Pleasant Bay Alliance

PLEASANT BAY TARGETED WATERSHED MANAGEMENT PLAN

A Compilation of the Wastewater and Nitrogen Management Plans of Brewster, Chatham, Harwich and Orleans in Support of a DEP Watershed Permit

May 2018

PLEASANT BAY TARGETED WATERSHED MANAGEMENT PLAN

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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 actions 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. Specifically, the Alliance is charged with coordinating joint activities under a Pleasant Bay Watershed Permit to be issued to the Towns by Massachusetts DEP. The Alliance has developed this Targeted Watershed Management Plan (TWMP) in response to that charge. The TWMP builds on previous analyses undertaken by the towns and the Alliance, as described below.

The *Pleasant Bay Composite Nitrogen Management Analysis*, the predecessor to this document, was issued in March 2017. Its primary purpose was to show the combined effect of four towns' wastewater management plans on nutrient removal within the Pleasant Bay watershed. That analysis was vetted by Town staff and technical consultants, as well as the Cape Cod Commission and DEP.

In June 2017, the Towns signed a joint resolution endorsing the Composite Analysis as an accurate representation of each Town's share of current nitrogen load and load removal responsibility. The Towns also agreed to participate in a Watershed Permit Pilot Project with the Alliance, DEP, US EPA, and the Cape Cod Commission to pursue efficiencies and cost savings through coordinated implementation of nutrient management actions. The Towns expect to be issued a Watershed Permit in 2018.

The Watershed Permit provides the following benefits to the towns:

- A DEP-accepted framework of nitrogen mitigation measures beyond a traditional DEP-issued groundwater discharge permit;
- A framework for obtaining nitrogen reduction credits for compliance with the Clean Water Act through non-traditional nitrogen management approaches;
- Higher ranking for State Revolving Loan Fund (SRF) financing for both traditional and non-traditional technologies for qualified projects;
- An assured procedure for documenting nitrogen removal credits toward TMDL compliance; and
- DEP's agreement to exercise enforcement discretion by forbearing from initiating unilateral enforcement actions against the towns related to water quality impairment in Pleasant Bay from excess nitrogen.

This TWMP is a core aspect of the Watershed Permit. The TWMP is an elaboration of the Composite Analysis and summarizes the nutrient management plans (i.e., CWMPs) already prepared by the towns in the watershed, and is not a new plan. The TWMP, like the Composite Analysis, documents what each town intends to do to reduce its share of nitrogen load in the Pleasant Bay watershed and when those removals will occur. 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.

The TWMP demonstrates that 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)[1]. 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

[1] When the term TMDL is used in this report, it refers to nitrogen-based TMDLs.

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 must 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. 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 equalize 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. This TWMP includes a detailed implementation schedule that shows how over the next five years the four towns will remove about 28% of the nitrogen required to meet TMDLs. It also presents a listing of future activities now planned for years 6 through 20 that could remove nearly all the nitrogen required to meet TMDLs. (Those future activities are presented for planning purposes and may change as the towns' adaptive management programs are applied to the results of the initial activities.)

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 phase 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.

Implementation activities within each community will be undertaken under the direction of the respective town as the designated Waste Management Agency. In accordance with the intermunicipal agreement for entering into a Watershed Permit, the Alliance is charged with coordinating joint activities of the Towns/WMAs including:

- Fully exploring the opportunities for efficiency and cost savings identified in the *Pleasant Bay Composite Nitrogen Management Analysis*;
- Sharing or developing engineering and economic studies and evaluations to define means of meeting the Towns' respective nitrogen reduction targets and to develop cost-performance relationships that define most cost-effective technologies and practices for the removal of nitrogen; and
- Coordinating system-wide monitoring and modeling of water quality and other nutrient-related ecological parameters in the Pleasant Bay system as needed to support implementation of the TWMP and compliance with the terms of the Watershed Permit.

1.0 PURPOSE

Water quality in Pleasant Bay is impacted by watershed inputs from 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 also addresses multiple watersheds, in addition to Pleasant Bay, and accounts for a variety of town-wide needs and priorities. It is the purpose of this Targeted Watershed Management Plan 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,
- document consistency with the Cape Cod Commission's 208 Plan Update, and
- provide the foundation for a Watershed Permit to be issued by the Massachusetts Department of Environmental Protection (DEP).

An earlier version of this report, the *Pleasant Bay Composite Nitrogen Management Analysis* (Composite Analysis), was issued in March of 2017. A Joint Resolution supporting the Composite Analysis was executed by the four Boards of Selectmen in June 2017.

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, and are anticipated in the implementation schedule to be contained in the Watershed Permit.

2.0 DATA SOURCES AND METHODS

This analysis incorporates information from the Pleasant Bay portion of each town's wastewater management plan as of March 2018. The nutrient loading and load reduction information is based on the analyses generated by the Massachusetts Estuaries Project (MEP), as modified by engineering studies 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 DEP 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 Bay's 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.

As reported in the 2006 MEP technical report, there were 8,637 separate land parcels located partially or totally within the Pleasant Bay watershed in the early part of that decade. Table 1 enumerates those parcels by town, and shows the extent to which those parcels were developed at that time.

Table 1. Enumeration of Parcels within the Pleasant Bay Watershed (MEP, 2006)

Number of Watershed Parcels	Brewster	Chatham	Harwich	Orleans	Total
Developed	709	2,724	1,517	2,365	7,315
Vacant but Developable	112	236	256	284	888
Vacant and Undevelopable	150	86	71	127	434
Total	971	3,046	1,844	2,776	8,637

Of all the parcels in the watershed, about 85% were developed at the time of preparation of the MEP report. Of the 15% that were not developed, about one-third were considered undevelopable due to zoning, ownership or other reasons. At full build-out, the number of developed parcels would increase to about 8,300, a 12% increase. This percentage increase understates the potential increase in nitrogen load in the watershed, because many of the currently undeveloped lots can be subdivided so that the build-out parcel count could be much higher than 8,300.

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.")

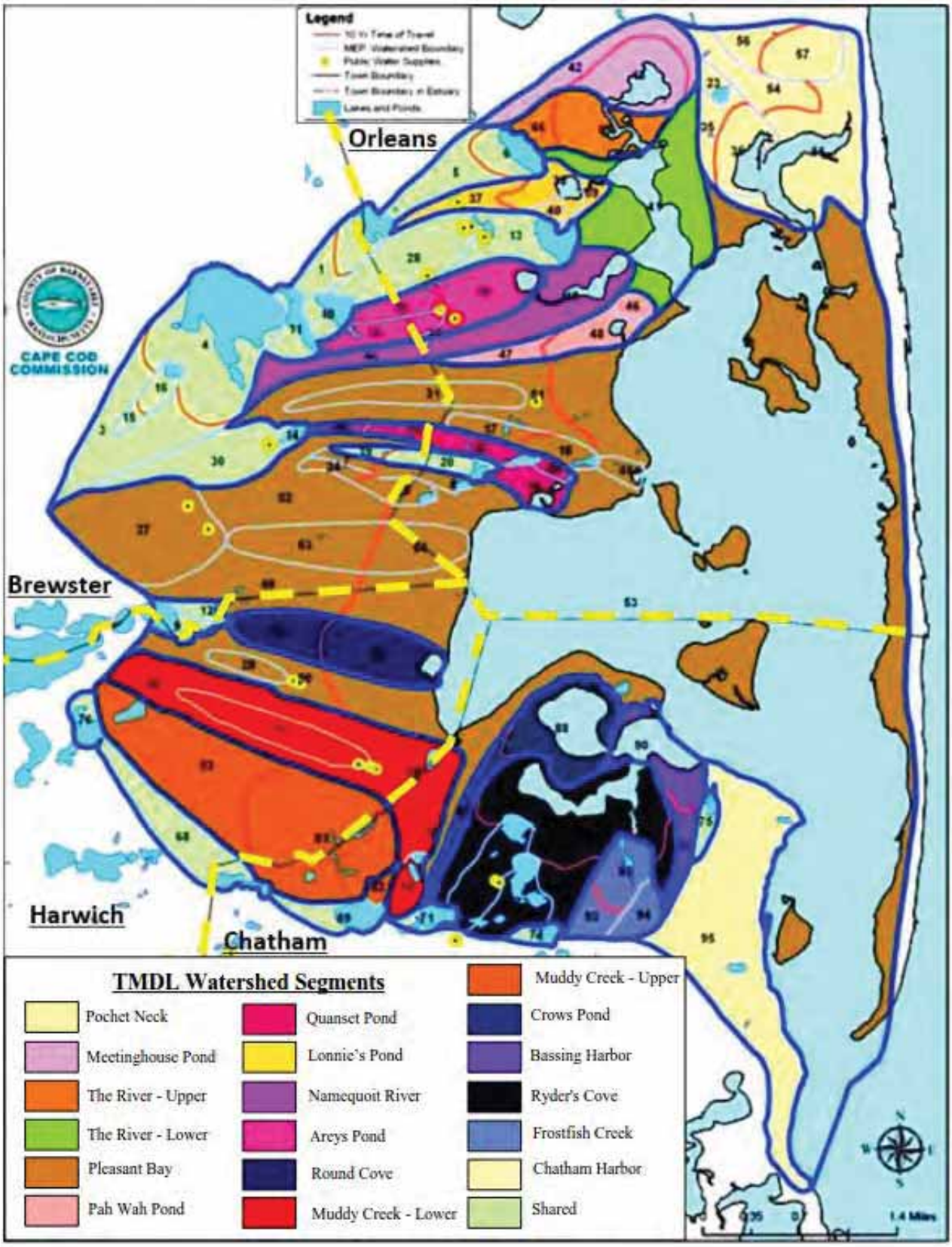
The MEP Technical Report presents estimates of nitrogen loads originating both within the watershed, as well as within the embayment. The "watershed loads" generally include nitrogen from septic systems; lawn, golf course and cranberry bog fertilization; and stormwater runoff. The watershed loads are 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 2 presents the annual nitrogen load removals allocated to each town and to each subembayment. The blue-shaded cells in Table 2 are those where the nitrogen removal requirement exceeds 5% of the overall 17,717 kg/yr (886 kg/yr).

Table 2. 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.

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
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 3 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 3 leads to the following key findings:

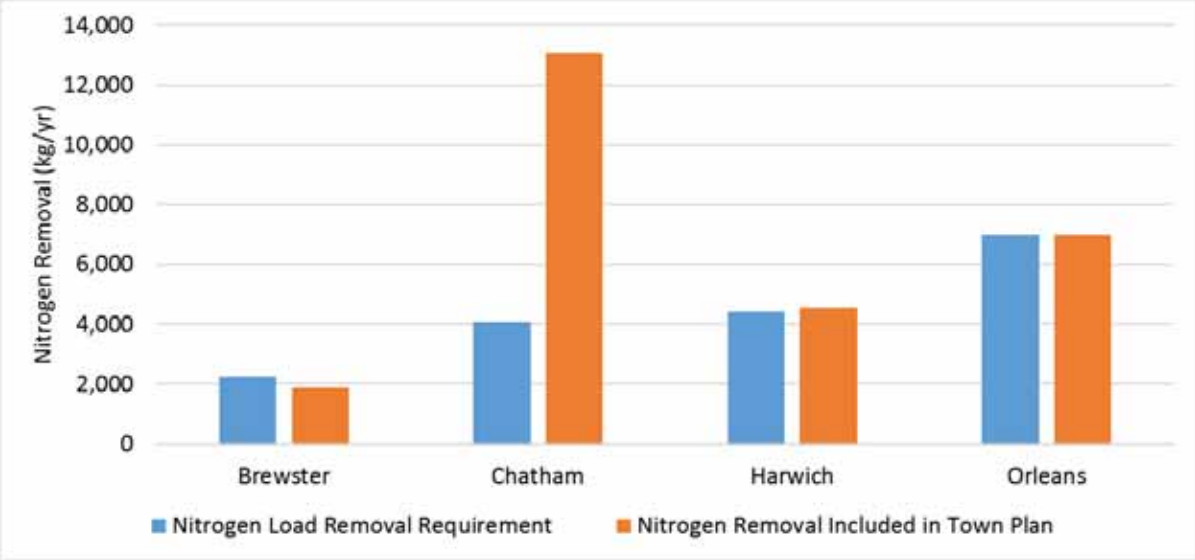
- In 10 subembayments, the town plans collectively achieve removals that are very close to those dictated by the TMDLs. In these places, all planned removals are within 5% of the removal need. Such minor differences are easily addressed through adaptive management.

- 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.

Table 3. 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



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 3 shows that Brewster's plan will remove 390 kg/yr less than required by the TMDL. Brewster developed its plan based on the nitrogen reductions that were determined from the original MEP model run for Pleasant Bay used to develop the TMDL for the system. The load reduction requirements used in this watershed plan are from a more recent modeling scenario that used updated water consumption in Harwich and simulated increased flushing in Muddy Creek as a result of the construction of the Muddy Creek bridge. These changes have altered the estimated nitrogen load in the main Pleasant Bay sub-embayment, where Brewster is responsible for a certain share of its removal. These changes will be evaluated further in future modeling scenarios, and the allocations of responsibilities for the changes will be discussed further among the towns. Brewster is committed to meeting its load reduction responsibility under the Watershed Permit.

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 CHOICE OF TECHNOLOGIES

Table 4 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.

Table 4. 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	2,024	2,614
Remediation					
Permeable Reactive Barriers	0	0	0	*Note 3*	0
Fertigation at Golf Courses	230	0	0	0	230
Shellfish Propagation	0	0	0	2,695	2,695
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	4,279	23,519
Remediation Subtotal, kg/yr	230	0	0	2,695	2,925
Percent Remediation Technologies	12%	0%	0%	39%	**11%**
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 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. Permeable Reactive Barriers are not part of the current plan, but are being tested in another watershed and may be added to the Pleasant Bay plan in the future.

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 4 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; see Section 18 on contingency planning.

Table 4 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 4 shows how the load reduction expected through remediation is somewhat different from that associated with non-traditional technologies.

DEP has asked each of the four towns to designate Core Areas, where proven source control methods will be employed to meet TMDLs. Figure 3 shows the Core Areas for Nitrogen Control to include the following:

- Brewster: Captains Golf Course, where the only measurable source control method is proposed (golf course fertilizer reduction)
- Chatham: all Phase 1 areas identified in the Chatham CWMP within the watershed[2]
- Harwich: all proposed sewer service areas in the watershed
- Orleans: the proposed sewer service area for Meetinghouse Pond (the only traditional component of the evolving town plan).

