

PLEASANT BAY ALLIANCE

2021 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. This document is the third annual report and summarizes that progress through mid 2021.

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

In the first three Annual Reports, the Alliance towns have documented these removals of attenuated nitrogen loads:

- Prior to permit issuance: 1,769 kg/yr
- First year: 60 kg/yr
- Second year: 115 kg/yr
- Third year: 1,622 kg/yr.

The cumulative to-date load removal of 3,566 kg/yr represents 73% of the five-year removal commitment of 4,916 kg/yr. Planned additional sewer work in Harwich and Chatham, and additional shellfish harvesting in Orleans, are expected to be accomplished over the next two years, allowing the 2023 target to be met.

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

- *On-site denitrification*: Through a SNEP-funded investigation, the towns have 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 has 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 has made progress toward the possible use of this technology in the watershed.

Investigations of nitrogen credit trading and credits for stormwater management are underway and full reporting will occur in the upcoming year.

SNEP funding has also allowed the updating of the SMAST 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 has nearly offset a small increase in watershed loads. There is an ongoing assessment of the model update results and the implications for potential modifications to town plans.

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.

Three basic goals of this third annual report have been accomplished:

- Compliance documentation
- Compilation of information to inform adaptive management
- Identification of key steps needed to ensure compliance with the 5-year nitrogen removal goal.

At the end of Year 3, it is appropriate to conclude that:

- The towns are proceeding under the terms of the permit, and
- The towns are on track to meet the nitrogen removals stipulated under the permit.

This program of annual reports allows the presentation of a snapshot 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 pollution in Pleasant Bay, and the recognition that new technical information, changes in system dynamics and community needs must all be factored into local decisions.

BACKGROUND

The Pleasant Bay Alliance has prepared this third 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 is expected that every five years there will 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.

The technical heart of the Watershed Permit is the May 2018 Targeted Watershed Management Plan. Section 15 of the TWMP Plan contains a list of 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. There are 14 items contained in one or both documents, and each item is addressed below.

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 third year of the first five-year segment.

The Annual Report required by the Watershed Permit is due to DEP on or before the anniversary date of the Permit, August 3. (That deadline was extended to October 3, 2020 for the 2020 report due to the turmoil created by the corona virus pandemic.) Each annual report is to contain information and data for the previous calendar year. Given the fact that significant actions are typically taken at annual town meetings in May, this report includes such information even though it is several months beyond the end of the previous calendar year. Further, some data are regularly reported on a fiscal year basis, that is, through the end of June. Therefore, this annual report contains information spanning from August 2020 to July 2021.

WATER CONSUMPTION

Water consumption is the most important indicator of septic 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 2020, along with the per-service residential and commercial use. The current version of Table 2 contains town-wide data. In future years, the Alliance will work with town water departments to explore the feasibility of 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 load (residential and commercial septic flows).

**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.

**Table 2
Summary of Water Consumption Data**

	2014	2015	2016	2017	2018	2019	2020	Avg
Number of Water Services								
Brewster	7,403	7,421	7,426	7,491	7,249	7,287	7,281	
Chatham	7,083	7,143	7,200	7,236	7,236	7,277	7,469	
Harwich	9,805	9,858	9,890	9,929	9,969	9,983	10,012	
Orleans	5,266	5,279	5,249	5,262	5,257	5,266	5,287	
<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>	
Total Metered Water, Mgal/yr								
Brewster	395	475	454	381	402	382	452	420
Chatham	413	481	473	408	464	422	487	450
Harwich	673	781	810	670	706	677	803	731
Orleans	303	334	340	299	303	279	348	315
<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>1,916</i>
Per-Service Residential Use, gpd								
Brewster	129	157	149	119	138	132	167	142
Chatham	143	172	170	140	169	140	169	158
Harwich	175	205	212	174	185	177	214	192
Orleans	142	158	163	140	144	130	176	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>160</i>
Per-Service Commercial Use, gpd								
Brewster	393	423	375	419	451	391	207	380
Chatham	336	296	331	382	266	252	253	302
Harwich	394	440	468	396	378	367	337	397
Orleans	252	271	280	272	251	240	194	251
<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>333</i>

Town-wide data shown above for illustrative purposes only

Rainfall at Chatham Airport, inches,								
in Jun, Jul, Aug, Sept	10.96	10.88	6.80	17.43	9.66	13.49	4.15	10.48
Deficit below 15 in.	4.04	4.12	8.20	-2.43	5.34	1.51	10.85	4.52

The calendar years 2016, 2018 and 2020 were relatively 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 below 15 inches as an indicator, the deficits in these three years were 8.2, 5.3 and 10.8 inches respectively. (The 5-year period of water consumption data being used in the SMAST update---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.)

