Appendix S

Technical Memo – Adaptive Management Plan, Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets

(May 4, 2016)

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Memorandum

To	George Meservey, Director of Planning & Community Development Michael Domenica, PE, Program Manager
CC	Betsy Shreve, AICP, AECOM Project Director Sia Karplus, Science Wares, Inc.
Subject	**Town of Orleans, MA** **Water Quality and Wastewater Planning** **Task Number 4.a.1 – Adaptive Management Plan** **Technical Memorandum Final Water Quality Monitoring and Modeling: Consolidation and Comparison of Baseline Monitoring Data Sets**
Project Number	60476644
From	Thomas Parece, P.E., AECOM Project Manager
Date	05/04/16

1. Introduction

The Orleans Marine and Freshwater Quality Task Force (OWQTF) and the Pleasant Bay Alliance (Alliance) coordinate the main water quality monitoring efforts in Orleans. The Alliance coordinates a comprehensive water quality monitoring program for Pleasant Bay. Volunteers currently collect samples from 24 stations, although the total number of stations has varied over the years ranging from 20 to 34. The University of Massachusetts School for Marine Science and Technology (SMAST) analyzes these samples and provides annual reports. Every five years, the Alliance evaluates this data. The most recent report includes updated statistical and trend analysis for data from 2000 – 2014 (Cadmus Group 2015). The Alliance provided the AECOM team the aggregated data sets from 2000 – 2015 in an Access database format for the 24 stations in Pleasant Bay.

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 reports. Historic data sets for the Nauset Harbor watershed were provided by the Town of Orleans planning department as separate Excel spreadsheets for 2003 – 2014. A consolidated spreadsheet for 2003 – 2009 was also provided. The consolidated data sets for Pleasant Bay (2000 – 2015) and Nauset Harbor (2003 – 2014) have been provided electronically to the Orleans Planning Department

2. Background

The natural estuaries in the town of Orleans, Massachusetts (Town) have been extensively studied over the last several decades (Howes et al., 2006, 2012). Research and monitoring data show that the estuarine ecosystems in Orleans are impacted by increased nutrient loading and eutrophication (Howes et al, 2006, 2012). The Town is currently planning to implement nutrient remediation measures to improve ecologic conditions in these systems along with ongoing monitoring to quantify changes and trends in water quality and biological parameters that result from these nutrient remediation efforts.

The purpose of this Technical Memorandum (TM) is to evaluate the adequacy of sampling locations and sampling methodology (protocols and parameters) in order to accomplish the following monitoring objectives:

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

To make this assessment, existing water quality data collected from 2000 to 2015 have been consolidated and reviewed, and missing data have been identified. These water quality samples were collected by citizen volunteers and were analyzed for Orleans by the Massachusetts Estuaries Project (MEP) laboratory. In addition, this water quality information is compared to baseline monitoring data from the MEP reports for Pleasant Bay and Nauset Harbor and trends have been documented.

Findings and recommendations for additional monitoring to meet the above monitoring goals are outlined below. Subsequent TMs will present the details of the recommended monitoring plans for meeting specific goals and objectives. TM 4.a.2: Long Term Waterbody Monitoring will present the plan for compliance monitoring for the Total Maximum Daily Load (TMDL) for nitrogen as well as Massachusetts Department of Environmental Protection (MA DEP) habitat restoration goals. TM 4.a.3: Non-Structural Performance Analysis will present the plan for monitoring non-traditional demonstration projects, and TM 4.a.4: MEP Study Update Monitoring will address the data needs for accurate and complete MEP model updates.

TM 4.a.5: MEP Model Update and Implementation Analysis will document the results of Adaptive Management Planning workshops held on April 1, 2016 and April 11, 2016 relative to updating the MEP model as well as other analyses needed to establish a baseline for Orleans. A matrix will be included that identifies information needs and responsible parties.

3. Definitions

Recorded water quality parameters contained in the data sets 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, in situ dissolved oxygen (DO), in situ DO (as percent saturation), in situ water temperature, laboratory salinities, laboratory conductivity, soluble reactive phosphate (SRP), ammonium (NH4), nitrate (NO3), dissolved inorganic nitrogen (DIN), dissolved organic nitrogen (DON), total dissolved nitrogen (TDN), particulate organic nitrogen (PON), total organic nitrogen (TON), total nitrogen (TN), particulate organic carbon (POC), chlorophyll a and pheophytin. Several of these terms, including weather, wind force, wind direction, water condition, sample depth, and field temperature are recorded to characterize the conditions under which the water quality sample is taken. The water quality parameters are defined as follows:

Ammonium (NH4): a molecule with a positive charge containing nitrogen and hydrogen.

Nitrate (NO3): a molecule with a negative charge containing nitrogen and oxygen with the molecular formula NO_3^-.

Dissolved Inorganic Nitrogen (DIN)/Total Inorganic Nitrogen: the sum of the concentrations of nitrate, nitrite and ammonia.

Dissolved Organic Nitrogen (DON): the soluble form of nitrogen bound to a molecule which contains carbon (such as amino acids, peptides, humic substances and protein), and which had its origin in living material. DON is measured as all organic nitrogen contained in particles less than 0.7 microns or 0.22 microns, depending on the laboratory protocol employed. The primary source of DON is atmospheric deposition.

Particulate Organic Nitrogen (PON): the nitrogen contained in suspended particles of organic matter in the water column. Particulate matter is larger than a standard filter size which generally ranges between 0.7 and 0.22 microns, depending on the laboratory protocol used. Subtracting the dissolved organic nitrogen fraction from total organic nitrogen yields PON.

Bioactive Nitrogen (BioN): the sum of Dissolved Inorganic Nitrogen + Particulate Organic Nitrogen

Total Dissolved Nitrogen (TDN): is the sum of DON and DIN.

Total Organic Nitrogen: the sum of DON and PON.

Total Nitrogen (TN): the combined sum of all organic and inorganic forms of nitrogen in a water sample. These forms of nitrogen can include nitrate, nitrite, ammonia, particulate organic nitrogen and dissolved organic nitrogen.

Dissolved Oxygen (DO): the amount of elemental oxygen, O2, in solution under existing atmospheric pressure and temperature. Low levels of dissolved oxygen (DO) can slow the growth rate and reduce the survival of many aquatic organisms (Gosling 2003; Whetstone et al. 2005). Field dissolved oxygen and field dissolved oxygen percent saturation refer to different methods of measuring DO.

Particulate Organic Carbon (POC): the carbon contained in suspended particles of organic matter in the water column. Particulate matter is larger than a standard filter size which generally ranges between 0.7 and 0.22 microns.

Soluble Reactive Phosphorus (SRP): inorganic phosphorus also referred to as orthophosphate which occurs as ions of HPO4-, with a small percentage present as PO4-. This macronutrient is required for the growth of marine organisms and in marine ecosystems is often present in low and, perhaps, limiting concentrations.

Total Phytopigments: the sum of chlorophyll a and pheophytin a. Chlorophyll a is a green pigment responsible for the absorption of light to provide energy for photosynthesis. Pheophytin a is also a photosynthetic pigment, often produced by the degradation of chlorophyll a. Total pigment concentration can be used as a proxy for food concentration.

Salinity: the concentration of sodium, potassium, magnesium, calcium, bicarbonate, carbonate, sulfate, and halides (chloride, fluoride, bromide) in water. DI salinity, field corrected salinity and laboratory salinity and conductivity refer to different methods of measuring salinity.

Secchi Depth: the depth at which a circular plate with black and white sections (Secchi disk) is no longer visible from the surface of ocean water, used to determine water clarity.

Turbidity: the relative clarity of a liquid, determined by measuring the amount of light that is scattered by suspended particles in the water column. The presence of suspended or colloidal matter or planktonic organisms reduces light penetration and increases turbidity.

4. Procedures and Protocols of Existing Monitoring Programs

A. Quality Assurance Project Plan (QAPP)

For data collection procedures and laboratory analysis protocols, both the Alliance and the OWQTF use the QAPP developed for the MEP by SMAST (Appendix A). According to the "Guidelines for Acceptable Water Quality Monitoring Sampling Approaches" contained in this QAPP, water is tested routinely in Orleans for the following basic parameters:

- Dissolved oxygen,
- Temperature,
- Salinity,
- Water clarity,
- Water samples for laboratory nutrient analysis, and
- Weather/tide observations.

The QAPP includes Field Sampling Protocols and example Data Sheets that accompany the water samples. According to the QAPP, sampling stations are placed along the long axis of an embayment, and within major coves or tidally restricted basins. Each station has a unique identification code. Station locations have been selected to be representative of overall embayment water quality conditions, not localized "hot spots". Stations were placed to give good geographic coverage throughout the inner and outer (where possible) portions of an embayment. Sample stations include central basins sampled by boat (best), boatyard docks, town landings or piers. An offshore reference station was also established for each embayment, outside of the influence of the ebb tidal plume from adjacent systems. All sampling stations are identified on a USGS Quadrangle sheet or Nautical Chart, with associated GPS latitude/longitude coordinates. The QAPP's appendices AI-AXXXIV include figures of maps showing all monitoring stations that are part of the MEP. Figures 1 and 2 show the locations of the monitoring stations in Pleasant Bay and Nauset Harbor respectively. GPS coordinates for these stations are included with the consolidated data sets.

Each year, dates and times for sampling are selected based on tidal regime, generally from 6:00am - 9:00am during the 3 hours around mid-ebb tide. Samples are typically collected the first and third weeks in July and August, with one sample in September. During this prescribed monitoring period, all personnel take samples at all stations throughout a given embayment. This simultaneous sampling schedule is critical to allow site-to-site comparisons of data. The critical seasonal interval for water quality sampling is June – mid September, when the lowest DO levels are expected and macronutrients in the water column are typically lowest, though inorganic N concentrations can also vary inter-annually, and along salinity gradients in estuaries.

Water samples at shallow stations (<1.5m) are collected only near the surface, and at the surface and bottom at deeper water stations (>1.5m). This vertical sampling allows for an evaluation of water column stratification and its associated nutrient and DO numbers. Surface water samples are collected at 15 centimeters below the surface, and bottom water samples 30 - 50 cm above the bottom. These depths have been determined by SMAST as representative of estuarine water quality that is important to ecosystems health. Collection of a sample 15 cm below the surface prevents entrainment of the overlying air into DO samples, and keeps floating material from fouling nutrient samples. Sampling 30-50 cm above bottom prevents stirring of the bottom sediments and subsequent contamination of the nutrient sample.