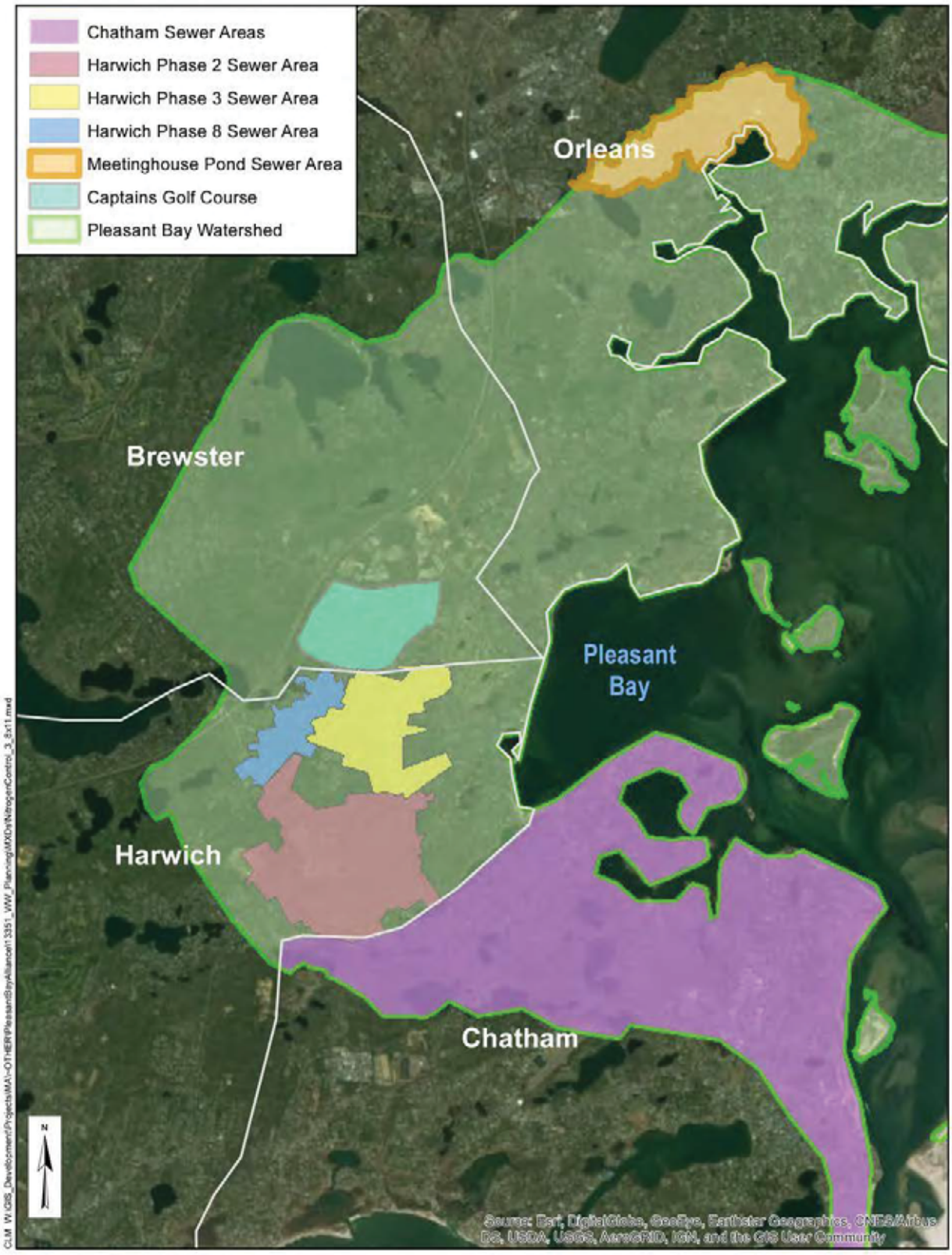
In the aggregate, 12,200 kg of nitrogen will be removed annually in these areas by the end of the 20-year permit cycle. This removal is roughly equal to 70% of the TMDL removal requirement in the aggregate. Implementation of proven source control measures in the Core Areas will address the following percentages the towns' requirements:

Brewster	41%
Chatham	123%
Harwich	98%
Orleans	30%.

[2] The Chatham "Core" area for the Pleasant Bay Watershed includes those sewersheds identified as part of Phase 1 on Figure 5-1 of the Town's 2009 CWMP. These "Core" sewersheds located within the Pleasant Bay watersheds are shown on Figure 9-6 of the Town's 2009 CWMP, and include the following: Sewershed Nos. 6, 7, 8, 9, 10, 11, 14, 17, 18, 20, 38, 39, 71, 72, 73, 74, 75, 79, and 80.

The Town of Chatham is continuing to propose the use of sewering to address its TMDL nitrogen loads. The Town is also planning to sewer all remaining areas within the watershed as part of the Town-wide plan; however, those areas are not "required" in order for Chatham to meet its contribution to the Pleasant Bay Watershed. Figure 3 shows both the Phase 1 sewersheds and the entire proposed sewer area in Chatham.

Figure 3. Core Areas for Nitrogen Control



9.0 MANAGING GROWTH IN NITROGEN LOADS

The Composite Analysis and the data presented earlier in this report all focus 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. The towns' build-out percentages are as follows, as described in Appendix C:

Brewster	19%
Chatham	22%
Harwich	41%
Orleans	26%

In the aggregate, the towns' estimates project watershed-wide growth of approximately 27% of the existing attenuated loads. Since 100% of "new" nitrogen loads must be controlled in nitrogen-sensitive watersheds, a 27% growth in loads translates to an 74% increase in the loads that must be removed. Therefore, the long-term viability of the watershed nitrogen management plan is very dependent on the towns' abilities to implement future phases of nitrogen control technologies 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. However, the town-prepared estimates are comparable, in the aggregate (27%), to those prepared for the MEP technical report (30%), and to those prepared by the Commission (26%).

If growth through build-out increases the nitrogen removal need by 74%, key questions then become:

- How much of that growth is likely to occur during the 20-year term of the Watershed Permit?
- How much of that growth is accommodated in the design of nitrogen control measures already planned?

To gauge the impact of growth on the ability of the towns to achieve their TMDL targets in 20 years, an analysis was conducted assuming:

- 75% to 80% of the build-out growth will occur in the next 20 years (by 2038)
- Growth will occur uniformly across all Pleasant Bay sub-watersheds
- The sewering plans of Chatham, Harwich and Orleans largely anticipate the growth in those areas.

Of the 13,100 kg/year of watershed-wide growth that has been projected, about 8,300 kg/year will be accommodated by the sewer systems in the three towns. The remaining 4,800 kg/year of "new" nitrogen must still be addressed by expanded or new nitrogen control initiatives, predominantly in Brewster and Orleans. The implementation schedule outlined in Section 11 indicates that over 90% of the TMDL load reductions will occur in 20 years without growth. This analysis indicates that only 75% to 80% of the goal will be achieved if the town growth projections occur. With these assumptions, Brewster must augment its plan by 50% and Orleans by 35%, if TMDL compliance is to occur at the same rate as with no growth.

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. Current town plans include the use of these tools:

- Increasing minimum lots sizes in area that will not be sewered
- Continued open space acquisition
- Reducing potential for accessory apartments
- Implementing flow-neutral regulations sufficient to allow enhanced funding by DEP
- Adopting nitrogen control regulations
- Providing incentives for growth in non-sensitive watersheds.

Zero-percent State Revolving Loan Fund (SRF) funding is available from DEP 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, all four towns should continue implementing whatever actions are necessary to secure that 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, consistent with their CWMPs and planning activities conducted following CWMP completion. To gain the benefits of a Watershed Permit, it will be necessary to formalize implementation schedules into a 20-year framework, consisting of four 5-year periods. A designated set of activities will occur in the first 5-year block of time, and the results of those activities will allow the towns, through adaptive management, to fine-tune their plans for the next 5-year period. After four cycles of adaptive management, it is expected that the towns will have each accomplished most of the work needed to achieve their shares of TMDL responsibility.

Table 5 presents the 20-year implementation plan currently envisioned by the towns, in a form that is acceptable to DEP as a key part of the Watershed Permit. The activities shown in this implementation schedule are the key elements of each town's plans, and include the nitrogen load reductions expected through implementation of fertilizer control regulations.

Table 5 first shows the activities that have been completed, or will have been completed, by the presumed July 1, 2018 effective date of the permit. Those include:

- The completion of the Muddy Creek bridge by Chatham and Harwich
- Nitrogen control activities at the Captains Golf Course in Brewster
- Development of this TWMP
- Execution of an inter-municipal agreement among the towns and
- Obtaining the Watershed Permit.

Not shown in this "pre-permit" timeframe are the CWMPs (and similar documents) prepared prior to 2015.

Figure 4 depicts a summary of the implementation plans in graphical form.

In the first 5 years of the permit (2019 to 2023), the towns are prepared to commit to the activities shown in the blue-shaded segment of Table 5. They include:

- Brewster: development of a plan for using on-site denitrification systems to remove approximately 590 kg/yr of attenuated nitrogen load;
- Chatham: construction of sewers that will allow Harwich to send wastewater to the Chatham WWTF;
- Harwich: completion of Phase 2 of its plan that will eliminate septic systems in East Harwich and allow the transport of wastewater (and about 2,700 kg/yr of nitrogen) to Chatham for treatment and discharge outside the Pleasant Bay watershed.
- Orleans: Completion of its Amended CWMP, initiation of a full-scale aquaculture system in Lonnie's Pond (to remove about 270 kg/y of nitrogen), and evaluation of PRBs for possible use in the Pleasant Bay watershed.

Table 5. Implementation Plan: Expected Project Completion and Potential Annual Nitrogen Removals

			Brewster		Chatham		Harwich		Orleans		Total
Phase	**Years**		**Activity**	**kgN/yr***	**Activity**	**kgN/yr***	**Activity**	**kgN/yr***	**Activity**	**kgN/yr***	**kgN/yr***
	up to 2018		Res. fertilizer control Capt GC fertigation Capt GC fert. reduction	121 230 930	Res. fertilizer control Muddy Creek Bridge	247	Muddy Creek Bridge		Res. fertilizer control	241	1,769
			All towns: develop TWMP; demonstrate 208 consistency; execute IMA; obtain Watershed Permit								
1 **	1 to 5	2019 to 2023	Develop denit plan Devel. conting. plan Strengthen GC plan		Harwich connection		Ph 2 sewers Res. fertilizer control	2,672 200	Amended CWMP Lonnie's Pond aqua. PRB evaluation	273	3,145
			All towns: update monitoring data, re-model Bay, evaluate nitrogen trading options, prepare plan for next 5 yr								
2 ***	6 to 10	2024 to 2028	On-site denit systems	118			Ph 3 sewers	1,565	MtgHouse Pond sewers Other aquaculture On-site denit systems	2,014 1,516 674	5,887
3 ***	11 to 15	2029 to 2033	On-site denit systems	118	Frostfish Creek sewers Ryders Cove sewers	803 2,605			On-site denit systems Other aquaculture	675 906	5,107
4 ***	16 to 20	2034 to 2038	On-site denit systems	118	Muddy Creek sewers	1,597			On-site denit systems	675	2,390
	after year 20	after 2038	On-site denit systems	236	Crows Pond sewers Bassing Harbor sewers Pleasant Bay sewers Chatham Harbor sewers	1,214 511 901 5,181	Ph 8 sewers Harwich effl. disposal	970 (867)	****		8,146
			Total	**1,871**	**Total**	**13,059**	**Total**	**4,540**	**Total**	**6,974**	**26,444**

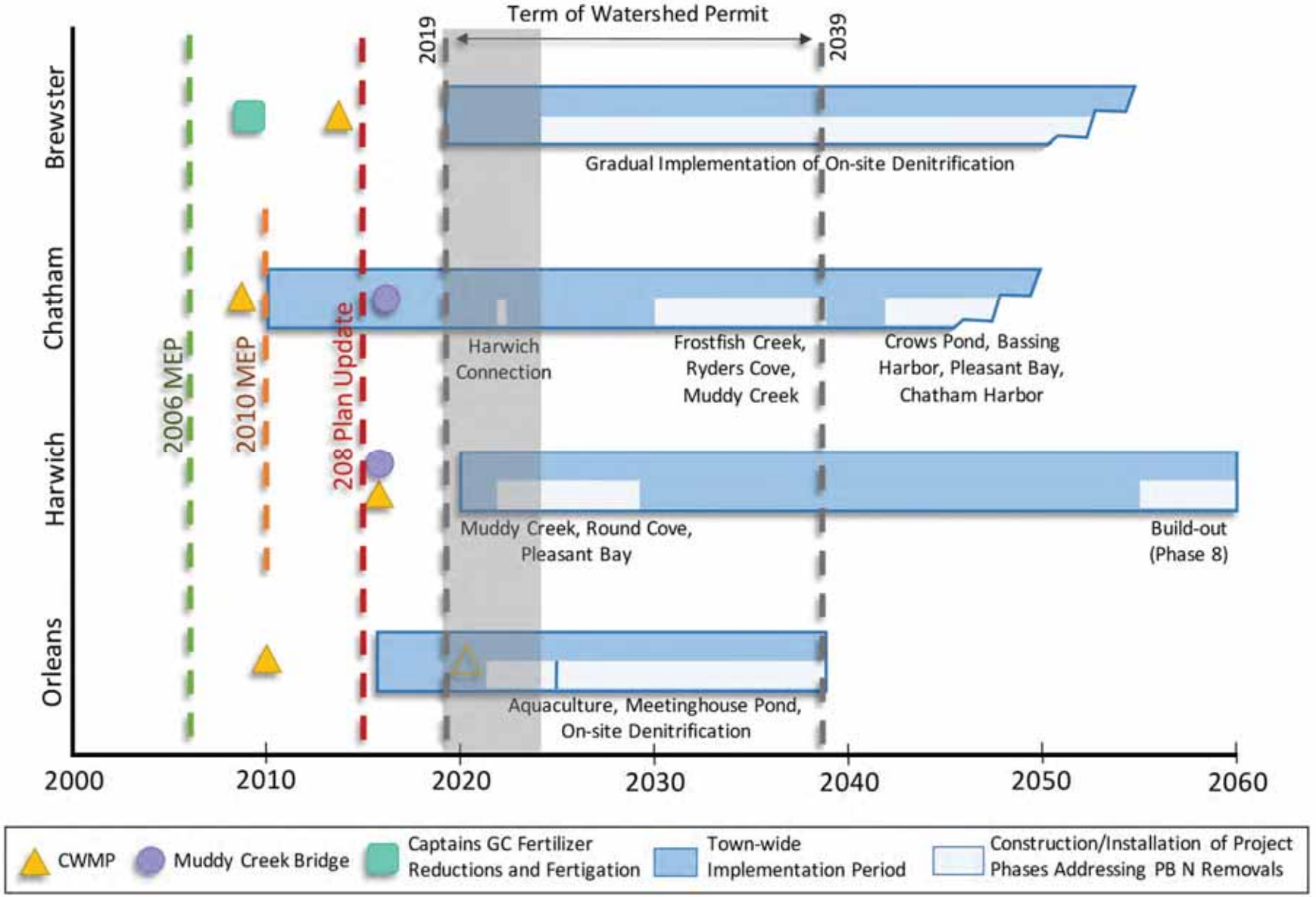
* Removals pertain to current nitrogen loads without growth, and represent estimates of removal potential.