The summer of 2020 was a very dry period. For all of 2020, the four towns together billed for nearly 2.1 billion gallons in town-wide water use, the highest total for the 7 years of record reported in Table 2. Average per-service residential use rose to 182 gpd, about 5% higher than the dry 2015-16 period. The impacts of the corona virus pandemic are reflected in the 2020 per-service commercial water use, which was 30% below commercial usage typical of 2014 to 2018.

STATUS OF NITROGEN REMOVAL ACTIVITIES AND ESTIMATES OF REMOVALS TO DATE

Table 3 summarizes the nitrogen removals accomplished to date for each town. In the first three years of the Watershed Permit, one new large-scale nitrogen removal project went on line, a portion of Harwich's sewer program accounting for 1,422 kg/yr of removal. In addition, Orleans removed 75 kg/yr in the Lonnie's Pond shellfish harvesting demonstration; Chatham provided for 100 kg/yr through sewer construction in the Muddy Creek sub-watershed; and Harwich enacted a residential fertilizer control regulation with an associated credit of 200 kg/yr.

The 2006 and 2010 MEP/SMASST reports have estimated that a load removal of 17,717 kg/yr is needed to restore water quality. Watershed-wide, the four towns removed 1,769 kg/yr prior to the Watershed Permit issuance. In the first five years of the permit, the towns have committed to another 3,145 kg/yr, most of which (2,672 kg/yr) is attributable to Phase 2 of Harwich's sewer program.

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

Load removed prior to Watershed Permit issuance:	10.0%
Additional load removed through FY 2021:	<u>10.1%</u>
Total load removed through FY 2021	20.1%
Targeted load removal through FY 2023	27.7%

The load removal through 2021 (20.1%) is 1,622 kg/yr higher than the 11.0% documented in the 2020 Annual Report, due to the Harwich sewer construction and fertilizer regulation.

If Harwich completes its Phase 2 sewer program, the 2023 goal is achievable. Figure 1 illustrates the progress to date and shows the importance of Harwich's sewer project to achievement of the five-year goal. In the summer of 2021, Harwich completed two of the three proposed construction contracts for Pleasant Bay sewerage, an important step toward achievement of the 5-year goal. The nitrogen removal credits included here should be confirmed as Harwich connects homes to its new system, with most connections expected to occur over the period of mid 2021 to mid 2023.

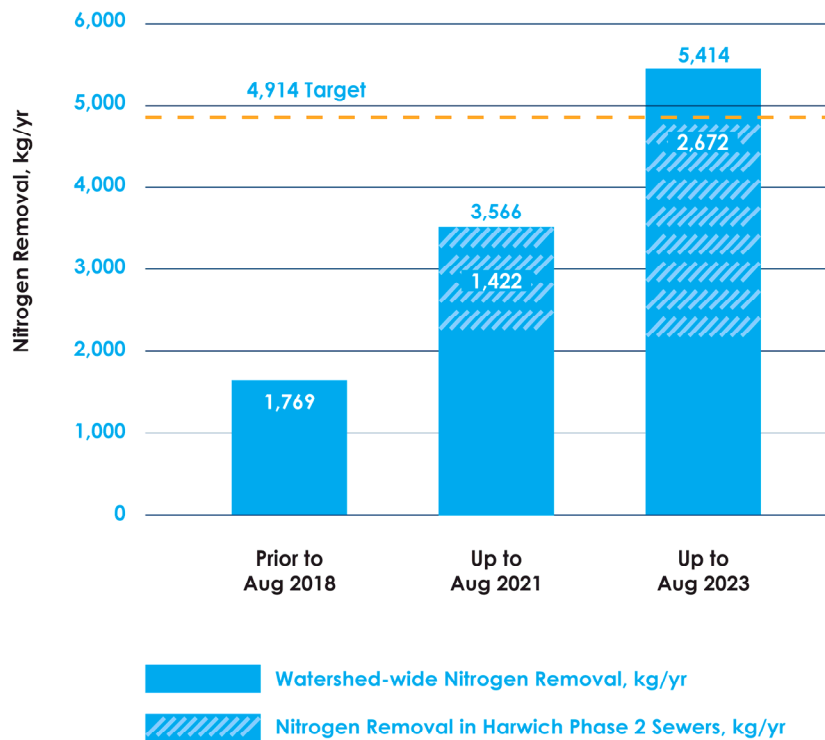
**Table 3
Summary of Nitrogen Removal Achievements and Goals**

