future discussions on allocation of responsibilities among the towns.

This analysis of the town plans reveals a difference in how fertilizer loads are handled. Orleans is basing its plan on a 25% reduction in residential fertilizer nitrogen loads, consistent with direction provided by the Cape Cod Commission. Brewster is including 50% residential fertilizer reduction

as part of its plan. Chatham and Harwich intend to implement fertilizer control programs, but their nitrogen management plans do not explicitly take credit for that removal. Further, there has been differing interpretation of the fertilizer nitrogen loads determined from the MEP technical reports. Tables presented in this analysis include a uniform 25% reduction in residential fertilizer load for all towns, based on a consistent interpretation of the unattenuated fertilizer loads reported in the MEP documents. Brewster's plan also includes 100% of the documented reduction in fertilizer use at the Captains Golf Course.

8.0 USE OF NON-TRADITIONAL TECHNOLOGIES

Table 3 summarizes each town's choice of technology for load reduction and the associated load to be removed under existing conditions. Individually, the plans differ in the degree to which they utilize traditional and non-traditional technologies. However, the combination of the four town plans provides a hybrid approach watershed wide, with non-traditional technologies accounting for about 25% of the estimated removal system-wide. The system-wide removal is comprised of 72% sewering, 7% fertilizer reductions, and 21% other non-traditional methods.

In developing their respective nitrogen management plans, each of the four towns has gone through a thorough assessment of alternative approaches to meeting nutrient reduction targets through an extensive public engagement process. The resulting plans represent community consensus on nitrogen management approaches, in view of competing municipal needs.

Table 3 shows two types of nitrogen removal strategies: "source control" and "remediation". Source control approaches, such as traditional sewering, prevent the nitrogen from reaching the environment. In contrast, remediation approaches address the nitrogen once it is in the groundwater or in the embayment to be protected. Remediation techniques, also referred to as non-traditional approaches, rely on natural processes and their performance will vary due to environmental factors. For this reason, non-traditional approaches are subject to a regulatory requirement for traditional back-up in the event that the non-traditional measures do not function as predicted. Table 3 includes fertilizer reduction strategies as source control measures; those strategies have not been historically used to meet TMDLs and their efficacy is more difficult to document than sewering.

Remediation or non-traditional approaches will be piloted and monitored by the towns to determine the effectiveness and the appropriate degree of application of these approaches Within an adaptive management program. Table 3 shows how the load reduction expected through remediation is somewhat different from that associated with non-traditional technologies

Table 3. Summary of Towns' Nitrogen Removal Plans by Technology

	Brewster	Chatham	Harwich	Orleans	Total
Town-Planned Removal of Attenuated Nitrogen Load, Kg/yr					
Source Control					
Sewering	0	12,812	4,340	2,014	19,166
Residential Fertilizer Reduction	121	247	200	241	809
Golf Course Fertilizer Reduction	930	0	0	0	930
On-site Denitrifying Systems	590	0	0	1,709	2,299
Remediation					
Coastal Habitat Restoration	0	0	0	1,805	1,805
Permeable Reactive Barriers	0	0	0	322	322
Fertigation at Golf Courses	230	0	0	0	230
Shellfish Propagation	0	0	0	883	883
Total	1,871	13,059	4,540	6,974	**26,444**
Source Control vs. Remediation					
Source Control Subtotal, kg/yr	1,641	13,059	4,540	3,964	23,204
Remediation Subtotal, kg/yr	230	0	0	3,010	3,240
Percent Remediation Technologies	12%	0%	0%	43%	**12%**
Traditional vs. Non-Traditional					
Traditional Subtotal, kg/yr	930	12,812	4,340	2,014	20,096
Non-traditional Subtotal, kg/yr	941	247	200	4,960	6,348
Percent Non-traditional Tech.	50%	2%	4%	71%	**24%**

Notes:

1. Traditional technologies include sewering and golf course fertilizer reductions. All other technologies and approaches are considered non-traditional.
2. Brewster is currently evaluating on-site denitrifying systems, and small shellfish propagation options for meeting the town's nitrogen reduction requirement. If the use of denitrifying systems is adopted by Brewster, they will be developed in sufficient numbers to meet the TMDLs under current and build-out conditions and to provide an appropriate margin of safety.
3. Orleans' load removal plan is evolving as its Amended CWMP is being prepared.

9.0 MANAGING GROWTH

This analysis focuses on the existing nitrogen loads to Pleasant Bay, without regard to potential future growth in the watershed. Nonetheless, it is important to remember the two-part requirement for nitrogen control when existing loads exceed thresholds:

- Reduce current bay-wide nitrogen loads by 36% to bring those loads below the thresholds.
- Control 100% of all future loads to ensure that loads always stay below the thresholds.

Failure to control nitrogen load increases in sensitive watersheds can negate actions to reduce current loads. The longer the implementation period for initial nitrogen removal activities, the more likely that growth will negate that progress.

A review of the towns' plans has identified the increases in wastewater flow or nitrogen load assumed to occur through build-out or other planning horizon. These growth percentages range from 22% in the Orleans CWMP to 40% in the Harwich CWMP. In the aggregate, the towns' plans include growth allowances that are about 30% of the existing loads,. Since 100% of "new" nitrogen loads must be controlled in nitrogen-sensitive watersheds, a 30% growth in loads translates to an 80% increase in the loads that must be removed. Therefore, the long-term viability of a town's nitrogen removal plan is very dependent on that town's ability to implement future phases in a timely fashion to keep pace with growth.

There is no accepted uniform method of conducting build-out analyses, and a great deal of judgement is involved. This makes it difficult to compare projections developed by the towns, or for the towns in the MEP evaluations.