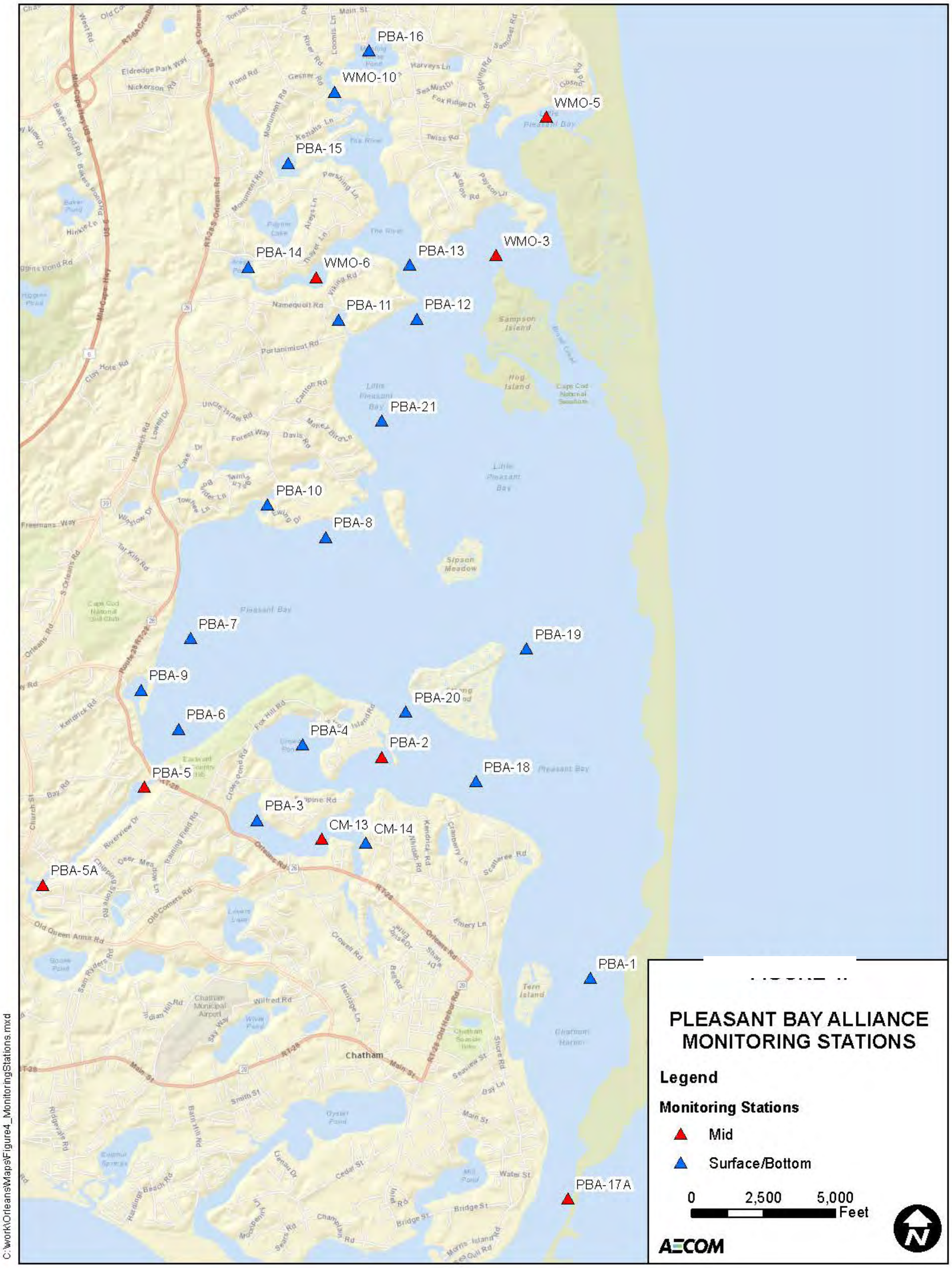


Figure 1 Pleasant Bay Alliance Sampling Stations

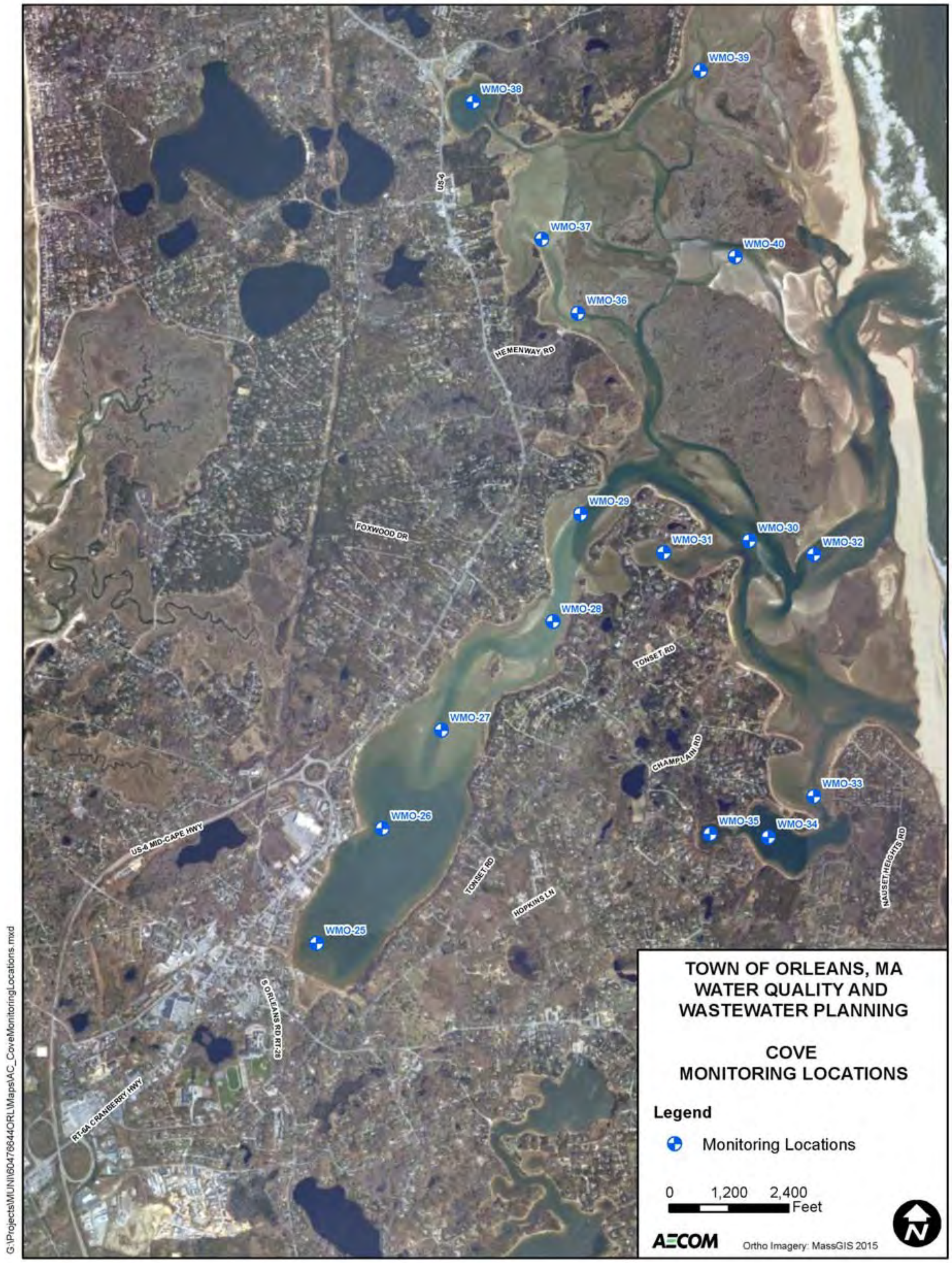


Figure 2 Nauset Harbor Sampling Stations

Bacterial sampling from sources such as waterfowl can be conducted in parallel with the nutrient sampling, with samples typically collected from the surface. In addition, storm water bacteria sampling may be conducted which focuses upon land-based point inputs, primarily from direct storm water inflows. These measurements can help determine nutrient sources with greater specificity than nitrogen sampling. Sampling is usually conducted during the daylight hours of a storm event, and should be timed to capture the first flush of rainfall discharge from storm water discharge pipes. Additional samples may also be collected upstream and downstream of the discharge pipe within river systems.

A specific volunteer or professional sampler is identified for each sampling event for each station. The Monitoring Coordinator also conducts a joint visit to each site prior to sampling. The QAPP specifies that all samples must be collected by trained staff or specially trained volunteers. SMAST reviews data for adherence to analytical protocols and to established holding times, surrogate recoveries, initial and continuing calibrations, matrix spikes during analysis, laboratory duplicates, and blank contamination. SMAST may use T-tests for paired samples and analysis of variance for interpretation. Data is transcribed for statistical analysis and each data point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in project files, which are maintained at SMAST.

Equipment used for sampling includes: thermometer, hydrometer, conductivity meter, oxygen meter (calibrated to dissolved gas standards), and Secchi Disk. For salinity, specific conductivity is preferred over hydrometer readings. The electrochemical sensors used to take an instantaneous reading of DO concentration and saturation in the field measure the current passing through a special electrode, which is proportional to the concentration of oxygen at the electrode surface. Because salinity impacts the amount of oxygen that can be dissolved in seawater at a given temperature, salinity affects the accuracy of field readings for DO. Salinity-corrected field DO is reported in the data sets provided by SMAST for 2008 – 2012 (Howes et al, 2012). The continuous sonde data for DO that is reported by MEP was collected using optical sensors.

B. Responsible Parties

Established by Town Meeting in 2000, the OWQTF is charged with the “development and maintenance of a database on the condition of Orleans marine resources since 1988 as a foundation for pertinent decisions at all levels of Town government”. Since 2001, the OWQTF has been coordinating with the Alliance and SMAST to distribute sampling equipment and provide annual training to citizen volunteers in Orleans for ongoing sampling that now includes three stations in Nauset Harbor, approximately sixteen of the twenty-four stations in Pleasant Bay and three stations in Cape Cod Bay, including Rock Harbor, Namskaket and Little Namskaket. A freshwater monitoring program addresses approximately seventeen lakes and ponds.

The OWQTF also handles the logging-in of water samples coming in from the field in Orleans, and for chain-of-custody documentation. Chatham and Orleans alternately deliver water samples to the SMAST laboratory in New Bedford for analysis. The data is recorded in Excel spreadsheets and provided to the Town as a one year data set. The town planner ensures that these spreadsheets are maintained on the Town’s computer system. OWQTF also participates in technical discussions related to all monitoring efforts and programs that involve Orleans. Additionally, this committee coordinates some of the Town’s short-term water quality monitoring projects, and provides recommendations to the Board of Selectmen (BOS) on issues related to water quality when requested.

The Alliance was formed in 1998 to oversee resource management planning for Pleasant Bay. For the past fifteen years, the Alliance has organized and trained volunteers to collect water quality data from sampling stations bay-wide, which are sampled two times per month during July and August and once in early September. Fourteen of these stations are in Orleans's waters, although volunteers from Orleans coordinate with Chatham to sample two additional stations. The Alliance contracted Cadmus Group to analyze the monitoring data for statistical changes over time.

These core water quality sampling efforts are enhanced by the following additional environmental monitoring activities in and around Orleans:

- SMAST: Targeted monitoring and evaluations for Cedar Pond (2007), Boland Pond (2007), Namskaket Marsh (vegetative survey, 2015) and Nauset Inlet to update flow and nutrient data (2015) were undertaken.

- Center of Coastal Studies: Ongoing monitoring in Pleasant Bay, Nauset Harbor, Rock Harbor/Cedar Pond, and Cape Cod Bay as follows:

  - Pleasant Bay: A tide gauge was installed in Meetinghouse Pond in 2005, providing continuous measurements since 2007. An ecosystem-wide study was recently initiated that includes bathymetric mapping, benthic habitat mapping, surveys for finfish and shellfish and seal population studies.

  - Nauset Estuary: The Center's Coastal Geology Program has completed the field component for benthic mapping and bathymetry throughout the system. Report and maps are pending.

  - Namskaket Creek: Four stations are monitored for water quality (Namskaket, Little Namskaket, Upper Namskaket and Inner Namskaket).

  - Rock Harbor/Cedar Pond: Water quality is monitored weekly from April - November for nutrients, temperature, salinity, DO, pH, chlorophyll, and turbidity. A continuous data logger for temperature, conductivity, and DO is maintained in Cedar Pond year round. For the rest of the estuary system, water quality parameters are measured every 2 weeks, May-October. Data exists for the mouth of Rock Harbor starting in 2006, and four additional stations were added in 2012. Data and analysis is presented in a final report (Center for Coastal Studies, 2014).

  - Cape Cod Bay: Deep water quality is monitored once a month, year round using hydrographic profiling instrumentation that measure conductivity, temperature, depth, DO, fluorescence, and photosynthetically active radiation (PAR). Phytoplankton and zooplankton samples are collected weekly during the North Atlantic right whale (NARW; Eubalaena glacialis) Cape Cod Bay Seasonal Management Area (SMA) period (January - May) and monthly from June – December. Aerial surveys for NARWs with opportunistic sightings of other marine mammals is conducted from December – May. Data and analysis is presented in a final report (Center for Coastal Studies, 2012).