** First Phase (Years 1 to 5) includes activities that are firm commitments by the towns and are necessary to gain DEP enforcement discretion.

*** Phases 2 through 5 (Years 6 to 20) include activities that are now planned and considered enforceable until such time as they may change depending on the outcomes of Phase 1 and application of each town's adaptive management program, as per the Watershed Permit.

**** The discharge of Harwich effluent within the Pleasant Bay watershed may become necessary if alternative disposal sites are not developed.

Figure 4. Town Implementation Schedules



In addition to those actions by each town alone, collectively the four towns will:

- Update and analyze databases of planning and water quality information;
- Update and run the Pleasant Bay hydrodynamics and water quality model;
- Explore nitrogen trading opportunities; and
- Finalize plans and commit to projects to be accomplished in the following 5-year period (2024 to 2028).

Based on CWMPs and subsequent analyses, it is expected that the activities to be conducted in the first 5 years of the Watershed Permit will remove about 2,940 kg/yr of attenuated nitrogen load. When combined with the 1,160 kg/yr already removed, that represents about 23% of the TMDL removal requirement.

Table 5 shows the towns' current plans for years 6 through 20 of the Watershed Permit period in similar 5-year increments. It is fully expected that the precise nature and timing of activities will be different from those shown in Table 5, due to the planned remodeling of the Bay, and the fact that performance of activities in years 1 to 5 will not be exactly as now envisioned. The activities shown in Table 5 for years 6 to 20 (the tan-shaded segments) are presented for planning purposes. Those activities are still enforceable under the Watershed Permit, but can be refined based on the results of actions taken in the first five years.

Figures 5 and 6 depict the geographic distribution of the nitrogen control measures to implemented by Year 5 and Year 20, respectively, of the Watershed Permit. The on-site denitrification and aquaculture elements of the Brewster and Orleans plans are shown somewhat schematically since the precise location of these elements has not been determined.

Figure 7 charts the expectations for removal of current nitrogen loads over the 20-year period of the Watershed Permit and beyond to the completion of all town programs. Non-traditional technologies are being relied upon for about one-third of the removals in each 5-year interval. The TMDL requirement of 17,717 kg/yr would be achieved in the last 5-year period, assuming good performance of the non-traditional technologies and no growth in watershed load.

Figure 5. Location of Nitrogen Control Measures Expected to be in Place by Year 5

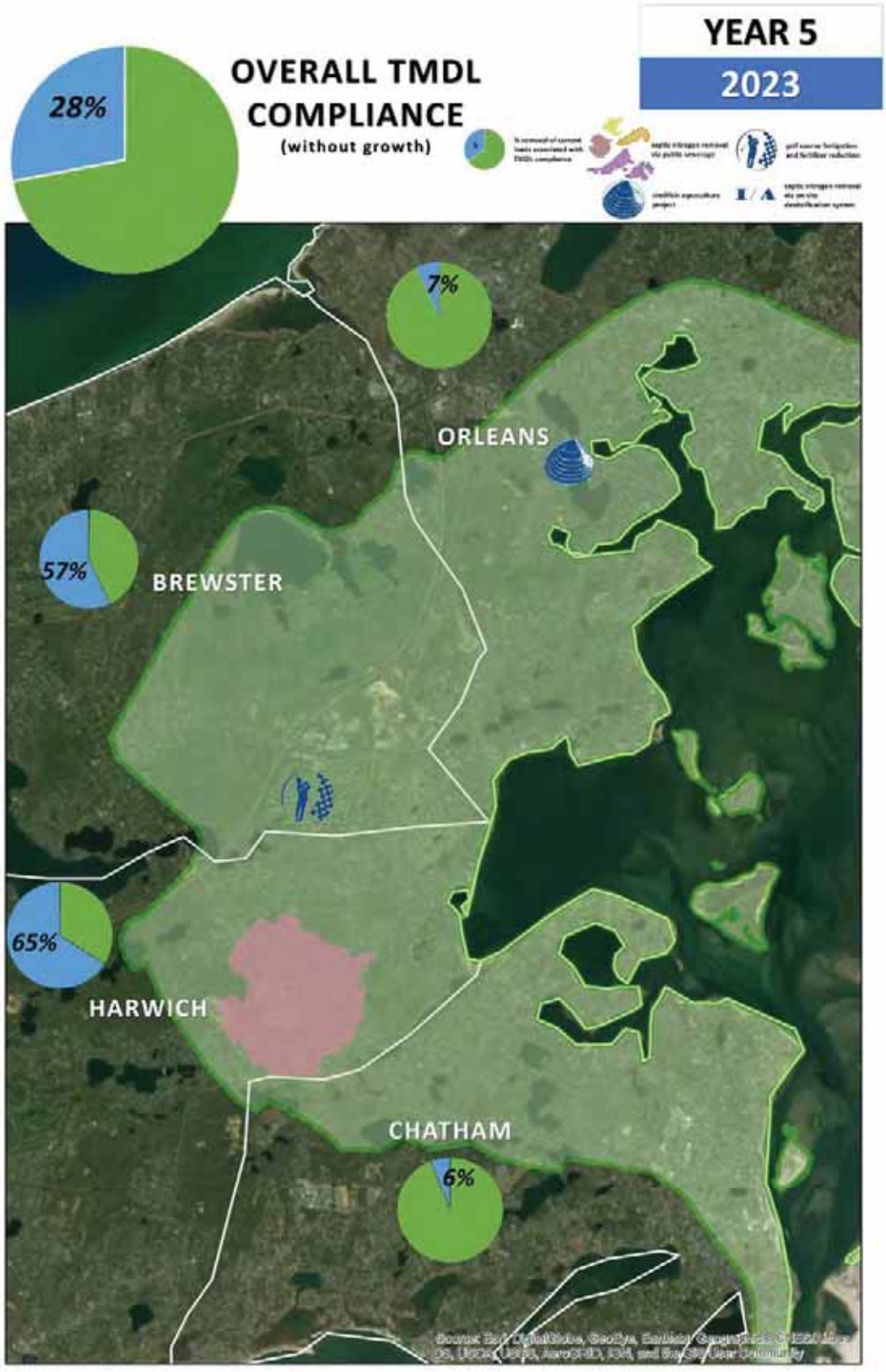


Figure 6. Location of Nitrogen Control Measures Expected to be in Place by Year 20

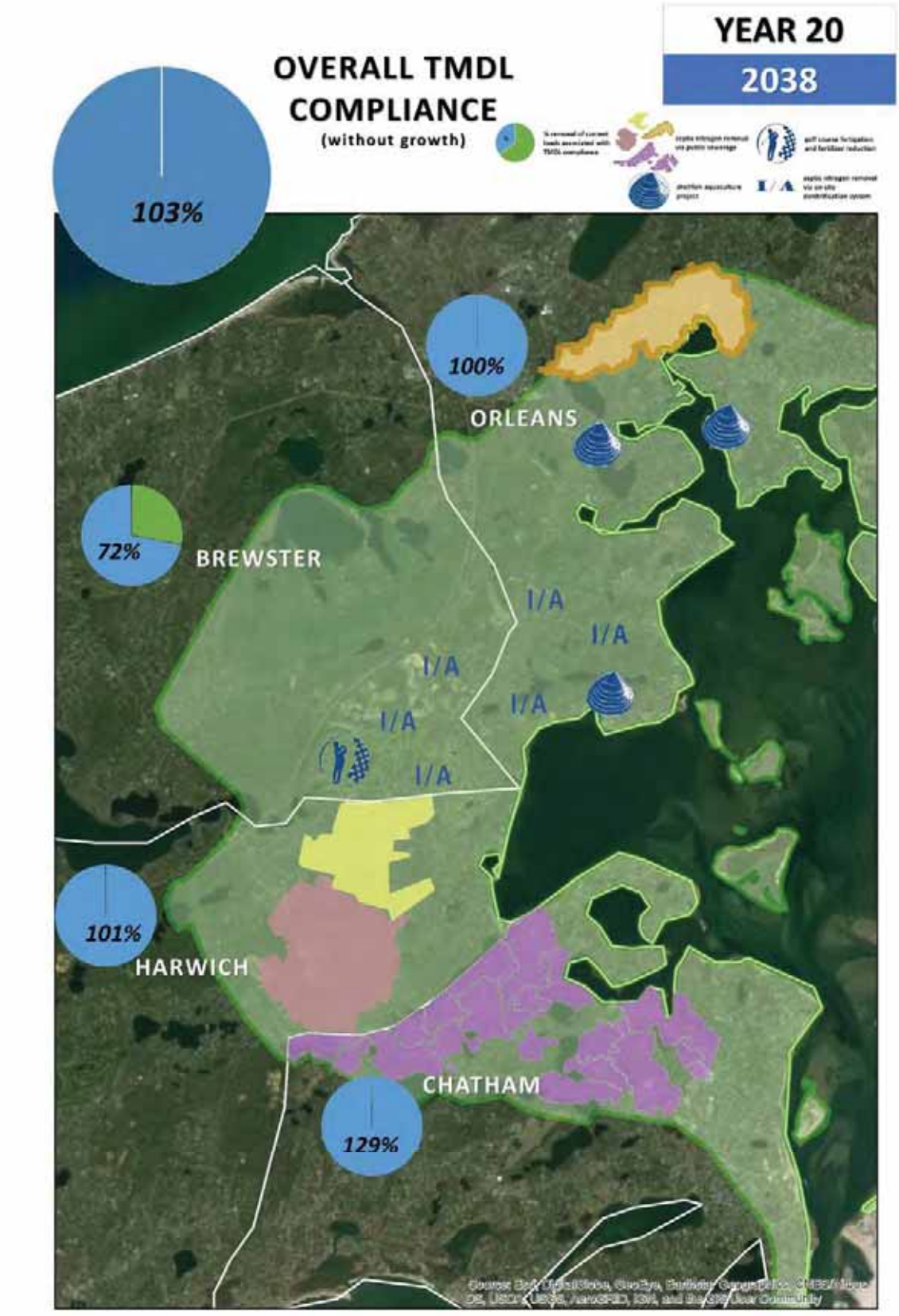
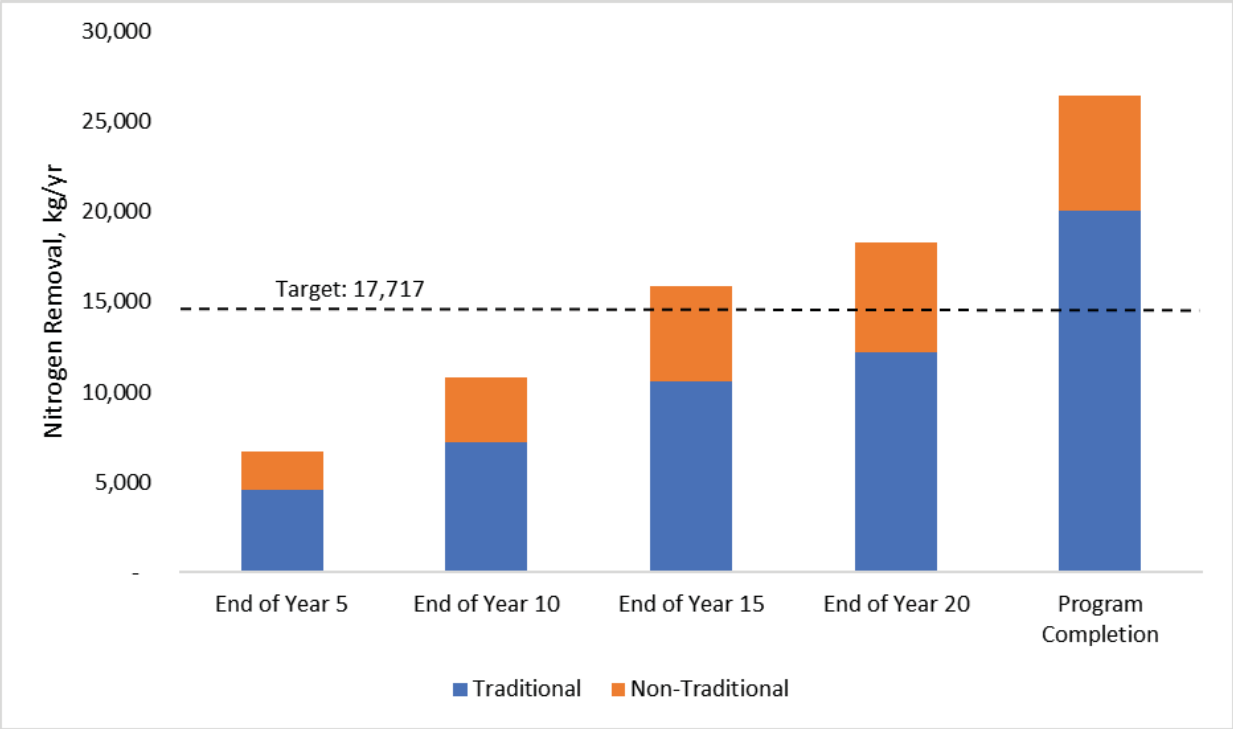


Figure 7. Cumulative Nitrogen Removal, kg/yr by Technology Type



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.

There are opportunities for nitrogen trading 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. The Towns should explore this opportunity. Brewster should also explore options for nitrogen trading in the Pleasant Bay subwatershed with Chatham and Harwich.

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

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 Lonnie's 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.

14.0 ADAPTIVE MANAGEMENT

Each town's plan incorporates adaptive management to allow monitoring results to direct or redirect implementation measures. A summary of each town's adaptive management approach is presented in Appendix D. While adaptive management will be an ongoing process, the Watershed Permit incorporates a regular 5-year updating of each town's plan, building on annual town reports documenting year-to-year progress.

15.0 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 must document implementation steps annually to inform the public, allow coordination with other towns and comply with the Watershed Permit. 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 will develop a standardized reporting form that each town will complete by the end of each February, 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 March. 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 TWMP and each town's CWMP;
- A spreadsheet-based estimate of the nitrogen load removals accomplished to date;
- A performance evaluation of each technology to identify performance challenges that should be corrected in the next year;
- 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, and to the five-year update of the implementation schedule and the Watershed Permit.

