

PLEASANT BAY ALLIANCE

2024 Annual Report pursuant to MassDEP Watershed Permit dated August 3, 2018

SUMMARY AND CONCLUSIONS

Under the terms of the 2018 Watershed Permit, the four towns in the Pleasant Bay watershed are required to report to MassDEP annually on their collective progress toward meeting their individual commitments for nitrogen removal to protect Pleasant Bay water quality. This document is the sixth annual report and summarizes progress through mid 2024.

Annual reports are called for in the Watershed Permit to track progress toward nitrogen removal goals, document findings related to monitoring of non-traditional technologies, summarize special-purpose studies, and facilitate the adaptive management approach that will enhance the overall nitrogen management program.

In the first five Annual Reports, the Alliance towns have documented these removals of attenuated nitrogen loads from the watershed and the embayments:

- Prior to permit issuance: 1,769 kg/yr
- First year: 60 kg/yr
- Second year: 115 kg/yr
- Third year: 1,622 kg/yr
- Fourth year: 485 kg/yr
- Fifth year: 411 kg/yr
- Sixth year: 1,005 kg/yr
- Total 5,467 kg/yr

The cumulative to-date load removal of 5,467y kg/yr represents 111% of the five-year removal commitment of 4,914 kg/yr and 51% of the ten-year removal goal of 10,801 kg/yr.

The four watershed towns have benefited from funding from U.S. EPA Southeast New England Program (SNEP) Watershed Grants. In the first five years of the Permit, important information on non-traditional technologies has been gathered:

- *On-site denitrification*: Through a SNEP-funded investigation, the towns learned more about the performance and cost of a municipal I/A program and that knowledge will allow Brewster to modify its nitrogen removal plans.
- *Shellfish harvesting*. Orleans used SNEP funding to better understand the technical and business issues related to oyster harvesting in Lonnie's Pond and to be able to explore opportunities to expand this program elsewhere.

- *Permeable reactive barriers.* Through a town-funded investigation of a PRB outside the Pleasant Bay watershed, Orleans made progress toward the possible use of this technology in the watershed.

SNEP funding has also allowed the updating of the Massachusetts Estuaries Project (MEP) linked watershed-embayment model to reflect growth in watershed loads, better estimates of natural attenuation, new information on benthic loads, improved hydrodynamics, and recent water quality data. The model update has shown that the current favorable hydrodynamics nearly offset a small increase in watershed loads. Projected growth through build-out will result in unfavorable water quality impacts unless additional nitrogen removal measures are undertaken by the towns experiencing growth. There is an ongoing assessment of the model update results and the implications for potential modifications to town plans.

Funding from SNEP also allowed the watershed towns to explore other issues:

- *Nitrogen credit trading:* Through a SNEP-funded investigation, the towns have identified potential cost savings through credit trading, where one town could remove more than its designated share of nitrogen load on behalf of another town which would remove less. The second town would pay the first town for its added removal, and both towns could save money.
- *Nitrogen credits for stormwater management.* The four watershed towns are making improvements to their stormwater management systems, in part to comply with the Massachusetts MS4 general permit. SNEP funds were used to set up a mechanism for measuring nitrogen removals from these activities. Although the magnitude of the credits is expected to be small, the towns may be able to use information collected under their MS4 programs to obtain these credits.
- *Natural attenuation.* A consultant addressed the levels of natural attenuation in three subwatersheds, where town nitrogen removal plans are dependent on the level of attenuation. The study confirmed prior estimates in two sub-watersheds, and recommended further investigation in one sub-watershed, and provided valuable interpretation of the methodology and results.
- *Growth in Watershed Loads.* Updating the watershed loading model to reflect build-out conditions has predicted a 17% increase in watershed loads, even with some load removal projects already in place. The towns have fine-tuned and extended those projections to account for future conditions.

These initiatives add measurably to the watershed towns' ability to adjust their removal plans in a true adaptive management approach. Plans in Harwich, Brewster and Orleans will be modified to account for these new findings. Chatham continues its whole-town sewerage approach.

Incorporating growth estimates into revisions to the nitrogen removal requirements for several sub-watersheds, and/or the re-evaluation of nitrogen removal technologies, will necessitate modifications in the Watershed Permit's implementation schedule. These issues have been the focus of the Alliance's recent activities, so towns' nitrogen management plans can be modified before key projects are implemented.

In addition to these important topics, this report summarizes current water use data, water quality monitoring programs, town capital commitments, growth in watershed nitrogen loads, and stakeholder involvement in the Bay restoration program.

Four basic goals of this sixth annual report have been accomplished:

- Compliance documentation
- Compilation of information to inform adaptive management
- Identification of key steps needed to ensure compliance with nitrogen removal goals
- Proposing changes in the Watershed Permit.

At the end of Year 6, it is appropriate to conclude that:

- The four towns are proceeding appropriately under the terms of the permit.
- Collectively, the towns have been on track to meet the nitrogen removals stipulated under the permit, having accomplished 111% of the Year-5 goal in the first six years of the permit.
- Studies have been completed to define changes in load removal requirements and have developed responsive plan changes.
- The towns are prepared to revise the Watershed Permit by December 31, 2025.

This program of annual reports has allowed the presentation of snapshots of current data and an update of how new findings are being used to inform the towns' adaptive management approaches. Progress to date reflects the considerable effort and investments expended by the towns to address nitrogen contamination in Pleasant Bay, and the recognition that important steps have been completed to move forward with a modified permit.

BACKGROUND

The Pleasant Bay Alliance has prepared this sixth annual report in accordance with the August 3, 2018 Pleasant Bay Watershed Permit issued to the Towns of Brewster, Chatham, Harwich, and Orleans. This report is intended to address the annual reporting requirements identified in the Watershed Permit, the Pleasant Bay Targeted Watershed Management Plan (TWMP) and the Cape Cod Commission 208 Consistency Determination on the TWMP. This report was authorized by the four towns.

The Watershed Permit sets forth aggressive goals for achieving nutrient reductions over the twenty-year term of the permit. Adaptive management is one of the fundamental aspects of the Watershed Permit. It was expected that every five years there would be an updated permit that reflects progress already made toward nitrogen removal goals, as well as changes in the watershed and Bay that may modify those goals.

An annual report is required under the permit so that key data are assembled as the five-year period unfolds. As noted in the Year-5 Annual Report, for many reasons, including the need to complete ongoing technical investigations and the issuance of new DEP regulations, the update of the Pleasant Bay Watershed Permit has been deferred until the end of Year 6.

The technical heart of the Watershed Permit is the May 2018 Targeted Watershed Management Plan. Section 15 of the TWMP Plan lists 10 items that were recommended be included in the annual report. When the Cape Cod Commission issued its Certificate of 208 Compliance for the TWMP, it requested information in 8 areas, some of which are the same as contained in the TWMP. The 14 items contained in one or both documents are discussed here.

A key part of the Watershed Permit is the one-page Implementation Schedule, which is reproduced in this report as Table 1. It shows the specific nitrogen removal projects included in each Town's plan, and the associated nitrogen removal expectations. The projects are shown in each of four five-year segments of the 20-year term of the agreement. This annual report covers the sixth year of the current permit and includes detailed information on how the Permit and the Implementation Schedule should change at the end of Year 6.

The Annual Reports required by the Watershed Permit are typically due to DEP on or before the anniversary date of the Permit, August 3. Each annual report generally contains information and data for the previous calendar year, but also information through July of the current year due to the fact that significant actions are typically taken at annual town meetings in May. Further, some data are regularly reported on a fiscal year basis, that is, through the end of June. Due the complexity of formulating prospective changes to the permit, the deadline for this Year-6 report was extended to December 31, 2024.

WATER CONSUMPTION

Water consumption is the most important indicator of septic nitrogen load and the principal determinant of the total watershed nitrogen load. Table 2 presents water consumption data for the four towns in a format that shows the total metered water in any year between 2014 and 2023, along with the per-service residential and commercial use.

The calendar years 2016, 2020 and 2022 were very dry years. A review of water consumption data indicates that summer (June through September) rainfall below 15 inches may be correlated with higher water use for irrigation. Using summer rainfall amounts below 15 inches as an indicator, the deficits in these three very dry years were 8.0, 10.8 and 8.2 inches respectively. (The 5-year period of water consumption data being used in the SMAST update of nitrogen loads---2011 to 2015---has an average deficit of 2.8 inches. The bases for the TWMP and Watershed Permit are 1.3 inches of deficit for Brewster, Chatham, and Orleans, and 4.8 inches for Harwich.) For 2023, the summer rainfall deficit was only about 1 inch.

For all of 2023, the four towns together billed for about 1.87 billion gallons in town-wide water use, about 7% more than in 2022, despite it being a significantly wetter summer. The water use in 2023 was about 10% less than in the previous very dry years of 2016 and 2020.

**Table 1
Implementation Plan as Contained in the 2018 TWMP
(Expected Project Completion and Potential Annual Nitrogen Removals)**

Phase	Years		Brewster		Chatham		Harwich		Orleans		Total kgN/yr*		
			Activity	kgN/yr*	Activity	kgN/yr*	Activity	kgN/yr*	Activity	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.

Average per-service residential use in 2023 was 157 gpd, above 2022, but about 14% lower than the previous driest year. Commercial water use per service in 2023 was also above 2022 consumption but 7% below the 10-year average.

All four towns implemented water use restrictions in 2022 and 2023. While the data reported here are town-wide, and not specific to the Pleasant Bay watershed, the impacts of the recent water use restrictions give some indication that dry-year irrigation is well above the 10% average widely used in nitrogen loading estimates. Water use in very dry years is not a good indicator of average septic nitrogen load in the absence of water use restrictions.

Table 2
Summary of Water Consumption Data

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Avg
Number of Water Services											
Brewster	7,403	7,421	7,426	7,491	7,249	7,287	7,281	6,958	6,816	6,929	
Chatham	7,083	7,143	7,200	7,236	7,236	7,277	7,469	7,210	7,798	7,251	
Harwich	9,805	9,858	9,890	9,929	9,969	9,983	10,012	10,050	10,098	10,128	
Orleans	5,266	5,279	5,249	5,262	5,257	5,266	5,287	5,377	5,295	5,363	
<i>Total</i>	<i>29,557</i>	<i>29,701</i>	<i>29,765</i>	<i>29,918</i>	<i>29,711</i>	<i>29,813</i>	<i>30,049</i>	<i>29,595</i>	<i>30,007</i>	<i>29,671</i>	
Total Metered Water, Mgal/yr											
Brewster	395	475	454	381	402	382	452	433	405	425	420
Chatham	413	481	473	408	464	422	487	415	410	413	439
Harwich	673	781	810	670	706	677	803	725	633	738	722
Orleans	303	334	340	299	303	279	348	314	300	292	311
<i>Total</i>	<i>1,784</i>	<i>2,071</i>	<i>2,077</i>	<i>1,758</i>	<i>1,875</i>	<i>1,760</i>	<i>2,090</i>	<i>1,888</i>	<i>1,748</i>	<i>1,869</i>	<i>1,892</i>
Per-Service Residential Use, gpd											
Brewster	129	157	149	119	138	132	167	167	157	155	147
Chatham	143	172	170	140	169	140	169	151	136	143	153
Harwich	175	205	212	174	185	177	214	190	164	191	189
Orleans	142	158	163	140	144	130	176	156	147	140	150
<i>Average</i>	<i>147</i>	<i>173</i>	<i>174</i>	<i>143</i>	<i>159</i>	<i>145</i>	<i>182</i>	<i>166</i>	<i>151</i>	<i>157</i>	<i>160</i>
Per-Service Commercial Use, gpd											
Brewster	393	423	375	419	451	391	207	310	276	279	352
Chatham	336	296	331	382	266	252	253	259	294	307	298
Harwich	394	440	468	396	378	367	337	374	340	386	388
Orleans	252	271	280	272	251	240	194	200	206	212	238
<i>Average</i>	<i>344</i>	<i>358</i>	<i>364</i>	<i>367</i>	<i>337</i>	<i>313</i>	<i>248</i>	<i>286</i>	<i>279</i>	<i>296</i>	<i>319</i>
<i>Town-wide data shown above for illustrative purposes only</i>											
Rainfall at Chatham Airport, inches,											
in Jun, Jul, Aug, Sept	10.96	14.59	7.05	16.71	8.76	13.49	4.15	15.78	6.82	14.02	11.23
Deficit below 15 in.	4.04	0.41	7.95	-1.71	6.24	1.51	10.85	-0.78	8.18	0.98	4.08

The current version of Table 2 contains town-wide data. In future years, the Alliance will work with town water departments to implement a system for reporting watershed-specific water consumption data. Such data are not intended to be the basis for a new estimate of watershed nitrogen load each year, but instead should be a straightforward way to identify trends in the largest sources of nitrogen load (residential and commercial septic flows).

The Cape Cod Commission seeks access to water consumption data such as reported here and as may be further detailed for each nitrogen-sensitive sub-watershed. As part of upcoming planning for the generation of sub-watershed-specific data, the towns should consider the option of having the Commission prepare the more detailed water consumption summaries.

STATUS OF NITROGEN REMOVAL ACTIVITIES AND ESTIMATES OF REMOVALS TO DATE

The 2006 and 2010 MEP/SMASST reports estimated that a load removal of 17,717 kg/yr is needed to restore water quality in Pleasant Bay. In the Watershed Permit Implementation Table, Table 1, the four towns have committed to a total load removal of 4,914 kg/yr in the first 5 years of the permit (that is, through mid-2023), and projected a cumulative removal of 10,801 kg/yr by 2028.

Table 3 summarizes the nitrogen removals accomplished to date for each town. Watershed-wide, the four towns removed 1,769 kg/yr prior to the Watershed Permit issuance. In the first six years of the Watershed Permit, an additional 3,698 kg/yr removal has been accomplished. The largest nitrogen removal efforts have been a portion of Harwich’s sewer program (accounting for 2,131 kg/yr of removal) and fertilizer management at the Captains Golf Course in Brewster (2,065 kg/yr). In addition:

- Orleans removed 63 kg/yr in the Lonnie’s Pond shellfish harvesting demonstration.
- Chatham facilitated the Harwich sewer project with the connection of the Harwich sewers to the Chatham sewer system.
- Chatham accomplished 520 kg/yr of removal through sewer construction in the Muddy Creek and Frostfish Creek sub-watersheds; and
- Harwich made progress toward a residential fertilizer control regulation with an associated credit of 200 kg/yr.