It is difficult to predict the extent and location of growth within the Pleasant Bay watershed. Each town should set a reasonable planning horizon, estimate the associated growth in watershed nitrogen load, and have a well-thought-out adaptive management plan to deal with that growth or with differing circumstances that actually play out.

Tools are available to control nitrogen loads from new development and redevelopment. Some of those tools can assist in addressing existing loads. Each town should adopt the appropriate nitrogen load management tools to specifically address new nitrogen loads from growth within the watershed.

Zero-percent State Revolving Loan Fund (SRF) funding is available from MassDEP for nutrient management projects that include plans to manage nitrogen load increases, including flow-neutral regulations. To the extent that zero-percent funding is crucial to the implementation of costly projects, the towns should be taking whatever actions are necessary to secure that funding. Chatham has a flow-neutral regulation and the Orleans CWMP includes an early draft. Harwich, which has the highest growth allowance in its plan, should be particularly aggressive in ensuring that growth does not negate early nitrogen removals or jeopardize enhanced funding.

10.0 COSTS

This analysis includes an assessment of town-provided cost estimates for Pleasant-Bay-related infrastructure and programs. That assessment is under development. Estimates prepared by the towns show comparable costs per pound of nitrogen removed for traditional technologies. Costs

for non-traditional approaches are still being developed and potential savings may not be clearly identified until extensive demonstration projects are complete. Once costs are more fully established, a composite cost analysis will be provided.

11.0 IMPLEMENTATION SCHEDULES

The four towns are in varying stages of implementation of their nitrogen management plans; see Figure 3.

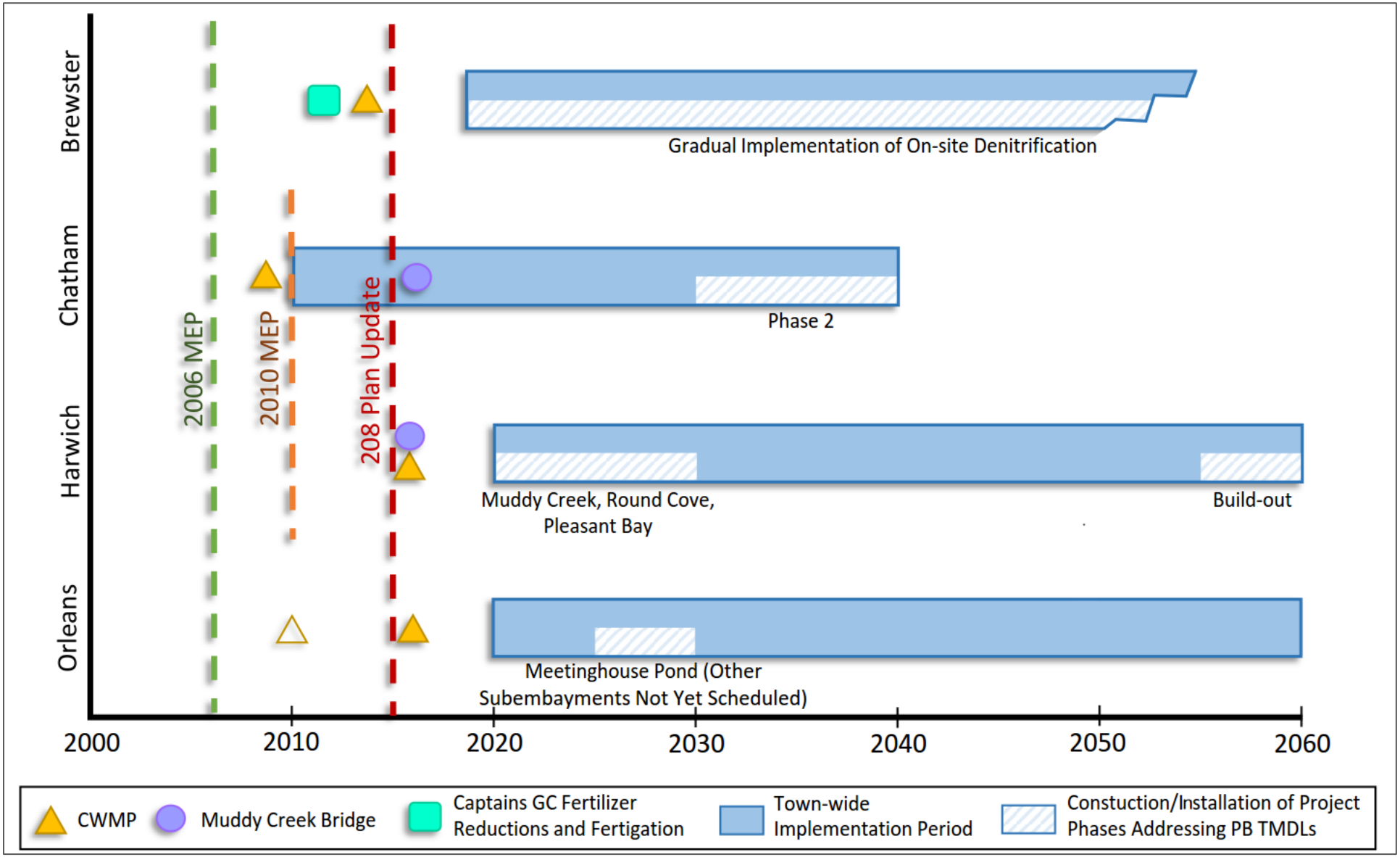
The fertilizer reductions that are a major part Brewster's plan have been implemented. Chatham and Harwich have jointly completed the Muddy Creek Restoration Bridge Project. Chatham has constructed a new, expanded state-of-the-art wastewater treatment plant and begun expansion of its collection system, and is in a position to begin sewering Pleasant Bay sub-watersheds. Orleans has embarked on a pilot project for nitrogen removal from Lonnies Pond (shellfish propagation) and is developing one for Quanset Pond (shellfish).