	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 fertilizer controls	1,160							
New Nitrogen Load Removals Accomplished in FY 2019 2020 & 2021, kg/yr	None	-	Muddy Ck sewers *	100	E. Harwich sewers *	1,422	Lonnie's Pond pilot shellfish harvest	75	375
					Res fert. controls	200			
Cumulative Nitrogen Load Removals Accomplished by end of FY 2021, kg/yr		1,281		347		1,622		316	3,566
Expected Load Removals in 2022 and 2023, kg/yr	Indeterminant	-	Frostfish Ck and Muddy Ck sewers	400	E. Harwich sewers	1,250	Additional shellfish harvesting **	198	1,848
2023 Goals, kg/yr		1,281		247		2,872		514	4,914
Accomplished by 2021, %		100%		140%		56%		61%	73%
Accomplished by 2023, %		100%		302%		100%		100%	110%
20-yr Goal (2038), kg/yr		2,262		4,076		4,399		6,980	17,717

* Sewers are constructed; tie-ins expected over next 2+ years

** Harvest data may change pending results of pilot project

**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. Additional reductions in fertilizer use on fairways and roughs at the Captains Golf Course are planned for 2021 and the estimate of nitrogen removal via fertigation is being refined.
- Chatham:** Its existing residential fertilizer control ordinance addresses all of Chatham’s goal for the first 5 years of the permit. In constructing the connection with Harwich, and addressing a neighborhood in the Frostfish Creek area, Chatham will provide sewer service to about 150 homes in the Muddy Creek and Frostfish Creek subwatersheds, accomplishing another 500 kg/yr, allowing it to exceed its 2023 goal.
- Harwich:** To accomplish its share of the required nitrogen removal, Harwich needed to enact residential fertilizer controls ordinance and complete Phase 2 of its proposed sewer system (East Harwich). On January 22, 2021, the Harwich Board of Health adopted the Town of Harwich Fertilizer and Nutrient Control Regulation. Harwich has now completed the first two contracts of its Phase 2 sewer construction and is ready to take 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 440 parcels in the Muddy Creek (Upper and Lower), Mill Pond, and Muddy Creek Well sub-watersheds; these sewers provide for 1,422 kg/yr nitrogen removal.

- **Orleans:** Through its residential fertilizer control ordinance and the Lonnie's Pond shellfish harvesting demonstration, Orleans has addressed about 60% of its 2023 target. The remainder is expected to be achieved through additional shellfish harvesting in Lonnie's Pond or at new sites.

In its 2021 updates to the Linked Watershed-Embayment Model, SMAST has estimated that recent nitrogen control measures by the towns have removed an attenuated load of about 1,000 kg/yr, exclusive of the East Harwich sewers and the 809 kg/y placeholder for residential fertilizer controls. While this independent estimate of removal is relatively close to that reported here, the individual segments of the SMAST-estimated removal are quite different. Better estimates of natural attenuation in Tar Kiln Stream result in a reduction in the estimated removal credits achieved by Brewster for the portions of the Captains Golf Course in that sub-watershed. Anticipated load reductions by Harwich are now expected to be greater than first estimated due to revised (downward) estimates of attenuation in Upper Muddy Creek) This revised attenuation estimate will also increase the estimated removals by Chatham in that sub-watershed.

Nitrogen removal progress reported in Table 3 and Figure 1 is based on prior estimates of natural attenuation and will be revised as more details are obtained on the SMAST model update. (Using the nitrogen thresholds established in 2010, it would appear that Harwich and Chatham may gain more credit for their plans than previously thought, and Brewster may have gained less, based on recent better attenuation estimates. However, if these better estimates of attenuation had been known previously, different thresholds and removal requirements may have been established. Therefore, more study is needed to inform possible changes in the towns' plans.)

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 is evaluating 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). The Town documented 60 kg of nitrogen removal in 2019 and 93 kg in 2020, for a two-year average of 76 kg/yr.

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 Fall 2020 monitoring, the additional nitrogen removal through denitrification was at least 9 kg and perhaps twice as much. 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).

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 that are about to be connected to be able to compute the nitrogen load removed from the watershed. Chatham is preparing a similar estimate. These estimates are expected to be completed in the fall of 2021 and 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.

Harwich's initial estimates of 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 better attenuation estimates (10% and zero, respectively). Since the attenuation is now thought to be lower, Harwich's sewer program in these sub-watersheds will actually remove significantly more attenuated nitrogen load than first thought. An estimate of that increased removal should be quantified so that the 2022 Annual Report can properly account for that change.

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 m.