- Woods Hole Group: 2015 study for dredging of Nauset estuary was completed (Woods Hole Group, final report pending).

- Association for the Preservation of Cape Cod (APCC): Namskaket Creek marsh is located on the border of Orleans and Brewster. An outdated one-foot culvert was replaced by two larger, side-by-side, box culverts in January 2007, allowing for increased infiltration of salt water into the marsh. The APCC monitored the marsh for one year before restoration (in 2006) and five years after restoration (2007 – 2011) in order to track the health of Namskaket marsh before and after tidal restoration of Namskaket Creek. Monitoring included vegetation (species and abundance within a 1 meter square (m2) quadrat), birds (species, abundance and behavior within delineated area) and salinity (pore and surface water).

- APCC and the Cape Cod Commercial Hook Fishermen Association: A study of Rock Harbor marsh was conducted in 2006. The marsh is restricted by Dyer Prince Road. The study includes pore and surface water salinity measurements, plant identification and percent cover (estimated within m2 quadrats). Bird monitoring was conducted, including point source counts and activity; and nekton (fish) were caught, identified, measured and weighed. Water temperature, DO, pH, and specific conductivity was measured at the fishing stations.

- Coastal Zone Management: The 2000 – 2003 Cape Cod Salt Marsh Assessment Project included studies of Boat Meadow Creek and Nauset Estuary at Mary Chase marsh in Eastham. Plant identification and percent cover was estimated within m2 quadrats, and pore and surface water salinity measurements were taken.

- US Geologic Survey (USGS): Groundwater evaluations have been completed for the tri-town plume and potential impact to Namskaket Marsh (final report pending, presentation made by Dr. Peter Weiskel to the Orleans Board of Selectmen on April 20, 2011, and to the OWQAP on April 20, 2016).

- Division of Marine Fisheries: The agency is providing ongoing technical support to Orleans regarding diadromous fish populations in Pilgrim Lake and Cedar Pond.

- Cape Cod Commission (CCC): The Commission reviewed and interpreted the freshwater pond volunteer monitoring data in 2006.

- Horsley and Witten, Inc.: In 2003, a qualitative survey of pond shore vegetation was completed at eleven freshwater ponds in the Pleasant Bay Area of Critical Environmental Concern including the following ponds in Orleans: Crystal, Pilgrim, Little Quanset, Sarah’s, Gould and Uncle Seth’s.

5. Monitoring Demonstration Projects

The preferred locations of demonstration sites selected by Shellfish, Permeable Reactive Barrier and Floating Constructed Wetlands teams are shown in Figure 3.

Based on the MEP model, both the Nauset Harbor and Pleasant Bay System watersheds have recommended nitrogen removal rates that are significantly higher than the expected TN or BioN removal of demonstration projects. The target nitrogen load reduction for the entire Pleasant Bay System is almost 17,000 kg N/year, with each sub-watershed in the Pleasant Bay system having a lower target nitrogen removal rate than the system as a whole. The target nitrogen load reduction for the Nauset Harbor system is approximately 8,600 kg N/year, while the Town Cove sub-embayment target load reduction is approximately 6,700 kg N/year. Since these estuarine systems circulate water and mix nutrients, it is not likely that a relatively small uptake of nitrogen in just one sub-embayment will register a reduced TN concentration at its sentinel station, even if it is a significant percent of the nitrogen load reduction for that sub-watershed.

Figure 3 Demonstration Project Sites

Therefore, to quantify the nitrogen-removal of a demonstration project, monitoring plans will need to be designed to capture localized water quality improvements near the demonstration sites. In the case of the shellfish and floating wetland demonstration projects this goal is accomplished by understanding the baseline (reference) conditions at each of the sites in addition to post monitoring, once the demonstration projects are installed. For these demonstration projects, positioning monitoring stations upstream, instream and downstream of the demonstration project location and with a high spatial resolution will be necessary. Water quality samples are then analyzed for different nitrogen fractions, including nitrate, ammonia, DON, PON as well as other water quality indicators such as DO and pigments. TM 4.a.3 presents a detailed monitoring plan for the demonstration projects based on this approach.

In terms of establishing baseline conditions, The MEP report for Nauset Harbor watershed includes fifteen monitoring stations, WMO-25 to WMO-40, as shown in Figure 2. The only stations that have a complete set of data from 2003-2014 are WMO- 27 (the Sentinel Station for the Nauset Harbor in Town Cove), WMO-34 (Mill Pond), and WMO-38 (Salt Pond). The remaining monitoring stations only have consistent data for 2003-2004, with sporadic data collected in 2005. These three stations do not provide sufficient spatial resolution within the sub-embayments of this estuary to establish a baseline to compare against demonstration monitoring data. Although Pleasant Bay is sampled at twenty-four stations, there are long distances between stations. Moreover, the standard deviation for annual average values in both Pleasant Bay and Nauset Harbor ranges from 10 percent to over 50 percent. This indicates that there is a large range of values in the approximately five data points collected within a season. Averaging these data points to establish an annual value for a given parameter is the accepted practice of the MEP for overall water quality determination. This data set is valuable for long term study and gross comparisons within the watershed, however, in order to quantify a small change in nitrogen that is removed from a shellfish or floating wetland installation, pre installation samples taken in close proximity to the demonstration sites are needed to establish reference values at a given demonstration location.

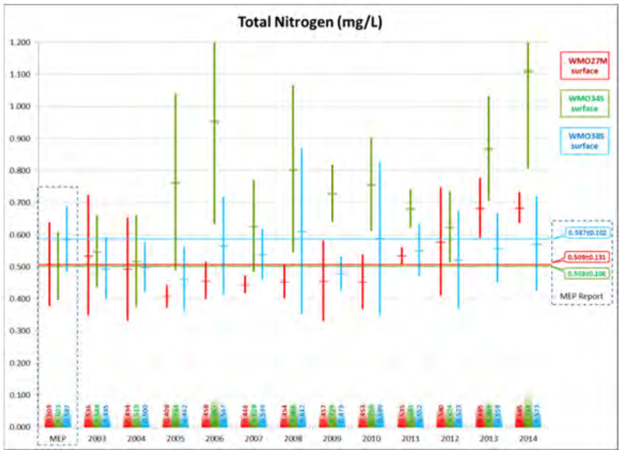
For permeable reactive barriers (PRB), the expected monitoring protocol will involve direct measurements of groundwater upstream, within and downstream of the PRB installation. This will enable clear quantification of the effectiveness of this technology. To capture the impact of a PRB to the waterbody, monitoring stations where groundwater is expected to enter the estuary are recommended. Current stations are not adequate for establishing baseline conditions with enough precision to identify fluctuations from demonstration monitoring. A detailed monitoring program is being developed with high spatial and temporal resolution and input from experts as part of the water quality and wastewater planning process. TM4.a.3: *Non-Structural Technology Performance Monitoring* presents the specifics of a recommended monitoring program for each proposed demonstration.

6. Evaluation of Current Data Sets and Comparison with MEP Baselines

The Nauset Harbor baseline parameters reported in the MEP Report (SMAST, 2012) include:

- TN and salinity at stations WMO 25 – 40, for the years 2001 – 2004.
- DO and Chl-*a* are provided in the MEP report as a trace of continuous monitoring SONDE data over an approximately 30 day period in 2003. The methodology used to present the measurements in the report is not comparable to the methodology used for grab samples collected in subsequent years. The source data required to make a meaningful comparison of the data sets was not available. Grab sample data collected in 2003 – 2004 as part of the MEP field investigations are presented for comparison with current data.

Figure 4 (a-d) compares the values from the MEP Report (2001-2004 averages) to the years 2003 – 2014 for TN and salinity at stations WMO-27 (Town Cove, red data), WMO-34 (Mill Pond, green data) and WMO-38 (Salt Pond, blue data). DO and Chl-a are compared to grab sample data for 2003 and 2004. Figures 5 and 6 show the difference between surface and bottom measurements at Mill Pond and Salt Pond for these same parameters. Town Cove only has samples taken at one depth.



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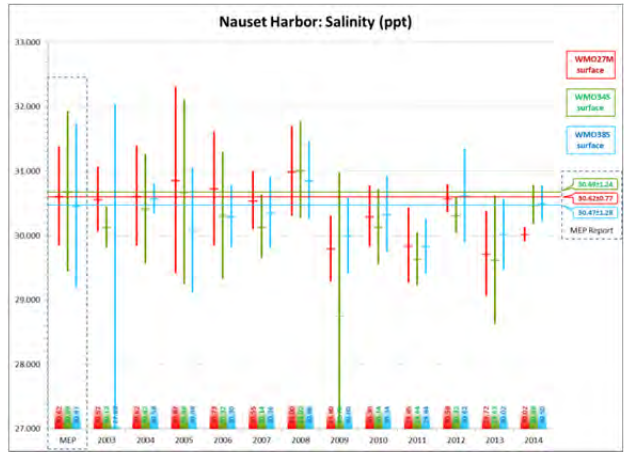

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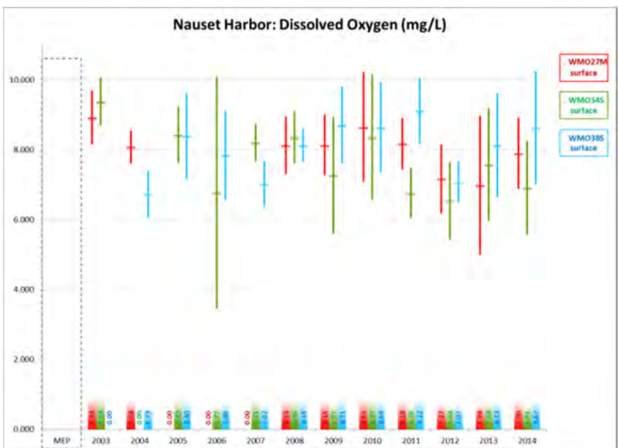

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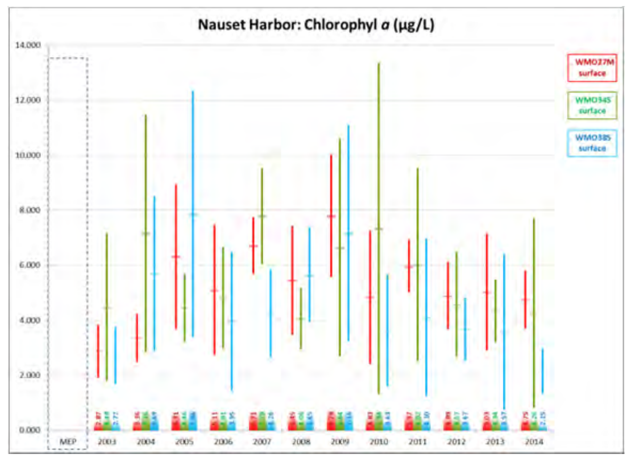
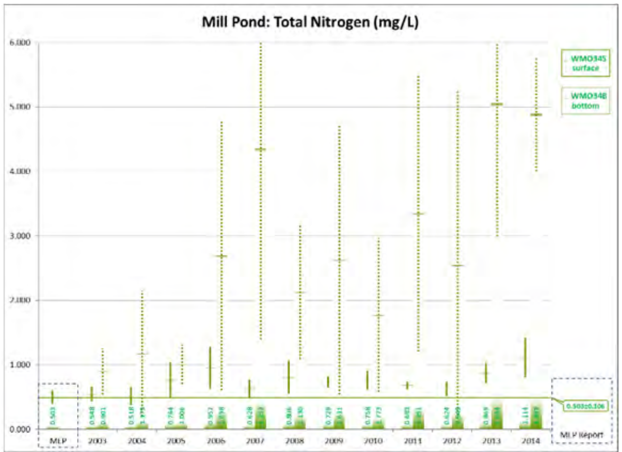


