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Memorandum

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Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 4.a.2 – Adaptive Management Plan** **Technical Memorandum Recommendations for Long Term Water Quality Monitoring Program**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	03/25/16

1. Introduction

Technical Memorandum 4.a.1: Baseline Monitoring describes Orleans's current monitoring programs, and compares data collected since 2003 to the data reported in the Massachusetts Estuaries Project (MEP) reports for Pleasant Bay and Nauset Harbor. Groups currently responsible for different monitoring programs and the types of data collected are described, and definitions are provided for the recorded water quality parameters contained in the data sets. This TM also provides an assessment of whether data sets are complete or additional data collection or methods are needed. The recommendations for long-term water quality monitoring contained in this TM are based on the findings of TM-AMP-BM. Monitoring and other assessments for evaluation of the performance of demonstration projects is the subject of a separate Technical Memorandum entitled "4.a.3: Non-Traditional Technology Performance Analysis".

2. Background

As solutions for reducing and otherwise controlling nitrogen load are implemented in Orleans, compliance with regulatory standards must be measured and documented in estuaries and ponds. Changes in ecologic conditions that are occurring over time should also be documented. The purpose of this Technical Memorandum (TM) is to provide the details for a monitoring program that can adequately quantify water quality and benthic conditions over the long term. This program includes locations of additional stations, as well as sampling points at different depths within the water column. The frequency of sampling, methodology and parameters for sampling, including benthic analysis are described. Recommendations for future data collection personnel (both volunteer and paid) as well as a system for long term coordination and management of all data sets generated for Orleans are also presented.


WMO38
WMO39
WMO37
WMO40
WMO36
WMO41
WMO29
WMO31
WMO30
WMO32
WMO28
WMO27
WMO33
WMO46
WMO26
WMO35
WMO34
WMO25
Nasset Bay
Salt Pond Bay
Minister Pond
Depot Pond
Herring Pond
Mill Pond
Eastham
Fort Hill
Snow Pt
Story Island
Hopkins Island
Weeset
Nauset Harbor
Tonset
Nauset Heights
Rocky Pt
Icehouse Pond
Cranberry Bog
East Orleans
Town Landing
Skiff Hill
Coast Guard Beach
NAUSET BEACH
ATLANTIC OCEAN
Nauset Beach

3. Evaluation of Reporting from Monitoring Programs and Recommendations for the Future

Orleans has successfully implemented and maintained a long-term program for water quality monitoring in both Town Cove and Pleasant Bay. Consistent data sets exist for Town Cove starting in 2003, and for Pleasant Bay starting in 2000. These data sets are provided annually by the UMASS Dartmouth School for Marine Science and Technology (SMAST). In order to be able to utilize this data to meet the above stated goals it is recommended that future data sets include the following:

- a notes page with the following documentation:
    - GPS coordinates for all sampling stations;
    - Definitions for all terms; and
    - Conversion factors for µM to mg/L for nitrogen species, POC, and PO4.
- Proposed values:
    - µm N x 0.0140067 = mg N/L
    - µm C x 0.012011 = mg C/L
    - µm PO_4 x 0.03097376 = mg P/L
- Description of methodology for dissolved oxygen (DO) columns and a discussion of which columns, if any, can be used to analyze trends continuously from 2003 through 2014. Specific explanation of how values are derived for these column headings should be provided:
    - Lab salinity;
    - Field corrected salinity;
    - DI salinity; and
    - Salinity-corrected DO.
- Each year documentation should be provided with the data sets that describes the data in each column, including:
    - If the value is a direct measurement;
    - Where measurement is made (field/lab);
    - Field sampling instrumentation or technique as well as laboratory technique and limits of detection for each parameter sampled;
    - Filter size for particulates;
    - If the value is calculated, what calculations are performed; and
    - Statement about any changes from previous years' methodology, if applicable.

These requirements should be incorporated into all future contracts with SMAST for laboratory analysis of water samples provided by Orleans. The data sets should be checked for the inclusion of this documentation prior to final payment to SMAST for these deliverables.