Using SNEP funding, the Barnstable County Department of Health and Environment has completed an analysis of performance data for more than 15 proprietary treatment systems in use across the US. That analysis found no system with full Massachusetts approvals able to reliably reach the 12-mg/l goal established by Brewster. Further, that analysis found two systems with provisional approval that show the potential for better removals, albeit after completing the extensive monitoring needed for the MassDEP approval process. The SNEP-funded study found that the use of provisionally-approved technologies is not a cost-effective option for meeting the Town's targeted nitrogen reductions. Brewster continues to evaluate the availability of systems to meet this goal in a reliable and cost-effective fashion. (Given the current information on the costs for the denitrification systems, Brewster is evaluating other options to meet the watershed permit goals including additional fertilizer management at the Captains Golf Course and/or the use of a neighborhood wastewater treatment facility.)

Captain's Golf Course Fertilizer Reduction

MEP modeling 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.

In 2020, Brewster conducted further studies that indicate that additional nitrogen removal of 362 kg/yr be accomplished by reducing the applications 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 will continue throughout all of 2021 and beyond. In 2020, the nitrogen loading rate to the golf course fairways was reduced from 3 lbs./1,000 sq. ft. to 2.75 lbs./1,000 sq. ft. Overall, the nitrogen applied to the golf course (factoring in the 20% leaching rate) was 157 kg/year lower in 2020 than in 2019.

Brewster's long-term credit for nitrogen removal at Captains depends on documented reductions in fertilizer use, a reassessment of the leaching rate, and refined estimates of downgradient natural attenuation. The current credit of 930 kg/yr is based on the prior estimate that no downgradient attenuation occurred, but the recent SMAST model update uses a more current attenuation estimate of 60% in the Tar Kiln sub-watershed. An updated estimate of Brewster' removal credit at Captains must include both recent fertilizer application data and the increased attenuation that applies to a portion of the golf course.

The Town is working with the Golf Course to collect fertilizer data from the last few years and to develop a standardized process for recording and analyzing the information.

Captain's Golf Course Fertigation

To estimate the nitrogen removal credit, 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 has estimated that an annual load reduction of 230 kg can be accomplished with this approach and that figure is included in the Watershed Permit and in Table 3 of this report.

Brewster compiled the following data in support of that 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

The pumping records for the irrigation well at the golf course indicate that 50.866 million gallons were withdrawn in 2020. Due to an oversight, the irrigation well was not sampled for total nitrogen in 2020. This issue will be corrected in 2021. However, regular sampling of six existing monitoring wells at the golf course continued in 2020 and the average nitrogen concentration in the wells was 2.7 mg/l for total nitrogen. (The highest measurement in the six wells was 4.1 mg/l and the lowest nitrogen concentration was 0.98 mg/l.) The average number is similar to the 2.3 mg/l measurement from the irrigation well in 2019. Given the 2.7 mg/l average nitrogen concentration in the monitoring wells, the nitrogen removal from the irrigation well in 2020 was likely similar to that removed in 2019, and above the 230 kg removal estimated in the Watershed Permit. Testing of the irrigation wells in subsequent years, along with the upcoming leaching rate study for the golf course will help refine this number moving forward.

Brewster's long-term credit for nitrogen removal at Captains depends on the quantity of nitrogen recovered in the irrigation well, a reassessment of the leaching rate, and refined estimates of downgradient natural attenuation. The current credit of 230 kg/yr is based on the prior estimate that no downgradient attenuation occurs, but the recent SMAST model update uses a more current attenuation estimate of 60% in the Tar Kiln sub-watershed. An updated estimate of Brewster' removal credit for fertigation at Captains must include multi-year nitrogen removals through the irrigation well and the increased attenuation that applies to a portion of the golf course.

Permeable Reactive Barriers

PRB performance is determined by the groundwater nitrogen load entering and leaving the reactor. 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.

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 22nd monitoring season in 2021. 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 on a five-year basis. 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 on a five-year basis.

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 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.

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 first two years of the Lonnie's Pond oyster growing project is contained in an SMAST report dated February 1, 2021.

- **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 currently beginning with 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-related water quality monitoring and vegetation monitoring to evaluate changes in water quality resulting from the Muddy Creek Restoration Bridge Project. The first Muddy Creek comprehensive monitoring report, and a vegetation monitoring report, 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' financial commitments and intentions are summarized in Table 4. The high points are as follow:

Brewster

Since 2011 Brewster has invested approximately \$1,100,000 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 underway. The results of this study will help guide what additional nitrogen removals will be needed using either onsite denitrification systems or a neighborhood wastewater treatment plant. At that point funding for additional steps needed to meet the permit obligations will be requested.