(d)

Figure 4: Comparison of data in the MEP report to recently collected data for Nauset Harbor (Town Cove, Mill Pond and Salt Pond sites) for: (a) TN (mg/L), (b) salinity (ppt), (c) DO (mg/L); and (d) chlorophyll a (mg/L)



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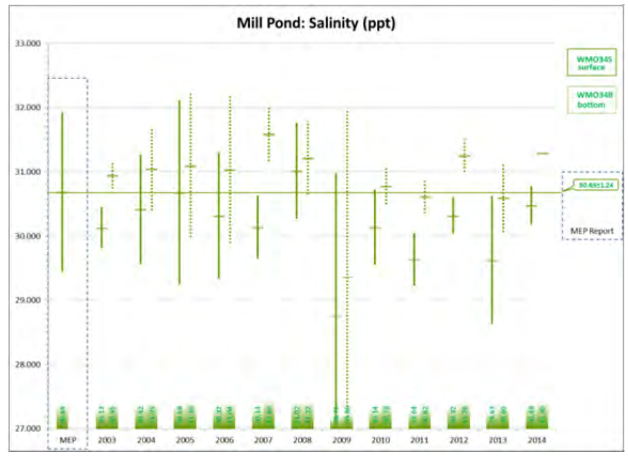

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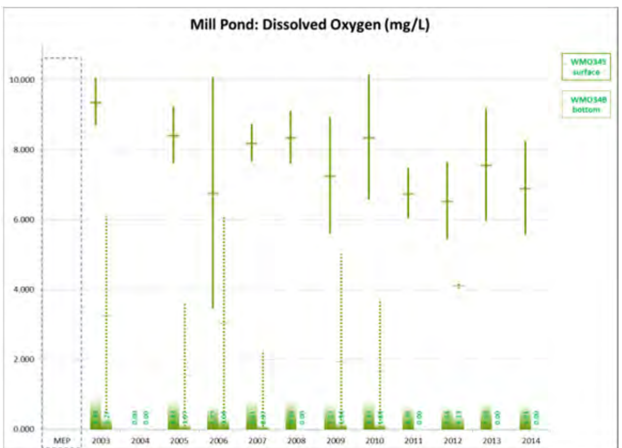

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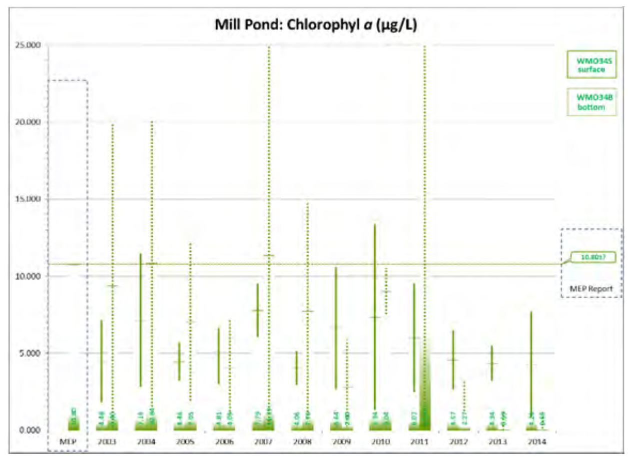
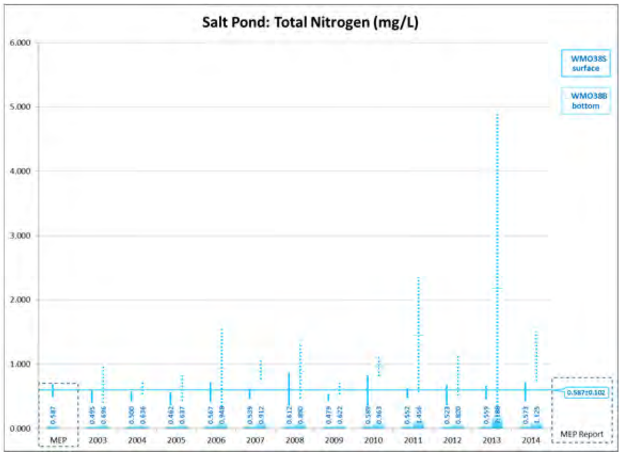


(d)

Figure 5: Comparison of data in the MEP report to recently collected data for Nauset Harbor (Mill Pond) showing the difference between surface and bottom measurements for: (a) TN (mg/L), (b) salinity (ppt), (c) DO (mg/L); and (d) chlorophyll a (mg/L).



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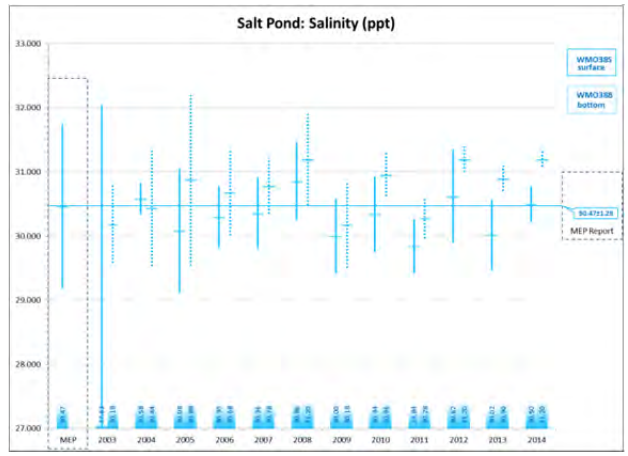

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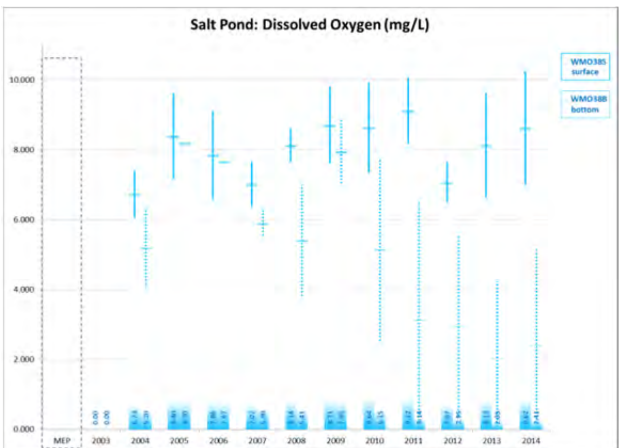

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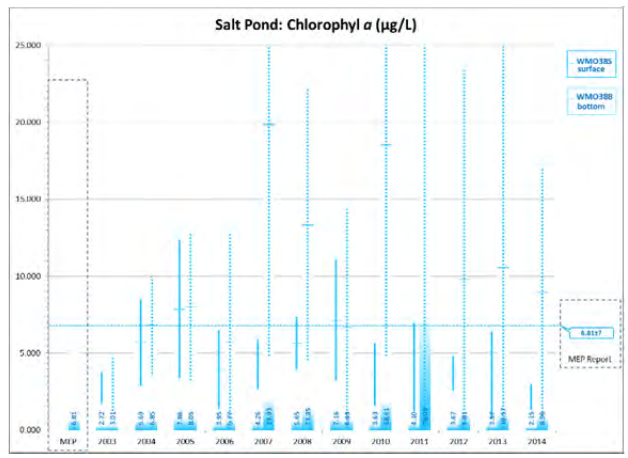

(d)

Figure 6: Comparison of data in the MEP report to recently collected data for Nauset Harbor (Salt Pond) showing the difference between surface and bottom measurements for: (a) TN (mg/L), (b) salinity (ppt), (c) DO (mg/L); and (d) chlorophyll a (mg/L).

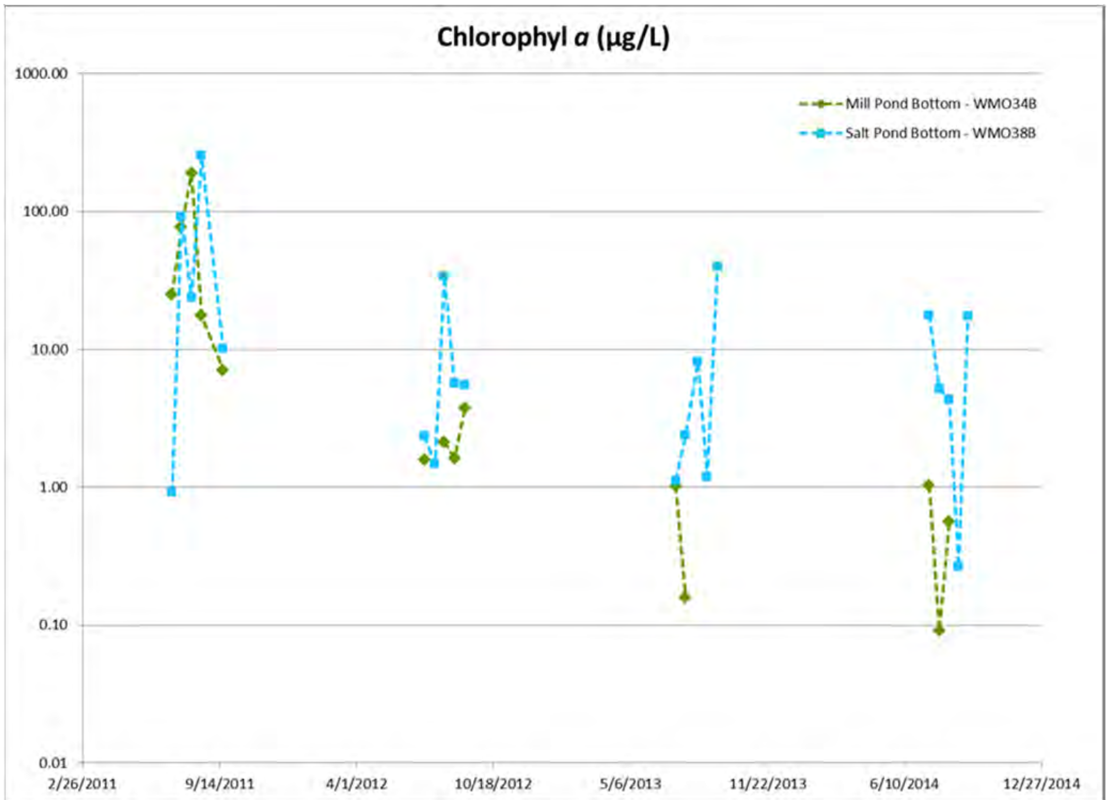

Figure 7: Chl-a for Mill Pond (WMO-34B) and Salt Pond (WMO-38B as a function of time (2011-2014)

A. Nauset Harbor Assessment

Figure 4 compares the MEP report to recently collected data for Nauset Harbor. The MEP report based water quality assessments on data from fifteen stations (only data from three stations shown). Currently, there are three stations being sampled, representing the Town Cove, Mill Pond and Salt Pond systems. To establish robust baseline conditions for Nauset Harbor, additional stations are recommended so that trends and values shown at the single stations in these sub-embayments can be compared to data from additional locations in the same system. Comparison of these stations is as follows:

TN: Since 2011, Town Cove has been consistently higher than the MEP baseline values; Mill Pond has been consistently higher than the MEP baseline values since 2010; and since 2011, Salt Pond has been consistently lower than the MEP baseline values, but has been rising towards the baseline since 2012.

Salinity: Town Cove has been consistently lower than the MEP baseline value since 2009; Mill Pond has been consistently lower than the MEP baseline value since 2009, but in 2011 began approaching that baseline; and Salt Pond has been above and below the MEP baseline value since 2003, and in 2014 was essentially at that baseline.

DO: Town Cove and Mill Pond have been consistently lower than the MEP data from the data sets from 2003; and Salt Pond has been higher than the MEP data from 2004.