Compared to the long-term target load removal of 17,717 kg/yr, the overall status of TMDL compliance is:

Load removed prior to Watershed Permit issuance:	10.0% (1,769 kg/yr)
Additional load removed through FY 2024:	<u>20.9%</u> (3,698 kg/yr)
Total load removed through FY 2024	30.9% (5,467 kg/yr)
Targeted load removal through FY 2023	27.7% (4,914 kg/yr)
Targeted load removal through FY 2028	61.0% (10,801 kg/yr)

The load removal through 2024 is 1,005 kg/yr higher than that documented in the 2023 Annual Report. That increase is the net effect of:

- Updated water use data for the Harwich sewer area (225 kg/yr more)
- Revised estimate of removals in the Orleans shellfish harvesting project (4 kg/yr less), and
- Refinement of the fertilization plan at the Captain Golf Course in Brewster (784 kg/yr more).

**Table 3
Summary of Nitrogen Removal Achievements and Goals**

	Brewster		Chatham		Harwich		Orleans		Total Load Removal
	Activity	Load	Activity	Load	Activity	Load	Activity	Load	
Nitrogen Load Removals Accomplished Prior to Watershed Permit, kg/yr	Res fertilizer controls	121	Res fertilizer controls	247	None	-	Res fertilizer controls	241	1,769
	GC fert. controls	930							
	GC fertigation	230							
New Nitrogen Load Removals Accomplished in FY 2019 to FY 2024, kg/yr	GC fert. controls	641	Frostfish Ck and		E. Harwich sewers *	2,131	Lonnie's Pond		
	GC fertigation	143	Muddy Ck sewers	520	Res fert. controls	200	shellfish harvest **	63	3,698
Cumulative Nitrogen Load Removals Accomplished by end of FY 2024, kg/yr		2,065		767		2,331		304	5,467
2023 Goals, kg/yr		1,281		247		2,872		514	4,914
Accomplished by 2024, %		161%		311%		81%		59%	111%
2028 Goals, kg/yr		1,399		247		4,437		4,718	10,801
Accomplished by 2024, %		148%		311%		53%		6%	51%
20-yr Goal (2038), kg/yr		2,262		4,076		4,399		6,980	17,717
	* Sewers are constructed; tie-ins are underway								
	** Harvest data may change year-to-year								
	*** Attenuated loads removals may be adjusted by ongoing re-evaluation of attenuation rates								

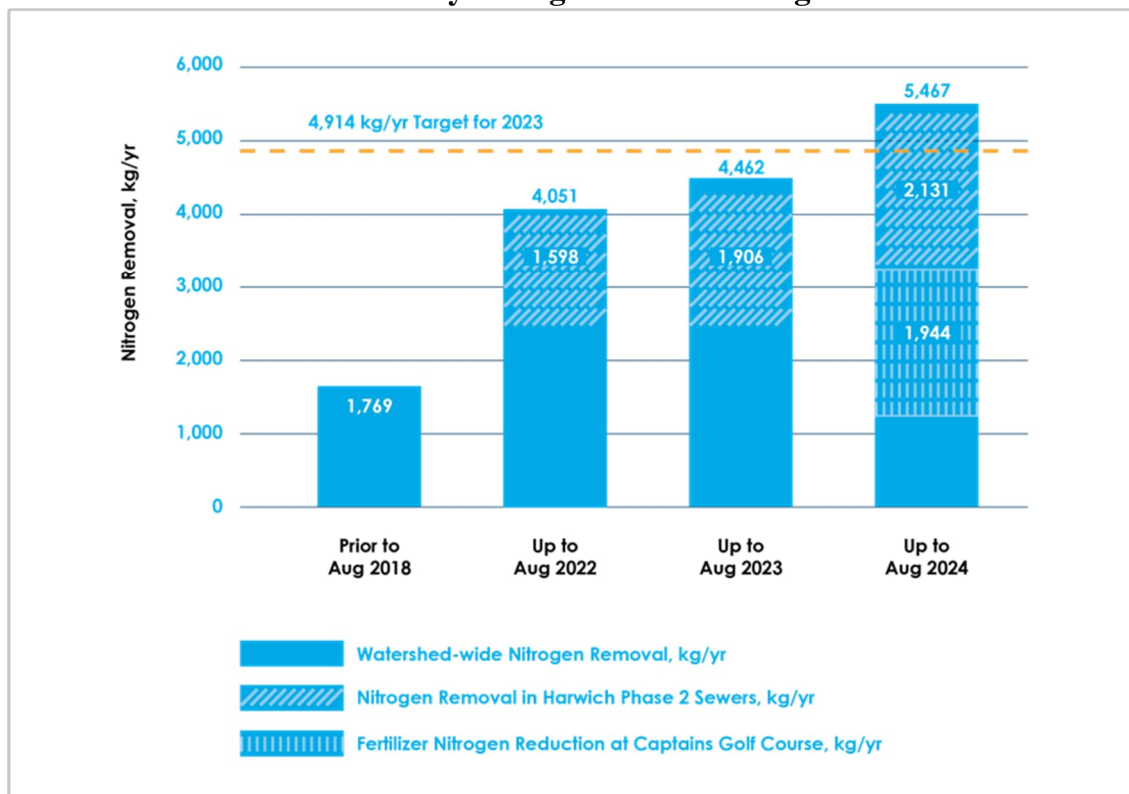
This Annual Report documents nitrogen removals attained by the four towns under the 2018 Watershed Permit. Those removals are based on attenuation estimates from 2006 and 2010 studies. The towns have been working to develop better estimate of attenuation in certain areas. Those revised attenuation estimates could result in significant changes in the computed nitrogen removals. While this Annual Report uses prior attenuation estimates, it is anticipated that future annual reports will include the associated revisions. Specifically,

- Harwich could be credited with an additional 1,347 kg/yr of nitrogen removal in the Muddy Creek sub-watersheds if the attenuation rates are changed from 57% to 10% (Upper) and from 10% to zero (Lower).
- Brewster’s nitrogen removals at the Captains Golf Course could be reduced by 670 kg/yr if the attenuation in the Tar Kiln Stream sub-watershed is increased to 60% where no attenuation was assumed in the past.

If these changes are made, the aggregate nitrogen removal will increase by 677 kg/yr. It must be recognized, however, that those attenuation changes also impact the nitrogen removal goals, so it is inappropriate to compare these potential adjustments with the current nitrogen removal requirements. The potential changes in attenuation percentages and in removal goals are discussed in the final section of this report entitled Updating the Watershed Permit.

Figure 1 illustrates the progress to date and shows the importance of Harwich’s sewerage project and Brewster’s golf course fertilizer management program.

Figure 1
Pleasant Bay Nitrogen Removal Progress



Individual town performance toward the 2023 goal is listed in Table 3 and summarized as follows:

- **Brewster:** With residential and golf course fertilizer controls in place at the time of Watershed Permit issuance, Brewster had already accomplished its share of the 2023 watershed-wide goal. The additional reductions in fertilizer use on fairways and roughs at the Captains Golf Course have allowed Brewster to achieve nearly all of its 20-year commitment.
- **Chatham:** Its existing residential fertilizer control ordinance addressed all of Chatham’s goal for the first 5 years of the permit. In constructing the connection with Harwich, and addressing neighborhoods in the Frostfish Creek area, Chatham has provided sewer service to about 200 homes in the Muddy Creek and Frostfish Creek subwatersheds, accomplishing another 520 kg/yr, allowing it to significantly exceed its 2023 goal.
- **Harwich:** To accomplish its share of the required nitrogen removal, Harwich needed to enact a residential fertilizer controls ordinance and complete Phase 2 of its proposed sewer system (East Harwich). Harwich has made progress toward an appropriate regulation related to residential fertilizer use. Harwich has now completed the first two contracts of its Phase 2 sewer construction and is taking advantage of its agreement with Chatham to receive the wastewater collected from the Pleasant Bay Watershed. Contracts 1 and 2 provide sewer service to about 500 parcels in the Muddy Creek (Upper and Lower), Mill Pond, and Muddy Creek Well sub-watersheds; these sewers provide for 2,131 kg/yr nitrogen removal, or over half of Harwich’s 20-year goal.
- **Orleans:** Through its residential fertilizer control ordinance and the Lonnie’s Pond shellfish harvesting demonstration, Orleans has addressed about 59% of its 2023 target. Orleans has moved ahead with construction of its Phase 2 sewers (Meetinghouse Pond) and the design of Phase 3 sewers (Lonnie’s Pond and vicinity). Those two sewer phases will accomplish nearly 3,000 kg/yr of nitrogen removal in upcoming years, allowing Orleans to reach 50% of its 20-year goal by Year 10 of the current permit.

PERFORMANCE OF SPECIFIC NITROGEN REMOVAL TECHNOLOGIES

Each town’s plan is based on a set of nitrogen removal technologies. The nitrogen removal associated with each technology is determined by a few key parameters, as outlined in the appendices to the TWMP. Findings to date are reported below. Monitoring and reporting these key factors are an important part of the towns’ adaptive management programs.

Shellfish Harvesting

Orleans has evaluated the regulatory, ecosystem, and private business issues of using aquaculture to remove nitrogen and improve water quality. Issues have included size and age of oysters, their marketability, the nitrogen removal in shell and flesh, nitrogen removal rates, sediment denitrification, scalability and transferability to other sites, and overall water quality impacts. After three years of using a pilot project in Lonnie’s Pond to identify and evaluate these parameters, the Town contracted with an aquaculture firm to move this effort to the next

step. Monitoring has shown that approximately 0.67% of oyster harvest weight is nitrogen (combined shell/flesh). In its March 2024 report on 2023 activities, SMAST documented 73 kg of nitrogen removal in 2023, within the prior range of 51 kg/yr (2021) to 85 kg/yr in (2020). The most recent three-year average removal is 63 kg/yr, down slightly from that reported last year.

On-going monitoring will quantify the nitrogen removal and water quality improvements, as well as continuing to develop information on denitrification in the sediments below the aquaculture beds. Based on past years' monitoring, the additional nitrogen removal through denitrification has been about 4 to 6 kg/yr. Further discussions are necessary with DEP to determine the amount of that removal that can be applied to the overall goals. Technical assistance to the Lonnie's Pond project was partially supported by the funding from EPA's Southern New England Program (SNEP).

In the spring of 2024, the Town renewed its contract with Ward Aquafarms.

The total nitrogen removal requirement for Lonnie's Pond is 298 kg/yr (284 kg/yr from Orleans and 14 kg/yr from Brewster). If the 2020-2023 performance continues, the shellfish harvesting project will accomplish about one-quarter of Orleans's responsibility in this sub-embayment.

Public Sewering

For determining nitrogen removal credits for sewerage projects in Chatham and Harwich, the operative variables are the measured water use at a given home or business, the estimated 10% consumptive use (water used outside the building that does not become wastewater), and the 26.25-mg/l estimate of septic system impact on the embayment (adjusted for natural attenuation). No adjustment is needed for the nitrogen in the Chatham treatment plant effluent, since the discharge location is outside the Pleasant Bay watershed.

Harwich has measured the water use at homes and businesses in East Harwich within the Phase 2 sewer service area to be able to compute the nitrogen load removed from the watershed. Construction activities under Phase 2 (Contracts 1 and 2) in East Harwich continued throughout 2021, making the public sewer system available to 509 parcels in the Upper and Lower Muddy Creek watersheds. Annual water use data from 2018 to 2020 were used to compute the anticipated unattenuated N load removal in both the Upper and Lower Muddy Creek subwatersheds. The Upper Muddy Creek sub-watershed includes 353 parcels generating an average wastewater flow of 77,818 gpd which results in an unattenuated N load removal of 2,821 kg/yr. The Lower Muddy Creek sub-watershed includes 156 parcels generating an average wastewater flow of 25,726 gpd resulting in an unattenuated N load removal of 932 kg/yr. Overall, these estimates translate to an average wastewater flow of 203 gpd per parcel and an average nitrogen removal of 7.4 kg/yr per parcel. These estimates will be reconciled with load removal estimates in the recent SMAST model update.

A wastewater flow measuring device exists at the Harwich connection point into the Chatham sewer system. Flow measurement can be used as a check against the computation above, once adjusted for infiltration/inflow and the nitrogen removal that would have occurred in the abandoned septic system.

A sensitivity analysis has been discussed for the future MEP modeling to address how several key input variables might change the estimated septic load and the overall watershed load. Those input variables include the 26.25-mg/l recharge concentration and the assumed consumptive use.

Prior estimates of attenuated nitrogen removal via East Harwich sewerage were based on the SMAST's 2010 estimate of 57% attenuation in Upper Muddy Creek and 2% in Lower Muddy Creek. The 2021 model update by SMAST uses different attenuation estimates (10% and zero, respectively). Since the attenuation could be lower, Harwich's sewer program in these sub-watersheds could actually remove significantly more attenuated nitrogen load than first thought. With the prior attenuation estimates, Harwich's attenuated load removal is 2,131 kg/yr, compared with 3,478 kg/yr with the new estimates. See discussion above in the report section Status of Nitrogen Removal Activities and Estimates of Removals to Date.

On-Site Denitrification

For estimating nitrogen removal credits, the key variables are the measured water use at a given home or business, the estimated consumptive use (water used outside the building that does not become wastewater), and the effluent concentration compared to the 26.25-mg/l estimate of septic system impact on the embayment (adjusted for natural attenuation).

Research conducted under the SNEP grant on behalf of Brewster has determined that on-site denitrification systems would need to produce an effluent nitrogen concentration no greater than 12 mg/l to achieve the TMDL for the major subwatersheds in the Town. For systems that could potentially be used in Brewster, this indicates a potential removal credit of 14.25 mg/l.

As discussed in the 2021 annual report, the Barnstable County Department of Health and Environment completed an analysis of performance data for more than 15 proprietary treatment systems in use across the US as of 2020. That analysis found no system with general approval in Massachusetts able to reliably reach the 12-mg/l goal established by Brewster. Since then, Brewster has been reviewing data from an ongoing study of the NitROE technology being tested in the Shubaels Pond watershed in Marstons Mill, through a project led by the Barnstable Clean Water Coalition. The NitROE system has provisional approval from DEP for an effluent nitrogen concentration of 11 mg/L. Data from the Shubaels Pond study are showing that the system has been able to produce an effluent with a nitrogen concentration at or below 11 mg/l. Based on the outcomes of the golf course projects discussed below, Brewster will continue to monitor the data from the Shubaels Pond program; the use of on-site denitrification systems could still be useful, depending on their performance and their installation and ongoing maintenance costs. Based on additional reductions in fertilizer use at

Captains Golf Course, the number of Brewster homes needing to install on-site denitrification systems may be less than first thought.