Figure 3 shows the plan implementation periods set forth in each town's plans. Chatham's plan is expected to cover 30 years (with the first 20 years focusing on subembayments with TMDLs), and Harwich's plan will take 40 years. The original 18-year program contained in the Orleans CWMP will be extended to 30 to 40 years in the Amended CWMP. Brewster's plan is open-ended. Figure 3 shows the expected periods of construction/installation of nitrogen removal measures. Actual reductions in nitrogen concentrations within the embayments will occur sometime after implementation of the control measures, particularly for source control measures implemented far from the shoreline.

The towns have designated the Pleasant Bay subembayments that will be addressed first in their plans. Table 1 highlights the six subembayments where 71% of the load removal is required. Figure 3 shows that the towns have given relatively high priority to five of those sub-watersheds including Meetinghouse Pond, Muddy Creek Upper and Lower (Harwich) and Round Cove. The Pleasant Bay subembayment is designated as a high priority by Brewster and Harwich. It will be addressed in later phases of the Chatham plan and the Orleans plan (although nitrogen removals in the headwaters embayments will have an indirect positive impact on Pleasant Bay.) Pochet, which accounts for nearly 9% of the total load reduction requirement, is not scheduled for early implementation by Orleans.

The implementation periods shown in Figure 3 for Chatham and Harwich are essentially as published in each town's CWMP. The plans of Brewster and Orleans are still being developed and Figure 3 shows the current thinking of each town's wastewater planning representatives. Many factors will influence actual implementation steps; Figure 3 represents the best available information as of November 2016.

Figure 3. Town Implementation Schedules



12.0 OPPORTUNITIES FOR NITROGEN TRADING

Looking at the Pleasant Bay watershed in its entirety, one can identify the most cost-effective locations for nitrogen load removal. The nitrogen removed at those optimum locations will not necessarily match the towns' responsibilities for TMDL compliance. That is, without a watershed-wide approach, one or more of the towns in a shared subwatershed may implement projects that are not as cost-effective as projects in other towns. That problem can be overcome through nitrogen trading, in which the town with the low-cost options removes more nitrogen than it is responsible for and another town removes less. The second town pays the first town for the "extra' nitrogen load that is removed on its behalf.

While the cost of nitrogen removal is a key factor in determining the "optimal" approach, other considerations are important as well. One must also consider the location of the removal in the watershed, because options that remove nitrogen along the shore or in the water body are preferred over those that remove nitrogen high in the watershed. Nitrogen removals upgradient of natural attenuation locations are not as favored as those downgradient of those locations.

Nitrogen trading should be considered between Brewster and Orleans in the headwaters subembayments at the north end of Pleasant Bay. In six shared subembayments (Lonnies Pond, Areys Pond, the Upper and Lower River, Namequoit River and Quanset Pond), Brewster is responsible for 5% of the nitrogen removal and Orleans for 95%. Brewster's raw loads are attenuated by 71% before reaching receiving waters, so removing 100 kg in Brewster reduces the load to the receiving waters by only 29 kg. It is likely that the most cost-effective solution is for Orleans to remove all of the load necessary for TMDL compliance, with Brewster paying Orleans 5% of Orleans' cost.

Nitrogen trading should also be considered between Chatham and Harwich in the Muddy Creek and Pleasant Bay subwatersheds. Chatham intends to remove all of its septic load in the Pleasant Bay watershed as part of a town-wide sewering program that is aimed at more than just nitrogen removal. In these three subembayments, Chatham's plan would remove 1,240 kg/yr more than required to meet the TMDL. This "over removal" is equivalent to about 40% of Harwich's responsibility in these subembayments. By nitrogen trading, Harwich could pay Chatham and avoid significant infrastructure.

An important consideration in nitrogen trading is the location of the nitrogen to be removed. Once specific trading scenarios are identified, it will be necessary run the MEP model to be sure that relocation of the removal still allows water quality goals to be met.

The actual cost paid for nitrogen trading would be determined through negotiations between the participating towns, and would likely fall somewhere between the cost avoided by the "buyer" and the incremental cost incurred by the "seller".

13.0 MONITORING AND ADAPTIVE MANAGEMENT

Pleasant Bay has an extensive database and ongoing monitoring to assess changes in ecological conditions resulting from implementation measures. Per MEP guidance, the focus of monitoring efforts is on water column nitrogen and dissolved oxygen concentrations, eelgrass coverage and vitality, and benthic infauna health and diversity.

Water column concentrations – The Alliance's Water Quality Monitoring Program recently completed its 17th monitoring season**.** Monitoring occurs at 24 station locations selected to track TMDL compliance. A MassDEP-approved Quality Assurance Project Plan (QAPP) is in place and includes the following parameters: nitrogen (DON, PON, DIN, TON, TN), oxygen, temperature, salinity, and phytoplankton pigments. Sample collection occurs five times annually from July through September. Data are analyzed by the UMASS Dartmouth School for Marine Science and Technology (SMAST) and reported to the Alliance. The Alliance issues periodic reports with basic statistics, and conducts in-depth statistical trend assessments on a five-year basis. The statistical trend assessments were further evaluated by SMAST to discern the ecological implications of any statistically significant trends. The Alliance monitoring program is funded annually by the towns and will continue.

Eelgrass coverage – The MEP relied on eelgrass coverage reported by the MassDEP Eelgrass Mapping Project. The project conducted mapping using aerial imagery and field verification methods. Data are available for the following years: 1994, 2001, 2006, 2010 and 2012. The schedule and extent of future mapping to be conducted by the program needs to be identified, to determine whether additional data collection will be necessary to monitor future changes in Pleasant Bay eelgrass beds.