Chl-a: Town Cove has been consistently higher than the MEP data from the data sets for 2003 but is declining; Mill Pond has been oscillating above and below the MEP data for 2003 but was lower in 2014; and Salt Pond has been higher than the MEP data for 2004 since 2009, but in 2010 began to decrease and in 2014 was slightly lower relative to 2004. There is significant variation in the data, as shown by the standard deviation bars.

While the Total Maximum Daily Load (TMDL) for TN has not yet been established by the Environmental Protection Agency for Town Cove and Mill Pond, neither Town Cove nor Mill Pond meet the target load for nitrogen that is prescribed in the MEP Report, which is 58.718 kg/day and 9.219 kg/day respectively. In addition, TN concentrations are higher than the MEP recommended threshold of 0.45 mg/L at the Sentinel Station in Town Cove. Nitrogen concentrations are also higher relative to the 2003 reference point. Increasing DO and Chl-a echo this TN trend. Lower salinity may indicate an occluded inlet and shoaling relative to the 2003 value.

An analysis of the available data also highlights the importance of surface and bottom measurements to understanding water quality trends as seen in Figures 5 and 6. Differences in data values for surface and bottom sampling locations are apparent for all four parameters at both stations where data was available for comparison. One notable example is the TN values. Focusing on trends at the surface will miss the higher TN values at the bottom in both Mill Pond (WMO-34B) and Salt Pond (WMO-38B). The MEP report seems to have reported surface TN data, but sampling depth is not stated in the documentation.

Another notable feature of the data was discovered when examining Chl-a for Mill Pond (WMO-34B) and Salt Pond (WMO-38B). Figures 4d and 5d show very large standard deviation for the 2001 bottom Chl-a data. Plotting each measurement as a function of time (Figure 7) suggests an exponential decline over the course of years. Note the logarithmic vertical scale of the graph. This may have been caused by an algal bloom occurring during the sampling time at Salt Pond (WMO-38B) in 2011, with the values in subsequent years showing a continuous declining trend. By 2014, values in Salt Pond had returned to typical pre-2011 levels. However, values in Mill Pond had decreased to near zero by 2014, possibly indicating a permanent change in this ecosystem. However, a change in the water depth from which the sample is taken can also impact results.

The significant difference between surface and bottom data in Nauset Harbor emphasizes the importance of sampling different depths in the water column in order to characterize water quality. The information in Figure 7 indicates that potentially significant spikes over the course of a season, as well as trends over the course of multiple seasons, may be obscured by simply averaging together data from individual year samples.

A brief review of the data sets provided to Orleans shows large anomalies in some of the data. These may be the result of sampling errors, an atypical event or natural temporal and spatial variations within a particular sub-embayment. For the purpose of this analysis, two anomalies for DO concentration, likely data entry or sampling equipment errors, were removed based on correlation to the DO percent saturation recorded for the same sampling event.

The comparison of current data sets to MEP baseline values for DO and Chl-a revealed several issues. MEP reported DO and Chl-a data as collected using continuous monitoring sondes deployed at the bottom of the water column for approximately 30 days, and tabulated as histograms. Surface data for DO and Chl-a was not collected as part of this MEP effort, and standard deviation for Chl-a data is not provided. Sonde data is not available in a way that allows extracting values that correlate with the sampling times established for grab sampling. Future monitoring efforts should include a review of data sets for outliers soon after the data is provided, and a provision that historic sonde data sets include a list of measured values and the date and time of each measurement.

B. Pleasant Bay Data Review: Bay-Wide Trends

In order to evaluate trends within all of Pleasant Bay, the Cadmus Report pooled water quality data from samples from all 34 monitoring stations (Cadmus 2015). The number and frequency of samples was considered adequate for establishing trends in overall data parameters. Water between Pleasant Bay and the Atlantic Ocean is currently exchanged through two tidal inlets. South Inlet was formed in 1987, and North Inlet was formed in 2007 when a breach occurred at the southern end of an unbroken, ten-mile stretch of barrier system known as "North Beach". Geographically the breach is located in North Chatham in the vicinity of Strong Island and Ministers Point. The formation of this new inlet was expected to bring increased tides and flushing to the bay. Both before and after the 2007 breach, several bay-wide trends are evident. The post-breach trends include:

- Increasing DIN, BioN;
- Decreasing Pigments;
- Increasing DO;
- Trends in TN, PO4 not considered statistically significant; and
- Increased salinity.

Figure 8 presents trends normalized to post-breach 2008 data for different nitrogen fractions and pigments. TN includes DON, PON, and DIN. TN is not used to establish the TMDL for Pleasant Bay because DON, which is mainly from atmospheric deposition, is almost 70 percent of the contribution of TN in this system (Figure 9, grey area at the top indicates DON contribution). BioN is used for the TMDL because it only includes DIN (anthropogenic sources) and PON.

C. Pleasant Bay Data: Bay-Wide Assessment

A Bay-wide analysis of the data shows several unexpected trends:

- DIN is increasing at a slower rate after the break, but PON and DON are not changing in ways that are consistent with this trend
- BioN (DIN +PON) is increasing but pigments are decreasing
- While Bay-wide trends show an increase in BioN, individual sampling station values increase at only two locations while eight show a decrease. Nine locations show no statistically significant difference.
- DO is higher at the bottom of the water column
- Temperatures are higher at the bottom of the water column

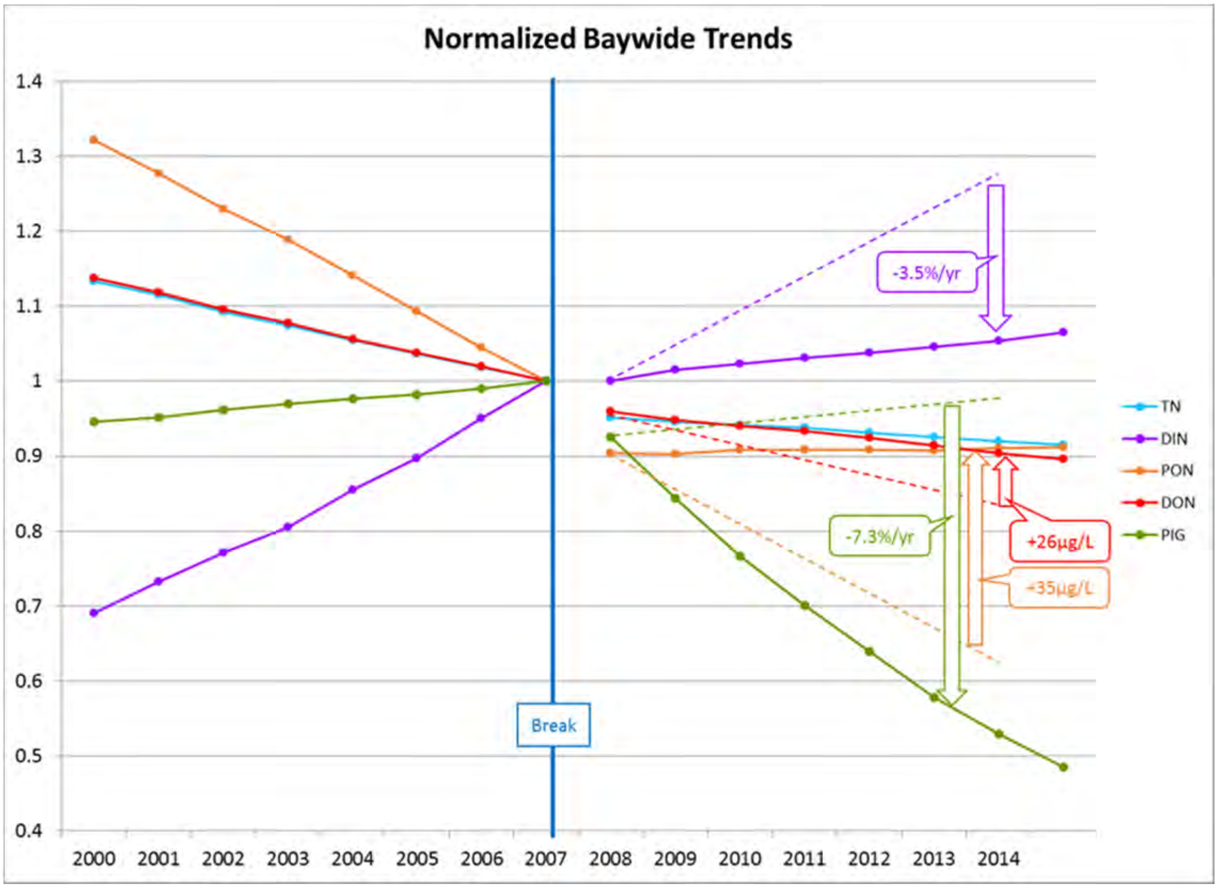

Figure 8: Normalized Trends in Nitrogen Species and Phytopigments

As shown in Figure 8, DIN was increasing rapidly before the inlet breach. After the breach, DIN continued to increase, but at a significantly slower rate. A steady decline in PON was occurring before the breach. If increased flushing due to the breach was responsible for improving water quality, the expected drop in PON would be more pronounced after the break. Instead, PON started to climb slightly. From 2000 to 2006, PON decreased from 165 µg/L to 131 µg/L, a reduction of 34 µg/L. If this rate had continued from 2008 to 2014, the concentration would have declined from 113 µg/L to 79 µg/L. The actual data shows an increase in PON of 1 µg/L (from 113 µg/L to 114 µg/L) over that time period. This results in 35 µg/L more PON from 2008 to 2014 than would be expected if the pre-breach trends had continued.

DON was also decreasing before the breach. This drop in DON would also have been expected to accelerate after the breach, but the data shows it is decreasing more slowly. Atmospheric trends should be expected to continue unaffected by the breach, but DON from biological activity should be lower if there were increased flushing. Instead the rate of DON decrease lessened. From 2000 to 2006, DON dropped from 484 µg/L to 434 µg/L, a reduction of 50 µg/L. If this rate continued from 2008 to 2014, the expected decrease would have been from 408 µg/L to 358 µg/L. Data shows a 24 µg/L reduction in the concentration of DON, to 384 µg/L. Thus, there is 26 µg/L more DON from 2008 to 2014 than what would be expected if the pre-breach trends had continued. If flushing were improving water quality, then the DON should have decreased below 358 µg/L, the value that would have been measured if the pre-breach trends continued. If this change in BioN were due to increased flushing, accelerated decreases in PON and DON should be observed, but this is not the case.