Captain’s Golf Course Fertilizer Reduction

MEP modeling in 2006 established baseline conditions for calculating golf course fertilizer impacts, including application rates and nitrogen leaching. Nitrogen removals from that baseline are computed based on the reduction in applied nitrogen and the assumed 20% fertilizer leaching rate. Brewster previously documented the 930-kg/yr removal already taken by Brewster for fertilizer reductions at the Captain’s Golf Course that occurred before issuance of the Watershed Permit.

In 2020, Brewster conducted further studies that indicate fertilizer applications could be reduced by lowering the amounts applied to golf course fairways and roughs and switching from granular fertilizers to sprayed fertilizers during the spring and summer that have lower nitrogen application rates and are applied in a manner that promotes uptake by the golf course turf. This is followed by one granular application in the fall. The new practices were initiated in the fall of 2020 and continued throughout all of 2021, 2022 and 2023.

The Captains Golf Course Superintendent provides an annual report to the Town that shows specific fertilizer application rates for greens, tees, fairways and rough areas. Summarized below are the annual nitrogen loads and the associated load reductions from the basis of the Watershed Permit.

	Nitrogen Load, kg/yr	Nitrogen Load Reduction from Permit Basis, kg/yr	Avg. Nitrogen Load Reduction in Previous 3 Years, kg/yr
2006 MEP report	2,420		
2011-2015 Avg. Fert. Use	1,440	980	980
2020 Fertilizer Use	1,301	1,120	
2021 Fertilizer Use	760	1,660	
2022 Fertilizer Use	770	1,650	1,476
2021 to 2023 Fert. Use	850	1,570	1,570

In 2021-2023, the golf course’s unattenuated load to Pleasant Bay was 1,570 kg/yr less than estimated in the 2006 MEP report, which formed the basis for the Watershed Permit. This reduction in nitrogen load corresponds with reductions in fertilizer applications to the fairways and rough areas, and a reduction in rough areas from 90 acres to 49 acres. The 2021-2023 fertilizer use includes an allowance for a supplemental application every three years.

These are reductions in unattenuated load, and do not reflect the proposed increase in attenuation rate in the Tar Kiln Stream sub-watershed. In 2021-23, the nitrogen applications to the Tar Kiln Stream sub-watershed were 429 kg/yr, about 53% of the total golf course nitrogen application. The remainder of the nitrogen applications at the golf course fall in the Pleasant Bay main and Little Pleasant Bay sub-watersheds.

Brewster is continuing to study the fertilizer leaching rate at the golf course, sampling six lysimeters and six monitoring wells quarterly for nitrogen and phosphorus compounds. The installation of a few additional monitoring wells occurred in the summer of 2023 to help refine the current information and better establish a local leaching rate through the turf. Information on this study will be available for the next annual report and is expected to show a leaching rate of about 11%, compared to the 20% basis for the current permit.

In addition, a few more years of data on the fertilizer applications and associated health of the turfgrass are needed to confirm the long-term average fertilizer application rates that can be used as a credit in the Watershed Permit. There may be a need to apply fertilizers to the fairways and rough areas every three to four years and therefore an average loading rate will need to be confirmed for long-term compliance with the Permit. Projections of future fertilizer use include an allowance for those periodic applications.

Captain's Golf Course Fertigation

To estimate the nitrogen removal credit for fertigation, the key variables are the annual volume of groundwater withdrawn for golf course irrigation, the average nitrogen concentration of that groundwater and the nitrogen leaching rate. Brewster originally estimated that an annual load reduction of 230 kg was accomplished with this approach and that figure is included in the Watershed Permit as having occurred prior to permit issuance.

Brewster has compiled the following data to update that original estimate:

- 2018: 44.429 million gallons pumped @ 2.1 mg/l: 282 kg/yr removed
- 2019: 41.999 million gallons pumped @ 2.3 mg/l: 293 kg/yr removed
- 2020: 50.866 million gallons pumped – no nitrogen sampling conducted
- 2021: 40.146 million gallons pumped @ 3.4 mg/l: 413 kg/yr removed
- 2022: 48.174 million gallons pumped @ 3.0 mg/l: 438 kg/yr removed
- 2023: 38.431 million gallons pumped @ 2.3 mg/l: 267 kg/yr removed

Given the data above, an average of 373 kg/year of nitrogen was removed by the irrigation well over the last three years that were measured. This takes into account a 20% leaching rate for nitrogen in the irrigation water applied onto the course that is assumed to reenter groundwater flowing towards Pleasant Bay. This three-year average represents a 143-kg/yr increase over the original credit of 230 kg/yr.

Permeable Reactive Barriers

PRB performance is determined by the groundwater nitrogen load entering and leaving the reactor, as measured from multiple monitoring wells.

Orleans has installed a PRB at the Nauset Middle School (located in the Town Cove watershed) and has monitored its performance through an on-going demonstration project; preliminary performance has indicated total nitrogen concentrations of 1 to 2 mg/l on the downgradient

side of the PRB. Additional monitoring is necessary to resolve other related issues, such as quantification of overall nitrogen removal, predominant groundwater flow directions, and the portion of wastewater nitrogen flowing through the PRB. Orleans has established a long-term target removal of 80% as the trigger for the renewal of the injected carbon source.

Based on the success of the Middle School demonstration project, the 5-year Capital Improvement Plan includes \$10.5 million beginning in FY 2027 for construction one or more PRBs in the Pleasant Bay watershed.

WATER QUALITY MONITORING DATA AND HABITAT ASSESSMENTS

Embayment Monitoring

The focuses of ongoing monitoring programs are:

- **Water column nitrogen and dissolved oxygen:** The Alliance's Water Quality Monitoring Program is currently conducting its 25th monitoring season in 2024. Monitoring occurs at approximately 24 stations selected to track TMDL compliance. A DEP-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. Water samples are analyzed by the Coastal Systems Analytical Facility at the UMass Dartmouth School for Marine Science and Technology (SMAST) and results are reported to the Alliance. The Alliance issues periodic reports reviewing the sampling results and conducts in-depth statistical trend assessments. The most recent statistical trend assessment was further evaluated by SMAST to recommend assessment improvements to better address ecological and regulatory implications. The Alliance monitoring program is funded annually by the towns and will continue.

The most current report on statistical trends in water quality data is the Cadmus Group report, July 2015 (*Pleasant Bay Alliance Water Quality Monitoring Program: Statistical Analysis of 2000-2014 Water Quality Monitoring Data*). Water quality data are being further reviewed as part of the updating of the SMAST linked model as funded by a grant from SNEP. Subsequent to this model update, the Alliance plans to resume updating of the statistical trend assessment.

Alliance-generated water quality data for the period 2015 to 2019 were used by SMAST in its 2021 update of the linked watershed-embayment model.

- **Eelgrass coverage and vitality:** Eelgrass coverage is a key parameter for TMDL compliance. The Alliance and its member communities have utilized eelgrass surveys conducted 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, 2012 and 2019. The MassDEP reports for 1994 to 2012 can be found at:

https://docs.digital.mass.gov/dataset/massgis-data-massdep-eelgrass-mapping-project?_ga=2.170582688.1209249591.1560872870-1878295305.1557759152

The 2019 report is not yet available at this site.

The Alliance will work with the MassDEP and others to identify the schedule and extent of future mapping needed to effectively monitor future changes in Pleasant Bay eelgrass beds and to gauge restoration needs.

An analysis of eelgrass coverage from 1951 to 2019 is presented in the 2021 SMAST update of the linked watershed-embayment model.

- **Benthic infauna health and diversity** – The diversity and species in the sediment animal population is a key indicator of ecosystem health in Pleasant Bay. As part of the integrated MEP assessment, quantitative sediment sampling for benthic animals was completed at 34 locations throughout the Bay and this information was compared with water quality and eelgrass measurements. This information was utilized in the characterization of ecosystem health and the development of Pleasant Bay TMDLs. In 2008, as part of the Muddy Creek inlet improvement plan, SMAST conducted an updated assessment of benthic infauna at six locations. In 2014, the Center for Coastal Studies (CCS) collected benthic infauna samples at all MEP locations except Muddy Creek. (The samples were collected at a different time of year, using different protocols from prior MEP work.) This effort was undertaken in concert with a benthic mapping project for the Cape Cod National Seashore. The results of this CCS study are provided in a report entitled *Below the Surface of the Bay, Marine Ecosystem Assessment of Pleasant Bay, Cape Cod, MA*, and is available at:

<https://fopb.wildapricot.org/resources/Documents/FCRV/FoPB-Below%20the%20Surface-CLEAN.pdf>

The SNEP-funded SMAST 2021 model update was based on assessments of water quality and eelgrass and includes the appropriate benthic infauna data needed for assessing ecological health in Pleasant Bay. The model update is available at:

https://pleasantbay.org/wp-content/uploads/PBA_Updated-MEP-2020-Modeling-Rpt-FINAL-063021.pdf

Project-Specific Monitoring

Monitoring programs related to mitigation measures for specific projects are:

- **Orleans** worked with SMAST to develop a management plan and monitoring program for an oyster growing pilot project in Lonnie's Pond. Orleans' latest reporting of monitoring data related to the last three years of the Lonnie's Pond oyster growing project is contained in an SMAST report dated March 2024.

- **Brewster** agreed to monitor groundwater irrigation water quality at the Captains Golf Course and to evaluate the ongoing reductions from fertilizer management at the golf course. This includes a two-year study to confirm the leaching rate for nitrogen applied in fertilizers at the course. Funding for this study was approved in May 2021, and the project is underway following the installation of monitoring wells and pan lysimeters to measure nitrogen in water leaching through the golf course turf.
- **Chatham and Harwich** are undertaking bacterial and nitrogen water quality and vegetation monitoring to evaluate changes in water quality resulting from the Muddy Creek Restoration Bridge Project. Muddy Creek monitoring reports are available at:

<http://pleasantbay.org/programs-and-projects/wetlands-protection/muddy-creek-restoration/muddy-creek-restoration-monitoring-results>

Copies of Alliance-sponsored reports are available on the PBA website, www.pleasantbay.org.

CAPITAL COMMITMENTS AND EXPENDITURES

The four towns have made substantial financial commitments to date and have expressed their intentions for continued major expenditures. The high points are as follows:

Brewster

Since 2011 Brewster has invested approximately \$1,550,000 in the development and implementation of the Town's Integrated Water Resource Management Plan (IWRMP). The IWRMP evaluates all the water resources in town, including management of the nitrogen load to Pleasant Bay from Brewster's portion of the watershed. The funding includes the golf course leaching rate study approved in May 2021 for \$140,000 that is currently being finalized.

Brewster has developed a preliminary concept plan for a traditional neighborhood wastewater treatment facility as required under the watershed permit. Given the nitrogen reduction achieved at the golf course, the need for a neighborhood plant is reduced significantly and once the current permit modifications are confirmed, the Town can review this issue and determine if such a facility is required.

Chatham

The Town of Chatham has an approved CWMP that partitions the Town into two phases; Phase 1 includes areas to be sewerred to achieve TMDL compliance including in the Pleasant Bay watershed, and Phase 2 calls for sewerred of the remainder of the Town not needed to meet TMDLs. To date, the Town has appropriated nearly \$150 million dollars toward these goals.

The Chatham-Harwich Regionalization Connection Project is complete. This continues to serve as the connection for East Harwich wastewater to be conveyed to the Chatham Water Pollution Control Facility for treatment, in addition to serving 60 properties within the Muddy Creek sub-watershed of Pleasant Bay. Two more recent projects are nearing completion; the 1D-2A project which will eventually collect wastewater from future sewer connections in the Pleasant Bay watershed near Route 137, and the Queen Anne Pumping Station Upgrade project which currently serves properties in both the Pleasant Bay watershed and Stage Harbor watershed.

The Town also has other sewer projects in design or construction: Phase 1E-2 will serve portions of Stage Harbor watershed, and the 1C-5 project which also serves portions of that watershed. The Town is currently preparing budgets for future sewer design and construction. The first of these projects is intended to extend sewers in areas adjacent to existing facilities and the second larger project (that would potentially enter design in the summer of 2025) is targeting a portion of Pleasant Bay in the vicinity of Route 28 and Frost Fish Creek. The extent of these projects has not been determined but are anticipated to continue to meet the Town's commitments to provide sewer service to the Town and each could be in the \$20M to \$50M total cost range.

Harwich

The Town of Harwich adopted its Comprehensive Wastewater Management Plan (CWMP) in 2016 to address wastewater and nitrogen mitigation challenges. Phases 2 and 3 of the CWMP focus on reducing Harwich's nitrogen contribution to Pleasant Bay using traditional wastewater collection and treatment technologies. Phase 2, funded by a \$22.45 million appropriation at the 2018 Town Meeting, involved two construction contracts designed to serve 440 parcels in the Upper and Lower Muddy Creek sub-watersheds. Value engineering during construction reduced overall costs, enabling a \$1.5 million change order to include an additional 57 parcels, increasing the total to 497 parcels. Harwich also secured a 0% interest state revolving fund (SRF) loan, benefiting from its nitrogen removal efforts and regional partnership with Chatham.

At the Fall 2021 Special Town Meeting, voters approved \$250,000 for CWMP revisions, \$2.1 million to design the Phase 3 wastewater collection system in the Pleasant Bay and Round Cove sub-watersheds, and \$200,000 for the Route 28 dry sewer design. The design for Phase 3 is now complete, with construction scheduled to begin in December 2024. Additionally, the Town allocated \$60,000 for an effluent recharge investigation, which, along with CWMP revisions, remains ongoing.

In Fall 2022, voters approved \$105,000 to acquire easements for Phase 3 pump stations and the collection system. In March 2023, Harwich received a \$616,255 ARPA grant from Barnstable County to design the Great Sand Lakes Collection System, located outside the Pleasant Bay watershed. A contract for this design was awarded in June 2024 and is currently underway. At the 2023 Annual Town Meeting, voters approved a \$50 million Proposition 2½ debt exclusion to fund the Phase 3 collection system construction, serving approximately 662

parcels in the Pleasant Bay Main and Round Cove watersheds. An additional \$6.5 million was approved to install a dry sewer pipe along Route 28 in West Harwich. Phase 3 construction contracts, totaling \$31,285,641, were awarded in May 2024. As CWMP revisions continue, Harwich is exploring regional solutions for wastewater generated outside the Pleasant Bay watershed. With the Dennis-Harwich-Yarmouth Clean Waters Partnership no longer feasible, the Town has initiated discussions with Dennis, which recently allocated \$248 million to fund the first phase of its wastewater management plan.