16.0 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). Among the purposes of the TWMP is to demonstrate consistency with the 208 Plan Update and provide a basis for watershed permitting of non-traditional technologies.

Specific guidance on the requirements for 208 Plan Update consistency has been provided by the Cape Cod Commission in Appendix G of the 2017 Addendum to the *Water Quality Management*

Plan Update. The 10 consistency requirements are listed below, with notations on how the four Pleasant Bay towns are meeting these requirements:

1. **Towns assume responsibility for controllable nitrogen for any part of the watershed within their jurisdictions** – As stated in the June 2017 Joint Resolution, the towns have assumed responsibility for removing their proportional shares of attenuated nitrogen load reduction necessary to achieve the TMDL, based on the towns' contributions of attenuated load, as further documented in this report.
2. **Plans meet nutrient reduction targets** – This TWMP shows that TMDLs will be met.
3. **Planning occurs at a watershed level with consideration of a hybrid approach**– This TWMP shows that the individual town plans vary in the degree to which they will employ non-traditional technologies. The composite of plans demonstrates a hybrid approach on a watershed basis, with 70% of the nitrogen reduction coming from traditional technologies, 6% from fertilizer reduction, and 24% from other non-traditional technologies.
4. **The public was engaged to gain plan consensus**– Each town plan has undergone extensive community review and vetting, as detailed in the respective plans.
5. **Plans include strategies to manage nitrogen loading from new growth** – Each town plan includes assumptions about growth in watershed nitrogen loads; see Appendix C. However, greater detail is needed to ensure that future phases are implemented in a timely fashion to keep pace with growth, particularly in Brewster and Orleans.
6. **Plans include adaptive management plans--** All town plans incorporate adaptive management programs, as detailed in Appendix E.
7. **Plans include monitoring programs**– 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. The Watershed Permit contains monitoring requirements for both traditional and non-traditional approaches.
8. **Plans include assessments of the towns' abilities to pay for the proposed work**—As summarized in Section 10 and Appendix D, all towns have addressed this issue.
9. **Towns commit to 5-yr reviews of 208 Plan Update consistency until water quality goals are achieved** – It is expected that an updated assurance of 208 Plan Update consistency will be obtained at the end of each 5-year segment of the Watershed Permit, based on the 5-year progress reports required by the Watershed Permit.

10. **Towns collaborate on nitrogen allocation, shared solutions, and cost saving measures** – 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 have executed an IMA for shared treatment and effluent disposal. This TWMP identifies other areas where joint action among the towns could be pursued such as nitrogen trading. A four-town IMA will be executed to support the Watershed Permit and confirm the towns' intentions to continue collaborative efforts.

This TWMP is intended to demonstrate the four towns' progress in meeting the requirements for consistency with the 208 Plan Update, and allows the Cape Cod Commission's certification to be an important supplement to the Watershed Permit.

17.0 PERMITS

Table 6 lists the permits that have been obtained or will be needed to implement most of the towns' nitrogen removal projects, based on current in-place permitting programs.

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. This TWMP has been prepared to support the application for the Pleasant Bay Watershed Permit. Discussions of permitting considerations for non-traditional technologies are contained in appendices to this TWMP, as follows:

Appendix F	Residential Fertilizer Controls
Appendix G	Commercial Fertilizer Reductions
Appendix H	Golf Course Fertigation
Appendix I	On-site Denitrification Systems
Appendix J	Shellfish Harvesting
Appendix K	Inlet Widening

These appendices describe the general intent of the technology, the nitrogen removal mechanisms, the important implementation steps, Watershed Permit conditions (where appropriate), and the methods for computing nitrogen removal credits.

Table 6. Traditional Permits Required for Town Plans

Permit or Approval	Brewster	Chatham	Harwich	Orleans
Groundwater Discharge Permit		✓	✓	✓
Reclaimed Water Permit Program and Standards				✓
Compliance with MA Wetlands Prot. Act	✓	✓	✓	✓
DEP Plan Review		✓	✓	✓
DEP Site Assignment			✓	✓
MEPA certificates		✓	✓	✓
Cape Cod Comm. 208 consistency review	✓	✓	✓	✓
Review by MA Nat. Heritage and Endangered Species Program		✓	✓	✓
Review by MA Historic Commission		✓	✓	✓
Compliance with local Historic District rules		✓	✓	✓
Local Permits		✓	✓	✓
MA DOT permits for work in state roads		✓	✓	✓
Local Board of Health Regulations-operation of small WWTFs	✓			✓
MA Surface Water Quality Certificate		✓	✓	✓
US CZM consistency review		✓	✓	✓
MA Div. Marine Fisheries approvals		✓	✓	
MA Div. Fisheries and Wildlife approvals		✓	✓	
US Coast Guard approvals		✓	✓	
US Army Corps of Engineers permits		✓	✓	✓
US NPDES general construction permit		✓	✓	✓
US NPDES MS4 stormwater permits	✓	✓	✓	✓

Commercial fertilizer reductions and golf course fertigation have already been accomplished at Captains Golf Course in Brewster, and the construction of the Muddy Creek bridge has accomplished inlet widening in Chatham and Harwich. The appendices describing these nitrogen reduction approaches (Appendices G, H and K) are intended to document how these technologies will be operated and monitored and how nitrogen removal credits will be computed.

On-site denitrification systems are proposed by Brewster and Orleans and each town will develop a town-specific program during the first five years of the Watershed Permit. The associated appendix in this TWMP (Appendix I) is intended to document current thinking on how such programs may be implemented, but each town's plan will allow this preliminary approach to be made more pertinent to the local conditions and town decisions.

The Watershed Permit will initially address commercial fertilizer reduction (Appendix G), fertigation (Appendix H) and shellfish harvesting (Appendix J). Other technologies will be added to the Permit as they are further developed. As more experience is gained, both the Permit Conditions and the appendices to this TWMP will be updated.

18.0 CONTINGENCY PLANS

DEP requires towns to prepare contingency plans to back up non-traditional approaches to nitrogen removal. Contingency plans are presented in Appendix L for Brewster and Orleans, with recommendations on how they should be made more robust.

19.0 AUTHORITY

The four towns have developed an Intermunicipal Agreement (IMA) to memorialize their intentions to address their respective responsibilities for nitrogen control, agree to a cooperative effort, and to be part of the DEP Watershed Permit. Town meetings are scheduled for the spring of 2018 that are intended to authorize the Boards of Selectmen to execute that IMA.

20.0 NEXT STEPS

The development of this Targeted Watershed Management Plan is an important step toward a coordinated four-town effort to improve water quality in Pleasant Bay. Several important steps should be taken to continue that effort:

This TWMP should be submitted to the Cape Cod Commission to obtain certification that the plan is consistent with the 208 Plan Update. Assuming favorable actions at spring 2018 town meetings, the Boards of Selectmen in each town should execute the inter-municipal agreement (IMA) that supports this plan and the Pleasant Bay Watershed Permit. With this TWMP, a 208 Plan consistency certification and a signed IMA, the four towns should collectively apply to DEP for the Watershed Permit. Upon anticipated receipt of the Watershed Permit, the Alliance will exercise its responsibilities as the entity charged with coordinating regional activities under the Permit.

Concomitantly, all four towns should continue to aggressively implement their nitrogen management plans, as summarized in Table 5.

The Alliance and member towns face multiple issues related to Watershed Permit implementation, administration, monitoring and reporting for which there is no guidance or precedent. The lack of clear regulatory pathways, cost models, monitoring and reporting requirements, and management frameworks hinders swift implementation of promising non-traditional technologies. The Alliance pledges to work with its member towns, DEP, EPA and the Cape Cod Commission to develop *Regional Watershed Permit Implementation Guidance for Nitrogen Management in Pleasant Bay*. As described below, the undertaking has the following interrelated objectives:

- optimizing non-traditional nitrogen reduction measures and exploring alternate funding mechanisms;
- providing a means for modeling the effects of optimized nitrogen reduction scenarios based on updated ecological conditions; and
- documenting steps required for effective implementation.

Pending funding, the following activities are proposed:

1. **Implementation and management protocols for non-traditional technologies.** Towns in the Pleasant Bay watershed are relying on non-traditional technologies as a cost-effective nitrogen reduction strategy. This task will identify steps for implementing non-traditional technologies and obtaining nitrogen reduction credit, and address how any of these steps might vary from town to town. Issues to be addressed for each technology include: development of sample regulations, bylaws, and policies needed for implementation; steps for obtaining required permits; analysis of implementation cost and cost sharing; performance monitoring and documentation required for nitrogen reduction credit; and best management practices for on-going municipal oversight and management.

2. **Nitrogen trading demonstration project.** Nitrogen trading is a promising strategy for optimizing cost savings while achieving reduction goals in shared watersheds. This task will develop a framework for employing nitrogen trading in the Pleasant Bay watershed and will provide a replicable template for other watersheds. This task will include: (a) criteria for selecting sites for nitrogen trading; (b) process for assessing economic costs of nitrogen mitigation; (c) procedure for negotiating and establishing nitrogen trading prices;

(d) analysis of legal and regulatory measures needed to implement nitrogen trading; and (e) development of a sample nitrogen trading agreement.

3. **Ecosystem monitoring and modeling for implementation.** The Massachusetts Estuaries Project model runs used as the basis for TMDLs were conducted in 2005 using data that is now fifteen years old. Since that time, major changes to the system have occurred, including formation of a second inlet. For this task, the Alliance will be the first regional watershed to: (a) update baseline ecosystem assessment data for water quality, eelgrass, benthic infauna, and other ecological indicators; and (b) develop updated linked watershed-water quality models to assess the impact of optimized TWMP scenarios.

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 2006
Final Pleasant Bay System Total Maximum Daily Loads for Total Nitrogen	Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs, MassDEP, Bureau of Resource Protection	May 2007
CCC Technical Memorandum - RE: Individual Town Nitrogen Loads by TMDL Watershed/Segments to Pleasant Bay	Cape Cod Commission (Ed Eichner)	Nov 28, 2007
Town of Chatham: Final Comprehensive Wastewater Management Plan and Final Environmental Impact Report	Stearns & Wheeler, LLC	May 2009
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	Oct 5, 2010
Town of Orleans: Comprehensive Wastewater Management Plan and Single Environmental Impact Report	Wright-Pierce	Dec 2010
Town of Brewster, Massachusetts: Integrated Water Resource Management Plan Phase II Final Report	Horsley Witten Group, Inc.	Jan 28, 2013
Town of Brewster, Massachusetts: Pleasant Bay Nitrogen Management Alternatives Analysis Report	Horsley Witten Group, Inc.	Mar 20, 2013
208 Plan: Cape Code Area Wide Water Quality Management Plan Update	Cape Cod Commission	Jun 2013
Final Comprehensive Wastewater Management Plan/Single Environmental Impact Report Town of Harwich, Massachusetts	CDM Smith	Mar 2016
Amended Comprehensive Wastewater Management Plan - Preliminary Draft (Prepared for the Town of Orleans, MA)	AECOM Technical Services, Inc.	Jun 2016
Pleasant Bay Composite Nitrogen Management Analysis	Wright-Pierce	Mar 2017

Table A-2. Unattenuated and Attenuated Watershed Loads, (kg/yr)

Subembayment	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%

Table A-2. Unattenuated and Attenuated Watershed Loads, (kg/yr)
(Continued)

Subembayment	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 (kg/yr)

Subembayment	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

Table A-3. Attenuated Watershed Load Removals (kg/yr)
(Continued)

Subembayment	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.

The Town of Chatham, in 2017, entered into an IMA with the Town of Harwich that will allow portions of Harwich, within the Pleasant Bay watershed, to be connected by sewer infrastructure to the Chatham WPCF for treatment. Chatham and Harwich have subsequently been listed to receive State Revolving Funds (SRF) for implementation of the initial phase of joint sewering to accomplish this task. In addition, Chatham continues with future phases of sewer implementation according to the Town-wide plan.

Chatham is proceeding under MEPA Certificate (EOEEA #11510) to implement Phase 1 of its plan to achieve TMDL compliance within all of its watersheds, including those related to Pleasant Bay.

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.

Under the Consensus Agreement, only the Meetinghouse Pond subembayment is scheduled for public sewering. If non-traditional methods are not found to be fully viable, the Town will need to utilize additional sewer extensions to meet TMDL requirements.

APPENDIX C

Town Plans Related to Managing Growth in Nitrogen Loads

APPENDIX C

TOWN PLANS RELATED TO MANAGEMENT OF GROWTH IN NITROGEN LOADS

BREWSTER

The Town has developed an Integrated Water Resources Management Plan (IWRMP). The IWRMP Phase II report was issued in final form in January 2013. Nitrogen management alternatives are further discussed in a March 2015 report addressing nitrogen loading to Pleasant Bay. As part of the IWRMP, the Town's consultant completed a build-out analysis which included parcel-by-parcel consideration of pre-existing, non-conforming lots to determine if future development is possible.

The build-out analysis conducted for the MEP technical report on Pleasant Bay indicated that attenuated nitrogen loads to the Bay from Brewster could increase by 19%. The Pleasant Bay sub-watershed was projected to have a 18% increase in loads; the Namequoit River sub-watershed would have a 90% increase; and the Arey's Pond sub-watershed would show little change.

Brewster is currently completing an updated build-out analysis by sub-watershed; preliminary figures indicate a growth in attenuated nitrogen load of 19% through build-out.

Brewster plans the following activities to manage growth in nitrogen load in its portion of the Pleasant Bay watershed:

- Continued acquisition of land for conservation;
- Regulations requiring the use of onsite denitrification systems for new development;
- Changes to the Town's water quality regulations to further control nitrogen loading for industrial and residential properties; and
- Changes to zoning and/or health regulations to limit future nitrogen loads.

CHATHAM

The Town of Chatham 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 2009 Final CWMP documents the town's expected 22% increase in wastewater flow within the Pleasant Bay portions of Chatham. This estimate represents a more detailed and current analysis than that conducted in the MEP technical report (which predicts a 11% increase).

The Chatham sewers will remove more septic nitrogen from the Pleasant Bay watershed than is needed because the septic nitrogen removal percentages will exceed those called for in the TMDL in all cases. Since the implementation of Chatham sewers in the Pleasant Bay watershed will not

occur until the later years of the watershed permit (and beyond), some of the expected growth will increase loadings to the Bay, to the extent it occurs in the next 10 years, but will be more than compensated for once sewers are installed.

Chatham manages growth through its zoning regulations and through Article 2 of its Sewer Use Regulations. The latter document allows a given property to be developed to the extent otherwise allowable under current Board of Health and Title 5 regulations. This "flow neutral" approach was deemed satisfactory by DEP for Chatham to receive enhanced funding for construction of its sewer system.