Benthic infauna – The MEP conducted quantitative sediment sampling in 2000 for benthic animals at 34 locations throughout the Bay. Species number and individual counts were assessed for diversity and evenness and compared to findings developed by SMAST over the past 30 years based on measurements in other Cape Cod estuaries. In 2008 MEP conducted a more detailed estimate of Muddy Creek that included collection of benthic infauna at six locations. In 2014, the Provincetown Center for Coastal Studies (PCCS) collected benthic infauna samples at all MEP locations except Muddy Creek. This effort was undertaken in concert with a benthic mapping project for the Cape Cod National Seashore. The results of this PCCS study are not yet available.

Recently the Alliance asked SMAST to assess the water quality, eelgrass, and benthic infauna data needed for assessing ecological health in Pleasant Bay through updated MEP modeling. The Alliance proposes to review the data needs for modeling with its member towns through the Watershed Work Group. Based on this review, the Alliance may recommend that the towns pursue joint actions to update data on a cost-effective watershed basis.

In addition, it should be noted that individual towns are developing monitoring programs tailored to pilot projects for non-traditional technologies. For example:

- Orleans worked with SMAST to develop a monitoring program for an oyster growing pilot project in Lonnies Pond;
- Brewster has installed groundwater test wells at several locations (mostly around Captains Golf Course) to track impacts of fertilizer reductions;
- Chatham and Harwich are undertaking bacterial and nitrogen-related water quality monitoring to evaluate changes in water quality resulting from the Muddy Creek Restoration Bridge Project.

Each town's plan incorporates adaptive management to allow monitoring results to direct or redirect implementation measures.

14.0 ANNUAL PROGRESS REPORTING

The ultimate TMDL compliance point is the restoration of habitat (eelgrass or benthic infauna); a town is not in compliance with the federal Clean Water Act until watershed nitrogen loads have been reduced to the point where that habitat is restored. A difficult regulatory issue is the travel time of nitrogen in the groundwater and the uncertainties associated with estimating how a reduction in watershed load will impact water-column nitrogen concentrations and how that reduction will lead to habitat restoration. Complicating the issue is the fact that the watersheds of most impacted embayments span multiple towns which may be proceeding with nitrogen control on different schedules and at different paces. Achievement of the nitrogen load reductions implicit in the TMDLs is the only substantive mechanism for compliance over the short term.

Towns will be well served to document implementation steps annually to provide assurances to regulatory agencies, inform the public and allow coordination with other towns. Such documentation would give each town the assurance that other towns are acting toward the common goals and help inform each town's adaptive management plan.

The Alliance's Watershed Work Group could develop a standardized reporting form that each town would complete by the end of each January documenting key information from the previous year. The Watershed Work Group would then compile the data to produce a composite report by

the end of each February. One important component of the proposed annual report would be an update of towns' water use by sub-embayment as a tool to judge changes in watershed nitrogen loads. Other information could include:

- The status of all of its activities called for in the CWMP;
- A spreadsheet-based estimate of the nitrogen load removals accomplished to date;
- The results of the water quality monitoring program conducted during the year;
- The results of habitat assessments (may not be done every year);
- Documentation of the capital expenditures that have been made and that are expected over the upcoming five years, from the town's Capital Improvement Plan;
- Progress made on non-structural elements of the CWMP; and
- Proposed changes in implementation (such as acceleration or delay of upcoming segments).

All of this information is critical input to the towns' adaptive management plans.

15.0 CONSISTENCY WITH 208 PLAN UPDATE

Pleasant Bay has been identified by the Cape Cod Commission as a priority watershed for the development of a Targeted Watershed Nutrient Management Plan (TWMP) by mid 2017. Among the purposes of the TWMP is to demonstrate consistency with the 208 Plan Update and provide a basis for future watershed permitting of non-traditional technologies.

Specific guidance on the requirements for 208 Plan consistency is anticipated from the Cape Cod Commission. The consistency requirements initially described at the June 2016 One Cape Conference are listed below, with notation of how the four Pleasant Bay towns are meeting this requirement:

- **Towns accept responsibility for their controllable loads** – As noted above, town plans assume responsibility for removing their proportional share of attenuated nitrogen load reduction necessary to achieve the TMDL based on the town's contribution of attenuated load.
- **Plans meet targets (TMDLs)** – The composite analysis shows that TMDLs will be met.
- **Towns plan a hybrid approach at a watershed level** – The composite analysis shows that the individual town plans vary in the degree to which they employ non-traditional technologies. The composite of plans demonstrates a hybrid approach on a watershed basis, with 71% reduction coming from traditional technologies, 23% non-traditional technologies, and 6% fertilizer reduction.

- **Public engagement has occurred**– Each town plan has undergone extensive community review and vetting, as detailed in the respective plans.
- **Growth management strategy** – Each town plan includes assumptions about growth in watershed nitrogen loads; however, greater detail is needed to ensure that future phases are implemented in a timely fashion to keep pace with growth.
- **Monitoring programs are planned** – The Alliance has extensive baseline data on water quality, eelgrass and benthic infauna, and an ongoing water quality monitoring program. Each town has instituted monitoring protocols for specific pilot projects and initial efforts, and each town plan incorporates adaptive management to adjust implementation based on monitoring results.
- **Plans include adaptive management and 5-yr consistency check-ins** – All town plans incorporate adaptive management programs.
- **Plans include evidence of collaboration and propose shared solutions** – The four towns have collaborated in addressing nutrient management issues in Pleasant Bay through the Pleasant Bay Alliance. Initial collaboration led to the watershed-wide MEP analysis. Coordination continues in the implementation stage. Chatham and Harwich have coordinated in constructing the Muddy Creek Restoration Bridge Project and are negotiating an IMA for shared treatment and effluent disposal. This composite analysis identifies other areas where joint action among the towns could be pursued such as nitrogen trading.