Orleans

Prior to the Watershed Permit issuance, Orleans spent \$3.4M on the design and installation of downtown sewers in the area of a Mass DOT construction project to avoid a road opening prohibition. Another \$2.7M was spent on the design of a new wastewater treatment facility (WWTF). At the 2019 and 2020 Annual Town Meetings, voters approved a total of \$59.1M for the construction of downtown sewers and the wastewater treatment plant. Construction began in September 2020. While these expenditures do not immediately accrue to the benefit of Pleasant Bay, they are part of the infrastructure that will eventually serve portions of Orleans in the Pleasant Bay watershed.

In May 2021, the Town Meeting authorized \$658,000 for final design of sewers in the Meetinghouse Pond sub-embayment of the Pleasant Bay system (Phase 2). That design was completed in FY 2022. The May 9, 2022 Annual Town meeting authorized \$32.9 million, enabling the construction to begin in FY 2023. Upon completion in FY 2025, septic nitrogen from households in the Meetinghouse Pond sub-watershed will be removed from this area and treated/disposed outside the Pleasant Bay watershed, at the WWTF mentioned above. The goal is the removal of an annual load of 2,115 kg, or about 30% of Orleans' share of the TMDLs. Under the current plan, those removals would begin in the second 5-year segment of the Implementation Schedule, consistent with the Watershed Permit.

The May 2023 Town Meeting authorized \$2.3 million for survey and design of a third phase of sewers, for the Lake and Ponds sewer service area. This project will protect two freshwater bodies, Crystal Lake and Pilgrim Lake, as well as removing nitrogen from the Lonnie's Pond watershed and areas upgradient of the River. Final design funds for Phase 3 sewers in the amount of \$960,000 were approved at the May 2024 Annual Town Meeting. Construction funding will likely be requested in FY25. Upon completion, the project will annually remove 1,216 kg, or 18% of Orleans' share of the Pleasant Bay TMDLs. The project will sewer areas upgradient of the freshwater bodies to reduce phosphorus loads, consistent with approved management plans for those waters.

The 2023 Annual Town Meeting also authorized \$275,000 to close out the Phase 1 Downtown Sewer Project, including the wastewater treatment facility which came online in March 2023.

Orleans has continued with its shellfish harvesting demonstration project in Lonnie's Pond. The Town has established an initial nitrogen removal target of 75 kg/yr through the Lonnie's

Pond Management Plan. The Plan is implemented through an aquaculture contractor and a monitoring contractor. Ward Aquafarms of Buzzards Bay was selected as the aquaculture contractor, while SMAST was selected as the monitoring contractor. The Plan provides the option to place 5.5 million small oysters or 2.1 million larger oysters in the Pond to achieve the nitrogen removal target. The oysters are grown for the summer and removed by the end of the growing season in the same year. Oysters are then grown to market size in another location. In 2020, 2021 and 2022, the demonstration project removed an average of 67 kg/yr of nitrogen from the Pleasant Bay Watershed. This represents about 2.4% of the Town's overall goal for multiple shellfish harvesting operations in the Pleasant Bay watershed. The Watershed Permit's Implementation Schedule calls for 272 kg/yr removal in place by the end of FY 2023, which translates to three other harvesting areas of comparable size to the Lonnie's Pond operation. Based on concerns of the abutters and the general public, the Town has decided not to further increase the shellfish operation in Lonnie's Pond or to initiate similar programs elsewhere in Orleans at this time. The Town intends to maintain the Lonnie's Pond program at the same level and will rely on sewerage to address remaining TMDL requirements.

Based on the results of a successful PRB demonstration at the Middle School, Orleans is now planning to add this technology to its plan. The 5-yr Capital Improvement Plan includes \$15M 10.5million beginning in FY 2027 for constructing one or more PRBs in the Pleasant Bay Watershed.

The Orleans Amended CWMP was approved by MADEP and the Cape Cod Commission in 2024. It includes 16 phases of public sewerage to protect marine receiving waters. In addition to its active involvement in the Pleasant Bay Alliance, the Town has a memorandum of understanding with the Town of Eastham to work cooperatively on Nauset Estuary and Rock Harbor.

PROGRESS IN NON-STRUCTURAL AND NON-SEWERING OPTIONS

Non-structural options include residential lawn fertilizer controls, land set-asides, rezoning, etc. Non-sewerage approaches include on-site denitrification, permeable reactive barriers, inlet widening, etc. Progress with alternate control approaches through FY 2024 includes:

Brewster

Brewster initiated a fertilizer leaching rate study at Captains Golf Course in 2021. Six lysimeters and six monitoring wells were installed below the fairways at the golf course. Quarterly sampling of water captured in the lysimeters and water from the monitoring wells began in November 2021, with additional samples taken on a quarterly basis through February 2024. Based on these data, an updated leaching rate of 11.4% was calculated and, pending review by DEP will be used to update the amount of nitrogen applied in fertilizer that leaches into the aquifer and migrates to Pleasant Bay.

At the November 2021 Town Meeting, the Town adopted a town-wide stormwater management bylaw that requires a permit for any project disturbing over 10,000 square feet of

land or creating more than 500 square feet of impervious cover. The bylaw requires the utilization of best management practices for stormwater to minimize nutrient inputs to groundwater and surface waters. An update to the Town's Water Quality Review Bylaw was also approved, clarifying the methods to calculate nitrogen loading and meet the 5-mg/l nitrogen performance standard for new development and redevelopment projects in the Pleasant Bay watershed. Subsequently, the Board of Health adopted a new regulation providing the requirements for developing nitrogen loading calculations to comply with the Water Quality Review Bylaw.

Since 2008, the Town, along with the Brewster Conservation Trust, has permanently preserved approximately 250 acres of open space in the Pleasant Bay watershed, removing land from development that would impact the buildout nitrogen load to the Bay. Preserving this land reduces the impact of buildout development on the future nitrogen load to Pleasant Bay.

Chatham

Chatham continues to pursue stormwater infrastructure improvements town-wide as part of its MS4 program. Since adopting a Fertilizer Regulation in 2014, the Town has maintained support and enforcement of these requirements.

In partnership with Harwich, Chatham completed the Muddy Creek Bridge project, replacing restrictive culverts with a clear-span bridge to enhance tidal flow. The Towns, along with the Pleasant Bay Alliance, continue to monitor the project's success.

The Town acquired 4.17 acres of open space along Goose Pond within the Pleasant Bay Watershed. Additionally, Chatham is collaborating with the Chatham Conservation Foundation, MassDOT, USDA NRCS, and Massachusetts DER to assess alternatives to two undersized culverts at Frost Fish Creek on Rt. 28. SMAST is modeling water quality impacts of an optimized inlet design, with results expected in early 2025 to guide permit-level design.

Chatham is also working with MassDOT and NRCS on a larger culvert for the herring run from Lovers Lake to Ryders Cove. The design contract is anticipated for winter 2024–25.

Harwich

In 2016, the Town, in cooperation with the Town of Chatham, removed an earthen dike and culvert structure that blocked tidal flow between Muddy Creek and Pleasant Bay, and replaced it with a new Muddy Creek Bridge. The two towns in coordination with the Pleasant Bay Alliance are monitoring the success of that project. As a result of the project, the tide range in Muddy Creek has increased and is nearly the same as for the main basin of Pleasant Bay.

The Harwich Board of Health adopted its Fertilizer and Nutrient Control Regulation in January 2021 to provide a regulatory framework that results in reducing nutrient loadings from the application of fertilizers. In October 2021, the Town was advised that the Attorney General

determined that Chapter 262 of the Acts of 2012 preempts local regulation of fertilizer application, as such the Board of Health rescinded the regulations and adopted Town of Harwich Fertilizer Policy Guidelines for Nutrient Control in February 2022. There has been no update to the Policy and Guidelines for nutrient control since February 2022.

The Town of Harwich, working through its Board of Selectmen and its Conservation Commission, works closely with Harwich Conservation Trust to purchase property or obtain the necessary conservation restrictions to protect environmental resources throughout the town. Over the past fifteen years this partnership has led to the purchase of the 43-acre Monomoy River Woodlands and the 49-acre Pleasant Bay Woodlands properties in the Pleasant Bay watershed. More recently this partnership led to the protection of the 17-acre Muddy Creek Headwaters Preserve adjacent to Muddy Creek in the Pleasant Bay Watershed.

Orleans

Open space acquisition has played a role in protecting Pleasant Bay. In 2020, the Town Meeting voted to acquire a 2.6-acre parcel fronting Arey’s Pond, preventing development of the parcel. There are no current zoning changes anticipated in the Pleasant Bay watershed, although 2017 rezoning in the downtown area is expected to help concentrate growth there, outside the Pleasant Bay watershed. The Town, in conjunction with the Orleans Conservation Trust (OCT), has purchased two existing homes in the Pleasant Bay watershed and modified the parcels to eliminate future septic loads there. In 2021, the Town and OCT purchased 3 additional building lots and “undeveloped” one of them as permanent open space.

In 2024, the Orleans Conservation Trust received a gift of land comprising 26 acres with substantial shoreline on The River portion of Pleasant Bay. This acquisition avoided the future impacts of up to 25 waterfront homes, in a location which is remote and not easily sewerred.

Orleans continues to make improvements to its stormwater system and is in compliance with its MS4 stormwater permit.

GROWTH IN NITROGEN LOAD

Growth in the watershed nitrogen loads, to the extent not already accounted for in a town’s plan, represents both a financial burden and the need to expand/modify that plan. Growth is defined as increased nitrogen load since the baseline years that are part of the 2006 MEP report and the 2010 update related to Harwich water use. Those baseline years are:

Brewster:	2002 to 2004
Chatham:	2002 to 2003
Harwich:	2004 to 2007 (updated from 2004 in 2006 MEP report)
Orleans:	2002 to 2003

In its June 2021 report “2020 Update”, SMAST presented estimates of watershed loads based on water use data from 2011 to 2015, a period approximately 10 years later than the loading

estimates included in the 2006 MEP report. Termed “existing conditions”, those loading estimates include load reductions accomplished by the towns since the MEP report, and revised attenuation percentages for certain sub-watersheds. The “existing conditions” attenuated loads are about 4% higher than the bases for the TWMP and Watershed Permit. The June 2023 SMAST technical memo on buildout scenarios presents the results of land use planning exercises conducted by SMAST for the four towns. That memo indicates a 13% increase in attenuated loads over “existing conditions” (reported in 2020 Update) until buildout.

The June 2021 SMAST report and the June 2023 SMAST technical memo, taken together, predict a 17% growth in attenuated load from the TWMP basis until buildout, in addition to the town removals in place since 2010. The four towns have reviewed that SMAST information and have prepared their own independent estimates of growth in watershed nitrogen loads. Brewster and Chatham have projected future nitrogen loads through build-out. Harwich has projected growth through 2040 and Orleans through 2044.

Across the four towns, it is estimated that attenuated watershed loads have increased by 2,237 kg/yr since the basis of the Watershed Permit, and that future growth will create an additional load of 4,470 kg/yr. With these increases, the attenuated watershed load will have increased by about 14% from 48,503 kg/yr to 54,878 kg/yr. The percentage load increase is largest in Chatham (24%) and smallest in Orleans (6%). Please refer to the section of this report entitled Updating the Watershed Permit for more information on these growth projections.

The four towns have confirmed prior commitments related to responsibilities for growth in watershed loads. Each town is fully responsible for the increases in watershed loads in that town which have occurred or will occur beyond the loads that are the basis for the TWMP.

MODELING OF WATERSHED LOADS AND EMBAYMENT WATER QUALITY

The SMAST/MEP technical report on Pleasant Bay was completed in 2006 and was supplemented with further analysis in 2010. That report formed the basis for the Pleasant Bay TMDLs, and with the updated information allowed the establishment of the nitrogen load removal requirements for each town. The Alliance has used funding from the EPA SNEP program to conduct additional modeling to better understand the impacts of watershed nitrogen loads on the water quality in the Bay.

Modeling Under SNEP-18 Grant

With funding from the 2018 EPA SNEP grant, the Alliance has able to complete the updating of the watershed loads and a re-modeling of receiving water quality under current hydrodynamic conditions. This effort has allowed the input of additional water quality data, and the consideration of habitat data accumulated since the early 2000s. This remodeling was completed in June 2021 and is summarized in the SMAST report *Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham and Harwich, Massachusetts*.

The 2021 SMAST study updated all the key components of the Pleasant Bay MEP assessment including:

- An update of watershed water use and nitrogen loads
- Updating nitrogen recycling from Bay sediments to reflect large changes in benthic flux
- Assessment of the status of eelgrass habitat based on MassDEP surveys
- Revised estimates of attenuation of two sub-basins (Muddy Creek and Tar Kiln Stream)
- Updated system tidal hydrodynamics, including new inlets (post-2006) and new bathymetry
- Scenarios to predict changes in water quality under current town nitrogen removal plans.

There are three fundamental variables considered in the 2021 SMAST study, and their impacts on predicted water quality provide insight into potential changes in the Watershed Permit:

- An increase in watershed loads
- Better estimates of attenuation and benthic recycling, and improved hydrodynamics
- Implementation of town nitrogen removal plans, full and partial.

The “Composite Scenario” considered by SMAST reflects full sewerage in Chatham (removing much more than Chatham’s responsibilities under the Watershed Permit) and removals in Brewster and Orleans that are significantly less than their commitments. The “TWMP Scenario” considers just the specific nitrogen removal requirements of the Watershed Permit.

The SMAST study involved these two primary future scenarios (Composite Scenario and TWMP Scenario), which are compared here with the 2010 work which is the basis for the Watershed Permit.

	SMAST-2010 (basis for Permit)	SMAST-2021 Composite Scenario	SMAST-2021 TWMP Scenario
Un-attenuated load, kg/yr	54,460	54,894	56,389
Attenuation, kg/yr	5,960	4,623	5,104
Attenuated load, kg/yr	48,500	50,271	51,285
Load removal, kg/yr	17,720	25,947	17,720
Remaining load, kg/yr	30,780	24,324	33,565
Sentinel station compliance			
Primary stations	2 of 2	2 of 2	2 of 2
Secondary stations	8 of 8	6 of 8	7 of 8

Comparing the first 2021 SMAST model run (Composite Scenario) with the 2010 evaluation shows the effect of increased watershed loads and a partial, unbalanced set of town load removals in the face of improved hydrodynamics. In this scenario, two of the secondary

stations are predicted not to meet the target concentrations, even though the remaining load (after town removals) is only 79% of the threshold loads. This is because the load removals, although larger than required under the Watershed Permit, are heavily influenced by larger-than-required removals in Chatham. The less-than-required removals in Brewster and Orleans do not allow two of the northerly secondary stations to reach their target concentrations.