Brewster is also developing a preliminary concept plan for a traditional neighborhood wastewater treatment facility as required under the watershed permit. Over the next few years this plan will be updated once more information is developed at the golf course and a better estimate of the facility's size can be developed.

**Table 4
Summary of Capital Commitments**

		Brewster	Chatham	Harwich	Orleans
Prior to July 2018					
Funds expended		\$0.75 M for IWRMP	\$75 M for sewers and WWTF	\$2.265 M paid to Chatham for capacity	>\$1 M for planning
Funds appropriated but not expended			\$47.5 M for sewers	\$22.45 M for sewer project (ATM 2018)	\$2.7 M for sewer and WWTF design
FY 2019 to FY2023	<i>Permit Yr 1 to 5</i>				
Funds expended			\$1M for sewers		\$6.1M for downtown sewers (portion)
Funds appropriated		\$0.075 M for on-site program (ATM 2019)	\$7.15 M for sewers	\$4.50 M to be paid to Chatham for capacity	\$59.1 M for sewer and WWTF constr. (ATM 2019, 2020)
Anticipated future appropriations		\$0.175 M to \$0.325 M for on-site program	\$10-20 M every 2 to 3 years for sewers		2021--\$0.85M Mtghse survey 2022--\$1.5M Mtghse design 2023--\$17M Mtghse constr.
FY 2024 to FY 2028	<i>Permit Yr 6 to 10</i>				
Anticipated future appropriations			\$15-20 M every 2 to 3 years for sewers		2024--\$3.4M PRB constr.

Note: Chatham expenditures and appropriatoinis are town-wide, not just Pleasant Bay

The option of using this traditional facility to manage future nitrogen loads under buildout will be considered and will be evaluated in context with the onsite denitrification option recognizing that new information on these systems' performance will likely be available at the five-year point in the watershed permit.

Chatham

The Town of Chatham has an approved CWMP that partitioned the Town into two phases; Phase 1 includes areas to be sewerred to achieve TMDL compliance in all Chatham watersheds (including Pleasant Bay), and Phase 2 calls for sewerred of the remainder of the Town not needed to meet TMDLs. To date, the Town has appropriated over \$130 million dollars toward these goals, and most recently appropriated approximately \$15 million to address areas targeting the Pleasant Bay Watershed, including support of the Harwich CWMP through the connection project that will allow portions of East Harwich to be sewerred and treated at the Chatham Water Pollution Control Facility (WPCF).

The Chatham-Harwich Regionalization Connection Project is essentially complete, and construction will be finished by August 2021. This will serve as the connection for East Harwich in addition to serving 60 properties within the Muddy Creek sub-watershed of Pleasant Bay. The Phase 1C 3&4 project that includes a neighborhood in the Frostfish Creek subwatershed is also nearing substantial completion and will be complete by September 2021. Finally, the Phase 1E Stony Hill/Crowell Road Infrastructure Improvements Project is approaching substantial completion with the sewer portions of the project completed and awaiting acceptance by the Town. That project will be complete by October 2021, serving an additional 10 properties within the subwatershed.

The Town also has one other sewer projects: Phase 1D-2: Route 137 – Morton Road Sewer Extension Project is in design. The Phase 1D-2 project will sewer 30 properties within sub-watersheds to Pleasant Bay (whereas the bulk of this project addresses the Town's southern facing estuaries).

Harwich

The Town of Harwich has an approved Comprehensive Wastewater Management Plan (CWMP) that calls for sewerred large sections of the Pleasant Bay watershed located in East Harwich. Town Meeting in 2018 approved over \$20 million of spending on the construction of a sewer system hooking in approximately 640 parcels in this area. The area known as Phase 2 of the CWMP was designed to include two construction contracts. Contract 1 was awarded to the Robert B. Our Company which commenced work in summer of 2019. As a result of a bid overrun associated with Contract 1, Contract 2 was reduced in scope to maximize the Town's existing appropriation. Contract 2 was awarded to RJV Construction which commenced work in January of 2020. Both construction projects progressed during 2020 and final completion is imminent. Contracts 1 and 2 will serve 440 parcels and the remaining 200 Phase 2 parcels beyond the limits of Contracts 1 and 2 have been incorporated in to a third construction contract to be completed upon a supplemental appropriation. Accordingly, the

schedule for Contract 3 is uncertain. The Phase 2 sewer system will connect into the Chatham wastewater treatment facility upon completion. Harwich was successful in obtaining a state revolving fund (SRF) loan at a 0% interest due to its nitrogen removal efforts as well as regional cooperation with Chatham.