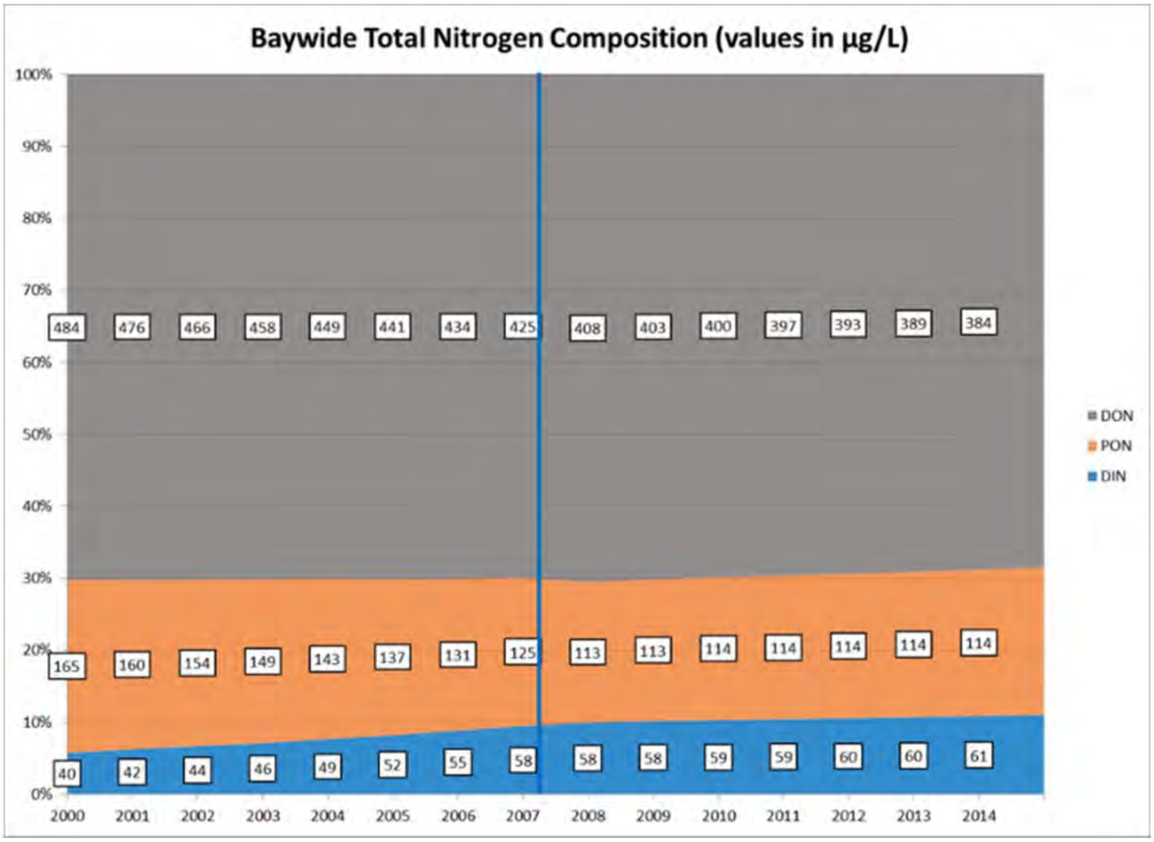

Figure 9: Nitrogen Species as a Percent of Total Nitrogen

A possible explanation for the observed post-breach DIN, DON and PON trends is that macroalgae is outcompeting phytoplankton for DIN uptake, and at the same time contributing additional DON and PON to the water column (MEP 2006). This explanation needs field verification, but matches several observed features of the Bay-wide data:

- The decrease in the rate of increase of DIN concentration at the breach cannot be explained by source reduction.
- Inconsistent DON and PON trends, which seem to rule out increased flushing as an explanation.
- There is 59 g/L more PON and DON combined than would have been expected if pre-breach trends continued, 35 g/L and 24 g/L respectively.
- PON comes from particles of decomposing organic matter and as it continues to break down, some becomes DON. The observed higher concentration of PON relative to DON suggests that the nitrogen fraction is coming from physically large organic matter.
- The rapid decrease in pigments, which had been increasing slightly before the breach, is not matched by a corresponding magnitude of decline in DIN. Figure 8 shows a net 7.3 percent per year decrease relative to the pre-breach trend for pigments (green line) and a net 3.5 percent per year smaller increase relative to the pre-breach trend for DIN (purple line). This suggests that something other than reduced DIN is responsible for the loss of pigments.

There are several potential explanations for the seemingly contradictory bay-wide trend that BioN (DIN and PON) is increasing and pigments are decreasing. Pigment reductions may be explained by lower populations of phytoplankton and other microalgae, but BioN may also be stimulating the growth of macroalgae. Macroalgae populations can be promoted by nitrogen levels that are lower than optimal for phytoplankton, yet still elevated (Hein, 1995). Sampling during the summer may not measure DIN and PON accurately because DIN is consumed and PON is produced as part of macroalgae cycling. Summer sampling may be underestimating actual DIN inputs, and may not capture PON. Increased grazing by zooplankton may also be reducing phytoplankton populations. Pigments are the sum of Chl-a and pheophytin. It may be more accurate to track Chl-a alone for a more representative measure of microalgae.

Macroalgae may also be impacting sedimentation as it becomes PON. The fraction of BioN related to PON may be resulting in increased deposition of organic matter to the sediments, and not necessarily increased pigment concentrations from algae. This would not show up in water sampling that occurs every 2 weeks, which is likely not to capture algae die-off and accumulation. Although higher DO in bottom samples may be indicating improved conditions, this may also be an artifact of snapshot sampling of this highly dynamic constituent. The DO and temperature difference between surface and bottom indicates an inversion, which may be caused by a number of different factors, such as 1) the relationship between water temperature and oxygen saturation; 2) less wind and therefore less mixing with the surface which lowers oxygen saturation; 3) less decomposition versus photosynthesis; and 4) time of day samples are taken.

Data analysis is based on the assumptions that DIN is comprised of nitrate and ammonium, DON is from particles smaller than a certain threshold, and PON is from particles larger than a certain threshold. Based on the SMAST Laboratory Analysis QAPP, the threshold is believed to be in the range of 0.22 to 0.45 microns. Macroalgae is likely not included in the reported concentrations, and water analysis does not account for sediment accumulation. Clarification from SMAST is required.

D. Pleasant Bay Data Review: Individual Sites

Long term data sets from Pleasant Bay were investigated to determine whether current water quality data are sufficient to establish baseline conditions for evaluating non-traditional demonstrations in Orleans. According to the Alliance, twenty-four stations are currently monitored in Pleasant Bay. Based on a recent evaluation (Cadmus 2015), as many as thirty-four stations have been monitored over the past fifteen years, and there is sufficient data from twenty (20) of these stations to enable long term trend analysis. This report presents trend lines that were fitted to sampling data for each of these 20 stations, including trends before and after the 2007 breach at Nauset Beach. The specific parameters include: dissolved inorganic nitrogen (DIN), bioactive nitrogen (BioN), total nitrogen (TN), phosphate (PO4), total phytopigments (pigments), dissolved oxygen (DO) and salinity. This trend analysis for Pleasant Bay monitoring stations includes the following stations in Orleans (Cadmus 2015):

- Meetinghouse Pond (PBA-16);
- The River at Rattles Dock (WMO-10);
- Namequoit South (PBA-12);
- Namequoit North (PBA-13);
- Namequoit Mid (WMO-6);
- Arey's Pond (PBA-14);
- Kescayogansett Pond (Lonnie's, PBA-15);

- Paw Wah Pond (PBA-11);
- Little Pleasant Bay near Quanset (PBA-8);
- Pochet Mouth (WMO-3);
- Pochet Upper (WMO-5);
- Quanset Pond (PBA-10); and
- Little Quanset Pond (WMO-12).

Stations in Orleans that were not included in this evaluation because of significant gaps in data include the following:

- Pochet (mid): WMO-4 which has not been sampled since 2004;
- The River (mid): WMO-8 which does not have data from 2005-2013;
- Namequoit River (mouth) WMO-7 which has not been sampled since 2004;
- Round Cove: WMO- 9 which does not have data from 2006 to 2013; and
- Pleasant Bay north of Round Cove: PBA-7 which does not have data after 2005.

In the Cadmus Report, the statistical significance of trend lines for individual sampling locations was assessed based on a 5 percent significance level, which corresponds to a 95 percent likelihood that the trend line slope is due to an actual change and not random variation. Based on a 5 percent significance level there are some sites with statistically significant trends, however there are no consistent trends in water quality parameters across the twenty (20) Bay-wide monitoring stations that were analyzed.

For each of the Pleasant Bay sites in Orleans, **no statistically significant results** (at 95 percent confidence) were found for the following parameters:

		DIN	BioN	TN	SRP (PO_4)	pigment	DO	salinity
Meetinghouse Pond	(PBA-16)	X	-	X	X	-	X	X
Namequoit South	(PBA-12)	X	-	-	-	-	-	-
Namequoit North	(PBA-13)	-	X	X	X	-	X	X
Namequoit Mid	(WMO-6)	X	-	-	X	-	X	X
Pochet Upper	(WMO-5)	X	X	X	-	-	-	X
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	-	-	-	-	X	X
Paw Wah Pond	(PBA-11)	X	-	-	X	-	X	-
Pochet Mouth	(WMO-3)	X	-	-	X	-	X	X
Little Quanset Pond	(WMO-12)	-	-	-	X	X	-	-
Arey's Pond	(PBA-14)	X	X	X	X	-	-	X
Quanset Pond	(PBA-10)	-	-	-	-	-	X	X

Table 1: Water Quality Parameters with no statistically significant results at the 95 percent confidence interval are indicated by an X. Boxes with a dash indicate statistically significant trends (based on Cadmus 2015).

From Table 1, DIN, SRP (PO4), DO and salinity data is not statistically significant for stations in Orleans. DO is highly dependent on time of day, so lack of trends with statistical significance may indicate variability in sample collection times, even if the samples were acquired within the QAPP range. The lack of trends for DIN and SRP (PO4) may be a function of the sampling period being restricted to summer when biologic activity is widely variable. Another observation for Orleans sites (Cadmus 2015) is that when BioN has a statistically significant result, the BioN is decreasing.

Appendix F of the Cadmus Report presents graphed data for DIN, BioN, TN, SRP (PO4), Pigments, DO and salinity for all monitoring locations (Cadmus 2015). These data were also evaluated and are presented in Table 2. Black text, a black "X" or arrow "↑" indicate an improved water quality value; and red text, a red "X" or arrow "↓" indicate a degraded water quality value. When values are not statistically significant, they are shown in brackets.

		BioN Above TMDL (X) or Below/Near TMDL (X)	Pigments Below 5 µg/L or Decreasing	DO Increasing (↑) or Decreasing (↓) or Steady State below 6 mg/L (SS)	DIN Increasing (X) or Decreasing (X) or Steady State (SS)	ACTION
Meetinghouse Pond	(PBA-16)	X	X	[↓]	[SS]	Confirm System Health
Namequoit South	(PBA-12)	X	X	↑	[X]	Confirm System Health
Namequoit North	(PBA-13)	[X]	X	[↑]	X	Confirm System Health
Namequoit Mid	(WMO-6)	X	X	[SS]	[X]	Confirm System Health
Pochet Upper	(WMO-5)	[X]	X	↑	[X]	Confirm System Health
The River at Rattles Dock	(WMO-10)	X	X	↑	[X]	Determine Why Inconsistent
Kescayogansett Pond (Lonnie's)	(PBA-15)	X	X	[SS]	[X]	Determine Why Inconsistent
Paw Wah Pond	(PBA-11)	X	above 5 µg/L	[SS]	[SS]	Determine Why Inconsistent
Pochet Mouth	(WMO-3)	X	X	[SS]	[X]	Determine Why Inconsistent
LPB Near Quanset (Big Bay NE)	(PBA-8)	[X]	X	↑	X	Determine Why Inconsistent
Little Quanset Pond	(WMO-12)	X	[X]	↓	X	Treat as Impaired
Arey's Pond	(PBA-14)	[X]	above 5 µg/L	↓	[SS]	Treat as Impaired
Quanset Pond	(PBA-10)	X	above 5 µg/L	[↑]	X	Treat as Impaired

Table 2: Water Quality Parameters with Action Items. Both statistically significant trends as well as trends that are not statistically significant are shown (based on Cadmus 2015).

From Table 2, BioN is below or near TMDL for seven of 13 stations in Orleans, and pigments are either below an acceptable level of 5 µg/L or are decreasing with statistical significance at all stations that were evaluated except three. This unexpected decrease in BioN and Pigments was further evaluated by reviewing Secchi depth (turbidity) data and calculating the standard deviation for select sites (Figure 10 and 11). Secchi depth was normalized to the average depth from years 2000 – 2002. In Figure 10, the solid lines indicate stations where Secchi depth is increasing (turbidity is decreasing) and that water clarity is improving after 2010. Data from Figure 8 shows decreasing pigments, which matches data (stations represented by solid lines) in Figure 10, suggesting decreased turbidity. However, neither DIN nor DO consistently follow the BioN and pigment trends for water quality improvement. DIN is increasing at both Quanset Pond and the Lower River, but only Quanset Pond shows a statistically significant increase in BioN.