Comparing the second 2021 SMAST model run (Composite Scenario) with the 2010 evaluation shows the effect of increased watershed loads and the balanced set of town load removals that the towns have committed to in the Watershed Permit. In this scenario, the Watershed Permit removals (17,720 kg/yr) result in a remaining attenuated load (after town removals) of 33,565 kg/yr, 7% higher than the threshold load. In this scenario, only one of the secondary stations is predicted not to meet the target concentrations. The near full compliance at the sentinel stations indicates that the improved hydrodynamics nearly offset the 5.7% increase in attenuated watershed load if the town remove their 17,720 kg/yr commitments.

Neither scenario considers the effect of future growth on any town's ability to meet nitrogen reduction targets.

Modeling Under SNEP-20 Grant—Build-Out

SMAST estimated future watershed loads based on its estimate of build-out conditions in all four watershed towns (see the Growth in Nitrogen Load section of this Annual Report) and used the water quality model to predict how nitrogen concentrations would change at the sentinel stations. (The SMAST analysis includes a 17% increase in loads at build-out; later town planning includes a 14% increase at build-out or in 20 years depending on the town.) The SMAST Technical Memorandum dated August 9, 2023 summarizes the modeling results for two scenarios with those build-out watershed loads. Scenario 1 is based on more favorable hydrodynamic conditions (post-breach outlets and presence of the Muddy Creek bridge), coupled with updated bathymetry and benthic loads. Scenario 2 is based on the less favorable pre-breach conditions, but with the Muddy Creek bridge and the significantly lower benthic loads that were the basis of the MEP model.

In Scenario 1, the water quality model predicts that the increased watershed loads through build-out will result in only one of the two primary sentinel stations meeting the threshold concentration of 0.16 mg/l bioactive nitrogen, and only one of the eight secondary stations meeting the 0.21 mg/l secondary threshold concentration.

In Scenario 2, the water quality model predicts that the increased watershed loads through build-out will prevent any of the primary or secondary sentinel stations from reaching their respective threshold concentrations.

This study shows the significant water quality impacts of increased watershed loads through build-out.

Modeling Under SNEP-20 Grant—Sensitivity to Attenuation Estimates

To help gauge the importance of natural attenuation in the Upper Muddy Creek and Tar Kiln Stream sub-watersheds, SMAST completed a sensitivity analysis under the SNEP-20 grant; see the SMAST Technical Memorandum dated August 9, 2023. Two scenarios were considered to determine the sensitivity of the predicted water column nitrogen concentrations to the level of attenuation in these two sub-watersheds.

In Scenario 1, the attenuation in the Tar Kiln Stream watershed was adjusted to zero and compared with the SNEP-18 predictions based on 60% attenuation. The existing conditions loadings were used as a basis, including the post-breach hydrodynamics. SMAST found that reducing the Tar Kiln Stream attenuation from 60% to zero (an increase in attenuated load of about 1,300 kg/yr) had little or no impact on predicted nitrogen concentrations throughout the Bay.

In Scenario 2, the change to no attenuation in the Tar Kiln Stream watershed was coupled with a reduction in Upper Muddy Creek attenuation from 10% to 4%. Again, the SNEP-18 existing conditions loadings were used as a basis, including the post-breach hydrodynamics. SMAST found that reducing the Upper Muddy Creek attenuation from 10% to 4% (a further increase in attenuated load of about 300 kg/yr) appreciably impacted the predicted water quality in both Upper and Lower Muddy Creek as well as causing small changes at five stations elsewhere.

In the upcoming year, the Alliance may use the SMAST model to help estimate possible new threshold loads to account for all of watershed and benthic loading changes determined since the 2006/2010 basis for the Watershed Permit.

REVIEW OF ATTENUATION ESTIMATES

After computing un-attenuated watershed loads, the MEP report for Pleasant Bay reduced those loads to account for attenuation occurring within the sub-watershed (generally through ponds and streams) and at the watershed-embayment interface. Including the SMAST updates for Harwich in 2010, the TWMP showed that natural attenuation reduces the unattenuated nitrogen load across the watershed by about 11%. In some watersheds, the role of natural attenuation is greater than average and has significant impact on the nitrogen removal needs.

SNEP-funded studies by SMAST in 2021 allowed re-estimation of attenuation percentages. Compared with the 2006 MEP report and SMAST updates in 2010, this more current SMAST work revised the attenuation estimates significantly downward in upper Muddy Creek and significantly upward in Tar Kiln Stream. Further, SMAST recommended that Orleans consider the possible attenuation in the salt marshes in the Pochet Neck sub-watershed where attenuation was not previously addressed. These new estimates could result in significant changes in the nitrogen removal requirements for Harwich, Brewster and Orleans, with significant impacts on the towns' costs for nitrogen control.

Since the Permit issuance in 2018, the Alliance contracted with SMAST to conduct nitrogen mass exchange evaluations in Muddy Creek and Pochet Neck, and Orleans retained SMAST to further evaluate the upper portion of Pochet Neck. HydroAnalysis reviewed those evaluations and offered new insights into the techniques and findings. SMAST reevaluated its MEP work on the Tar Kiln Stream system and recommended that natural attenuation also be considered there.

As a result of all of these investigations, the Towns have revised their nitrogen management plans to reflect the following changes in natural attenuation rates and amounts:

- Upper Muddy Creek: reduce attenuation from 57% to 10%
- Lower Muddy Creek: reduce attenuation from 2% to zero
- Tar Kiln Stream: increase attenuation from zero to 60%
- Upper Pochet Neck increase attenuation from zero to 470 kg/yr

While the net effect of these changes on the overall situation is small (612 kg/yr increase in attenuated watershed loads), the effect is significant in the four sub-watersheds where changes are made. Please refer to the section of this report entitled Updating the Watershed Permit.

GROUNDWATER DISCHARGE PERMITS AND I/A SYSTEMS

There are 16 Groundwater Discharge Permit (GWD) holders in Brewster, Chatham, Harwich, and Orleans. There are four facilities with GWD permits located in the Pleasant Bay watershed:

- Pleasant Bay Health & Living Center (Brewster), 26,500 gpd permitted maximum
- Chatham Bars Inn (Chatham), 60,000 gpd permitted maximum
- Wequassett Inn (Harwich), 45,000 gpd permitted maximum
- Nickerson State Park (Brewster), 50,900 gpd permitted maximum

Each of the first three facilities has a total nitrogen discharge limit of 10 mg/l of total nitrogen. From July 2023 to June 2024, all three of these facilities routinely met their permit requirements with only infrequent exceedances. The average effluent nitrogen was below 5 mg/l. All three facilities received wastewater flows at or near their permitted flow limits in the summer months, indicating the need for capacity expansions. The SMAST 2021 model update states that the aggregate nitrogen load from these three facilities is 705 kg/yr.

At the time of permit renewal for these facilities, it is expected that DEP will add limits for total annual nitrogen load.

The permit for Nickerson State Park allows Title 5 discharges up to the stated maximum flow and it limits total nitrogen recharge to 2,120 kg/yr. Not all of the permitted activities are in the Pleasant Bay watershed.

As of July 2024, there are no applications pending for new GWD permits in the watershed.

There are two other GWD permits of note in the region. The municipal wastewater treatment facility in Chatham discharges outside the Pleasant Bay watershed and in 2023 began to receive wastewater and nitrogen load from the Pleasant Bay watershed in Harwich. Similarly, the Town of Orleans holds a GWD permit for the Orleans municipal WWTF with its discharge at a site off Lots Hollow Road outside the Pleasant Bay watershed. That Orleans facility began to receive and treat wastewater and nitrogen load from the Nauset Harbor watershed in 2023 and is planned to remove nitrogen load from at least the Meetinghouse Pond and The River sub-watersheds of Pleasant Bay in the next few years.

SMAST has reported that there were 119 I/A systems in the Pleasant Bay watershed in 2020 (3 in Brewster, 84 in Chatham, 5 in Harwich and 27 in Orleans). Analysis of reported effluent data indicates an average total nitrogen concentration of 21.9 mg/l, or an average 17% reduction from the 26.25 mg/l baseline for traditional septic systems.

DATA FROM BUILDING DEPARTMENTS AND ASSESSORS

In future annual reports, town departments will provide information on development and redevelopment as derived from the towns' traditional annual reports that are released before Town Meetings. The Commission has also requested data on the location and square footage of new structures and the number of new bedrooms in the watershed. The Alliance and the towns will work with Commission staff to develop a practical cost-effective approach toward meeting this reporting goal for future annual reports.

EVALUATION OF NITROGEN TRADING OPPORTUNITIES

The Alliance has investigated "nitrogen trading", whereby one town could remove more than its share of nitrogen load on behalf of another town that would remove less than its share. The second town would pay the first town for the nitrogen load removed on its behalf. That investigation was funded in part by the 2018 EPA SNEP grant.

In early 2021, data were obtained from the towns to compute overall costs for nitrogen control and to estimate expected annual nitrogen removals. These costs and removal estimates were adjusted for a common set of assumptions to allow comparison of each town's plans on a "dollar per pound of nitrogen removed" basis. Of the five technologies being used or considered by the towns (sewers, on-site denitrification systems, permeable reactive barriers, golf course fertilizer controls and shellfish harvesting), these unit costs were found to vary from less than \$10/lb to over \$700/lb. The cost differentials among technologies can provide the impetus for nitrogen trading.

The investigation identified three trading scenarios, wherein some towns would scale back their use of the relatively more expensive technologies (I/A systems and permeable reactive barriers) and other towns would increase their use of relatively less technologies (principally sewers). The identified scenarios would result in savings in equivalent annual costs of \$660,000 to the "buyers" and an equivalent cost benefit to the "sellers".

The report summarizing this investigation was issued September 24, 2021; it is entitled *Report on Nitrogen Trading Opportunities Among Watershed Towns*. The towns now have this tool available to them as they refine and update their nitrogen management plans. Should towns elect to pursue trading opportunities, a change in the Watershed Permit would be needed to modify towns' nitrogen removal commitments. No permit changes related to nitrogen trading are proposed for the Year-6 update.

In its 2024 sewer planning, Orleans has identified the opportunity to extend its sewer system in the watershed of the River system to provide septic nitrogen removal on behalf of Brewster. Orleans would remove about 150 kg/yr more than its requirement in subwatersheds where Brewster's nitrogen load are heavily attenuated and difficult to remove cost-effectively. There have been some initial discussions between the two Towns that are expected to continue in 2025.

NITROGEN REMOVAL CREDITS FOR STORMWATER MANAGEMENT ACTIVITIES

None of the watershed towns has yet proposed to gain nitrogen removal credits from their stormwater removal activities, on the premise that such removals are apt to be small. The attenuated nitrogen load from impervious surfaces estimated in the 2006 MEP report is 3,796 kg/yr (9% of the total load from all sources), and only about one-third of that load originates from town roadways. Nonetheless, towns are required to address stormwater issues under the EPA General Permit for Municipal Small Storm Sewer Systems (the MS4 Permit) and the nitrogen removal from those activities may be worth documenting. Using funds from the 2020 EPA SNEP grant, the Alliance has estimated the nitrogen removals from several Best Management Practices (BMPs), including both non-structural practices (such as street sweeping and catch basin cleaning) and structural facilities (such as grassed swales and rain gardens).

The nitrogen removal capabilities of some BMPs can be estimated from EPA performance curves, largely for structural BMPs. (If those BMPs include infiltration of stormwater, the EPA performance curves should be adjusted for Cape Cod conditions.) A computational procedure has been developed by the Alliance to also account for nitrogen removals from non-structural BMPs. Initial investigations, based on a sample sub-watershed, show that current non-structural practices may remove about 5% of the total impervious nitrogen load, and that about 15% removal may be possible with enhanced practices. A draft report on this investigation was reviewed by the SNEP Technical Assistance Network and the final report was issued March 24, 2003 (see *Report on Feasibility of Nitrogen Removal Credits Related to Stormwater Management*). Once the towns have more fully compiled data on the amount of street sweepings and catch basin cleanings that are collected, then they will be able to estimate the associated nitrogen removals and gain a small credit in upcoming Annual Reports.

STAKEHOLDER INVOLVEMENT

Since the issuance of the Watershed Permit in August 2018, the following public meetings and hearings have been conducted related to Pleasant Bay nitrogen reductions:

Brewster

Brewster developed a watershed permit update report to provide the Pleasant Bay Alliance and MassDEP information on the Town's revised plans to meet the nutrient reduction requirements described in the Watershed Permit. This update discussed the application of the new fertilizer leaching rate for the Captains Golf Course. It also updated the potential buildout nitrogen load in Brewster and the plans to manage this load. A joint meeting of the Select Board and Board of Health was held on September 22, 2024 to present this information and answer questions from the Boards and the public.

Chatham

Chatham is well underway with Phase 1 of its Comprehensive Wastewater Management Plan, initiated in 2009. The Town has secured strong support at Town Meetings, approving numerous projects totaling nearly \$150 million to date. Upcoming projects will extend sewer services to parts of Pleasant Bay near Route 28 and Frost Fish Creek. While the full scope of these projects is still being determined, they are expected to fulfill the Town's commitments to expand sewer service and could range from \$20 million to \$50 million each in total cost.

The Town also maintains a detailed page on its website that provides information regarding the approved plan and links to current sewer infrastructure projects:

<https://www.chatham-ma.gov/185/Comprehensive-WastewaterNutrient-Managem>

In addition, the Town provides a construction implementation webpage to inform residents of ongoing work related to the sewer implementation that can be found at:

<https://www.chatham-ma.gov/467/Sewer-Construction-Project>

Harwich

The Town of Harwich is currently in the process of revising its 2016 Comprehensive Wastewater Management Plan (CWMP). To kick off the CWMP revisions, the Town hosted two public input sessions (one in-person and one remote) to obtain stakeholder input on recommended changes. The input sessions were recorded and broadcast by Harwich Channel 18 and resulted in 38 comments on a range of categories with a strong emphasis on addressing freshwater ponds. In addition to the two public input sessions, Town staff and consultant GHD have also hosted private information/education sessions with various homeowners' associations and residents covering topics such as nutrient management, stormwater, wastewater and their impacts on fresh and salt water bodies. The Town's wastewater project is actively covered on the Town website and

regularly discussed by the Select Board and Water & Wastewater Commissioners. The Select Board, Board of Health and Water/Wastewater Commission will continue outreach efforts throughout this project. Proposed watershed permit modifications were reviewed and discussed at the October 29, 2024 Select Board meeting.