4. Analysis of Long Term Water Quality Monitoring Program and Recommendations for the Future

In addition to the recommended revisions to analysis and reporting described in Section 3 of this TM, there are additional monitoring and other assessments that should be added to current program to enable verification of compliance with water quality standards, and overall ecosystems health. Additional monitoring should include:

a. Station Locations

There are currently three stations monitored in Nauset Harbor. Based on the analysis in TM-AMP-BM, additional monitoring locations are recommended in order to accurately assess this estuary. The MEP Report included data from eighteen monitoring stations (Figure 1). This program recommends monitoring ten of these stations: WMO Station Numbers 25, 27, 29, 3, 33, 35, 37, 38, 39, and 40.

There are currently twenty-four stations monitored in Pleasant Bay. Based on the analysis detailed in TM-AMP-BM, these station locations seem adequate for assessing overall water quality in Pleasant Bay. However, the stations in Orleans where different water quality parameters do not show consistent trends are recommended for further evaluation. This study of ecosystems response to TMDL-compliance may require additional stations in Pleasant Bay.

b. Monitoring Frequency, Depths and Parameters

The frequency of recommended sampling is as indicated in Table 1, and the depth of sampling and other protocols should follow the Quality Assurance Policy Plan (QAPP) developed by SMAST for the Massachusetts Estuaries Project. Water quality parameters that should continue to be sampled for Pleasant Bay and Nauset Harbor include: weather, wind force, wind direction, water condition, secchi depth, DI salinity, field corrected salinity, sample time, sample depth, field dissolved oxygen, field dissolved oxygen percent saturation, field temperature, laboratory salinities, laboratory conductivity, phosphate (PO_4), ammonium (NH_4), nitrate (NO_3), dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), total dissolved nitrogen (TND), particulate organic carbon (POC), particulate organic nitrogen (PON), total organic nitrogen (TON), total nitrogen (TN), chlorophyll *a* and pheophitin.

	May 1 - 15	May 16 - 31	Jun 1 - 15	Jun 16 - 30	Jul 1 - 15	Jul 16 - 31	Aug 1 - 15	Aug 16 - 31	Sept 1 - 15	Sept 16 - 30	Oct 1 - 15	January	TOTAL SAMPLES Surface and Bottom
STATION ID													
WMO-25	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-26	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-27	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-29	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-30	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-33	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-35	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-37	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-38	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-39	2	2	2	2	2	2	2	2	2	2	2	2	24
WMO-40	2	2	2	2	2	2	2	2	2	2	2	2	24
subtotal													264
QA/QC (10%)													26
Total Samples													290

Table 1. Recommended frequency of sampling for stations within Nauset Harbor.

In addition to data collection and laboratory analysis of samples, a data analysis report should continue to be completed annually. Data evaluation should include a sorting of DIN and PON concentrations by temperature, as well as pigment assessments based on Chl-a only. The extent to which data values lend themselves to the creation of data triggers should be addressed in these reports. Data analysis for the Pleasant Bay Alliance indicated that the Namequoit South, Namequoit North and Namequoit Mid systems were improving; therefore the first years of data analysis should include a confirmation of the health of these systems.

Cost estimate for additional samples in Nauset Harbor:

- Annual sample analysis cost: $29,000
- Annual data analysis cost: $10,000

c. Special Studies recommended for Town Cove and Pleasant Bay

1) Study of macroalgae populations and benthic assessments of infauna and nutrient flux

One explanation for reductions in DIN that are shown in the Pleasant Bay data sets is that DIN is being assimilated into macroalgae. Macroalgae consume DIN but release PON. Because pigments seem to be decreasing as DIN increases in some sub-embayments, macroalgae should be surveyed and quantified as a possible sink for DIN and a source of PON. Because taxa respond differently, identifying macrophyte (macroalgae and eelgrass) species can help evaluate changes in nitrogen regimes. Macroalgae may be impacting the nitrogen budget in ways that would otherwise seem contradictory by looking at water quality parameters alone. Therefore, water sampling should be supplemented with an assessment of macrophytes in the water column, as well as in bottom sediments in the following locations in Pleasant Bay and Nauset Harbor:

- LPB Near Quanset (Big Bay NE);
- Pochet Mouth;
- Meetinghouse Pond;
- The River at Rattles Dock;
- Kescayogansett Pond (Lonnie's);
- Paw Wah Pond; and
- Pochet Upper.