The Town of Harwich is currently undergoing a review of its CWMP with a potential to re-sequence some of the phases of the plan. Phase 3 was anticipated to also be in the Pleasant Bay watershed, but this East Harwich work may be delayed until a future phase. Harwich is currently in the process of developing a town-wide SewerCAD model which will inform re-sequencing efforts and provide updated construction costs. The Towns of Dennis, Harwich and Yarmouth continue discussions regarding the DHY Clean Waters Community Partnership; however, no action has been taken.

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 in the design of a new 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. Final design will be completed in FY 2022, enabling the \$17M construction to begin in FY 2023. Upon completion in FY 2025, septic nitrogen from households in the Meetinghouse Pond sub-watershed would 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 2,015 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.

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 will be grown for the summer and removed by the end of the growing season in the same year. Oysters will be grown to market size in another location. In CY 2019, the demonstration project removed 60 kg of nitrogen from the Pleasant Bay Watershed. This represents about 3% of the Town's overall goal for multiple shellfish harvesting operations in the Pleasant Bay watershed. The Watershed Permit's Implementation Schedule calls for 273 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 the results of a PRB demonstration at the Middle School, Orleans is now planning to add this technology to its plan, and its 5-yr CIP includes \$3.4 million in FY 2024 for constructing one or more PRBs in the Pleasant Bay Watershed.

The Orleans Amended CWMP is in draft form and the Town plans to complete it before the end of FY 2023, consistent with the Implementation Schedule.

(The Commission has requested annual documentation of each town's ability to support the level of funding that is proposed, as well as the financial impact on users. That request will be addressed in subsequent annual reports.)

PROGRESS IN NON-STRUCTURAL AND NON-SEWERING OPTIONS

Non-structural options include such techniques as residential lawn fertilizer controls, land set-asides, rezoning, etc. Non-sewering approaches include on-lot denitrification, inlet widening, etc. Progress through FY 2021 includes:

Brewster

Brewster has approved the funding to conduct the leaching rate study at Captains Golf Course and has begun implementing the project which will extend over the next two years. The Town has also developed the framework for an advanced onsite septic system program and evaluated the level of treatment needed from each septic system in the main subwatersheds that are located within the Town. The framework includes recommendations for a general bylaw and Board of Health regulation to implement the onsite system requirements. It also includes initial approaches for managing the operation, maintenance and monitoring of systems that would be installed for nitrogen removal. This progress is well documented in the July 2020 report by the Horsley Witten Group, Inc. entitled *SNEP Task 1A: Onsite Denitrification Systems Summary Report*. That report was funded in part by SNEP.

In addition, 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 investigate opportunities to address stormwater infrastructure improvements throughout the town as part of its MS4 program. The Town adopted its Fertilizer Regulation in November 2014 and continues to support and enforce these requirements.

The Town, in cooperation with Harwich, completed construction of the Muddy Creek Bridge several years ago. The two towns in coordination with the Pleasant Bay Alliance are monitoring the success of that project. The project changed out small culverts which limited flow with a clear span bridge to allow for increased tidal flow during each tide cycle.

Chatham is purchasing additional open space adjacent to Goose Pond as part of its Land Bank Open Space, and closing is expected by year-end 2020. A conservation restriction has been approved by the Conservation Commission and the Board of Selectmen and is awaiting final state approval. This purchase will preserve an additional 4.17 acres within the Pleasant Bay Watershed.

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, 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.

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 Marini property adjacent to Muddy Creek in the Pleasant Bay Watershed.

Orleans

In 2020, the Town Meeting voted to acquire a 2.6-acre parcel fronting on 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.

GROWTH IN NITROGEN LOAD

Growth in the watershed nitrogen load, to the extent not already accounted for in a town's plan, represents both a financial burden and the need to expand/modify the 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 Harwich water use. Those baseline years are:

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

A broad assessment of growth trends is possible through analysis of the water use data described above and in Table 2. That assessment will be included in later-years' annual reports once watershed-specific data are available.

Reporting by SMAST, under the SNEP-funded update of watershed nitrogen loads, indicates an approximate 3.5% increase in watershed-wide un-attenuated load between the 2010 SMAST report (data mid-point of 2003), and the 2011-to-2015 basis for the 2021 update (data mid-point of 2013). The associated increase in attenuated load is approximately 5.7% over the 10-year period. The increase in attenuated load reflects both the increase in un-attenuated load and revised estimates of attenuation that are, in the aggregate, less than 2010 estimates.