Harwich maintains a Wastewater Project Information Page that provides updates, documents, and information for Phase 3 Sewer Construction Project. The website includes information from the Community Engagement Forums held for this project:

<https://www.harwich-ma.gov/431/Wastewater-Project-Information>

Orleans

Orleans developed a Consensus Plan to move forward with wastewater management solutions through a comprehensive public process involving local boards, citizens, and regional and state officials. The public process was critical to a successful program. Since adopting a plan for limited public sewers, augmented by non-traditional remediation technologies, in March 2015, the Town has made all wastewater planning decisions at the Board of Selectmen level, with opportunity for public input at every step.

In May 2022, the Orleans Town Meeting approved construction funding for public sewers in the Meetinghouse Pond watershed. A community meeting was held in Orleans Town Hall to explain the construction process and property owner responsibilities in March 2024, and was attended by nearly 100 residents.

The Town hired an engineering consultant to conduct strategic planning with regard to future sewer extensions and implementation of non-traditional technologies.

In June 2022, the Wastewater Management Advisory Committee (WMAC) was established to plan future steps to address water quality needs. The WMAC has met publicly twice a month. In May 2023, the WMAC successfully brought forward a Town Meeting article to plan for a Phase 3 sewer extension. This area includes two freshwater and one salt pond, all within the watershed of Pleasant Bay. Throughout the process, the committee has listened to and engaged the public in future infrastructure decisions.

Also in 2023, the WMAC developed and recommended an Amended Comprehensive Wastewater Management Plan. During the plan preparation process, all materials developed were made available to the public prior review at a public meeting. The WMAC sought public comment at each of its meetings.

Lonnie's Pond residents have been advised of the Town's ongoing demonstration project to grow oysters in Lonnie's Pond. All pond abutters were notified as part of the Conservation Commission approval process.

Alliance

An update on the status of Watershed Permit implementation activities is included in the Alliance's annual reports submitted for inclusion in the annual Town Report of each member town.

In 2023 and 2024, the Alliance developed a Climate Adaptation Action Plan for Pleasant Bay with funding from the Massachusetts Vulnerability Preparedness Program. The action plan included measures to enhance the resilience of infrastructure designed to protect water quality in the estuary, including wastewater and stormwater infrastructure. The development of the plan included an online citizen survey, an in-person community resilience forum, and three virtual community workshops.

In 2022 and 2023, the Alliance participated in work groups with MassDEP staff to understand the scope of proposed modifications to Watershed Permit and Title 5 regulations. Subsequently the Alliance submitted detailed comments to MassDEP regarding the draft regulations, based in large part on the experience of the Pleasant Bay Watershed Permit. The Alliance Coordinator also was invited to participate in the Title 5 Working Group assembled by MassDEP to review outstanding issues related to draft regulations.

The Alliance has created a dedicated Watershed Permit page on the Pleasant Bay Alliance website that is a repository for historical and current documents related to the formation and implementation of the Watershed Permit. This page includes a link to a Watershed Permit Guidebook that summarizes the Alliance's experiences operating under the first Watershed Permit for nitrogen removal in the Commonwealth, and provides lessons learned for other communities to consider.

In previous years, the Alliance made public presentations on the Pleasant Bay watershed permitting approach at well-attended conferences:

- The Cape Cod Commission's OneCape conference in Harwich in August 2018 (an update presentation occurred at the 2019 OneCape conference.)
- WBNERR's Cape Coastal Conference in Hyannis in December 2018, and
- The Annual Conference of the New England Water Environment Association in Boston in January 2019.

Specific elements of the Pleasant Bay approach were shared in public forums in 2022:

- Alliance staff participated in a January 22 charette on alternative septic system sponsored by the New England Water Environment Association
- The Alliance's nitrogen trading study was presented to municipal officials, state regulators and environmental planners during a webinar on April 2022, sponsored by SNEP.

In the upcoming year, additional stakeholder involvement will occur as follows:

Brewster

Additional meetings with the Select Board, Board of Health and the public are planned in 2023 and 2024 to discuss the implementation of the Watershed Permit and how Brewster will meet its nitrogen reduction goals. Interim results on the golf course fertilizer leaching rate study will be presented and will be used to help predict what other nitrogen reduction strategies will be needed to meet Brewster's nitrogen reduction goals.

Chatham

The Town remains an active member of both the Pleasant Bay Alliance and the Cape Cod and Islands Water Protection Fund Management Board. Additionally, the Town engages the public through Select Board meetings, the Town Meeting process, and the Water & Sewer Advisory Committee, which offers advice and recommendations to the Water & Sewer Commissioners (Select Board) on the Town's water and sewer infrastructure.

Harwich

The Town of Harwich is actively pursuing multiple wastewater projects that will affect residents and stakeholders throughout the year. Revisions to the Harwich Comprehensive Wastewater Management Plan are underway and are anticipated to be completed by 2025. Stakeholder involvement will be critical to ensuring the successful adoption and implementation of the updated plan.

In parallel, the design of the Great Sand Lakes Sewer Collection System, fully funded by an American Rescue Plan Act (ARPA) Grant, is progressing steadily. Additionally, construction on the Phase 3 Wastewater Collection System and the Route 28 Dry Sewer Pipe project will require enhanced public outreach and communication efforts.

Stakeholders will have numerous opportunities to engage through public meetings, informational sessions, digital updates, and coverage in local news outlets. The Town is committed to keeping residents informed and involved as these essential projects move forward.

Orleans

The Wastewater Management Advisory Committee will hold regular, formally-noticed meetings to review progress on sewer master planning. Regular reporting to the Town regarding the Lonnie's Pond oyster project will be made to the Marine & Fresh Water Quality Committee, and all reports will be posted on the Town website. The Town's engineering consultant will meet with the Select Board to report on progress of a demonstration Permeable Reactive Barrier currently installed at Nauset Middle School.

An amended CWMP was prepared by the WMAC and presented to the Select Board for public review and approval in 2023. In 2025, the Town's engineering consultant will present proposed Phase 3 plans at a public meeting on local cable access TV. This is in addition to regular public meetings with the Board of Water & Sewer

Commissioners. Direct outreach to Phase 3 property owners is planned in advance of an anticipated construction start in Fall 2026.

Alliance

The Alliance will continue to provide updates on compliance with the Watershed Permit to Select Boards and residents of Brewster, Chatham, Harwich and Orleans residents through the submission of annual reports.

The Alliance will continue to support public access to all current Watershed Permit documents and reports, which are available on the Alliance website:

<https://pleasantbay.org/programs-and-projects/watershed-planning/pleasant-bay-watershed-permit>.

Key issues for the public are:

- The large cost of nitrogen removal programs
- Fairness in allocation of costs among users and non-users and between residential and commercial property owners
- Proper incorporation of non-traditional approaches to nitrogen removal
- The pace of nitrogen removal activities and the need to achieve water quality goals in an accelerated fashion.

UPDATING THE WATERSHED PERMIT

One of the important aspects of the Watershed Permit is its incorporation of adaptive management principles. Under the terms of the 2018 Watershed Permit, the four towns in the Pleasant Bay watershed have the ability to propose modifications to the permit every five years of the permit term. This allows the towns to reevaluate their nitrogen management plans with respect to the technologies they will use, the timing and locations of nitrogen control projects, and the overall amount of nitrogen to be removed. While the requirements of the 2018 permit were appropriate to what was known at the time, it has been fully expected that new knowledge should be incorporated into the permit as adaptive management every 5 years.

Several important investigations have been completed by the Alliance and separately by the member towns since 2018. The planned Year-5 permit update has been delayed until Year 6 to allow the completion of these studies and for towns to modify their plans accordingly. This section of the Year-6 Annual Report summarizes the permit changes that the Towns propose.

Modifications to TWMP Table 2 (Necessary Nitrogen Load Reductions) reflect these changes:

1. Dis-aggregation of what was originally called the “Pleasant Bay sub-watershed” into its four component parts

2. Incorporation of updated watershed load estimates to reflect growth since the 2006 MEP report and into the future
3. Application of new estimates of natural attenuation in four sub-watersheds.

Modifications to TWMP Table 5 (Implementation Plan) reflect these changes:

1. Formalization of the nitrogen load removals accomplished by the four towns through 2024
2. Revised town plans for completing their nitrogen control programs from 2025 onward, based on several factors
 - updating and refining CWMPs related to location and timing of control measures
 - refining estimates of the performance of nitrogen control technologies and approaches
 - establishing the going-forward schedule as the 20-year period of 2026 to 2045.

The pages that follow provide the data and assumptions supporting all of these changes and identify the important tasks that the Alliance towns will complete in Years 1 through 5 of the modified permit.

Dis-aggregation of Pleasant Bay Sub-Watershed

In the Targeted Watershed Management Plan, the “Pleasant Bay” sub-watershed was treated as a single sub-watershed, because then-available data required the aggregation of loads and thresholds for four sub-watersheds from the 2006 MEP report. The TWMP refers to the “Pleasant Bay” sub-watershed as the aggregate of Pleasant Bay Main, Little Pleasant Bay, Tar Kiln Stream, and The Horseshoe.

To support Brewster’s effort to better address nitrogen removal in the Tar Kiln Stream sub-watershed, SMAST was able to provide the attenuated loads for the four separate sub-watersheds, data that were previously unavailable to the Alliance. The analysis of those data revealed the need to refine the load estimates used in the TWMP. This refinement results in an attenuated nitrogen load for the four sub-watersheds that is 332 kg/yr less than used in the TWMP. The dis-aggregation and data refinement decrease the attenuated load in these four sub-watersheds from 15,694 kg/yr to 15,362 kg/yr, a 2% decrease. It is important to note that this exercise involved the dis-aggregation of reported watershed load data, not the reconfiguration of the linked model.

The details of this exercise are summarized in the Wright-Pierce memo dated 14 June 2023, as revised 16 October 2023; see Appendix A.

Estimates of Growth in Nitrogen Loads

One important step in updating the Pleasant Bay Watershed Permit is to estimate the increases in watershed nitrogen loads that have occurred since the 2006 MEP report, and to consider possible load increases into the future.

The 2006 MEP report is based on water consumption data from the period of 2002 to 2004. In 2010, SMAST updated the Harwich watershed loads to reflect better land use data, and a longer period of water use data. Taken together, those two SMAST documents establish the watershed loads that are the basis of the Targeted Watershed Management Plan and the Watershed Permit. SMAST completed an update to the MEP work in 2021 (the SNEP report) that includes watershed loads based on water consumption data for 2011 to 2015. The 2021 SMAST report thus provides some indication of growth in watershed loads from approximately 2003 (the midpoint of the MEP data) to 2013 (the midpoint of the SNEP data).

The general intent of the four towns is to look 20 years or more into the future so their nitrogen management plans can readily accommodate future growth. Looking 20 years beyond the existing Watershed Permit (2018) results in an end-date of 2038. Looking 20 years beyond the expected date of modification of the permit (2024) results in an end-date of 2044. This report reflects a “resetting of the clock” in the modified permit and treats Permit Year 20 as 2045.

The growth estimates of the four towns are summarized in Table 4.

**Table 4.
Growth in Watershed Nitrogen Loads**

	Brewster	Chatham	Harwich	Orleans	Total
Attenuated Watershed Loads, kg/yr					
TWMP/Watershed Permit	6,359	16,572	10,929	14,643	48,503
Adjustment for Disaggregation	6	67	(442)	37	(332)
Growth from 2003 to "Current"	124 <i>to 2013</i>	958 <i>to 2021</i>	675 <i>to 2020</i>	480 <i>to 2013</i>	2,237
Planning Horizon	Build-out	Build-out	2040	2043	
Growth from "Current" to Planning Horizon	429 <i>from 2013</i>	3,073 <i>from 2021</i>	568 <i>from 2020</i>	400 <i>from 2013</i>	4,470
Total Growth (2003 to Plan.Hor.)	553	4,031	1,243	880	6,707
Updated Loads for Revised Permit	6,918	20,670	11,730	15,560	54,878
Growth as % of TWMP Loads	8.7%	24.3%	11.4%	6.0%	13.8%

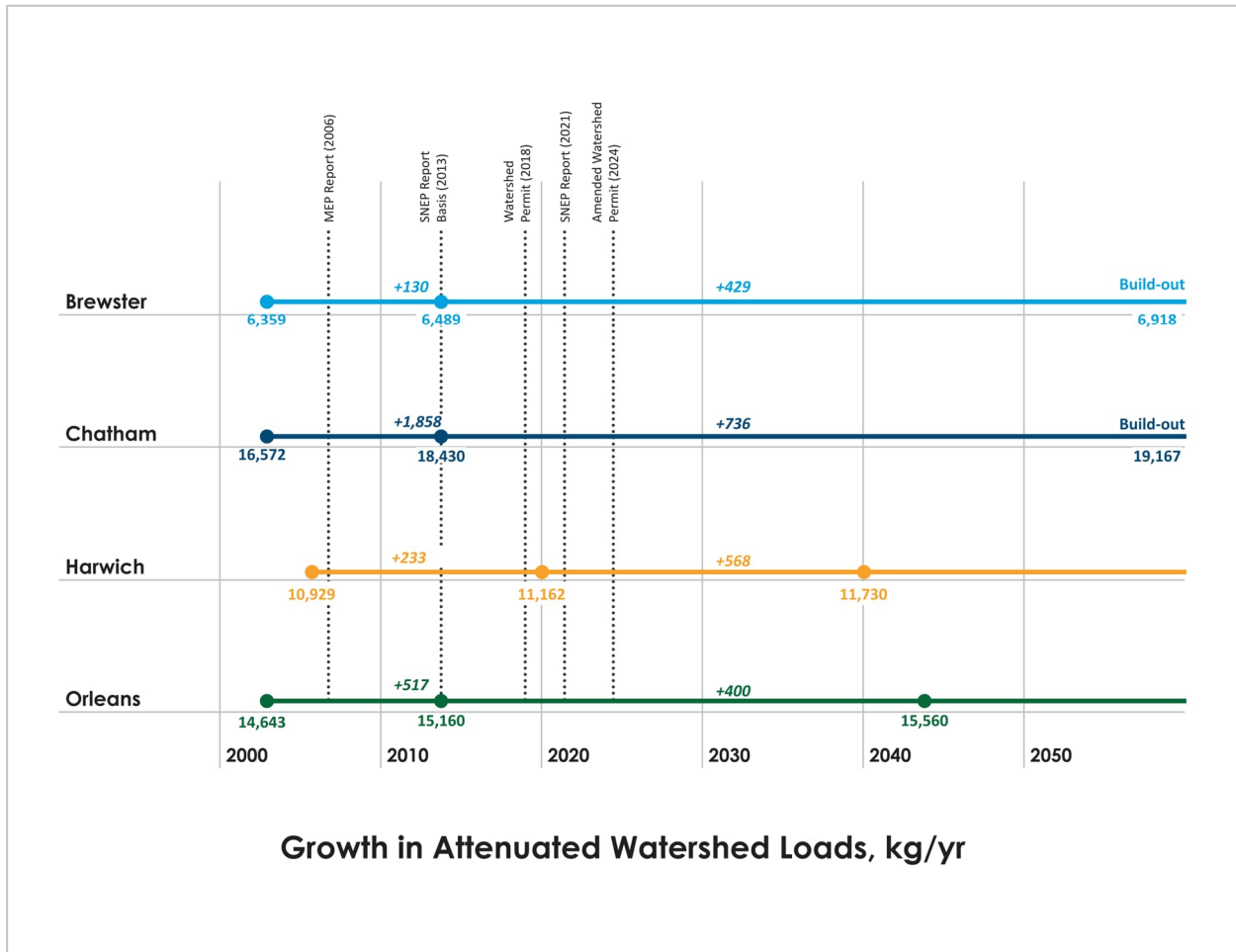
Brewster and Orleans have adopted the updated loads presented in the 2021 SNEP report and added estimates for growth beyond the 2013 basis of that report. Brewster projected growth from 2013 to full build-out. Orleans estimated growth in the watershed for 30 years from 2013 to arrive at projected loads for 2043.