In addition, a baseline benthic assessment that includes both nutrient flux and infauna surveys should be completed for Pleasant Bay and Nauset Harbor. This assessment would include sampling XX stations in Pleasant Bay and XX stations in Nauset Harbor for nutrient flux, and XX stations in Pleasant Bay and XX stations in Nauset Harbor for benthic infauna. This will provide a baseline benthic habitat assessment that will aid in assessing overall ecosystem health and improvements after Nitrogen reduction methods have been implemented.

2) Study of DON reductions due to changes in atmospheric deposition

The TMDL for Pleasant Bay and its sub-embayments is based on BioN because the DON fraction that comes from atmospheric sources is approximately 70 percent of total nitrogen (TM-AMP-PB). Recent research in Waquoit Bay suggests that the amount of DON contributed by atmospheric sources has declined over 50 percent since 2000 (NEED REFERENCE). Data from Pleasant Bay (NEED REFERENCE) shows that since the breach in 2007, DON has been decreasing at a significantly lower rate than before the break. Based on the Waquoit Bay study there is reason to believe that contributions to Pleasant Bay from atmospheric sources were higher before the breach and have continued to decrease since. The stalling of the DON decrease may be due to contributions from the decay of microorganisms. If this is the case, it is a significant problem for the health and future of the Pleasant Bay ecosystem. Because DON is a major contributor to the total nitrogen that stimulates biological activity, this hypothesis should be confirmed.

3) Continuous DO and Chl-a monitoring at Sentinel Stations

DO and Chl-*a* are highly variable parameters. To evaluate these parameters, continuous data loggers located at the Sentinel Station in Town Cove are recommended. After completion of a macroalgae study in Pleasant Bay, the need for continuous monitoring of these parameters should be confirmed.

4) Summary of recommended additional monitoring and evaluations include:

- Additional sampling dates;
    - o Dormant period (January);
    - o Late spring (May); and
    - o Fall (Sept/October).
- DIN and PON concentrations sorted by temperature, based on additional sampling;
- DON changes due to reduced atmospheric deposition;
- Data triggers; and
- Special Studies;
    - o Macroalgae populations, and benthic assessments of infauna and nutrient flux;
    - o Pigment assessments based on Chl-a only; and
    - o Continuous DO and Chl-a monitoring at Sentinel Stations.

5. Responsible Parties and Next Steps

The main water quality monitoring efforts in Orleans are currently coordinated by the Orleans Marine and Freshwater Quality Task Force (OWQTF) and the Pleasant Bay Alliance (Alliance). The Alliance coordinates a comprehensive water quality monitoring program for Pleasant Bay. Volunteers currently collect samples for twenty-four stations, although the total number of stations has varied over the years ranging from 20 to 34. SMAST analyzes these samples and provides annual data sets. Every five years, the Pleasant Bay Alliance also commissions an evaluation of this data.

The OWQTF organizes water quality sampling for the Nauset Harbor watershed and the Orleans portion of Pleasant Bay. Volunteers collect samples from three monitoring stations and the SMAST analyzes these samples and provides annual data sets. Historic data sets for the Nauset Harbor watershed are managed by the Town of Orleans planning department as separate Excel spreadsheets for 2003 through 2014.

In order to finalize this recommended plan, a review by SMAST and others is needed. The logistics and labor to increase the sampling efforts to include an additional ten stations with a much higher sampling frequency in Nauset Harbor should be discussed with the OWQTF.

6. References

Howes, B., R. Samimy, D. Schlezinger, E. Eichner, Kelley, S, Ramsey, J and Detjens, P 2012. Massachusetts Estuaries Project: Linked Watershed-Embayment Approach to Determine Critical Nitrogen Loading Thresholds for the Nauset Harbor Embayment System Towns of Orleans and Eastham, Massachusetts. 188 pp.

Howes, B., R. Samimy, D. Schlezinger, E. Eichner, Kelley, S, Ramsey, J and Detjens, P, 2006. Massachusetts Estuaries Report: Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for the Pleasant Bay System, Orleans, Chatham, Brewster and Harwich, Massachusetts.