In their CWMPs or other planning studies, the towns have projected nitrogen loads out to either build-out or to an earlier planning horizon. Those projections are for a 27% increase in nitrogen load watershed-wide, with individual town projections ranging from 19% to 41%. The towns have not clearly laid out their plans for accommodating the growth in load that has already occurred (2003 to 2013) or the further growth anticipated through their planning horizons. Accommodating growth in watershed loads is an important task that the towns must address.

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 removals requirements of each by towns. With funding from the 2018 EPA SNEP grant, the Alliance has overseen 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 and 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

- Assessment of status of eelgrass habitat based on MassDEP surveys
- Revised estimates of attenuation of two sub-basins (Muddy Creek and Tar Kiln Stream/Salt Marsh)
- 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 “TMDL Scenario” considers just the specific nitrogen removal requirements of the Watershed Permit.

The SMAST study involved these two primary future scenarios, 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.

In the upcoming year, it is proposed that the SMAST model will be run to help estimate possible new threshold loads that would apply to current hydrodynamics, and to consider added watershed loads through build-out. The results of these further studies will be reported in full in the fourth annual report due in August 2022.

GROUNDWATER DISCHARGE PERMITS AND I/A SYSTEMS

There are 16 Groundwater Discharge Permit 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. In 2020, The Pleasant Bay Health & Living Center regularly met its permit requirements with no exceedances. The Chatham Bars Inn regularly met its permit requirements with no exceedances. The Wequassett Inn has experienced some minor excursions, but generally produces very good effluent with respect to nitrogen and its other permitted parameters. The SMAST 2021 model update reports that the aggregate nitrogen load from these three facilities is 705 kg/yr.

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

As of July 2021, 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 but is soon to receive wastewater and nitrogen load from the Pleasant Bay watershed in Harwich. Similarly, the

Town of Orleans has obtained a GWD permit for the under-construction Orleans municipal WWTF discharge at a site off Lots Hollow Road. That Orleans facility will receive and treat wastewater and nitrogen load from at least the Meetinghouse Pond sub-watershed.

SMAST has reported that there are now 119 I/A systems in the watershed (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.

Each Town’s Health Department has provided data on new (between January 2019 and December 2019) Title 5 systems and new private wells in the Pleasant Bay watershed, as follows: The counts of new Title 5 permits include both new systems and system repairs and upgrades.

	All Title 5 Permits Issued Town-wide	New Title 5 Systems in Pleasant Bay Watershed	New Private Potable Wells in Pleasant Bay Watershed
Brewster	126		
Chatham	71		0
Harwich	135	5	30
Orleans	110	6	1

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 during the fourth and fifth years of the permit to develop a practical cost-effective approach toward meeting this reporting goal.

EVALUATION OF NITROGEN TRADING OPPORTUNITIES

The Alliance is investigating “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 is 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, I/A systems, permeable reactive barriers, golf course fertilizer controls and shellfish harvesting), these unit cost were found to vary from less than \$10/lb to over \$700/lb. The cost differentials between technologies can provide the impetus for nitrogen trading.

The investigation identified three trading scenarios, wherein 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/yr to the “buyers” and an equivalent cost benefit to the “sellers”.

The report summarizing this investigation is undergoing final review and is expected to be completed in early fall 2021. Should towns elect to pursue trading opportunities, a change in the Watershed Permit would be needed to modify towns’ nitrogen removal commitments. It is unlikely that nitrogen-trading-related changes would be known before the end of the first 5-year period of the current Permit.

CONSIDERATION OF NITROGEN REMOVAL CREDITS FOR STORMWATER MANAGEMENT ACTIVITIES

None of the watershed towns has 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 might be worth documenting. Using funds from the 2020 EPA SNEP grant, the Alliance is estimating the nitrogen removals from several Best Management Practices (BMPs), including 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. A computational procedure is being developed by the Alliance to account for non-structural BMP removals. Initial investigations show that current Cape Cod practices may remove about 5% of the total impervious load, and that about 15% removal may be possible with enhanced practices. A draft report on this investigation is being reviewed by the SNEP Technical Assistance Network and is expected to be complete by the fall of 2021. If agreement is reached on a methodology, and if towns are able to provide pertinent data, then the Alliance may be able to document some small credits for stormwater management in the 2021 Annual Report.

POSSIBLE CHANGES IN THE IMPLEMENTATION PLAN AND PERMIT

The Watershed Permit anticipates “mid-course corrections” in any of the towns’ nitrogen removal plans by allowing changes to the implementation schedule at the end of each 5-year

segment of the permit term. After the first three years, there have been no formal announcements of proposed changes, but there have been informal discussions that changes are being contemplated, as discussed above.

The Town of Harwich is currently undergoing a review of its CWMP with a potential to re-sequence some of the future phases, due to the recent large increases in construction costs. Nitrogen removal activities in the Pleasant Bay watershed may be impacted in the first 5 years of the Watershed Permit.

