Executive Summary

Pleasant Bay MEP 2020 Update

FINAL REPORT
June 2021

The Pleasant Bay estuary is the largest embayment on Cape Cod, Massachusetts and is comprised of large open water areas and a number of smaller tributary sub-embayments, such as Meetinghouse Pond, Areys Pond, Lonnie's Pond, Round Cove, Muddy Creek and Bassing Harbor. The barrier beach that includes the Bay inlet and separates the Bay from the Atlantic Ocean is dynamic and the inlet structure and number changes often.

As part of the Massachusetts Estuaries Project (MEP), the MEP project team completed a 2006 ecological assessment of the Pleasant Bays system that included extensive data collection (*e.g.*, water column data, tidal elevations, bathymetry, sediment nutrient regeneration) and organization of the collected data into a series of linked models of the watershed nitrogen loading, tidal hydrodynamics, and measured water quality. These linked models were calibrated and validated using different sets of water quality parameters so they could be used to reliably predict the impacts of potential nitrogen management options and/or changes to the tidal regime. The MEP assessment concluded that large portions of the system, including all of the terminal ponds, were significantly impaired due to excessive nitrogen and that nitrogen had caused the estuary to lose more than 20% of its eelgrass since 1951.[1]

The Massachusetts Department of Environmental Protection (MassDEP) used the MEP assessment of Pleasant Bay to promulgate 16 nitrogen Total Maximum Daily Loads (TMDLs)[2] for various estuarine segments. TMDLs are required under the Clean Water Act for any state waters that are impaired. Following the 2007 adoption of the TMDLs, the watershed Towns began to work on developing and evaluating potential strategies to reduce nitrogen loads and concentrations to achieve acceptable water quality through Pleasant Bay.

As might be expected in such a highly dynamic system, the Pleasant Bay Estuary has changed since the completion of the MEP assessment. The most significant of these changes relates to the formation of new inlets with associated changes in hydrodynamics. A major shift occurred with the 2007 opening of a large new inlet opposite Allen Point in Chatham, which altered tides and water quality throughout most of the system. Various measurements have been collected to define how the initial post-breach conditions varied and how these conditions changed as the system continued to evolve. Towns in the watershed began to develop Comprehensive Wastewater Management Plans (CWMPs) and other strategies (*e.g.*, the new inlet to Muddy Creek) to address

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[1] Howes B., S.W. Kelley, J.S. Ramsey, R. Samimy, D. Schlezinger, E. Eichner. 2006. Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Pleasant Bay, Chatham, Massachusetts. Massachusetts Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA. 245 pp.

[2] MassDEP. 2007. FINAL Pleasant Bay System Total Maximum Daily Loads For Total Nitrogen (Report # 96-TMDL-12, Control #244.0). 53 pp.

the observed water quality impairments while remaining flexible to accommodate further changes in the Pleasant Bay system.

Through the existing cooperative agreements established through the Pleasant Bay Alliance (PBA), the towns applied to MassDEP for a first-of-its-kind Watershed Permit under the updated Cape Cod 208 project. The 208 Plan provided a structure for coordinated activities by Cape Cod towns to address TMDL provisions and compliance with the Clean Water Act. The 2018 Watershed Permit included a schedule for various Town activities, generally coordinated through CWMPs, to meet the TMDL nitrogen limits. The schedule and the nitrogen reduction activities were included in a 2018 Pleasant Bay Targeted Watershed Management Plan (TWMP). The TWMP schedule included provisions to incorporate new insights and the impact of changes in the system since the completion of the MEP assessment through regular adaptive management review.

In 2018, the PBA, Towns, and Coastal Systems Program at the School for Marine Science and Technology, University of Massachusetts Dartmouth (CSP/SMAST), technical lead of the MEP team, began discussing updating the MEP assessment of Pleasant Bay to better reflect current conditions in the Bay and using the updated linked models to review the water quality impacts of planned Town nitrogen management strategies. Using resources from the Southeast New England Coastal Watershed Restoration Program (SNEP) grant program and the Towns, CSP/SMAST and the rest of the MEP Technical Team updated key portions of the MEP linked models and provided updated tools for reliably predicting the impacts of potential nitrogen management options and/or changes to the tidal regime.