HARWICH

The Town of Harwich filed its final CWMP in March 2016 for regulatory approval which was received in August 2016.

The Harwich CWMP reports a build-out evaluation that predicts a town-wide increase in wastewater flow and nitrogen loading of 30%. In the areas to be served by the proposed sewer system, increases in septic nitrogen load are projected to range from 3% to 10% in five of the eight areas, 29% in the Herring River watershed, and 41% in the Pleasant Bay watershed. The basic build-out for the Pleasant Bay watershed is 15%; an additional 26% was added to account for expected extra growth in East Harwich related to rezoning. The build-out analysis conducted for the MEP report predicts a 34% increase in attenuated nitrogen load in the Harwich portions of the Pleasant Bay watershed.

The areas of highest growth in Harwich, including the East Harwich Village Center, are in the Muddy Creek sub-watershed.

Harwich has laid out a multi-phased plan to build sewers in nitrogen-sensitive watersheds. Phases 2 and 3 of that program address septic nitrogen loads in the Pleasant Bay watershed. The sewer layouts accommodate the growth expected there through build-out. That is, the completion of Phase 2 and 3 sewers will provide capacity for the 41% growth expected in the Pleasant Bay watershed. Only if growth exceeds that percentage will additional nitrogen controls be needed.

The Harwich CWMP also includes stormwater best management practices (BMPs) throughout town, and a review of potential open space acquisition parcels to minimize buildout impacts.

ORLEANS

The Town's CWMP was completed in 2010 and received MEPA and DRI approvals with conditions in 2011. In Section 4 of the CWMP, build-out is estimated to create a 36% increase in wastewater flow and nitrogen load. The Town adopted a planning horizon that was assumed to allow about two-thirds of the build-out flows and loads, or a 22% increase from current conditions. Those increases apply town-wide, and it was then assumed that the growth would occur uniformly in all watersheds impacted by Orleans (Pleasant Bay, Nauset system, Atlantic Ocean and Cape Cod Bay).

In conjunction with the Town ‘s supplemental planning activities, its consultant prepared a build-out analysis specific to the Pleasant Bay watershed in 2018. That analysis found:

- 2,912 existing dwellings in the watershed
- 916 potential new dwellings
- 657 potential accessory dwellings

Assuming that only 25% of the potential accessory dwellings would be built, these data indicate 1,080 new dwellings at build-out.

By applying average per-dwelling flows from town-wide 2014-2015 data, the Town estimates there will be a 26% increase in wastewater flows and a 26% increase in watershed nitrogen loads at build-out in the Pleasant Bay watershed. Build-out percentages for each Pleasant Bay sub-watershed are not available.

Orleans has identified the following measures to influence growth in the nitrogen load in Pleasant Bay:

- Continued open space acquisition
- Maintaining one-acre zoning in the R District
- Reducing potential for new apartments in the Rural Business District
- Implementing flow-neutral regulations sufficient to allow enhanced funding by DEP
- Maintaining the Orleans Nutrient Regulation in un-sewered areas.

These steps are to be implemented in conjunction with zoning changes that will help divert growth to the downtown area, which is to be sewered and which is not in the Pleasant Bay Watershed.

APPENDIX D

Town Financial Plans

APPENDIX D

SUMMARY OF TOWN FINANCIAL PLANS

BREWSTER

Brewster's plan for nitrogen reduction in the Pleasant Bay watershed includes a reduction in fertilizers at the Captains Golf Course, a recapture of nitrogen through the irrigation well at the course, residential fertilizer management and the implementation of a program to build and operate on-site denitrification septic systems for a number of homes and businesses in the watershed. Little or no additional funding is needed for the golf course and residential fertilizer management components of the plan. However, there is a cost for the implementation of the on-site septic treatment systems and the Town has begun deliberations on how to finance their design, construction and operation. Final funding plans will be completed during the pilot testing of these systems in the first five years of the Watershed Permit.

The Town expects that a portion of the cost of these systems will be funded by the property owner, with the remaining portion covered by the Town. The cost sharing percentage has not yet been determined. Brewster anticipates participating in any zero-interest State Revolving Loan Fund financing available through the implementation of the Watershed Permit, and is also evaluating the use of general tax revenue to finance the Town's cost for the systems. Financing of the property owner's portion of the cost through a betterment program, similar to the Town's road betterment program, will also be considered. Funding provided by the Town may be tied to an incentive program where property owners can obtain more funding in an initial phase of implementation in an effort to accelerate the restoration of Pleasant Bay.

The impact to property owners will depend on the final cost share approved by the Town. The current estimated cost for the onsite treatment systems is $8,000 to $12,000 and will vary from parcel to parcel. There will be an annual cost for operation and maintenance that will be determined during the pilot phase of the project. If a betterment program is adopted, the property owner's capital cost could be financed over many years. The funding provided by the Town will not impact its ongoing ability to fund other Town services.

CHATHAM

The Town's CWMP financing plan is outlined in Section 11.4 of the 2009 Chatham CWMP. As originally proposed, the Town anticipated appropriations of $15 to $20 million every two years for design and construction. Over the last eight years Chatham has maintained that approach.

Chatham has appropriated over $150 million since 2010 and has successfully obtained 0% SRF funding for each of its sewer infrastructure projects, and an $18 million grant from USDA for the Water Pollution Control Facility (WPCF) upgrade. All projects to date, and moving forward, are funded on the Town's tax rate. This approach was taken to provide fiscal fairness and to use debt drop-off for increased affordability. This approach was developed through extensive efforts of the Town Manager and Finance Director to develop and present an approvable financing plan for implementation to the community. The Town agreed to this method following several public

meetings and presentations during and following completion of the CWMP with the approach independently reviewed for the Board of Selectman by an outside consultant not related to the planning/design consultant.

The Town created its own cost calculator for residents to estimate the impact to their tax rate based on their property value.

The Town to date has not adjusted its sewer user fees, and, on an ongoing basis, is collecting data on sewer connection costs paid by property owners.

HARWICH

Harwich's nitrogen management plan has a cost of between $2.6 to $47.2 million for each phase of the program for a total potential program cost of $230 million. This total includes an additional allowance of $3.8 million for the Muddy Creek and Cold Brook attenuation projects and includes $1.3 million allowances for the study and restoration of Hinckley's Pond, Seymour Pond, Bucks Pond and John Joseph Pond.

Harwich's Wastewater Implementation Committee (WIC) evaluated various cost recovery models. The WIC received input from several Town representatives. During these discussions, three tenets developed. Most importantly, the WIC felt that everyone in the Harwich community will receive benefits from restored water quality and that everyone contributes in some manner to the biggest problem – nitrogen coming from on-site septic systems.

To this end, one if the Committee's recommendations was that capital costs for Harwich's wastewater plan be funded primarily through property taxes. Future use of various user fee possibilities was explored and may be utilized if warranted.

Harwich's 40-year Plan will be constructed in phases:

Phase 1: 2013 to 2015	$2,550,000
Phase 2 2016 to 2020	**$24,300,000 (Pleasant Bay Watershed)**
Phase 3: 2021 to 2025	**$21,010,000 (Pleasant Bay Watershed)**
Phase 4A: 2026 to 2028	$34,400,000
Phase 4B: 2029 to 2032	$22,300,000
Phase 5: 2033 to 2037	$23,200,000
Phase 6: 2038 to 2042	$21,200,000
Phase 7: 2043 to 2047	$47,200,000
Phase 8: 2048 to 2052	**$33,900,000 (Pleasant Bay Watershed)**

This results in a total potential cost of $230 million over 40 years. However, the CWMP is a living document and the Town will continue to pursue means to lower that overall cost.

The near-term plan calls for design and construction of the Pleasant Bay watershed sewer collection system such that initial flow to the Chatham facility will start in 2021. Since near-term needs are capital only, property taxes will be used to service the debt. Once customers are connected and utilizing the system, they will be charged for a portion of the system operation and maintenance costs.

The average tax increase for a resident in a $350,000 assessed value home to fund the Phase 2 amount is about $150 annually assuming all construction costs are recovered via general property tax. The average annual tax increase for the entire 40-year wastewater program is about $400. Those connected to a sewer would also pay a portion of the operation and maintenance costs and the initial hook-up costs to connect their home to the pipe in the street. It is assumed the Town would utilize the State Revolving fund (SRF) loan program at zero- to two-percent interest over a 30-year bond to fund this program.

The Harwich Board of Selectmen endorsed a cost recovery policy for wastewater program implementation that utilizes the combination of town-wide property taxes, an infrastructure investment fund and a sewer enterprise account based on water consumption. Where appropriate, grant funds will be applied for, and if awarded, will be used to offset costs as applicable. This policy will be utilized to support the implementation of at least the first three phases of the eight-phase program and is subject to change should other potential beneficial funding programs become available to the Town and the actions of town meeting and subsequent ballot results.

ORLEANS

Orleans' Amended CWMP recommends traditional sewering of 24% of total properties. Non-traditional methods will be used to meet TMDL requirements, including aquaculture projects, PRBs, and enhanced individual septic systems. Total capital cost of the program (in FY17 dollars) is $83,000,000. This includes projects that are predominantly outside the Pleasant Bay watershed.

Orleans will use rely on a combination of betterments and property taxes to pay for the capital costs of the program. Traditional sewering is expected to be divided into collection system costs paid through betterments, and treatment facility/ disposal costs paid through general taxation. The rationale is that the whole community will benefit from a treatment facility with septage handling capacity, so those costs will be borne by taxpayers.

The Town of Orleans is moving forward with final design for public sewers in its downtown in FY19. This area is located outside of the Pleasant Bay watershed but is a precursor to future efforts that will benefit the bay. In planning for a downtown sewer system and non-traditional technologies in other locations, the Town evaluated the annual costs to commercial and residential property owners, including those located outside the sewered area. The results are as follows, and pertain to the entire Orleans program, not just the portion in Pleasant Bay:

METHOD 2 TRADITIONAL COSTS ONLY Collection System 100% Betterments WWTF/Effluent Disposal 100% Property Taxes						
Area of Orleans	**Number of Users in Category**	**Average Property's Additional Tax Burden (100% WWTF/Effluent Disposal Costs only)**	**Average Total Betterment Amount (100% for Collection System Costs only)**	**10-Year Term @ 2% Interest**	**20-Year Term @ 2% Interest**	**30-Year Term @ 0% Interest**
Non-Residential - Sewered	**477**	**$85**	**$19,373**	**$2,150**	**$1,172**	**$645**
Residential - Sewered	**1,084**	**$60**	**$13,108**	**$1,455**	**$793**	**$436**
Unsewered Areas	**4,999**	**$125**	**$0**	**$0**	**$0**	**$0**

The above table demonstrates the costs to Orleans property owners to complete a downtown sewer project and proceed with non-traditional technologies. The calculations above assume 0% interest financing for construction costs, and 4% borrowing for non-eligible costs over 20 years. The Town has developed a 40-year repayment schedule for full CWMP implementation that will be refined as the results of non-traditional demonstration projects allow the Town to adapt its plan.

The Town of Orleans is fully aware that wastewater management infrastructure is one of many services that that the municipality provides its residents. In 2018, the Town was in construction on a new Police Station and DPW facility, and is working to address all of its facility and infrastructure needs while maintaining affordability in its tax structure. This is an ongoing effort, and wastewater management needs are acknowledged as a necessary part of the Town's capital planning program moving forward.

APPENDIX E

Town Adaptive Management Plans

APPENDIX E

Adaptive Management Plan Summary for Towns in the Pleasant Bay Watershed

BREWSTER

The Town of Brewster has developed a plan to meet its nitrogen reduction requirements for the Pleasant Bay TMDL. The plan includes three actions that have already occurred; 1) fertilizer reductions at the Captains Golf Course; 2) the recapture of nitrogen through the golf course irrigation well; and 3) the implementation of a town-wide fertilizer bylaw. These actions constitute 56% percent of the total reduction for the Town. Brewster plans to use on-site denitrifying septic systems to meet the remainder of its nitrogen reduction goal.

If the on-site denitrifying systems do not work as planned, the town has a contingency plan to develop a neighborhood sewage collection and treatment system in the upper reaches of the Pleasant Bay watershed. This option was presented in the Town's Pleasant Bay Nitrogen Management Alternatives Analysis Report (HW March 20, 2015). The neighborhood is sufficiently large enough to provide the necessary nitrogen reduction to replace the on-site system option, and there is land available for the treatment and disposal facilities.

CHATHAM

Chatham's CWMP relies exclusively on sewering so that restoration targets will be highly dependent on wastewater treatment plant (WWTP) performance and verification will be based on effluent monitoring at the WWTP and monitoring at the sentinel stations within Pleasant Bay as well as mapping eelgrass and monitoring benthic infauna. The environmental monitoring will track water quality and habitat changes within Pleasant Bay. As trends are observed, it may be necessary to reevaluate the implementation plan for possible mid-course corrections. The CWMP identified the following steps for its Adaptive Management Plan:

1. ***Implementation of the CWMP:*** Areas of town affecting Pleasant Bay will be sewered in both Phase 1 (extending to 2030) and Phase 2 (extending to 2040).

2. ***Documentation of Capital Expenditures:*** This will verify that Chatham is meeting its obligations as prescribed in the CWMP.

3. ***Compliance with the Groundwater Discharge Permit:*** Monthly discharge monitoring reports will verify WWTP performance.

4. ***Reporting on Groundwater Elevation and Quality Monitoring in the Vicinity of the WWTP:*** This is conducted as part of the groundwater discharge permit monitoring requirements.

5. ***Reporting on Estuarine Water Quality Monitoring:*** This monitoring is ongoing and coordinated with the Pleasant Bay Alliance.

6. ***Habitat Assessments:*** Habitat monitoring programs will be focused primarily on eelgrass mapping and benthic infaunal analysis. MassDEP will continue its eelgrass mapping program while benthic infaunal analysis monitoring programs are still under discussion.

7. ***Coordination with the Pleasant Bay Alliance for Regional Model Runs:*** This anticipates the need to update the MEP model for Pleasant Bay to address the dynamic nature of the system and to provide guidance on how to best address physical changes that may affect water and habitat quality.

8. ***Periodic Watershed Assessments and Other Evaluations:*** Assessments will be completed every 5 to 10 years to review water consumption, septic system discharges, WWTP performance and non-wastewater nitrogen loads. These data will be compared to water quality data to further deduce correlations between mitigation activities and impacts on water quality and habitat health.

9. ***Evaluate Possible Changes to the CWMP as Part of Adaptive Management:*** The above tasks will guide the community, in consultation with MassDEP and the CCC, in determining if changes to the CWMP are warranted.