Chatham and Harwich relied on their CWMP documents instead of the SNEP report. Chatham projected growth from the time of its 2009 CWMP through build-out. Harwich estimated 20 years of growth from its recent CWMP update to arrive at projected loads for 2040.

Across the four towns, it is estimated that attenuated watershed loads have increased by 2,237 kg/yr since the basis of the Watershed Permit, and that future growth will create an additional load 4,470 kg/yr. With these increases, the attenuated watershed load will have increased by about 14% from 48,503 kg/yr to 54,878 kg/yr. The percentage load increase is largest in Chatham (24%) and smallest in Orleans (6%).

Figure 2 illustrates the key dates associated with past nitrogen load estimates and shows the specific planning horizons adopted by each town. These are attenuated nitrogen loads, based on the same attenuation percentages used in the current Watershed Permit, for consistency. For all towns, the first segment of growth also includes the small correction in watershed loads associated with the dis-aggregation of the Pleasant Bay sub-watershed. The growth in watershed loads shown in Figure 2 are accounted for in each town’s updated implementation strategy.

Figure 2. Growth in Attenuated Watershed Loads, kg/yr



More details on the Towns' estimates of growth in watershed load are presented in the Wright-Pierce memo dated 11 July 2024 (revised 4 September 2024). That memo provides excerpts from the four town reports that detail the methodologies used for estimating growth. See Appendix B.

It is the intent of the four towns to develop databases of water consumption information to allow a regular update of these growth projections, to be published in the 2030 Year-5 report and every five years thereafter.

New Estimates of Natural Attenuation

After computing un-attenuated watershed loads, the MEP report for Pleasant Bay reduced those loads to account for attenuation occurring within the sub-watershed (generally through pond and streams) and at the watershed-embayment interface. Since the Permit issuance in 2018, the Alliance contracted with SMAST to conduct nitrogen mass exchange evaluations in Muddy Creek and Pochet Neck, and Orleans retained SMAST to further evaluate the upper portion of Pochet Neck. HydroAnalysis reviewed those evaluations and offered new insights into the techniques and findings. SMAST reevaluated its MEP work on the Tar Kiln Stream system and recommended that natural attenuation also be considered there. Pertinent documents are contained in Appendix C.

As a result of all of these investigations, the Towns have revised their nitrogen management plans to reflect the following changes in natural attenuation rates and amounts:

- Upper Muddy Creek: reduce attenuation from 57% to 10%
- Lower Muddy Creek: reduce attenuation from 2% to zero
- Tar Kiln Stream: increase attenuation from zero to 60%
- Upper Pochet Neck increase attenuation from zero to 470 kg/yr

While the net effect of these changes on the overall situation is small (612 kg/yr) increase in attenuated watershed loads, the effect is significant in the four sub-watersheds where changes are made.

Updating of Necessary Nitrogen Load Reductions

Table 2 of the TWMP lays out the nitrogen removal requirements for each town and for each of the 18 sub-watersheds considered at that time. Those nitrogen removal requirements are computed as the attenuated sub-watershed loads less the nitrogen load threshold. While there has been no change in the load thresholds since 2018, the un-attenuated loads have increased through the incorporation of growth for all sub-watersheds, and the degree of attenuation has changed in four sub-watersheds. Further, the dis-aggregation of the Pleasant Bay sub-watershed adds three more sub-watersheds to the table. These changes in load and attenuation dictate an update of TWMP Table 2.

TWMP Table 2 (Revised) Nitrogen Removal Requirements

Sub-Watershed	Basis	Nitrogen Load Removal Requirements, kg/yr					Increase
		Brewster	Chatham	Harwich	Orleans	Total	
MtgHouse Pond MHP	TWMP Revised				1,876 2,265	1,876 2,265	21%
Lonnie's Pond LP	TWMP Revised	14 44			284 251	298 295	-1%
Arey's Pond AP	TWMP Revised	29 39			113 236	142 275	94%
The River--Upper RU	TWMP Revised	3 11			375 305	378 316	-16%
The River--Lower RL	TWMP Revised	6 20			518 495	524 515	-2%
Namequoit River NR	TWMP Revised	19 42			348 353	367 395	8%
Pah Wah Pond PWP	TWMP Revised	- -			413 435	413 435	5%
Quanset Pond QP	TWMP Revised	29 51			227 98	256 149	-42%
Round Cove RC	TWMP Revised	1 2		1,209 1,349		1,210 1,351	12%
Muddy Ck--Upper MCU	TWMP Revised		193 1,050	584 2,835		777 3,885	400%
Muddy Ck--Lower MCL	TWMP Revised		584 924	986 1,536		1,570 2,460	57%
Ryder's Cove RC	TWMP Revised		1,954 2,939			1,954 2,939	50%
Crows Pond CP	TWMP Revised		- 354			- 354	
Bassing Harbor BH	TWMP Revised		- 178			- 178	
Frost Fish Ck FFC	TWMP Revised		803 1,099			803 1,099	37%
Pochet Neck PN	TWMP Revised				1,569 1,170	1,569 1,170	-25%
PB-aggregated	TWMP Revised	2,161	542	1,620	1,257	5,580 -	
The Horseshoe TH	TWMP Revised					- -	
Pleasant Bay Main PBM	TWMP Revised	1,348	704	1,627	761	- 4,440	
Little Pleasant Bay LPB	TWMP Revised	482	249	287	946	- 1,964	
Tar Kiln Stream TKS	TWMP Revised	-				- -	
Chatham Harbor CH	TWMP Revised		- 1,448			- 1,448	
Total	TWMP Revised	2,262 2,039	4,076 8,945	4,399 7,634	6,980 7,315	17,717 25,933	

The Wright-Pierce memo dated 12 September 2024 describes the methodology for updating TWMP Table 2 and presents a table showing both current and proposed new requirements for nitrogen load removal; see Appendix D. That table is attached hereto as TWMP Table 2 (Rev).

Updating of CWMPs

All four towns have revisited their original planning documents related to nitrogen management in Pleasant Bay. Brewster prepared its *Pleasant Bay Watershed: Revised 2024 Permit Update* in September 2024. Chatham's review of its 2009 CWMP is underway, and the Town has provided portions of the updated report to the Alliance in support of the permit update. That Chatham update continues. Harwich updated its growth projections in 2022 as part of its CWMP Update Project. Orleans has prepared a Sewer Master Plan which forms the basis for its Amended CWMP issued in late 2023. Orleans has revised its estimated nitrogen removals based on five recent years of water consumption data.

Evaluation of Alternative Control Approaches and Technology

The Implementation Plan contained in the 2018 Watershed Permit included several non-traditional technologies, many of which have been evaluated in the first 6 years of the permit.

Brewster's initial plan included the use of individual on-site denitrifying septic systems (I/A systems) for a significant amount of nitrogen removal. A SNEP-funded evaluation of the capability and cost of those systems (see *Pleasant Bay Alliance: Task 1A: On-Site Denitrification Systems Summary Report*, Horsely Witten Group, July 28, 2020) demonstrated that this technology may not be the best choice for the Brewster circumstances. Brewster will reconsider this option in the future as a possible component of its nitrogen control plan, expecting that the performance and cost of I/A systems may improve over time.

In its original plan, Orleans expected to provide 70% of its removal needs with the extensive use of I/A systems and shellfish aquaculture. Further consideration of I/A systems has eliminated this option from Orleans' plan. The Lonnie's Pond shellfish harvesting demonstration project has proven successful and continues to be included in Orleans' nitrogen management plan. The small nitrogen removal there and the lack of other viable sites has sharply reduced Orleans' proposed reliance on this option. No other aquaculture sites are being considered at this time. Orleans has completed a successful demonstration of PRBs, and an extensive siting investigation, and has added this technology as a supplement to its plan.

In the 2018 Implementation Plan, non-traditional technologies were proposed to address 24% of the overall nitrogen removal needs. Under updated plans, the non-traditional component is less than 5%. Brewster has requested a reconsideration of golf course fertilizer reduction as a non-traditional approach.

Refinement of Technologies

During the first six years of the Watershed Permit, the four towns have had the opportunity to learn more about the practical aspects of their nitrogen removal plans and have refined their

approaches. Brewster has refined its approach to fertilizer management at the Captains Golf Course by adjusting the types and application rates of fertilizer, by reducing fertilized areas, and by measuring actual nitrogen leaching rates. With thorough oversight and adjustment, Orleans' demonstration project at Lonnie's Pond has matured into a reliable shellfish aquaculture system with consistent year-to-year nitrogen removals.

Revised Town Plans

Each town has modified its nitrogen removal plan to account for the lessons learned during the first six years of the Permit, and to account for the revised necessary load reductions that have evolved. All towns received a small credit for residential fertilizer management, and the rest of the current plans are summarized here:

Brewster. Based on a revised Tar Kiln Stream attenuation rate of 60%, an enhanced fertilizer management program at Captains Golf Course has removed 1,394 kg/yr of nitrogen load there, with an additional 252 kg/yr is expected with a refined estimate of nitrogen leaching (236 kg/yr from fertilizer reduction and 16 kg/yr from fertigation). Together with the residential fertilizer regulation, this work will provide 1,647 kg/yr removal or 81% of Brewster's revised goal before 2030, Year 5 of the expected modified permit. Brewster has proposed fertilizer reduction credits at the National Golf Course and associated with the public water supply wells that would together achieve another 338 kg/yr of removal, bringing the total to 1,984 kg/yr or 97% of its goal by 2030, Year 5 of the expected modified permit.

Chatham. The Town's long-standing intent to provide public sewers across the entire town will allow the removal of septic nitrogen loads totaling 19,504 kg/yr, about 10,000 kg/yr more than required under the Permit. Current plans will allow Chatham to achieve 87% of the town's nitrogen removal requirement by Year 15 of the expected modified permit and over 100% by Year 20.

Harwich. Having completed Phase 2 of its sewer program in 2022, Harwich has begun construction of Phase 3. When completed, and including a fertilizer control regulation, Harwich will have completed 101% of its removal goal by 2027, Year 2 of the expected modified permit.

Orleans. The Town's sewer master plan will result in 7,942 kg/yr septic removal in addition to the 308 kg/yr removal attributable to the residential fertilizer regulation and the Lonnie's Pond aquaculture project. The total of 8,250 kg/yr is 113% of the revised necessary nitrogen load reduction. Still to be resolved are possible further nitrogen attenuation in the Pochet Neck system and the TMDL compliance issue at Meetinghouse Pond. Orleans will have removed 87% of its responsibility by Year 20 of the expected modified permit, without considering those possible enhancements.

Table 5 summarizes the amount of attenuated nitrogen load proposed to be removed by the four watershed towns, compared with the current and proposed necessary load reductions. In the aggregate, the plans of Brewster, Harwich and Orleans are all substantially in line with the

new removal requirements (97% to 113%), and Chatham’s plan continues to be well in excess of the requirements (over twice the removals need).

**Table 5.
Necessary Nitrogen Load Reductions and Town Plans**

Table 5. Comparison of Nitrogen Removal Requirements and Town Plans						
	Brewster	Chatham	Harwich	Orleans	Total	
Necessary Nitrogen Load Reduction, kg/yr						
TWMP/Current Permit	2,262	4,076	4,399	6,980	17,717	
Proposed Revision	2,039	8,945	7,634	7,315	25,933	
Removals in Town Plans, kg/yr						
Removal Surplus		10,559	107	935	11,601	
Removal Deficit	(54)				(54)	
Compliance with Revised Removal, %						
	-3%	118%	1%	13%	45%	

Figures 3 and 4 show the geographic distribution of the towns’ removal plans, expressed as either “**deficits**” (removals less than required) or “**surpluses**” (removals greater than required). The largest deficits are associated with these sub-watersheds, as detailed in Table 6.