This composite analysis is intended to help demonstrate the four towns' progress in meeting the requirements for 208 consistency, and lays the foundation for a future TWMP.

16.0 PREPARING FOR A POSSIBLE FUTURE WATERSHED PERMIT

Massachusetts DEP is formulating a watershed permitting program to accomplish multiple goals including the facilitation of non-traditional nitrogen management technologies. Application for a watershed permit will require submission of a TWMP that demonstrates 208 compliance. Additional guidance on watershed permitting will be forthcoming from DEP.

17.0 NEXT STEPS

This analysis of the four town plans has identified several issues that should be addressed to optimize the overall nitrogen removal program and to prepare for a TWMP and watershed permit(s):

1. The Boards of Selectmen in each town should establish a process to develop and execute memoranda of understanding (MOUs) that address watershed-wide issues. The

first such MOU could be an agreement that each town is responsible for the load removals summarized in Table 1.

2. Once specific guidance is obtained from the Cape Cod Commission on TWMPs and consistency with the 208 Plan Update, steps should be taken to address any issues not addressed by the individual plans or by this composite analysis.
3. A bay-wide compilation of nitrogen management costs should be completed to identify aggregate needs and to serve as a basis for funding requests. Efforts by Brewster and Orleans should continue to identify costs of non-traditional technologies and the requisite traditional back-up plans.
4. Efforts should be made to synchronize the plans so that expenditures lead to improved water quality at the earliest possible time in as many subembayments as possible. Table 1 identifies six subembayments where 71% of the load removal is needed; other prioritization options should also be considered, such as focusing initial expenditures on the smaller removal requirements in the headwaters embayments to demonstrate early progress to the public.
5. Harwich and Chatham should consider nitrogen trading, so that Chatham's nitrogen control measures that will exceed TMDLs can be used by Harwich to address its requirements without duplication of capital expenditures. Such trading might result in capital savings of tens of millions of dollars.
6. Brewster should consider nitrogen trading with Harwich, Chatham and Orleans, respectively, to augment its load reduction in watersheds.
7. Where non-traditional approaches are proposed, town plans should be made more robust by identification of the nature and timing of traditional technologies that will be put in place if non-traditional means are insufficient, as required by DEP.
8. The four town plans should be made more specific as to how future increases in nitrogen load will be accommodated. Flow-neutral approaches should be adopted as tools to manage future growth in nitrogen-sensitive watersheds and to ensure zero-interest DEP funding.
9. Figure 3 illustrates the long-term nature of the planned nitrogen removal program, and highlights important steps that have already been taken. An annual reporting mechanism should be developed to track additional progress, document evolving estimates of nitrogen loading, and facilitate public involvement.
10. MEP modeling should be undertake to ensure that the amount and location of load removal will achieve the desired water quality. This is best done after the towns have fully explored and further defined scenarios for joint action such as nitrogen trading.

APPENDIX A

Data Tables

Table A-1. Information Sources

Report	Author	Date
MEP Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts	MassDEP, University of Massachusetts Dartmouth School of Marine Science and Technology	May-06
Final Pleasant Bay System Total Maximum Daily Laods for Total Nitrogen	Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs, MassDEP, Bureau of Resource Protection	May-07
CCC Technical Memorandum - RE: Individual Town Nitrogen Loads by TMDL Watershed/Segments to Pleasant Bay	Cape Cod Commission (Ed Eichner)	28-Nov-07
Town of Chatham: Final Comprehensive Wastewater Management Plan and Final Environmental Impact Report	Stearns & Wheeler, LLC	May-09
MEP Techincal Memorandum - RE: MEP Scenarios to Evaluate Water Quality Impacts of the Addition of a 24-ft Culvert in Muddy Creek Inlet	MassDEP, University of Massachusetts Dartmouth School of Marine Science and Technology	5-Oct-10
Town of Orleans: Comprehensive Wastewater Management Plan and Single Environmental Impact Report	Wright-Pierce	Dec-10
Town of Brewster, Massachusetts: Integrated Water Resource Management Plan Phase II Final Report	Horsley Witten Group, Inc.	28-Jan-13
Town of Brewster, Massachusetts: Pleasant Bay Nitrogen Management Alternatives Analysis Report	Horsley Witten Group, Inc.	20-Mar-13
208 Plan: Cape Code Area Wide Water Quality Management Plan Update	Cape Cod Commission	Jun-15
Final Comprehensive Wastewater Management Plan/Single Environmental Impact Report Town of Harwich, Massachusetts	CDM Smith	Mar-16
Amended Comprehensive Wastewater Management Plan - Preliminary Draft (Prepared for the Town of Orleans, MA)	AECOM Technical Services, Inc.	Jun-16

Table A-2. Unattenuated and Attenuated Watershed Loads

Subembayment, kg/yr	Brewster	Chatham	Harwich	Orleans	TOTAL
Meetinghouse Pond					
Unattenuated Watershed Load				2,256	2,256
Attenuated Watershed Load				2,256	2,256
% Attenuation				0%	0%
Lonnies Pond (Kescayo Gansett Pond)					
Unattenuated Watershed Load	248			1,139	1,387
Attenuated Watershed Load	40			838	878
% Attenuation	84%			26%	37%
Areys Pond					
Unattenuated Watershed Load	282			367	649
Attenuated Watershed Load	95			367	462
% Attenuation	66%			0%	29%
The River - Upper					
Unattenuated Watershed Load	61			1,174	1,235
Attenuated Watershed Load	7			998	1,005
% Attenuation	89%			15%	19%
The River - Lower					
Unattenuated Watershed Load	107			1,549	1,656
Attenuated Watershed Load	16			1,390	1,406
% Attenuation	85%			10%	15%
Namequoit River					
Unattenuated Watershed Load	117			1,034	1,151
Attenuated Watershed Load	51			935	986
% Attenuation	56%			10%	14%
Paw Wah Pond					
Unattenuated Watershed Load				679	679
Attenuated Watershed Load				679	679
% Attenuation				0%	0%
Quanset Pond					
Unattenuated Watershed Load	142			723	865
Attenuated Watershed Load	72			569	641
% Attenuation	49%			21%	26%
Round Cove					
Unattenuated Watershed Load	2		2,291		2,293
Attenuated Watershed Load	1		2,277		2,278
% Attenuation	50%		1%		1%
Muddy Creek Upper					
Unattenuated Watershed Load		1,234	3,808		5,042
Attenuated Watershed Load		531	1,637		2,168
% Attenuation		57%	57%		57%