HARWICH

The AMP associated with Harwich's recommended program will have several components to allow for systematic review of the implementation phase and the resulting changes to water quality, community growth, and economic viability. Specifically, the following items are proposed to comprise the AMP:

1. ***Technical Review Committee:*** A technical review committee (TRC) will be established to review the progress of implementing the CWMP recommended program and the potential need to modify the plan during the implementation phase.

2. ***Water Quality Monitoring:*** The Town plans to continue monitoring water quality at the sentinel and check stations. Monitoring will move from the detailed sampling program required for the MEP modeling to periodic monitoring to track the progress of the program's implementation.

3. ***Habitat Monitoring:*** The Town anticipates that MassDEP will continue eelgrass mapping, to assess the results of the recommended program's implementation. Benthic habitat monitoring may also be beneficial to evaluate the effects of the program's implementation. The feasibility and responsibility for such monitoring will be determined through discussion between the Town, CCC, and MassDEP.

4. ***Wastewater Treatment Plant/Groundwater Discharge Reporting:*** The Towns of Harwich and Chatham will be required through their groundwater discharge permits from MassDEP to develop regular compliance reports.

5. ***CWMP Implementation and Funding Status:*** The TRC will be provided an annual implementation progress report following each calendar year containing an update regarding the implementation of the recommended program and the status of the project's funding.

6. ***Community Growth Status:*** Each year, concurrent with preparation of the implementation progress report, a written update will be prepared and submitted to the TRC describing community growth both in the community at-large and within the sewered areas.

7. ***CWMP Recommended Program Modifications:*** Based on the information provided, the TRC may recommend updates or modifications to the CWMP recommended program over the course of the implementation phase.

ORLEANS

Orleans has an approved CWMP from 2010 that described its Adaptive Management Plan; however, the town is developing an amended CWMP that relies on both traditional and non-traditional approaches and is therefore modifying its original plan. The following tasks will be incorporated in the revised plan:

1. ***Baseline Water Quality Data Assessment:*** This task is to evaluate the adequacy of sampling locations and sampling methodology (protocols and parameters) in order to accomplish the following monitoring objectives:

    - Establish current baseline conditions for evaluating water quality improvements as the town's overall nutrient management program is implemented;
    - Establish baseline conditions for evaluating specific demonstration projects;
    - Allow Massachusetts Estuaries Project (MEP) model revisions where physical conditions and nutrient loads have changed;
    - Verify MEP model runs made as part of CWMP updates; and
    - Determine data gaps and recommend additional monitoring to meet the above monitoring goals.

2. ***Long Term Water Quality Monitoring:*** This will continue the water quality monitoring program in conjunction with the Pleasant Bay Alliance in order to track changes in water quality as a result of land based mitigation strategies or physical changes in Pleasant Bay due to its dynamic nature. The monitoring program will be continuously evaluated to provide pertinent data as conditions warrant.

3. ***Demonstration Project Monitoring:*** The demonstration projects currently active in Orleans (shellfish in Lonnie's Pond and the PRB at the Nauset Middle School) will be evaluated for effectiveness and, depending on results, will be assigned nitrogen removal credit, as appropriate, for integration in the overall mitigation plan.

4. ***MEP Model Update:*** The MEP model for Pleasant Bay will be updated to account for physical changes in the system since the original 2001 to 2004 study period. The updated model can then run scenarios based on the activities proposed under the amended CWMP to evaluate effectiveness.

5. ***Stormwater and Fertilizer Monitoring:*** The town has two consultants evaluating the effectiveness of the town's efforts at fertilizer BMPs through a fertilizer by-law and protocols for fertilizing town properties. The town is implementing its NPDES Phase II stormwater permit as well. The data collected to determine the effectiveness of these programs can then be incorporated in mitigation scenarios run through the MEP model to predict their impact on water quality improvement.

APPENDIX F

Permitting Considerations for Residential Fertilizer Controls

APPENDIX F

Permitting Considerations for Residential Fertilizer Controls

BASIC CONCEPT

Lawn and garden fertilization is a very widespread source of nitrogen loading. While one home or even one neighborhood do not represent a large nitrogen load, a watershed-wide reduction in fertilizer use is a low-cost method of estuary protection.

FATE OF APPLIED NITROGEN

Fertilizer applied to lawns and gardens is typically of the slow-release type. When applied to vegetated surfaces, the nitrogen will take one or more of five routes:

- Mineralization of organic forms into ammonium and nitrate
- Nitrification of ammonia into nitrate
- Denitrification of the nitrate producing nitrogen gas
- Uptake in the grass as organic nitrogen
- Leaching to the groundwater

If the grass is removed from the lawn after cutting, the nitrogen is transported to a disposal or recycling site and may be removed from the watershed. If the grass is mulched and left in place, its organic nitrogen will mineralize over time and be available to support additional grass growth, or will leach, or will be denitrified.

If the property owner spills or inadvertently applies fertilizer on a paved surface, and fails to clean up, then the fertilizer nitrogen is likely to directly impact the groundwater through stormwater facilities and may not be taken up by vegetation.

BASELINE CONDITIONS

The MEP watershed model estimated fertilizer nitrogen loads based on 5,000-square-foot lawns, and nitrogen leaching at 0.22 lb per 1,000 square feet, assuming that 20% of the nitrogen that is applied reaches the groundwater.

Watershed-wide, the MEP baseline is 7,100 lb/yr of nitrogen from residential and commercial lawns, slightly more than the estimated total leaching from the four golf courses (roughly 5,300 lb/yr). The MEP estimate is noted to be conservative, but it does not explicitly address fertilizer use in home gardens.

ELEMENTS OF AN EFFECTIVE MUNICIPAL CONTROL PLAN

It is generally agreed that municipal bylaws or regulations are the most appropriate ways to effect water-quality-related improvements in residential fertilize practices. An effective town bylaw or regulation should address:

- Reducing the lawn area that is fertilized
- Reducing the fertilizer application rate
- Use of slow-release fertilizers
- Improving the fertilizer application practices to avoid days prior to expected heavy rainfall, eliminate spillage, avoid application to non-pervious surfaces, etc.
- Greater public awareness of fertilization practices

EXISTING TOWN BYLAWS AND REGULATIONS

Bylaws have been enacted to influence nitrogen leaching from residential fertilization in:

- Brewster
- Chatham
- Orleans

In 2013, the Cape Cod Commission created a cape-wide Fertilizer Management District of Critical Planning Concern that allows towns to adopt fertilizer management regulations at the local level. The Commission has established guidelines on acceptable local regulations and has produced consumer-awareness materials. The Commonwealth of Massachusetts has addressed the ability of towns to control fertilization through statute, and the UMass Extension Service has developed Best Management Practices. The Town of Harwich has relied on the Massachusetts program as a substitute for a local bylaw.

BASIS FOR NITROGEN REMOVAL CREDIT

Since residential lawn/garden fertilization is such a widespread practice, it is impractical to try to accumulate information on the amount of fertilizer used at each home, or the area to which it is applied. It is generally agreed that a municipal bylaw addressing the points listed above should, over time, achieve a 25% reduction in fertilizer leaching compared with the MEP baseline.

A 25% reduction from the MEP-estimated fertilizer loads would be a reduction of 809 kg/yr across the watershed. By town, the nitrogen removals would be:

Brewster	121 kg/yr
Chatham	247 kg/yr
Harwich	200 kg/yr
Orleans	241 kg/yr

In light of the watershed-wide removal requirement of 17,717 kg/yr, a 25% reduction in fertilizer loads will address about 5% of the problem. (Note: some lawn fertilization occurs up-gradient of natural attenuation sources, so these statistics overstate somewhat the relative importance of fertilizer controls.)

Orleans is basing its nitrogen control plan on the above-noted 25% reduction and Brewster's 2015 plan include a 50% reduction. To the extent that actual reductions in Brewster and Orleans are less than expected, other plan components must be adjusted to make up the difference. Neither Chatham nor Harwich has formally included the 25% credit in its plans, so any actual reduction in fertilizer leaching will allow other plan components to be cut back somewhat.

Harwich's reliance on the state allowance is viewed as less likely to achieve the 25% reduction that should occur with the types of local bylaws adopted by the other towns. It would be a reasonable, low-cost measure for Harwich to institute its own bylaw to more fully take advantage of this nitrogen control approach.

APPENDIX G

Permitting Considerations for Commercial Fertilizer Reductions

APPENDIX G

Permitting Considerations for Commercial Fertilizer Reductions

BASIC CONCEPT

Golf courses can be a significant source of nitrogen loading, and closer control of application rates can have meaningful benefits in estuary protection. Brewster intends to use this approach to reduce the nitrogen loading from the municipally-owned Captains Golf Course in the Pleasant Bay watershed. It could also be used at other golf courses within the watershed.

FATE OF APPLIED NITROGEN

Nitrogen applied to golf courses is typically of the slow-release type. When applied to vegetated tees, greens and fairways, the nitrogen will take one or more of five routes:

- Mineralization of organic forms into ammonium and nitrate
- Nitrification of ammonia into nitrate
- Denitrification of nitrate producing nitrogen gas
- Uptake in the grass as organic nitrogen
- Leaching to the groundwater

If the grass is removed from the site after cutting, the nitrogen is transported to a disposal or recycling site and is presumably removed from the watershed. If the grass is mulched and left in place, its organic nitrogen will mineralize over time and be available to support additional grass growth, or will leach, or will be denitrified.

The baseline condition is the estimated nitrogen load from the golf course as reported in the 2006 MEP report. The MEP report, and the proposed reduction strategy here, are founded on an assumption that 20% of the chemical fertilizer applied to the course leaches into the groundwater. Specifically, the MEP load estimate is based on 26,700 lb/yr of applied fertilizer nitrogen and 5,340 lb/yr reaching the groundwater.

SPECIFIC CONDITIONS AT CAPTAINS GOLF COURSE

The following facts are reported in the March 2015 document *Pleasant Bay Nitrogen Management Alternatives Report*, prepared by Horsley Witten:

- The fertilizer applications at the Captains course in 2009 to 2010 were 14,900 to 18,000 lb/yr, indicating an average reduction of 10,250 lb/yr compared to the estimates made in the MEP.
- In 2014, fertilizer applications were even lower, indicating a reduction of 12,900 lb/yr.
- There was been an increase in groundwater nitrogen concentrations as measured at golf course monitoring wells, between 2010 and 2015.

Brewster has requested a nitrogen reduction credit of 2,050 lb/yr reduction in groundwater nitrogen load, based on the reported 10,250 lb/yr reduction in application rate and the leaching rate of 20% used in the MEP model.

OUTLINE OF FORMAL PROGRAM

To formalize the fertilizer reduction program at the Captains Golf Course, and gain DEP approval under the Watershed Permit, the Town will undertake a series of actions. These actions will include:

1. Instituting a formal tracking procedure for fertilizer purchase, storage and use at the Captains course. This will include an annual evaluation of the nitrogen contribution from golf course fertilizers based the quantity of fertilizers applied in a given years and the leaching rate assumptions used in the MEP model.
2. Conducting a nitrogen leaching evaluation in Year 1 of the permit based on available data, including the historical nitrogen fertilization rates at the golf course, data from the ongoing golf course groundwater monitoring program and literature research on the assimilation of nitrogen in soils over time. This analysis will evaluate various phenomena such as fertilizer-related nitrogen retention in the soil and release time. This analysis will be provided to DEP in the first annual report. In consultation with the Town, DEP may determine the need for additional water quality sampling, including the possible installation of lysimeters under the golf course, to further understand and document fertilizer leaching to groundwater.

The formal fertilizer reduction program would be based on the following assumptions:

1. The golf course is (and will continue to be) town-owned.
2. The lead town contact is Chris Miller, Natural Resources Director.
3. The fertilization will be conducted by town employees or by contractors under Town supervision
4. The record keeping for fertilizer applications will be carried out under the terms of a written protocol.
5. Any water quality samples, including those for nitrogen analyses (nitrate, ammonia and TKN), will be analyzed by a DEP-certified laboratory.
6. DEP will review and approve the annual computation of load reductions.
7. DEP will review the nitrogen leaching evaluation and work with the Town to evaluate if any changes to the nitrogen loading assumptions are appropriate.

BASIS FOR NITROGEN REMOVAL CREDIT

Monitoring of the fertilizer reduction program should include:

1. Formal accounting of all fertilizer purchased by type and nitrogen content.
2. Documentation of fertilizer quantities on hand at beginning and end of year.
3. Quantification of fertilizer nitrogen applied in the given year, both in total and on a pound-per-1000-sf basis.

Each year's data will be summarized in the annual report documenting the reduction in nitrogen load that has occurred. That load reduction estimate will be based on the records of fertilizer applied and the MEP model's leaching percentage, unless more accurate leaching data become available.

The nitrogen load reduction due to reduced fertilizer use will be evaluated in context of the estimated nitrogen reduction as a result of fertigation practices.

SAMPLE CALCULATIONS

To help understand the proposed computation of nitrogen load removal, the following sample calculations are provided to illustrate the approach:

Load reduction based on curtailment of fertilizer use

1.	Fertilizer nitrogen purchased during the year	15,000 lb
2.	Fertilizer nitrogen in storage at beginning of the year	2,000 lb
3.	Fertilizer nitrogen in storage at end of the year	1,000 lb
4.	Fertilizer use in the year	
	• Purchased	15,000 lb
	• Change in storage	+1,000 lb
	• Applied	16,000 lb
5.	Fertilizer leached in year (at 20%)	3,200 lb
6.	MEP baseline leaching	5,340 lb
7.	Reduction in leaching compared to MEP	2,140 lb/yr (970 kg/yr)

APPENDIX H

Permitting Considerations for Golf Course Fertigation

APPENDIX H

Permitting Considerations for Golf Course Fertigation

BASIC CONCEPT

Golf course fertigation involves the capture of groundwater nitrogen through irrigation wells, whose output is used to irrigate and fertilize a golf course. Brewster intends to use this technology to reduce the impact of the municipally-owned Captains Golf Course in the Pleasant Bay watershed.

FATE OF APPLIED NITROGEN

Nitrogen collected from the fertigation wells is likely to be entirely in the form of nitrates. When applied to vegetated tees, greens and fairways, that nitrate will take one or more of three routes:

- Denitrification in the soil
- Uptake in the grass as organic nitrogen
- Leaching to the groundwater

If the grass is removed from the site after cutting, the nitrogen is transported to a disposal or recycling site and is presumably removed from the watershed. If the grass is mulched and left in place, its organic nitrogen will mineralize over time and be available to support additional grass growth, or will leach, or will be denitrified.