In the SNEP update completed for this project, the MEP Technical Team collected updated Pleasant Bay data and incorporated it into a new version of the Pleasant Bay linked models. The Team also reviewed more recent eelgrass distribution in the system which showed that eelgrass loss has continued and this showed that the Bay now has 55% less eelgrass than 1951. Updated information included in the SNEP updated assessment of Pleasant Bay:

- Review of 2015 to 2019 monthly summer water quality data
- Collection and incubation of 67 sediment cores to measure nitrogen regeneration
- 2018 bathymetry based on Lidar
- Tidal elevation data from 2017, 2018, and 2019
- Eelgrass areas in 2010 and 2019
- 2019 land use within the watershed with 2011 to 2015 water use for individual parcels, denitrifying septic systems, updated sewered parcels, building areas, agricultural uses, private treatment plant performance
- Natural N attenuation in Tar Kiln and Muddy Creek tributaries

Updated information was incorporated into updated linked models, including a watershed nitrogen loading model based on existing land use conditions, a hydrodynamic model of tidal exchanges and circulation, and a water quality model incorporating the results of the watershed nitrogen loading and the tidal hydrodynamics. Among the notable changes in the input data to the watershed nitrogen loading model from the MEP version were the following:

- 380 additional parcels in the Pleasant Bay watershed (4% increase from the MEP)
- 550 parcels with new municipal water accounts (9% increase from the MEP) and 272 fewer private wells

- 119 innovative and alternative denitrifying septic systems with results from three or more monitoring events (84 of which are in Chatham)
- 158 acres of additional building footprint (61% increase from MEP mainly due to better database records)
- 366 acres of road impervious surfaces (9% increase from MEP)

Among the notable changes in the input data to the tidal hydrodynamic model from the MEP version were the following:

- Meetinghouse Pond tide range has decreased about 17% since its post-breach maximum in 2007, and is now similar to the pre-breach range measured in 2004
- Chatham Fish Pier tide range is essentially the same as it was in 2007
- Muddy Creek residence time has decreased from 3.6 days in 2004 to 0.8 days in 2019 mainly due to the new inlet/bridge.
- Flood tide flow at the reconfigured 2007 breach inlet is divided among Pleasant Bay (85%) and Chatham Harbor (15%)
- Chatham Harbor is close to being functionally separate from the rest of Pleasant Bay with only 2% to 4% of the Bay tidal ebb flow exiting through Chatham Harbor
- Pleasant Bay system volume has decreased by 8% with increases in some subembayments (*e.g.*, Crows Pond, Ryders Cove) and decreases in others (*e.g.*, Muddy Creek, Lonnie's Pond)

The updated SNEP water quality model incorporates the results from the hydrodynamic model and the watershed nitrogen loading model. The model is calibrated with one set of water quality parameters (salinity) and validated with a separate set (bioactive nitrogen). The water quality model check of measured water column concentrations was based on watershed nitrogen loads from existing development and land uses. The overall difference between the measured bioactive nitrogen at the 27 monitoring stations in Pleasant Bay and the modeled results was 4% or 0.018 mg/L. This exceptionally good fit between measured and modeled results is slightly better than the 2006 MEP modeling results and supports the reliability of predictions based on the model.

Once the reliability of the model was ensured, the MEP Technical Team created a watershed nitrogen management scenario based on current nitrogen management plans within each of the four watershed towns. The current plans in the Towns are different than what was included in the 2018 TWMP. Team staff incorporated details from Town staff and their consultants regarding nitrogen management plans including the following for each town:

- Chatham: connect <u>all</u> of its wastewater discharges within the Pleasant Bay watershed (including one private treatment plant) to a sewer system and discharge the treated wastewater outside of the watershed
- Harwich: phased installation of sewers to connect most wastewater discharges within the Pleasant Bay watershed and discharge the treated wastewater outside of the watershed
- Brewster: a) reductions in golf course fertilizers at the town-owned Captains Golf Course and b) installation of innovative/alternative denitrifying septic systems with 12 mg/L TN discharge in two subwatersheds that directly discharge to Pleasant Bay (Freemans Way Well and Tar Kiln Stream)

- Orleans: a) a sewer system to collect wastewater mostly within the Meetinghouse Pond watershed and discharging the treated effluent outside of the Pleasant Bay watershed, b) installing 16 permeable reactive barriers (PRBs) to remove nitrogen from groundwater, and c) enhanced aquaculture in Lonnie's Pond to remove nitrogen within the pond (goal = 300 kg/yr removal)

The net result of the update of the linked MEP models and the town nitrogen management strategies showed that current CWMP activities will collectively attain the Pleasant Bay nitrogen TMDLs at its sentinel stations. The results of the nitrogen management scenario showed that the combined nitrogen management strategies within the four watershed towns generally result in bioactive nitrogen concentrations that meet or are less than the TMDL thresholds at both of the primary sentinel stations and 6 of the 8 secondary stations (Table E-1). The two secondary water monitoring stations where the TMDL thresholds were not attained were WMO-5, Pochet and WMO-6, Namequoit River.

An additional scenario was also completed using the 2020 watershed nitrogen loads in the SNEP model and combined with the watershed reductions in the TWMP. This scenario adjusted watershed loads by removing nitrogen loading reductions Towns have completed since the MEP to avoid "double counting" (*e.g.*, additional sewered properties in Chatham, golf course fertilizer reductions in Brewster, enhanced aquaculture in Orleans/Lonnie's Pond) and utilized the 2020 hydrodynamic model. The TWMP scenario results showed that the combined nitrogen reductions within the four watershed towns generally resulted in bioactive nitrogen concentrations that meet or are less than the TMDL thresholds at both of the primary sentinel stations and 7 of the 8 secondary stations (the TMDL threshold was not attained was WMO-5, Pochet).