- Meetinghouse Pond (342 kg/yr---Orleans)
- Upper Muddy Creek (205 kg/yr---Harwich and Chatham)
- Pleasant Bay Main (387 kg/yr---all towns)
- Little Pleasant Bay (362 kg/yr---all towns)

Table 6. Largest Load Removal Deficits

Table 6. Largest Load Removal Deficits						
Sub-Watershed	Basis	Nitrogen Load Removal Requirements, kg/yr				
		Brewster	Chatham	Harwich	Orleans	Total
MtgHouse Pond	Town Plan				1,923	1,923
	Rem. Goal				2,265	2,265
	Deficit				342	342
Muddy Creek--Upper	Town Plan		844	2,836		3,680
	Rem. Goal		1,050	2,835		3,885
	Deficit		206	(1)		205
Pleasant Bay Main	Town Plan	1,029	705	1,512	807	4,053
	Rem. Goal	1,348	704	1,627	761	4,440
	Deficit	319	(1)	115	(46)	387
Little Pleasant Bay	Town Plan	415	178	229	780	1,602
	Rem. Goal	482	249	287	946	1,964
	Deficit	67	71	58	166	362

Figure 3
Adequacy of Proposed Nitrogen Removals—Orleans and Brewster

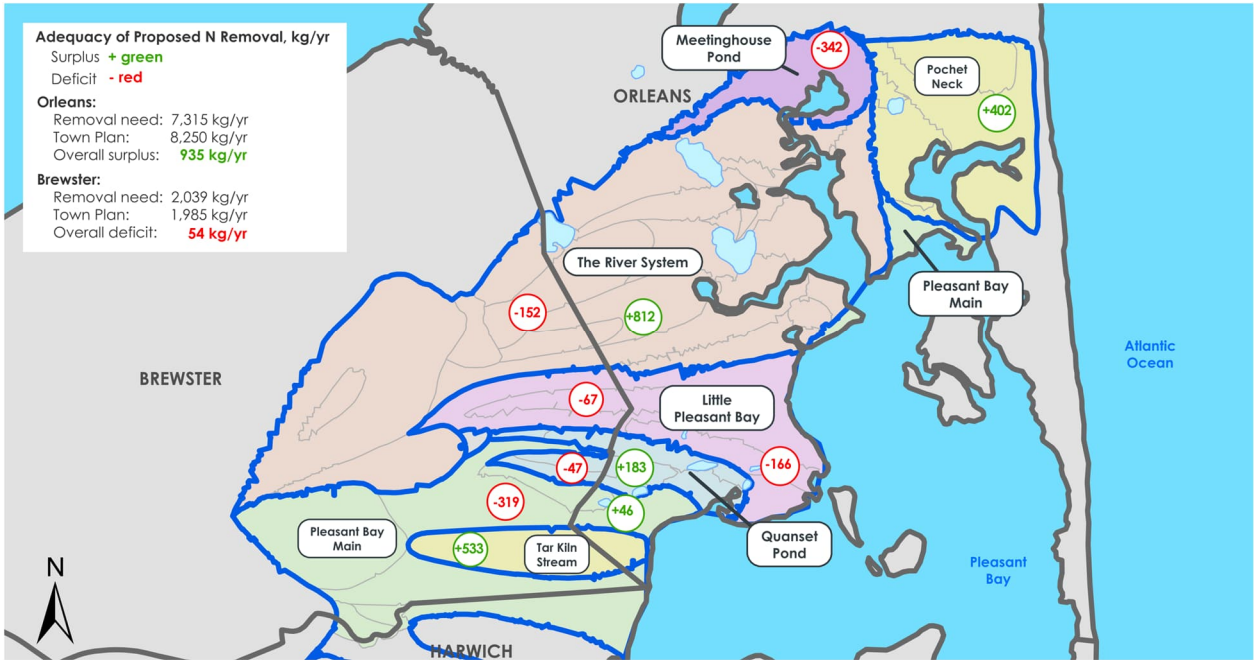
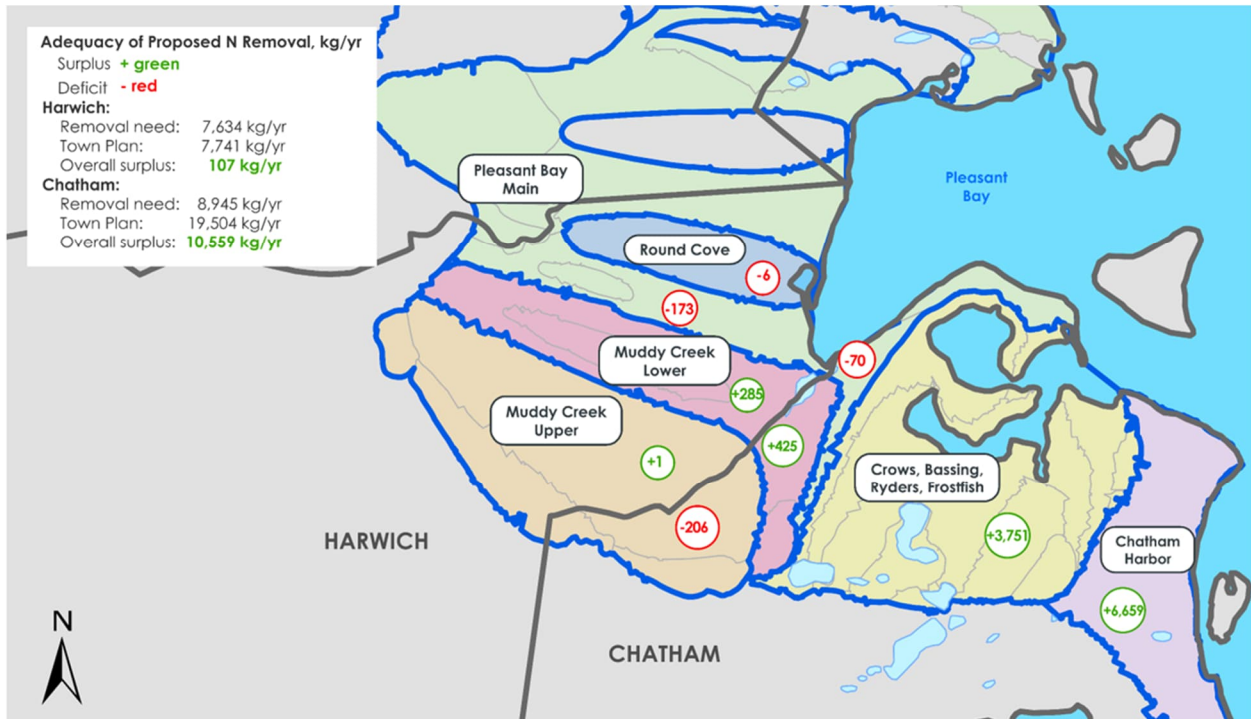


Figure 4
Adequacy of Proposed Nitrogen Removals—Harwich and Chatham



The largest surpluses are

- Tar Kiln Stream (533 kg/yr---Brewster)
- Lower Muddy Creek (710 kg/yr---Chatham and Harwich)
- Chatham Harbor (6,659 kg/yr---Chatham)
- Crows Pond (1,434 kg/yr---Chatham)
- Ryder’s Cove (945 kg/yr---Chatham)
- Bassing Harbor (943 kg/yr---Chatham)
- Frostfish Creek (429 kg/yr---Chatham)

These surpluses and deficits are based on the TMDLs and one potential scenario for load reduction, as laid out in the 2006 MEP report. It will be important for the Linked Watershed-Embayment model to be re-run to determine if the four town plans allow target water column nitrogen concentrations to be achieved. The Alliance believes that removal surpluses in some areas will offset removal deficits in other areas, but it is impossible to determine this without a model run.

It is interesting to note that removal deficits are shown for two sub-watersheds (Meetinghouse Pond and the Chatham portion of Upper Muddy Creek) even though those towns intend to remove 100% of the septic load by sewerage. Orleans has investigated this situation in the Meetinghouse Pond sub-watershed and found that several factors contribute to this matter including year-to-year water consumption data that differs significantly from the basis for the TMDL. This discrepancy should be addressed before towns consider modifying their removal plans in these sub-watersheds.

Implementation Schedule

An implementation plan is included as Table 5 of the TWMP and in Section IV of the Watershed Permit. The towns should propose to DEP that the permit be updated to include a revised implementation program, as summarized herein. The proposed revised Implementation Plan is shown in TWMP Table 5 (Rev) of this document. The Implementation Plan includes specific nitrogen removals already accomplished by the towns through 2024, and the removals proposed by each town in the appropriate 5-year segments of the expected modified permit beginning in 2026 (Year 1 of the modified permit). It also includes actions required by the towns to support those removal commitments.

Table 7 summarizes the current and proposed necessary load reductions and shows how quickly the towns intend to achieve those new requirements. Brewster and Harwich have the most aggressive approach to achieving their nitrogen removal requirements, and those two towns plan to complete their programs before 2028 (Year 10 of the current permit and Year 3 of the revised permit). Chatham and Orleans have developed multi-phased plans that will extend beyond the current Permit’s 20-year term but allow substantial completion before the end of the expected revised permit term. By Year 20 of the revised permit, the aggregate removals are expected to be 98% of the required nitrogen reduction.

TWMP Table 5 (Revised)
Implementation Plan (Revised in Year 6)
Expected Project Completion and Potential Annual Nitrogen Removals

Phase	Years		Brewster		Chatham		Harwich		Orleans		Total kgN/yr*
			Activity****	kgN/yr*	Activity****	kgN/yr*	Activity****	kgN/yr*	Activity****	kgN/yr*	
	up to 2018		Res. fertilizer control Capt GC fertigation Capt GC fert. reduction	121 92 662	Res. fertilizer control Muddy Creek Bridge	247	Muddy Creek Bridge		Res. fertilizer control	241	1,363
	2019 to 2025		Evaluate I/A systems Strengthen GC plan		Sewers (MC) Sewers (FFC)	280 240	Phase 2 sewers (MC) Res. fertilizer control	3,478 200	Amended CWMP Lonnie's Pond aqua. PRB evaluation		4,780
1	1 to 5	2026 to 2030	PWS well loads National GC fert. red. Doc. lower leaching Devel. conting. plan	300 38 252			Phase 3 sewers (MC, RC, PBM, LPB)	4,063	Phase 2 sewers (MP) Phase 3 sewers (River, AP, LP, NR)	2,084 1,141	7,878
All Towns: update monitoring data, prepare plans for next 5 years, update model, update growth, etc.: see text											
2**	6 to 10	2031 to 2035			Sewers (RC, FFC)	5,102			Phase 4/5 sewers (NR, PWP, LPB, OP) Design WWTF expansion	1,028	6,130
3***	11 to 15	2036 to 2040			Sewers (MCU, MCL)	1,886			Phase 6 sewers (NR, PWP, PBM, LPB) Construct WWTF expansion	603	2,489
4***	16 to 20	2041 to 2045			Sewers (CH)	1,500			Phase 7 sewers (PB, OP) Phase 8 sewers (NR, PWP)	583 599	2,682
	after year 20	after 2045			Sewers (CP, BH, PBM, LPB, CH)	10,249			Phase 9 sewers (RU, RL) Phase 10/11 sewers (PN) Phase 15 sewers (LP, RU)	1,007 841 55	12,152
			Total	1,984	Total	19,504	Total	7,741	Total	8,245	37,474

- * Nitrogen removals include allowances for growth over at least 20 years and represent estimates of removal potential
- ** Activities in Permit Years 1 to 5 represent firm commitments by the towns and are necessary to gain DEP enforcement forbearance
- *** Activities in Permit Years 6 to 20 include activities that are now planned and are considered enforceable until such time as they may change depending on the outcome of activities through Permit Year 10 and application of each town's adaptive management plan
- **** See Table 2 for sub-watershed abbreviations

**Table 7
Necessary Nitrogen Load Reductions and Pace of Attainment**

Table 7. Nitrogen Removal Requirements and Pace of Attainment						
	Brewster	Chatham	Harwich	Orleans	Total	
Necessary Nitrogen Load Reduction, kg/yr						
TWMP/Current Permit	2,262	4,076	4,399	6,980	17,717	
Proposed Revision	2,039	8,945	7,634	7,315	25,933	
Portion of Proposed Req'ment						
associated with Future Growth	388	3,192	750	382	4,712	
Achievement of Revised Req'ment						
Modified Permit Year 10 (2035)	97%	66%	101%	62%	77%	
Modified Permit Year 15 (2040)	97%	87%	101%	71%	87%	
	(120% core)	(135% core)	(112% core)	(74% core)	(107% core)	
Modified Permit Year 20 (2045)	97%	104%	101%	87%	98%	
	(120% core)	(161% core)	(112% core)	(92% core)	(119% core)	

The new DEP Watershed Permitting regulations provide for the situation where towns are unable to complete the required nitrogen removals in 20 years, as long as the town can show “reasonable progress” which includes attainment of 75% of the removal requirements within 20 years. The Chatham and Orleans plans reflect a systematic expansion of their sewer systems at a pace which is sustainable within each town’s capital planning approach, and 87% or more of the necessary load reduction is projected to occur within 20 years of the permit update (by Year 26 of the current permit, or 2044).

The Pleasant Bay towns recognize that, overall, 18% of the revised necessary nitrogen load reductions are associated with future growth and there is uncertainty over the amount of the load increase and when it will occur. Accordingly, it is appropriate to consider the “core” removal requirement (current known loads) when judging the adequacy of the towns’ progress. Table 7 shows the portion of the necessary load reduction associated with future growth, ranging from 5% in Orleans to 36% in Chatham. Excluding that component of the removal need shows that Orleans will have achieved 92% attainment by Year 20 of the modified permit and Chatham will have achieved 160% by that date. Should Orleans demonstrate the expected large additional attenuation in the Pochet Neck system, its removal requirement could decline by enough that Orleans could show over 100% removal by Year 20. The same is true for potential resolution of the TMDL issue in Meetinghouse Pond.

The proposed actions by the four towns clearly demonstrate reasonable progress toward achievement of the required nitrogen load reductions. Harwich and Brewster are positioned to achieve their removal goals before 2030. Chatham and Orleans have developed aggressive sewerage plans that are well underway, and those two towns expect to appropriate the large

sums required to achieve their Pleasant Bay goals through steady implementation of their established sewer phases.

Tasks for Next Segment of Permit Term

Consistent with the adaptive management framework of the Permit, several important issues should be addressed and resolved in Years 7 to 10 of the Permit. These include:

1. The Alliance should re-run the Linked Watershed-Embayment Model to determine if the expected load removal surpluses and deficits are significant with respect to the predicted attainment of target water-column nitrogen concentrations at threshold monitoring stations.
2. A standard approach should be developed for estimating the nitrogen removals associated with public sewerage. (Similar protocols are included in the TWMP for some technologies, including golf course fertilizer reduction, on-site denitrification systems and shellfish harvesting.) A computational procedure should be established for sewerage, focused on the extent and characteristics of the water consumption database used to compute septic nitrogen loads. This protocol should address consistency with the MEP model and TMDL development, and it should consider loads from areas such as public water supply recharge areas and the expected year-to-year variations in water consumption databases.
3. Brewster should provide further documentation of reduced fertilizer leaching rates at the Captains Golf Course which are part of its nitrogen reduction plan.
4. Orleans should conduct studies to document the degree of natural attenuation of nitrogen that may be occurring in the portions of the Pochet marshes that have yet to be fully studied.
5. Consideration should be given to a thorough review of the MEP nitrogen loading thresholds, in concert with resolution of the apparent removal shortfalls in certain sub-watersheds where complete sewerage is proposed.
6. There should be discussion on whether Brewster's nitrogen removal plan can include fertilizer reductions at the privately-owned National Golf Course and the steps necessary to make that a suitable long-term approach.
7. Brewster and Orleans should be prepared to amend their nitrogen removal plans, in response to these tasks, as appropriate. If plan refinements are underway or intended anyway, they should be completed prior to the recommended model runs.
8. All towns should establish a mechanism for reporting on growth in nitrogen loads at Year 5 of the modified permit.
9. The Alliance should identify a metric or series of metrics that can be used to track changes in the Bay hydrodynamics and report that information in every five-year report.

These activities can be conducted by the Alliance or by the individual towns and should be made part of the Implementation Plan.