The direct application of nitrates in the irrigation water (and the secondary release of mineralized organic nitrogen from the clippings) should result in a reduction in chemical fertilizer addition

The baseline condition is the estimated nitrogen load from the golf course as reported in the 2006 MEP report. That estimate is based on the assumption that 20% of the chemical fertilizer applied to the course leaches into the groundwater. It also assumes that no nitrogen is recaptured by the irrigation well. Specifically, the MEP load estimate is based on 26,700 lb/yr of applied fertilizer nitrogen and 5,340 lb/yr reaching the groundwater.

SPECIFIC CONDITIONS AT CAPTAINS GOLF COURSE

The following facts are reported in the March 2015 document *Pleasant Bay Nitrogen Management Alternatives Report*, prepared by Horsley Witten:

- The single existing golf course irrigation well pumps about 30 million gallons per year.
- From 2006 to 2010, the recovered groundwater had a nitrogen concentration 1.0 to 5.5 mg/l, with most measurements falling between about 2.0 mg/l and about 3.0 mg/l.

The current fertigation program is removing approximately 500 lb/yr of nitrogen, based on these data and an assumed leaching rate of 20%. The reduction may different from that figure if fertigation leaching is shown to be different from the leaching of commercial fertilizer.

OUTLINE OF FORMAL PROGRAM

To formalize the fertigation system at the Captains Golf Course, and gain DEP approval under the Watershed Permit, the Town will undertake the following actions:

1. Utilize the existing irrigation well and monitor total nitrogen concentrations in the water withdrawn from the well and applied to the golf course.
2. Calculate the total amount of nitrogen withdrawn from the well and calculate the nitrogen load reduction assuming that 20% of this nitrogen returns to the aquifer as leachate.
3. Evaluate if additional fertigation wells will optimize capture of nitrogen and if this could lead to additional credit.
4. As part of the nitrogen leaching evaluation described in Appendix G, evaluate the leaching rate of return irrigation water in the context of ongoing fertilization practices.

The formal fertigation program would be based on the following assumptions:

1. The golf course, irrigation well is, and will continue to be, town-owned.
2. The lead town contact is Chris Miller, Natural Resources Director.
3. The fertigation program will be operated and maintained by town employees and or conducted under Town supervision if contracted out.
4. Flow meters on the irrigation wells used to document compliance with the Water Management Act Permit for the golf course will be used to quantify the volume of water pumped each year
5. The irrigation well flow meters will be calibrated biennially.
6. Any water quality samples, including those for nitrogen analyses (nitrate, ammonia and TKN), will be analyzed by a certified DEP laboratory.
7. DEP will review and approve the computations of annual nitrogen load removal.
8. DEP will review the nitrogen leaching report and work with the Town to evaluate if the there is sufficient information to revise the nitrogen leaching assumptions for irrigation water.

BASIS FOR NITROGEN REMOVAL CREDIT

Monitoring of the fertigation project should include:

1. Monthly measurement of flow pumped from each irrigation well and the associated nitrogen concentration (based on the collected data, the measurement frequency may be reduced after Year 1.)
2. Calculation of the nitrogen load reduction based on a 20% leaching rate for returned irrigation water.
3. In consultation with the Town, DEP will determine if periodic measurement of recharge nitrogen concentrations in lysimeters is needed to estimate leaching rates.

The estimate of nitrogen load removal via fertigation should be coordinated with the estimated reduction in fertilizer applied; see Appendix G on this subject.

SAMPLE CALCULATIONS

To help understand the proposed computation of nitrogen load removal, the following sample calculations are provided to illustrate the approach:

Load reduction based on nitrogen removed from aquifer

1. Irrigation volume: 30 Mgal/yr
2. Irrigation N concentration: 2.5 mg/l
3. Irrigation N load applied: 630 lb/yr
4. Irrigation N load leaching to groundwater (based on 20% leaching): 130 lb/yr
5. Commercial fertilizer load replaced: 630 lb/yr
6. Commercial fertilizer leaching avoided (based on 20% leaching): 130 lb/yr
7. Net fertigation reduction in N leaching:
    - N removed from groundwater 630 lb/yr
    - Change in N leaching -0 lb/yr
    - Net 630 lb/yr (290 kg/yr)

Over the first five years of the Watershed Permit, fertilizer applications and groundwater nitrogen concentrations shall be measured and compiled, to allow the Year 5 report to update/confirm the load reduction now estimated at 500 lb/yr (230 kg/yr).

APPENDIX I

Permitting Considerations for On-Site Denitrification Systems

APPENDIX I

Permitting Considerations for On-Site Denitrification Systems

Use of on-site denitrification systems is proposed for the Pleasant Bay watershed. Programs will be developed for this approach during the first five years of the Watershed Permit. The following material is provided as general guidance on what those programs may include, and how performance will be measured. It is expected that those programs will be somewhat different than what is summarized here.

BASIC CONCEPT

Individual on-site septic systems are the largest source of groundwater nitrogen loading on Cape Cod. This nitrogen load can be reduced by the installation and operation of modular wastewater treatment systems or by leaching field modifications that are designed to remove a portion of the nitrogen load reaching the groundwater. Brewster and Orleans intend to use this approach to address a portion of their responsibilities in TMDL compliance in the Pleasant Bay watershed.

FATE OF APPLIED NITROGEN

Nitrogen leaving a septic system is predominantly in the ammonia and organic forms and is largely *converted* to nitrates in passage through the leaching field. On-site denitrification systems convert ammonia to nitrate and then convert the nitrate to nitrogen gas, thus effecting the nitrogen *removal*.

The baseline condition is the estimated nitrogen load from the residential and commercial septic systems in Brewster and Orleans, as reported in the 2006 MEP report. Those estimates are based on the assumption that 90% of the water use at a home or business becomes wastewater and that the septic system recharge adds 26.25 mg/l nitrogen to the groundwater. Specifically, the MEP estimated an attenuated load of 8,600 lb/yr reaching the groundwater from septic systems in Brewster and 24,400 lb/yr reaching the groundwater in Orleans.

BASIS FOR DETERMINING EFFECTIVENESS OF ON-SITE DENITRIFICATION

For mechanical treatment systems that are installed after septic tanks, the effectiveness of the system can be measured by sampling its effluent. No further credit is given for nitrogen removal through the leaching system because the removal of solids and organics in the treatment unit largely eliminates the conditions conducive to nitrogen removal in the leaching system.

For on-site systems using a horizontal reactive barrier (often called the “layer cake” system), the supplemental nitrogen removal occurs in the leaching field and the system effectiveness must be measured through buried lysimeters located below the leaching field.

The two primary parameters that determine the nitrogen load from a given home or business are the wastewater flow (estimated from the water use) and the septic system effluent nitrogen concentration. For a given water use and measured effluent concentration, the computed groundwater nitrogen load can then be compared to the load based on 26.25 mg/l nitrogen to determine the load removed by installing the nitrogen removal system. This table summarizes the computations:

Unattenuated Nitrogen Removed per Property, lb/yr, based on MEP Baseline

	Water Use, gpd				
Effluent N conc., mg/l	**130**	**140**	**150**	**160**	**170**
6	7.2	7.8	8.3	8.9	9.4
8	6.5	7.0	7.5	8.0	8.5
10	5.8	6.2	6.7	7.1	7.6
12	5.1	5.5	5.9	6.2	6.6
14	4.4	4.7	5.0	5.4	5.7
16	3.6	3.9	4.2	4.5	4.8
18	2.9	3.2	3.4	3.6	3.8
20	2.2	2.4	2.6	2.7	2.9
26.25	0.0	0.0	0.0	0.0	0.0

Based on Cape Cod experience with on-site denitrification systems and considering the lower wastewater flows at seasonal properties, these calculations indicate that Brewster and Orleans should plan on per-property removals of 3 to 6 lb/yr.

These computed load removals apply to systems located downgradient of natural attenuation sites, such as ponds or streams. The amount of natural attenuation must be considered when crediting actions against removal targets that are based on attenuated loads. That is, a system that is documented to remove 5.2 lb/yr can only be credited at 2.6 lb/yr if it is located upgradient from a freshwater pond.

OUTLINE OF FORMAL PROGRAM

The towns of Brewster and Orleans are proposing to address some of their TMDL responsibility through the use on on-site denitrification systems. To formalize these programs in Brewster and Orleans, and gain DEP approval under the Watershed Permit, the towns should undertake a series of actions. These actions are aimed at a thorough accounting of system performance, and proper accounting for natural attenuation. The actions should include:

1. Establish a mechanism for mandating the installation of on-site denitrification systems on private properties in designated sub-watersheds, and requiring their proper operation, maintenance and monitoring.
2. Establish a system for collecting and compiling data on water use and effluent quality at the properties using on-site denitrification systems.
3. Set forth the management role the town will have in the performance monitoring program and develop the details of that program.

4. Determine what town action will be taken to deal with poorly performing systems, and put in place a program to accomplish that objective and to obtain the associated easements.
5. Obtain and archive record ("as-built") drawings to document the nature and locations of all on-site systems installed under this program.

The formal on-site denitrification program would be based on the following assumptions:

1. The on-site denitrification systems will be privately owned, with the towns having access for supplemental/confirmatory monitoring and for emergency repair and replacement.
2. The lead town contacts will be:
    - Name, title in Orleans
    - Name, title in Brewster
3. System design and installation will be in accordance with Title 5, and the responsible party will provide a certification that the system is designed/installed properly.
4. Operation and monitoring of all on-site systems will be conducted by licensed operators that may be pre-qualified by the towns.
5. A treatment-system-specific O&M manual will be maintained either at the property or at a central Town facility.
6. Effluent sampling will be carried out under the terms of a written protocol.
7. A DEP-certified laboratory will conduct nitrogen analyses (NO3, TKN, NH3).
8. DEP will review and approve the annual computation of load reductions.

BASIS FOR NITROGEN REMOVAL CREDIT

Monitoring of the on-site denitrification program should include the following:

1. Annual water use at each participating home or business, based on water meter reading for properties served by public water, and based on estimates for others.
2. Periodic effluent samples analyzed for nitrogen species (NO3, NH3, TKN). (Assume quarterly sampling of each system initially, and then the establishment of a less frequent, statistically-based routine, based on actual performance variability.)

All of these monitoring data should be included in the Town's annual reporting of nitrogen removal activities. The first four years of data should be summarized in a report that presents the data and draws conclusions on the reduction in nitrogen load that has occurred. That load reduction estimate will be based on:

- The computed load removal based on actual effluent quality compared with the MEP 26.25 mg/l baseline, and
- Adjustments for natural attenuation, based on the location of each system in the watershed and MEP estimates of attenuation.

Removals will be reported by sub-watershed.

SAMPLE CALCULATIONS

To help understand the proposed computation of nitrogen load removal, the following sample calculations are provided to illustrate the approach:

Load reduction for properties <u>not</u> subject to natural attenuation

1. Water use at home X, annual average	140 gpd
2. Average effluent quality, total N (4 analyses)	15.75 mg/l
3. Baseline effluent quality	26.25 mg/l
4. Nitrogen removal (unattenuated)	
• Concentration below MEP baseline	10.5 mg/l
• Load removal	4.0 lb/yr
5. Natural attenuation	none
6. Nitrogen removal (attenuated)	4.0 lb/yr

Load reduction for properties subject to natural attenuation

1. Water use at home Y, annual average	150 gpd
2. Average effluent quality, total N (4 analyses)	13.45 mg/l
3. Baseline effluent quality	26.25 mg/l
4. Nitrogen removal (unattenuated)	
• Concentration below MEP baseline	12.8 mg/l
• Load removal	5.2 lb/yr
5. Natural attenuation (one pond)	50%
6. Nitrogen removal (attenuated)	2.6 lb/yr

Overall load reduction (illustrative of an idealized sampling program)

Sum of load removals at all properties, considering attenuation	450 lb/yr
Number of properties	100
Average attenuated load removal per property	4.50 lb/yr

Based on an idealized average load removal of 4.5 lb/yr per system from the example above, the towns would continue to require on-site systems with the total goal of:

Brewster	290 homes
Orleans	990 homes

APPENDIX J

Permitting Conditions for Shellfish Harvesting

APPENDIX J

Permitting Considerations for Shellfish Harvesting

BASIC CONCEPT

Shellfish, particularly oysters, remove particulate matter from the water column and increase water clarity. In so doing, they remove nitrogen from coastal waters. The Town of Orleans intends to foster the growth and harvest of oysters to address a portion of its responsibilities in TMDL compliance in the Pleasant Bay watershed.

FATE OF NITROGEN

Nitrogen sources in the watershed are largely transformed to nitrate in passage through the unsaturated soils above the groundwater and in the groundwater itself on its way to down-gradient coastal ponds. Upon entering the estuarine environment, watershed-based nitrates are converted to phytoplankton, which are then filtered out by shellfish, serving as their food source. Once converted to oyster biomass, the nitrogen

- Leaves the estuarine environment when the shellfish are harvested
- Is excreted by the shellfish as feces and pseudo feces

The feces accumulate on the bottom of the estuary and the incorporated nitrogen is either

- stored long-term in the sentiments
- converted to nitrogen gas through denitrification or
- released back into the water column.

BASELINE CONDITIONS

The baseline condition is that reported in the 2006 MEP report. Shellfish were being harvested at various places the Pleasant Bay at that time, and that nitrogen removal is indirectly accounted for in the linked watershed embayment model based on water quality sampling data. New initiatives to increase nitrogen removal via aquaculture achieve additional nitrogen removal above that baseline. In Lonnie's Pond, the focus of Orleans' initial investigation, shellfish harvesting has occurred on a recreational basis, with far smaller harvests than now contemplated.

ORLEANS PLAN

The Orleans Amended Comprehensive Wastewater Management Plan (ACWMP) includes shellfish aquaculture as a means of nutrient removal to meet TMDLs. Since 2016, the Town of Orleans has been operating an oyster aquaculture pilot project in Lonnie's Pond, to determine (1) the ability to grow oysters in this basin, (2) oyster survival, (3) the incorporation of nitrogen into oyster tissue and shell, (4) oyster filtration and bio-deposition rates, and (5) the fate of nitrogen deposited to bottom sediments. Results from the first two years of growing and monitoring are being evaluated.

The Orleans ACWMP identifies areas in Paw Wah, Arey's, Lonnies and Meetinghouse Ponds, and portions of the River and Pochet Creek, as potential Aquaculture Demonstration Areas for the purpose of nutrient removal to meet TMDLs. Aquaculture grants in these areas for this purpose will continue to be evaluated and, if demonstrated appropriate and effective, may be established and operated. Similar efforts that may be proposed by other towns should be evaluated.

BASIS FOR DETERMINING NITROGEN REMOVAL

Studies of the Lonnie's Pond aquaculture demonstration project have determined that there are three pathways for nitrogen removal and concluded that oyster harvest and benthic denitrification are the primary ones, with long-term storage considered to be inconsequential.