The Town of Chatham may be providing sewer service to some homes in the Pleasant Bay watershed earlier than first anticipated. If so, Chatham will remove about 10% of the load that the Watershed Permit shows occurring in the last 10 years of the permit term.

Orleans and Brewster have yet to fully define the technologies or approaches that will be employed to complete their five-year load removal requirements.

Each annual report will contain an update on possible modifications to the implementation schedule. Expect further reporting on these potential changes next year.

STAKEHOLDER INVOLVEMENT

Over the past year, outreach activities undertaken by the towns and Pleasant Bay Alliance have been curtailed due to the Covid-19 pandemic. It is anticipated that outreach efforts will be renewed now that public meeting restrictions have been relaxed.

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

Meetings were held with the Select Board and Board of Health to discuss implementation of the Town's IWRMP, including the actions proposed for Pleasant Bay.

Chatham

Chatham is well into implementation of Phase 1 of its Comprehensive Wastewater Management Plan that was completed in 2009. The Town has had many successful votes at Town Meetings to support multiple projects (totaling over \$130 million to date), including the most recent vote of an additional \$7 million dollars for wastewater authorization and debt exclusion that passed in May 2019. A portion of these funds is for work related to sewerage in the Pleasant Bay watershed.

The Town also maintains a detailed site on its webpage that provides information regarding the approved plan and links to current sewer infrastructure projects.

<https://www.chatham-ma.gov/comprehensive-wastewaternutrient-management-plan>

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

<https://chathamscproject.info/>

Harwich

The Town's wastewater project is actively covered on the Town website and regularly discussed by the Board of Selectmen. The Town hired Weston & Sampson (whose representative is Charlie Sumner a former administrator in the town of Brewster) to assist in outreach efforts along with CDM Smith pertaining to the Pleasant Bay watershed area improvements contained in Phase 2. The Board of Selectmen, Board of Health and the recently approved by town meeting Water/Wastewater Commission will continue outreach efforts throughout this project.

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, the Town made all wastewater planning decisions at the Board of Selectmen level, with opportunity for public input at every step.

With approval of a downtown public sewer system in May 2019, responsibility for implementing the construction program was transferred to the Board of Water & Sewer Commissioners. The Town is presently working to develop sewer regulations and will seek public input before they are approved.

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

The Alliance has 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.

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 2021 and 2022 to discuss the implementation of the Watershed Permit and how Brewster will meet its nitrogen reduction goals. The options for using advanced onsite systems will be presented and input will be solicited on issues related to the implementation of the Town program, including financing options and the requirements of the operation, maintenance, and monitoring of the onsite treatment system.

Chatham

The Town continues as an active member of the Pleasant Bay Alliance, the Cape Cod Water Protection Collaborative, and the Cape Cod and Islands Water Protection Fund Management Board.

In addition, the Town actively engages the public through its Board of Selectmen meetings, Town Meeting process, and the Water & Sewer Advisory Committee, who provide advice and recommendations to the Water & Sewer Commissioners (Board of Selectmen) regarding the water and sewer systems of the Town, and neighborhood meetings related to implementation of the CWMP.

Harwich

The Town’s past efforts will continue to be modified and improved to seek additional input from the various stakeholders involved in the town’s compliance with its Comprehensive Wastewater Management Plan. The Town is currently in the process of revising its CWMP, and it is anticipated that several stakeholder meetings will be scheduled over the next year to provide an opportunity for public input regarding the proposed revisions. The Town continues to be an active member of the Pleasant Bay Alliance.

Orleans

The Board of Water & Sewer Commissioners will hold regular, formally-noticed meetings to review progress on public sewer construction. Regular reporting to the Town regarding the Lonnie’s Pond oyster project will be made to the Water Quality

Committee, and all reports will be posted on the Town website. The Town's engineering consultant will meet with the Board of Selectmen to report on progress of a demonstration Permeable Reactive Barrier currently installed at Nauset Middle School. Planning for future installation of PRBs at strategic locations will take place during 2021-2022.

Alliance

A public outreach program is part of the watershed permit implementation activities funded by EPA under the SNEP grant and is now ongoing. That outreach program will be rolled out in the second half of 2021. The Alliance is preparing a series of video recordings to provide a citizen-friendly summary of each task funded by the 2018 SNEP grant:

- Municipal program for I/A systems
- Orleans shellfish harvesting program
- Opportunities for nitrogen trading
- The 2021 SMAST update to the linked watershed-embayment model

These and other public outreach materials 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.