These results are not surprising since in estuaries, N concentrations, especially the inorganic forms, typically vary widely seasonally, interannually, and along salinity gradients. As detailed in the discussion on Bay-wide trends, the timing of sample collection and macroalgae uptake and organic contributions may be impacting DIN, DON and PON concentrations. Systems may be achieving water quality standards based on N sampling, measures of algal biomass (e.g., chlorophyll a), water clarity (e.g., Secchi depth) or DO, yet still show inconsistencies in long term data sets because nitrogen fractions are cycling in new ways in response to environmental changes. For example, the concentration of the primary N variables may not correlate well with one or more response variables such as phytoplankton production. Physical factors such as salinity, pH and temperature gradients and input and outputs of fresh or salt water (e.g. flushing) play an important role in the N process and phytoplankton productivity.

Discerning patterns in N loads and cycling is further complicated by biogeochemical processes such as: N2 assimilation directly from the atmosphere by N fixation; the high solubility of DIN, especially nitrite and nitrate that does not precipitate easily or sediment out when freshwater enters a brackish zone; varying sediment biogeochemical conditions (e.g., due to macroinfauna presence/absence, oxic or anoxic conditions in the overlying bottom water, and water column depth). Biological factors such as the increase or decrease in seagrass and submerged aquatic vegetation, macroinfaunal community structure, phytoplankton species composition, and organic carbon concentrations can also play a role in N dynamics.

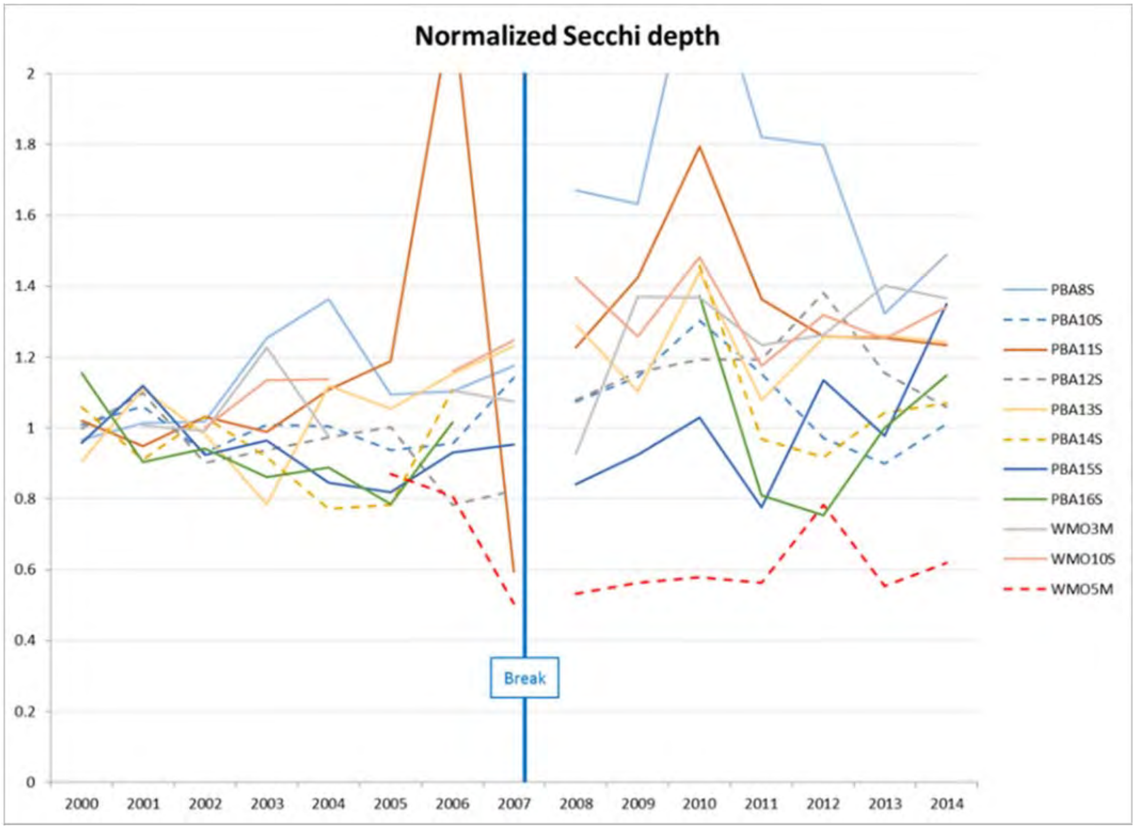

Figure 10: Normalized Secchi Depth

The Figures presented in this TM for Nauset Harbor include standard deviation bars for each site. The trend analysis for Pleasant Bay (2015) does not show the internal variation in the annual averages plotted and fit to a trend line. A hallmark of water quality data is the wide variability in data values. The MEP-approved technique of averaging the approximately five sample values taken over a season to establish an annual value yields standard deviation that are typically around 20 percent and often over 30 percent. Figure 11 shows Standard Deviation for representative sites:

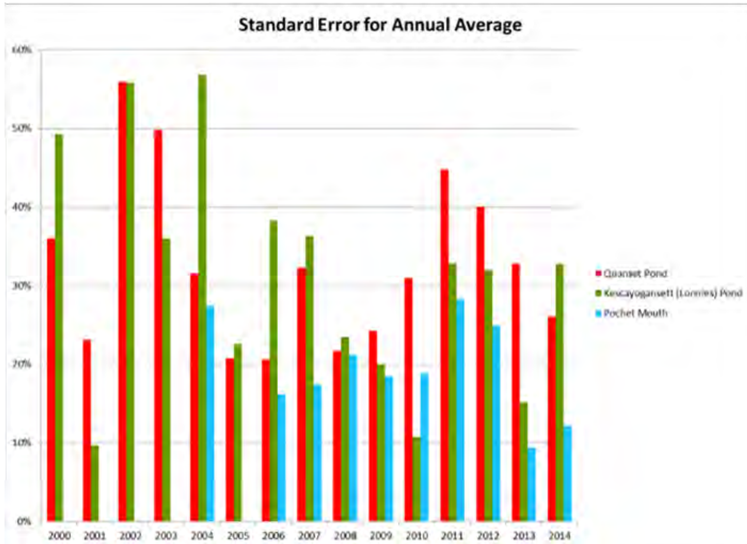

Figure 11: Standard Deviation for Select Sites

As shown in Table 2, Orleans stations are grouped based on three action items:

- Confirm system health;
- Determine why inconsistent; and
- Treat as impaired.

Confirming system health is recommended when the station is below the TMDL for BioN and other water quality parameters such as total pigments show improved conditions that reflect acceptable BioN concentrations. Five of thirteen stations are in this category. Determining why parameters are inconsistent is suggested for sites where either BioN is at or near the TMDL, but other parameters indicate impairment, or BioN is above the TMDL but other parameters seem to show that the system is in good condition. Five of thirteen sampling stations are in this category. Treating systems as impaired is designated for sub-embayments where the range of water quality parameters consistently show degraded conditions. Three of thirteen stations are in this category.

Ecosystems are impacted by many different variables. Trend observations from fifteen years of Pleasant Bay data underscores this complexity. For this reason, the MEP recommends quantifying several indicators of health, including water quality, benthic environment and key species such as eelgrass and macroalgae. Implications for a long term monitoring program based on this data analysis follow in Section 6: Findings/Recommendations.

7. Findings/Recommendations

A review of data from monitoring programs in both Pleasant Bay and Nauset Harbor reveal a significant variability in water quality data. There are several key implications of this analysis:

- Establishing current baseline conditions requires additional sampling locations in Nauset Harbor, and additional study of the biogeochemical processes impacting nutrient cycling in select sub-embayments of Pleasant Bay;
- Establishing baseline conditions that will enable the effect of demonstration projects to be quantified requires site-specific monitoring with high spatial and temporal resolution to capture the localized range in values for water quality and benthic parameters; and

- A recalibration and rerun of the Massachusetts Estuaries Project (MEP) model for Pleasant Bay and Nauset Harbor is warranted based on the changes in physical conditions and measured nutrient concentrations.

A detailed monitoring program, including assignment of responsibility for accomplishing program tasks, is provided in TM 4.a.2: Long Term Waterbody Monitoring Program. The following findings provide the framework for this subsequent TM:

A. Utility and Recommendations for Existing Station Locations

There are currently three stations monitored in Nauset Harbor. Based on the analysis detailed in Section 5, additional monitoring locations, such as the original fifteen MEP stations, are recommended in order to accurately assess this estuary.

There are currently twenty-four stations monitored in Pleasant Bay. Based on the analysis detailed in Section 5, these station locations may be adequate. However, the stations in Orleans where 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. Recommended Monitoring Frequency, Parameters, and Analyses

Recommended additional monitoring and evaluations include:

- Additional sampling dates;
    - Spring (March/April)
    - Fall (Sept/October)
- DIN and PON concentrations sorted by temperature, based on additional sampling;
- Macroalgae populations and nutrient flux;
- DON changes due to reduced atmospheric deposition;
- Pigment assessments based on Chl-a only; and
- Benthic assessments.

Based on the analysis presented in Section 5, sampling dates in early spring (March/April) and fall (October/November) should be added for several reasons. Samples collected in the spring are recommended because the nitrogen associated with biologic activity within the ecosystem is minimized and the human-derived component can be more easily quantified. DIN is assimilated during July and August when biologic activity is at its maximum, therefore samples taken during this timeframe likely underestimate DIN, therefore BioN concentrations are inaccurate. Conversely, PON and DON concentrations may be higher during the summer because they are a by-product of biologic activity from salt marshes and macrophytes.

The July and August sampling period was established over a decade ago because it was believed that eutrophic conditions were peaking, but monitoring before peak conditions may facilitate discerning trends. The other benefit of early and late season monitoring is that it will capture peaks, and will show data before and after these peaks. In this way, nitrogen species can be better correlated to their sources, and PON and DON cycling can be captured. The large variability in data values, as shown by the standard deviation of annual averages, has implications for the number of sampling events that should be occurring. Additional sampling should be grouped according to water temperature to assess the impact of temperature on trends.

If the hypothesis that DIN is assimilated into macroalgae is correct, then water sampling should be supplemented with assessment of macrophytes in the water column, as well as in bottom sediments. Macrophyte surveys (macroalgae and eelgrass) are recommended for both Pleasant Bay and Nauset Harbor. 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 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.

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 TN (Figure 8). Recent research in Waquoit Bay suggests that the amount of DON contributed by atmospheric sources has declined over 50 percent since 2000 (Valiela, in press). Data from Pleasant Bay shows that since the breach, DON has been decreasing at a significantly lower rate than before the break. There is reason to believe that contributions from atmospheric sources were higher before the breach and have continued to decrease since (Valiela, in press). 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 biologic activity (Bronk, 2007), this hypothesis should be confirmed.

In addition, BioN as defined in the TMDL includes DIN and PON. To understand ecosystem loading, tracking DIN separately from PON during the early spring is advised. In addition, characterizing PON as well as DON cycling and fluxes in the Pleasant Bay system may explain some of the inconsistencies in the parameter trends for water quality. Laboratory analysis of water samples for nitrogen fractions of nitrate, ammonium, DON, and PON should continue. Organic fractions should not be determined arithmetically.

Baseline data analysis indicates that it may improve water quality evaluations if data triggers were instituted. When values exceed a certain threshold, in-depth monitoring of these outlier events could be undertaken. For example, a ten-fold increase in Chl-a between samples could trigger the deployment of sensors with high temporal and spatial resolution to confirm algae blooms. DO falling below 2 mg/L could trigger evaluation of the duration of anoxic events. Another trigger could be weather-related. Periods of overcast conditions could trigger additional sampling to collect data that yields process information used to assess sensitivity of ecosystems to nutrient loads. This would require connecting sampling efforts to near-real-time sample processing and data analysis. Over time, this documentation of algal blooms and sustained periods of anoxia could provide an additional set of baseline conditions. As projects are implemented to reduce nutrient loading, the frequency and duration of these events could be compared to this baseline. This would serve as an additional, perhaps more representative tool for evaluating ecosystems health in response to load reduction.