The comparison between the results of the two nitrogen management scenarios show that different sets of nitrogen loads can generally attain the TMDL nitrogen thresholds. They also show that Towns may want to reconcile and update the balance of responsibilities among the towns around Pleasant Bay to meet the TMDLs as CWMPs and system hydrodynamics change. During these discussions, Towns should also consider the need to discuss the following factors:

- The impact of future development within the watershed (changes in development between MEP and the SNEP update increased attenuated watershed nitrogen loads by 3% over approximately 10 years).
- The impact of future changes in tidal hydrodynamics. The tidal inlet to Pleasant Bay is constantly readjusting. The current configuration has essentially isolated Chatham Harbor, but the MEP configuration had significant Pleasant Bay flow through this basin.
- The regulatory and planning implications of plans from certain towns to remove more nitrogen than originally planned in the TWMP. For example, Chatham plans to connect all watershed properties to the municipal sewer system, which discharges outside of the Pleasant Bay watershed. This level of nitrogen removal benefits the water quality in the overall Pleasant Bay system, but analysis has not been completed to evaluate how this benefits other towns.

Evaluation of these issues and other anticipated issues could be clarified with additional model runs (*i.e.,* scenarios) using the updated Pleasant Bay model. The updated SNEP version of the Pleasant Bay model was developed using the same procedures approved by EPA and MassDEP

for the MEP, including calibration and validation to ensure that the model could be used for predictive analysis of scenarios. As additional changes occur in the Pleasant Bay system and in Town nitrogen management strategies, the linked models can be used to evaluate the responses in water quality throughout this large estuarine systems and changes in the ability to attain the nitrogen TMDLs for Pleasant Bay.

Table E-1. Comparison of model average bioactive N (DIN+PON) concentrations in Pleasant Bay for 2020 present conditions, 2020 Composite loading and the TWMP scenario. The primary sentinel threshold stations (0.16 mg/L target) are shaded orange, secondary threshold stations (0.21 mg/L target) are shaded blue. The Ryders Cove threshold is set as the average of the PBA-03 and CM-13. The Composite and TWMP nitrogen management scenarios attain the target concentration at both sentinel stations. The Composite scenario attains the threshold concentration at all but two of the secondary stations (*i.e.*, WMO-5, Pochet and WMO-6, Namequoit River; both shaded green), while the TWMP scenario attains the threshold at all secondary stations except WMO-5. Although the Composite watershed loads is significantly lower than the TWMP scenario load, the comparisons to the threshold loads are largely the same because of the updated 2020 tidal flushing in Chatham Harbor.

Sub-Embayment	monitoring station	2020 existing (mg/L)	2020 composite (mg/L)	2021 TWMP (mg/L)
Meetinghouse Pond	PBA-16	0.288	0.218	0.218
Meetinghouse @Rattles Dock	WMO-10	0.238	0.196	0.194
Meetinghouse @Off Lonnie's Inlet	WMO-08	0.192	0.171	0.170
Lonnie's Pond	PBA-15	0.246	0.205	0.210
Areys Pond	PBA-14	0.334	0.308	0.284
Namequoit River Upper	WMO-6	0.239	0.220	0.209
The River-Mouth	PBA-13	0.148	0.140	0.138
Pochet - Upper off Town Landing	WMO-05	0.279	0.256	0.230
Pochet - Basin@ Mouth	WMO-03	0.146	0.138	0.137
Little Pleasant Bay - Head	PBA-12	0.139	0.132	0.131
Little Pleasant Bay - Main Basin	PBA-21	0.132	0.126	0.126
Paw Wah Pond	PBA-11	0.207	0.187	0.158
Little Quanset Pond	WMO-12	0.185	0.173	0.159
Quanset Pond	WMO-01	0.153	0.143	0.137
Round Cove	PBA-09	0.254	0.150	0.180
Muddy Creek - Upper	PBA-05A	0.503	0.220	0.427
Muddy Creek - Lower	PBA-05	0.224	0.152	0.192
Pleasant Bay - Head	PBA-08	0.121	0.115	0.115
Pleasant Bay - Upper Strong Island	PBA-19	0.104	0.101	0.101
Pleasant Bay - off Muddy Creek	PBA-06	0.140	0.123	0.129
Pleasant Bay - lower Strong Island	PBA-20	0.103	0.100	0.100
Ryders Cove Upper	PBA-03	0.218	0.140	0.172
Ryders Cove Lower	CM-13	0.113	0.103	0.106
Crows Pond	PBA-04	0.116	0.106	0.112
Chatham Harbor - Upper	PBA-01	0.099	0.098	0.098