DEP has reviewed the Lonnie's Pond results to date and determined that the denitrification pathway is not yet fully characterized and that oyster harvesting is the only mechanism by which nitrogen removal credits can be gained.

OUTLINE OF FORMAL PROGRAM

The Town of Orleans is proposing to address some of its TMDL responsibility through the use on shellfish aquaculture. To formalize this programs in Orleans, and gain DEP approval under the Watershed Permit, the Town should undertake a series of actions. These actions are aimed at an establishing a robust on-going program, thorough accounting of nitrogen removal, and proper monitoring of water quality. The actions should include:

1. Establish the appropriate locations for aquaculture equipment.
2. Provide for acquisition of land and/or rights of access
3. Establish a system for collecting and compiling data on oyster inventory and harvest.
4. Set forth a thorough water quality monitoring program aimed at documenting long-term changes in water quality.
5. Establish a plan to deal with natural occurrences that may disrupt the program.
6. Address citizen concerns on the possible impacts of aquaculture equipment and activities on the public use of Lonnie's Pond.
7. Obtain and archive record ("as-built") drawings to document the nature and locations of all physical structures and equipment installed under this program.

The formal aquaculture program would be based on the following assumptions:

1. The aquaculture equipment will be publicly owned, with the town having access across private property for maintenance activities including repair and replacement.
2. The lead town contacts will be:
    - Nathan Sears, Natural Resources Department
3. System design and installation will be in accordance with a plan prepared by responsible professionals who will provide a certification that the system is designed/installed properly.
4. Operation of all aquaculture systems and oyster harvesting may be conducted by private licensed operators that may be pre-qualified by the towns, with approval by DEP or designee.
5. A staffing plan and O&M manual will be maintained either at the site or at a central Town facility.
6. Water quality and oyster sampling will be carried out under the terms of a written protocol.

7. A DEP-certified laboratory will conduct tissue and water quality analyses.
8. DEP will review and approve the annual computation of load reductions.

BASIS FOR NITROGEN REMOVAL CREDIT

Monitoring of the shellfish harvesting program should include the following:

1. Tracking of all oyster harvests, including organism count and wet weight
2. Periodic sampling of harvested oysters to determine average dry weight and nitrogen content.
3. Periodic water quality samples analyzed for temperature, salinity, transparency, alkalinity, nitrogen species (NO3, NH3, TKN, DON, PON), chlorophyll-a, pheophytin-a, dissolved oxygen, etc.

All of these monitoring data should be included in the Town's annual reporting of nitrogen removal activities. The first four years of data should be summarized in a report that presents the data and draws conclusions on the reduction in nitrogen load that has occurred. That load reduction estimate will be based on:

- The measured wet and dry weight of harvested oysters and
- Average nitrogen content of oysters based on statistical sampling.

The load reduction estimates based on harvest data shall be supported by data showing improvements in water column samples.

SAMPLE CALCULATIONS

To help understand the proposed computation of nitrogen load removal, the following sample calculations are provided to illustrate the approach:

1. Annual oyster harvest	400,000 organisms per year
2. Average oyster nitrogen content	0.30 grams per organism
3. Nitrogen removal	
• Grams	120,000 grams per year
• Pounds	260 lb/yr

APPENDIX K

Permitting Conditions for Inlet Widening

APPENDIX K

Permitting Considerations for Inlet Widening

BASIC CONCEPT

Nitrogen loads from the watershed reach coastal embayments by way of groundwater and surface water flow. Those loads are diluted by the exchange of lower-concentration water from the open ocean or from downstream embayments, and it is the degree of dilution that largely determines the trophic status of the embayment. In some embayments, that critical tidal exchange has been impeded by the construction of a roadway across the mouth of the embayment. The widening of embayment opening can be an effective tool for improving upstream water quality by restoring historical tidal flushing.

FATE OF NITROGEN

With this approach, water quality is improved not by the conversion of nitrogen to harmless forms, but by the transport of nitrogen to downstream water bodies. This shifting of nitrogen load benefits the upstream water body, but the subsequent downstream load increase must still must be addressed.

MUDDY CREEK PROJECT

Muddy Creek is a tidal river shared by the Towns of Chatham and Harwich. Two undersized box culverts restricted tidal flow between Muddy Creek and Pleasant Bay for more than a century.

In 2014, the two Towns launched the Muddy Creek Restoration Bridge Project in partnership with Massachusetts Division of Ecological Restoration, US Fish & Wildlife Service, and NOAA Restoration Center. The restoration encompassed the removal of two restrictive box culverts and construction of a new single-span bridge with an open channel. Partial tidal flow was restored through the east (Chatham) side of the channel on February 11, 2016 and the channel was fully open to tidal flow on April 1, 2016. The restoration of tidal flow benefits 55 acres of wetlands upstream of the new bridge and channel, and also is expected to reduce nitrogen concentrations in Muddy Creek.

BASELINE CONDITIONS

Two subwatersheds shared by Harwich and Chatham contribute nitrogen to Muddy Creek: Upper Muddy Creek subwatershed and Lower Muddy Creek subwatershed.

According to the 2006 MEP Technical Report, the existing watershed load to these subwatersheds was 9.98 kg/day in Upper Muddy Creek and 8.48 kg/day in Lower Muddy Creek. At buildout, watershed loads are predicted to increase to 13.96 kg/day in Upper Muddy Creek and 10.19 kg/day in Lower Muddy Creek.

There are separate TMDLs for nitrogen for Upper and Lower Muddy Creek. The TMDLs calls for a 75% removal of septic load in Upper Muddy Creek and 100% removal in lower Muddy Creek.

EXPECTED IMPACTS ON NITROGEN REMOVAL REQUIREMENTS

A 2010 technical memo by SMAST predicted that the inlet widening could potentially result in a 20% drop in the difference between the existing conditions modeled and the threshold concentration at the lower Muddy Creek station. Based on this information, Harwich included the Muddy Creek Bridge as a Phase 1 element of its CWMP.

Given that the new culvert directly effects Muddy Creek, the percent removal of existing septic watershed loads to meet threshold in Upper Muddy Creek is predicted to decline from 75% removal to 45% removal. In Lower Muddy Creek, a decline from 100% removal to 50% removal is predicted.

Table 13-13 in the final Harwich CWMP shows a 13.7 kg/day removal in the Pleasant Bay watershed following Phase 1 (inlet widening), and another 10 kg/day following the conclusion of Phase 2 (sewering), for a total of 23.7 kg/day.

Additional nitrogen reductions are still required in the Muddy Creek watershed to meet the threshold concentration in Lower Muddy Creek, but the magnitude is reduced through the installation of the wider culvert. This modification is expected to save roughly $5.7 million in collection system costs alone, at $25,000 per lot, according to the Harwich CWMP.

MONITORING PROGRAM

Pleasant Bay Alliance has monitored water quality at two monitoring stations in Muddy Creek: one in lower Muddy Creek (PBA 5), and one in Upper Muddy Creek (PBA 5A). A DEP-approved Quality Assurance Project Plan is in place and includes the following parameters: nitrogen species (DON, PON, DIN, TON, TN), dissolved oxygen, temperature, salinity, phytoplankton pigments, etc.). Sample collection occurs five times annually from July through early September. Samples are analyzed by the UMASS Dartmouth School for Marine Science and Technology. There are sixteen years of pre-construction data and one year of post-construction data analyzed to date. This monitoring effort is ongoing and will continue following project completion to document long-term water quality changes.

A comparison of pre-construction baseline data with one year of post-construction water quality data suggest that it is too early to see major changes in water quality due to the bridge. However, the following changes were observed:

- Total nitrogen decreased from the prior year at both Stations 5 and 5A. The change in total nitrogen at Station 5 does not appear to be significant. Total nitrogen at Station 5A is lowest level observed. There was no significant change observed in the distribution of other forms of nitrogen compared to prior years
- Pigment concentrations went up at both stations. A similar trend was observed at other Pleasant Bay stations and so it is likely due to a factor such as weather and is unrelated to the bridge.
- While the range of DO values narrowed, levels were not inconsistent with prior years.

- Salinity was the area where the most significant changes were observed.

The Pleasant Bay Alliance will continue to collect nutrient-related water quality data as described above.

BASIS FOR NITROGEN REMOVAL CREDIT

Use of the MEP Linked Watershed-Embayment Model has predicted that the post-construction nitrogen removal requirements in the Muddy Creek sub-watersheds will be less than under pre-construction conditions. Harwich has based its CWMP on achieving the lower (post-construction) removal requirements. (Since Chatham intends to sewer the entire sub-watershed for reasons beyond just nitrogen control, the Muddy Creek project does not change the Chatham load removal.)

The "nitrogen credit" attributable to the Muddy Creek inlet widening is the reduction in load removal afforded to Harwich. The monitoring data will allow adaptive management of the Harwich program. If either more or less extensive sewering is needed in Harwich to actually achieve the target sentinel station nitrogen concentrations, that finding will represent the confirmation or adjustment of the "nitrogen credit" now attributed to the Muddy Creek inlet widening. Remodeling of the Pleasant Bay system may give a better indication of predicted improvements in overall water quality resulting from the inlet widening.

APPENDIX L

Town Contingency Plans to Support Use of Non-Traditional Technologies

APPENDIX L

CONTINGENCY PLANS TO SUPPORT NON-TRADITIONAL TECHNOLOGIES

NEED FOR CONTINGENCY PLANS

While many non-traditional technologies hold promise for low-cost and quickly-implemented nitrogen control, the lack of widespread experience with these technologies poses a risk to the towns that intend to rely on them. DEP requires that towns proposing non-traditional solutions develop contingency plans based on proven technology that can be readily implemented if the non-traditional solution turn out to be ineffective.

CONTINGENCY PLAN FOR BREWSTER

Brewster's share of the Pleasant Bay nitrogen removal requirement is 2,262 kg/yr. The Town proposes to remove 930 kg/yr of nitrogen load by reducing fertilizer applications at the municipally-owned Captains Golf Course, and this approach carries little risk and needs no back-up plan. Another 941 kg/yr is proposed to be removed through golf course fertigation, on-site denitrification systems and residential fertilization controls, all of which are considered non-traditional and require a proven back-up.

The Town's contingency plan involves the development of a neighborhood wastewater collection and treatment system in the upper reaches of the Pleasant Bay watershed. This option was presented in the Town's Pleasant Bay Nitrogen Management Alternatives Analysis Report (Horsley-Witten, March 20, 2015). The neighborhood is sufficiently large enough to provide the necessary nitrogen reduction to replace the on-site system option, and there is land available for the treatment and disposal facilities.

Brewster will update and expand this contingency plan in the first five years of the Watershed Permit. Additional information on future control of land for a treatment and disposal facility will be provided. The number of homes that would be served will be updated based on the extent of nitrogen removal from golf course fertilizers and the Town's non-traditional options. Opportunities for locating a disposal facility on Town land outside the Pleasant Bay watershed will be explored, as well as on Town-owned land in the watershed, such as at the Captain's Golf Course or the golf course driving range. In addition, nitrogen trading opportunities that rely on traditional solutions will be evaluated in consultations with the other watershed towns. The updated contingency plan will document the extent of treatment to be provided, the ability to utilize land for treatment facilities, the type of treatment system proposed and estimated costs for implementation.

CONTINGENCY PLAN FOR ORLEANS

Orleans completed it CWMP in late 2010 and secured regulatory approval in the subsequent 15 months. That 2010 plan has a traditional "backbone" of a municipal sewer system that would be built in phases. Concurrent with the phased construction of sewers and treatment/disposal capacity, Orleans would explore non-traditional nitrogen removal methods, and depending on their success and cost, avoid one or more of the later sewer phases. Since 2012, Orleans has been pursuing various non-traditional methods, with emphasis on shellfish propagation, PRBs, on-site denitrification, and residential fertilizer controls.

Orleans' share of the Pleasant Bay nitrogen removal requirement is 6,980 kg/yr. The Town proposes to remove 2,014 kg/yr of nitrogen load by fully sewering the Meetinghouse Pond sub-watershed, and this facet of the Orleans program needs no back-up plan. Another 4,960 kg/yr is proposed to be removed through non-traditional means, and requires a proven back-up.

Underlying this effort is the recognition that the 2010 CWMP serves as the contingency plan, in whole or in part, for the non-traditional options that are being pursued. The first phase of sewering is now in the design phase. While those first-phase sewers will not remove nitrogen from the Pleasant Bay watershed, constructing the Phase 1 infrastructure is a necessary step to allow later traditional phases to be built that will serve Pleasant Bay properties and remove Pleasant Bay nitrogen load.

Because the 2010 CWMP is accepted by the Town and has received regulatory approval, it represents a robust contingency plan. However, current efforts to design and construct wastewater infrastructure for Phase 1 should also include those steps necessary to identify and secure effluent disposal sites with capacity for the entire traditional plan. If the CWMP must be implemented in the future due to the failure of non-traditional options (or their performance below expectations), effluent disposal sites may have been developed in other uses, and the needed capacity may not be available.

NECESSARY NEXT STEPS

To strengthen the contingency plans of Brewster and Orleans, additional steps should be taken.

- Brewster should update and refine its contingency plan in the first five years of the permit as discussed above.

- Orleans should take steps to identify and secure land for effluent disposal of the flows that would be generated in the full 6-phase plan, as part of its Amended CWMP.

APPENDIX M

Acknowledgments

APPENDIX M

ACKNOWLEDGEMENTS

This Targeted Watershed Management Plan 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 Erin Perry and other staff of the Cape Cod Commission have also been incorporated. Substantial guidance also was provided by Jill Goldsmith, Chatham Town Manager; Chris Clark, Harwich Town Administrator; Michael Embury, Brewster Town Administrator; and John Kelly, Orleans Town Administrator.

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

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May 4, 2018
WP Project No. 13351C

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

Subject: Pleasant Bay Targeted Watershed Management Plan
Final Report

Dear Carole:

Enclosed is the final report entitled "Pleasant Bay Targeted Watershed Management Plan: A Compilation of the Wastewater and Nitrogen Management Plans of Brewster, Chatham, Harwich and Orleans in Support of a DEP Watershed Permit". We are providing you 50 printed copies and one electronic copy of this report.

We have enjoyed collaborating with you on this 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 and other town representatives. All technical aspects of this report have been prepared by me or under my direction.

We look forward to assisting the Alliance in integrating this report into the application for the DEP Watershed Permit and coordinating it with the four-town inter-municipal agreement.

Please contact me with any questions you may have.

Very truly yours,
WRIGHT PIERCE

Michael D. Giggey, PE
Senior Vice President