Subembayment, kg/yr	Brewster	Chatham	Harwich	Orleans	TOTAL
Muddy Creek Lower					
Unattenuated Watershed Load		1,488	2,512		4,000
Attenuated Watershed Load		1,458	2,462		3,920
% Attenuation		2%	2%		2%
Ryder's Cove					
Unattenuated Watershed Load		4,054			4,054
Attenuated Watershed Load		3,613			3,613
% Attenuation		11%			11%
Crows Pond					
Unattenuated Watershed Load		1,542			1,542
Attenuated Watershed Load		1,537			1,537
% Attenuation		0.3%			0.3%
Bassing Harbor					
Unattenuated Watershed Load		620			620
Attenuated Watershed Load		607			607
% Attenuation		2%			2%
Frost Fish Creek					
Unattenuated Watershed Load		1,059			1,059
Attenuated Watershed Load		1,059			1,059
% Attenuation		0%			0%
Pochet					
Unattenuated Watershed Load				3,135	3,135
Attenuated Watershed Load				3,073	3,073
% Attenuation				2%	2%
Pleasant Bay (including Little Pleasant Bay)					
Unattenuated Watershed Load	6,212	1,526	4,743	4,055	16,536
Attenuated Watershed Load	6,077	1,526	4,553	3,538	15,694
% Attenuation	2%	0%	4%	13%	5%
Chatham Harbor					
Unattenuated Watershed Load		6,308			6,308
Attenuated Watershed Load		6,241			6,241
% Attenuation		1%			1%
ALL SUBEMBAYMENTS					
Unattenuated Watershed Load	**7,171**	**17,831**	**13,354**	**16,111**	**54,468**
Attenuated Watershed Load	**6,359**	**16,572**	**10,929**	**14,643**	**48,503**
% Attenuation	**11%**	**7%**	**18%**	**9%**	**11%**

Notes:

1. Unattenuated and attenauted loads are as reported by the Cape Cod Commission (Eichner, November 28, 2007) and by the MEP (MEP Technical Memorandum, October 5, 2010) for Round Cove, Muddy Creek (Upper and Lower), and Pleasant Bay.

Table A-3. Attenuated Watershed Load Removals

Subembayment, kg/yr	Brewster	Chatham	Harwich	Orleans	TOTAL
Meetinghouse Pond					
Attenuated Watershed Load				2,256	2,256
Threshold Watershed Load				386	386
Removal Required				1,870	1,870
Lonnies Pond (Kescayo Gansett Pond)					
Attenuated Watershed Load	41			838	879
Threshold Watershed Load	27			566	593
Removal Required	14			272	286
Areys Pond					
Attenuated Watershed Load	95			367	462
Threshold Watershed Load	69			265	334
Removal Required	26			102	128
The River - Upper					
Attenuated Watershed Load	7			998	1,005
Threshold Watershed Load	4			630	634
Removal Required	3			368	371
The River - Lower					
Attenuated Watershed Load	16			1,390	1,406
Threshold Watershed Load	10			882	892
Removal Required	6			508	514
Namequoit River					
Attenuated Watershed Load	51			935	986
Threshold Watershed Load	33			599	632
Removal Required	18			336	354
Paw Wah Pond					
Attenuated Watershed Load				679	679
Threshold Watershed Load				266	266
Removal Required				413	413
Quanset Pond					
Attenuated Watershed Load	72			569	641
Threshold Watershed Load	44			350	394
Removal Required	28			219	247
Round Cove					
Attenuated Watershed Load	1		2,277		2,278
Threshold Watershed Load	1		1,068		1,069
Removal Required	0.3		1,209		1,209
Muddy Creek Upper					
Attenuated Watershed Load		531	1,637		2,168
Threshold Watershed Load		346	1,046		1,392
Removal Required		185	591		776

Subembayment, kg/yr	Brewster	Chatham	Harwich	Orleans	TOTAL
Muddy Creek Lower					
Attenuated Watershed Load		1,458	2,462		3,920
Threshold Watershed Load		874	1,476		2,350
Removal Required		584	986		1,570
Ryder's Cove					
Attenuated Watershed Load		3,613			3,613
Threshold Watershed Load		1,630			1,630
Removal Required		1,983			1,983
Crows Pond					
Attenuated Watershed Load		1,537			1,537
Threshold Watershed Load		1,540			1,540
Removal Required		0			0
Bassing Harbor					
Attenuated Watershed Load		607			607
Threshold Watershed Load		609			609
Removal Required		0			0
Frost Fish Creek					
Attenuated Watershed Load		1,059			1,059
Threshold Watershed Load		257			257
Removal Required		802			802
Pochet					
Attenuated Watershed Load				3,073	3,073
Threshold Watershed Load				1,505	1,505
Removal Required				1,568	1,568
Pleasant Bay (including Little Pleasant Bay)					
Attenuated Watershed Load	6,077	1,526	4,553	3,538	15,694
Threshold Watershed Load	3,913	981	2,932	2,275	10,101
Removal Required	2,164	545	1,621	1,263	5,593
Chatham Harbor					
Attenuated Watershed Load		6,241			6,241
Threshold Watershed Load		6,241			6,241
Removal Required		0			0
ALL SUBEMBAYMENTS					
Attenuated Watershed Load	**6,360**	**16,572**	**10,929**	**14,643**	**48,504**
Threshold Watershed Load	**4,101**	**12,478**	**6,522**	**7,724**	**30,825**
Removal Required	**2,259**	**4,099**	**4,407**	**6,919**	**17,684**

Notes:

1. Attenuated watershed loads are taken from Table A-2. Total threshold watershed loads are taken from Table VIII-4 of the 2006 MEP report and Table 2 of the 2010 MEP Technical Memo. Town shares of thresholds are proportional to their attenuated loads.

Table A-4. Town Plan Removals (kg/yr) and Reliance on Non-Traditional Technologies

Subembayment	Brewster	Chatham	Harwich	Orleans	Total
Meetinghouse Pond				1,876	1,876
Non-Traditional Technologies Share				2%	10%
Lonnies Pond	0.5			284	285
Non-Traditional Technologies Share	100%			100%	100%
Areys Pond	1.0			113	114
Non-Traditional Technologies Share	100%			100%	100%
The River - Upper	0.1			374	374
Non-Traditional Technologies Share	100%			54%	47%
The River - Lower	0.3			517	517
Non-Traditional Technologies Share	100%			100%	100%
Namequoit River	0.8			348	349
Non-Traditional Technologies Share	100%			100%	100%
Paw Wah Pond				413	413
Non-Traditional Technologies Share				100%	100%
Quanset Pond	1.0			228	229
Non-Traditional Technologies Share	100%			100%	100%
Round Cove	0.0		1,251		1,251
Non-Traditional Technologies Share	100%		3%		3%
Muddy Creek Upper		438	805		1,243
Non-Traditional Technologies Share		2%	3%		3%
Muddy Creek Lower		1,192	1,073		2,265
Non-Traditional Technologies Share		2%	4%		3%
Ryder's Cove		2,674			2,674
Non-Traditional Technologies Share		3%			3%
Crows Pond		1,248			1,248
Non-Traditional Technologies Share		3%			3%
Bassing Harbor		514			514
Non-Traditional Technologies Share		1%			1%
Frost Fish Creek		832			832
Non-Traditional Technologies Share		3%			3%
Pochet				1,564	1,564
Non-Traditional Technologies Share				100%	100%
Pleasant Bay (including Little Pleasant Bay)	1,867	930	1,411	1,257	5,465
Non-Traditional Technologies Share	50%	3%	6%	100%	48%
Chatham Harbor		5,229			5,229
Non-Traditional Technologies Share		1%			1%
Total (All Subembayments)	1,871	13,058	4,540	6,974	26,442
Non-Traditional Technologies Share	50%	2%	4%	71%	24%

Notes:

1. Non-traditional technologies are considered to be remediation technologies, residential fertilizer reductions, and on-site denitrification systems.
2. All town plans have been adjusted for a uniform 25% residential fertilizer reduction.
3. Yellow shaded cells identify subembayments where town plans rely on non-traditional technologies for >25% of their planned removals.

Table A-5. Town Plan Nitrogen Removals Compared to TMDL (kg/yr)

Subembayment	Brewster	Chatham	Harwich	Orleans	Total
Meetinghouse Pond *Amount Town Plans Over / Under*				0	0
Lonnies Pond *Amount Town Plans Over / Under*	13			0	13
Areys Pond *Amount Town Plans Over / Under*	28			0	28
The River - Upper *Amount Town Plans Over / Under*	2.5			1	4
The River - Lower *Amount Town Plans Over / Under*	5.8			1	7
Namequoit River *Amount Town Plans Over / Under*	18			0	18
Paw Wah Pond *Amount Town Plans Over / Under*				0	0
Quanset Pond *Amount Town Plans Over / Under*	28			1	27
Round Cove *Amount Town Plans Over / Under*	0.8		42		42
Muddy Creek Upper *Amount Town Plans Over / Under*		245	221		466
Muddy Creek Lower *Amount Town Plans Over / Under*		608	87		696
Ryder's Cove *Amount Town Plans Over / Under*		720			720
Crows Pond *Amount Town Plans Over / Under*		1,248			1,248
Bassing Harbor *Amount Town Plans Over / Under*		514			514
Frost Fish Creek *Amount Town Plans Over / Under*		29			29
Pochet *Amount Town Plans Over / Under*				5	5
Pleasant Bay (including Little Pleasant Bay) *Amount Town Plans Over / Under*	294	388	209	0	115
Chatham Harbor *Amount Town Plans Over / Under*		5,229			5,229
Total (All Subembayments) *Amount Town Plans Over / Under*	**390**	**8,982**	**141**	7	**8,726**

Notes:

1. Orange font and shading indicate the amount a town plan is under the TMDL.
2. Green font and shading indicate the amount a town plan is over the TMDL.
3. All town plans have been adjusted for a uniform 25% residential fertilizer reduction.

APPENDIX B

Summary of Town Plans for Pleasant Bay

APPENDIX B

SUMMARY OF TOWN PLANS FOR PLEASANT BAY

Brewster

The Town of Brewster contributes approximately 13% of the attenuated wastewater nitrogen load to the Pleasant Bay watershed and is responsible for 13% of the aggregate removal. The Town has developed an Integrated Water Resources Management Plan (IWRMP). The IWRMP Phase II report was issued in final form in January 2013 with assessments and recommendations addressing nitrogen loading to Pleasant Bay, existing and future drinking water, and stormwater and freshwater pond needs. Nitrogen management alternatives are further discussed in a March 2015 report. The Brewster Plan includes significant fertilizer reductions that have already taken place at the Captain's Golf Course, fertigation at the golf course, and reductions in residential fertilizer loads. Brewster considered shellfish propagation or aquaculture to meet the remaining nitrogen reduction for the Town. The Town is currently looking at new septic leachfield technologies for nitrogen reduction (since the shellfish management option may not be feasible) and is investigating potential pilot projects to test this option. Sewering of a residential neighborhood has been identified as a backup option, but the proposed location is at the upper end of the watershed, meaning it would take decades for there to be water quality improvement in the Bay.

Chatham

The Town of Chatham contributes approximately 34% of the attenuated wastewater nitrogen load to the Pleasant Bay watershed and is responsible for 23% of the overall removal. The Town began implementing its Comprehensive Wastewater Management Plan (CWMP) in 2010. The CWMP includes the sewering of the entire town, with the implementation of later sewering phases being contingent upon results of on-going monitoring under the adaptive management plan. The Town of Chatham, in cooperation with the Town of Harwich, recently completed the construction of a new bridge to replace inadequate culverts that will provide increased tidal flushing and improved water quality in Muddy Creek.

Harwich

The Town of Harwich contributes approximately 22% of the attenuated wastewater nitrogen load to the Pleasant Bay watershed and is responsible for 25% of the overall removal. The Town developed a recommended program to address nitrogen removal and meet other town needs. That program, described in a draft CWMP, was submitted for review to MEPA and the CCC in February 2013. Upon further refinement of infrastructure and non-infrastructure program components and review of the 208 Water Quality Plan, the Town filed the final CWMP in March 2016 with MEPA and the CCC. MEPA issued a Certificate of Approval on May 13, 2016. The Commission gave Development of Regional Impact Individual (DRI) approval in August 2016.

The CWMP proposes wastewater collection in the Pleasant Bay watershed and recommends a community partnership with Chatham to treat wastewater generated and collected in the Pleasant Bay watershed at the existing Chatham treatment facility. Treated effluent would initially be

recharged at the Chatham facility but may in the future be conveyed back to East Harwich for recharge, depending on water quality results. The Harwich CWMP also includes several nontraditional components such as the Muddy Creek inlet widening, and inclusion of stormwater best management practices (BMPs) throughout town. Several non-infrastructure components are included, such as review of potential open space acquisition parcels to minimize buildout, and fertilizer education programs (instead of a fertilizer control ordinance).

Orleans

The Town of Orleans contributes 30% of the attenuated wastewater nitrogen load to the Pleasant Bay watershed and is responsible for 39% of the overall removal. The Town's CWMP was completed in 2010 and received MEPA and DRI approvals with conditions in 2011. The CWMP characterizes nitrogen reduction needs pursuant to the MEP and TMDL reports for Pleasant Bay. The Needs Assessment completed in 2009 identifies other wastewater needs to address Title 5 compliance and economic development. The Town's CWMP is a phased sewering plan supplemented with non-traditional solutions that may reduce the scale of later sewering requirements.

The Town has embarked on supplemental planning aimed at accelerating the use of non-traditional solutions to minimize sewering. The Orleans Water Quality Advisory Panel developed a "Consensus Agreement" in 2015 that recommends a strong emphasis on evaluation of the ability of non-traditional technologies to meet the TMDL requirements for Pleasant Bay. In 2016, the Town has installed a demonstration oyster-growing project in Lonnie's Pond and is planning another shellfish project in Quanset Pond, The Town is also seeking funds to install a pilot project of four on-site septic systems with nitrogen removing biofilters.

APPENDIX C

Acknowledgements

ACKNOWLEDGEMENTS

This composite nitrogen management analysis has been prepared by the Pleasant Bay Alliance with technical assistance from Wright-Pierce. Substantive input was obtained by the members of the Alliance's Watershed Work Group:

Brewster	Mr. Chris Miller, Director, Natural Resources Dept.
Chatham	Dr. Robert Duncanson, Director, Natural Resources Dept.
Harwich	Mr. Heinz Proft, Natural Resource Director
Orleans	Mr. George Meservey, Planning Director
Coordinator	Ms. Carole Ridley

Technical consultants of the four towns have reviewed this document, and their comments have been addressed. Comments by Brian Dudley of MassDEP and the staff of the Cape Cod Commission have also been incorporated.

This report was approved by the Pleasant Bay Alliance Steering Committee:

Brewster	Mr. Chris Miller, Director, Natural Resources Dept.
	Ms. Ryan Bennett, Town Planner
Chatham	Ms. Jane Harris
	Mr. Chuck Bartlett
Harwich	Mr. Allin P. Thompson, Jr.
	Ms. Dolly Howell
Orleans	Ms. Judith Bruce
	Ms. Fran McClennen

March 24, 2017
WP Project No. 13351A,B

Ms. Carole Ridley
Pleasant Bay Alliance
115 Kendrick Road
Harwich, MA 02645

Subject: Pleasant Bay Composite Nitrogen Management Analysis
Final Report

Dear Carole:

Enclosed is the final report entitled "Pleasant Bay Composite Nitrogen Management Analysis: An Assessment of the Wastewater and Nitrogen Management Plans of Brewster, Chatham, Harwich and Orleans".

We have enjoyed collaborating with you on the analysis of the four towns plans and the development of this report, and we are pleased by the active involvement of the Alliance's Watershed Work Group. All technical aspects of this report have been prepared by me or under my direction.

We look forward to assisting in the presentation of this report to each of the four towns.

Please contact me with any questions you may have.

Very truly yours,
WRIGHT PIERCE

Michael D. Giggey, PE
Senior Vice President

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Phone: 978.416.8000 | Fax: 978.470.3558


ORLEANS
CHATHAM
BREWSTER
HARWICH