C. Recommended Additional Demonstration Monitoring

As described in Section 5, demonstration monitoring requires data collection at high spatial and temporal resolution. Standard deviation has implications for the number of sampling events that are needed for evaluating a demonstration project that removes modest amounts of nitrogen. Current data sets are not adequate for establishing a baseline to which the impact of demonstration projects can be compared. A detailed monitoring program for evaluating demonstration projects is the subject of TM 4.a.3: Non-Structural Technology Performance Monitoring (task 4.a.3) which will present the specifics of a recommended monitoring program for each demonstration site.

D. Recommended Monitoring Coordination, Compilation and Review of Data

There are valuable data collection programs occurring across water bodies in Orleans. To maximize the benefit of these efforts, annual compilation, review and analysis is recommended. In addition, it is suggested that reports present figures in a way that allows the data points to be known. Increasing the number of monitoring stations in Nauset Harbor will require a higher level of volunteer coordination. Meeting the personnel and technical support requirements is an important aspect of the overall monitoring program in Orleans.

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Appendix A

Massachusetts Estuaries Project

Quality Assurance Project Plan (QAPP)

Year 1 Final

Massachusetts Estuaries Project
Quality Assurance Project Plan (QAPP)
Year 1 Final

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts Department of Environmental Protection

Quality Assurance Project Plan

The DEP/SMAST Massachusetts Estuaries Project

Year One Final

June 13, 2003

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TABLE OF CONTENTS

A. PROJECT MANAGEMENT

A.1 Title and Approval Page

A.2 Table of Contents: Estuaries Project, Quality Assurance Project Plan

A.3 Distribution List

Name (#copies)	Address
Coastal Systems Program (10 copies)	School of Marine Science & Technology University of Massachusetts-Dartmouth 706 Rodney French Blvd. New Bedford, MA 02744 508-910-6316
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A.4 Project Organization and Responsibilities

The Estuaries Project was established in December 2001 as a joint effort between The Massachusetts Department of Environmental Protection and scientists from the School of Marine Science and Technology at UMass-Dartmouth (SMAST). The goal of this effort is to provide technical guidance to DEP relative to policies on nitrogen sensitive embayments and to perform the data collection and modeling required for the management and restoration of southeastern Massachusetts' 89 embayment systems. These 89 embayments are contained within the 5 EOEA Massachusetts Watershed Initiative Basins (Cape Cod & Islands, Buzzards Bay, South Coastal, Mt. Hope Bay and Taunton River). This program will also provide the scientific foundation for the development of MA DEP nitrogen (and to a lesser extent bacterial) TMDLs on these estuaries. SMAST technical experts will work with DEP to classify the nitrogen sensitivity of Massachusetts shallow coastal water bodies, conduct quantitative linked watershed-embayment water quality modeling and site-specific thresholds analysis while also putting forward some available options for meeting nitrogen goals (or targets) for these embayments. Additional key technical partners include the Cape Cod Commission and the U.S. Geological Survey.

The Estuaries Project requires three years of baseline nutrient related water quality data on an embayment prior to the implementation of its full field data collection, modeling and thresholds development program. These data are needed both to guide field sampling and to validate the water quality model. At present the SMAST Coastal Systems Program is responsible for training guidance, development of sampling methodologies, preparation of field sampling gear, database preparation and preparation of reports for almost all baseline water quality monitoring programs within the study area. SMAST scientists will be responsible for review of existing monitoring data for suitability of inclusion into the Estuaries Project database. The SMAST Team will be responsible for identification of gaps in monitoring data needs for participating embayments and will work together with DEP to assist participating municipalities in establishing monitoring programs to acquire the necessary long term data as appropriate. All nutrient analyses are conducted within the Coastal Systems Analytical Facility at SMAST; bacterial analyses will be conducted primarily by the Barnstable County Health Laboratory. Alterations in program, quality assurance issues, and any other technical issues are dealt with through regular discussions between individual monitoring program coordinators and the Coastal Systems Program Manager/Project QA Officer.

While water quality monitoring data is a precursor to implementation of the Estuaries Project Approach in a specific embayment, the core of the Project is a detailed quantitative assessment and modeling approach to provide site-specific thresholds for management and restoration. Field data to be collected by the Project relates to site-specific determinations of hydrodynamics, habitat indicators, nitrogen attenuation and recycling, and current and future land-use. These data are used in the Linked Watershed-Embayment Approach (Phase I, Estuaries Project Report: Howes et al. 2001). SMAST will be responsible for review of existing estuarine process data to determine suitability for inclusion into the water quality modeling, synthesis and development of site specific thresholds. Decisions regarding data incorporation will be made by the Estuaries Project Technical Team (which includes the DEP Project Manager, see below).

The technical and scientific aspects of the Estuaries Project are under the direction of Dr. Brian Howes, SMAST-UMassD (Technical Manager). He will be assisted by Roland Samimy (Technical Coordinator) in the coordination of this effort with DEP. Given the scope of the work, SMAST has established an Estuaries Project Technical Team (Technical Team) consisting of experts in each of the major data collection and modeling areas that comprise the Linked Watershed-Embayment Approach to be used. The Technical Team will provide judgment as to the suitability of historic data for inclusion into the Project database, develop project schedules, provide technical resources for outreach for DEP, and oversee each of the specific data collection efforts. The Technical Team will also serve to forward recommendations to the DEP Project Steering Committee as to alterations of approach, needs/issues arising on the local level that might be addressed, etc.

DEP is responsible for the regulatory aspects of this program, including implementation of results, completing the TMDL process and interfacing with town boards and local authorities on regulatory and wastewater management issues surrounding this effort. Brian Dudley is the primary responsible person representing DEP and serves as an interface between the scientific effort and other DEP, EPA and USGS officials. Together DEP and SMAST will work with individual towns as needed to establish water quality monitoring efforts where lacking so as to enable participation of these towns in the overall project.

The overall organization and primary personnel for the scientific aspects of the Estuaries Project are is follows:

Name	Roles	Responsibilities	Affiliation
Technical Team Personnel:			
Dr. Brian Howes	Technical Manager Technical Team, Chair	Science Oversight Synthesis/Thresholds	SMAST-UMassD
Roland Samimy	Technical Coordinator Technical Team	Science/DEP Coordination Surface Water Hydrology	SMAST-UMassD
Dr. Dave Schlezinger	Technical Team	N regeneration, D.O. Instrumentation	SMAST-UMassD
John Ramsey, P.E.	Technical Team	Modeling	ACRE
Dr. David White	Technical Team	Laboratory Analytical	SMAST-UMassD
Dr. Robert Hamersley	Technical Team	N attenuation in lakes	SMAST-UMassD
Paul Henderson	Technical Team / Lab Manager	General Field Program	SMAST-UMassD
Charlie Costello	Technical Team	Macrophyte Mapping	DEP
Ed Eichner	Technical Team	Land-use Analysis	Cape Cod Comm.
Tom Cambereri	Technical Team	Land-use Analysis	Cape Cod Comm.
Dale Goehringer	Lab Coordinator	Water Quality Monitoring	SMAST-UMassD
Mike Rapacz	Science/Policy Liaison	SMAST-DEP Coordinator	SMAST-UMassD
DEP / EPA Personnel:			
Brian Dudley	DEP–Project Manager Technical Team	DEP Oversight & input to Planning/Steering Comm. Communication to MWI	DEP-SERO
Arthur Screpetis	MA DEP Quality Assurance Officer	Guidance to DEP needs for TMDL Program	DEP/DWM
Bruce Rosinoff	EPA Project Officer	Policy & Coordination	USEPA, Region I
Arthur Clarke	EPA Quality Assurance Officer	QA/QC Guidance	USEPA, Region I
Affiliated Personnel:			
John Masterson Don Walter Peter Weiskel	Technical Team (as needed)	Watershed Delineation & Aquifer Modeling	USGS
Dr. Tom Bourne	Lab Director (sub-contractor)	Bacteria assays and VOCs as necessary	Barnstable County Laboratory

The USGS is performing the watershed delineations for the Cape Cod watersheds as part of another DEP project, to support water supply planning. However, after model development and parameterization for this project, the model will be used to support the watershed delineation needs of the Estuaries Project. The USGS is be responsible for providing that information to the Estuaries Project and for evaluating and assisting in the watershed delineation of embayment watersheds in the other regions of the study area.

The USGS will use its West Cape Model with an increased discretization to map the watershed each of the embayments on Cape Cod. The model will also yield watersheds to freshwater ponds (greater than 16 acres) and streams. Additional model output will include both time of time of travel contours (<>10 years) and freshwater discharge volumes for sub-watersheds. The USGS will confirm watersheds to embayments not on Cape Cod using the USGS Watershed Tools approach.

Bacterial assays will be performed by a DEP certified laboratory (generally Barnstable County Health Laboratory (Dr. Tom Bourne, director, 508-375-6608). The Coastal Systems Program at SMAST-UMassD will oversee the sample collection. DEP and SMAST in cooperation with the Massachusetts Watershed Initiative, Cape Cod Commission, EPA and various organizations will be responsible for the dissemination of results.

A.5 Project Background and Introduction

Purpose

The overarching project mission is the protection and restoration of the health of each of the each coastal embayments within Southeastern Massachusetts through integrated watershed-embayment nitrogen management planning. Embayment health is directly connected to the concentrations of specific nutrient species. Nitrogen is the limiting nutrient in coastal marine waters. It is the addition of nitrogen to estuaries which is causing their declining habitat quality through the process of eutrophication. The increasing nitrogen load to our estuaries results primarily through changing watershed land-use, converting forests to residential housing and associated development. This land-use shift typically results in increased wastewater discharges, fertilizer applications, and surface runoff, all of which contain high concentrations of nitrogen. This nitrogen reaches the estuaries through both stream and groundwater pathways. It is the stimulation of plant production (algae, phytoplankton and nuisance plants) by the increased nitrogen inputs that ultimately results in declines in oxygen levels within the bay waters and loss of diverse animal and plant populations. Therefore it is critical to quantify its sources and sinks for its multiple forms and manage its loading to an embayment.

The proposed effort will provide technical guidance to DEP relative to policies on nitrogen sensitive embayments and will perform the data collection and modeling required for the management and restoration of southeastern Massachusetts' 89 embayment systems. This program will also provide the scientific foundation for DEP's development of nitrogen (and to a lesser extent bacterial) TMDL's on these estuaries. Technical experts through SMAST will work with DEP to classify the nitrogen sensitivity of Massachusetts shallow coastal water bodies, conduct quantitative linked watershed-embayment water quality modeling and site-specific thresholds analysis and put forward some available options for meeting nitrogen goals (or targets) for these embayments.

In support of the overall Estuaries Project mission, the long-term project goal is to conduct the quantitative assessments of nitrogen within all of the 89 embayments of Southeastern Massachusetts (from Duxbury south: including Cape Cod and the Islands.)

Rationale

Coastal embayments throughout the State of Massachusetts (and throughout the U.S. seaboard) are becoming impaired by a host of pollutants and nutrient enriched, also a form of aquatic pollution. As such, the federal government (USEPA) through the implementation of the Clean Water Act, is mandating that states assess the health of their water resources. For those waters that have been identified by states as being impaired, the state must submit to the USEPA the names of the impaired water resources for listing on the federal 303(d) list of impaired waters. Water resources listed on the federal 303(d) listing must then be studied adequately and Total Maximum Daily Loads (TMDLs) must be developed for the pollutants of concern in the water resource under investigation.

Recently, excessive nutrient loading to a water resource has been identified as a form of water pollution that leads to the deterioration of the ecological health of the water resource, even though a certain level of naturally occurring nutrient is necessary for the healthy function of aquatic habitat. Many of Massachusetts' embayments are approaching or are currently over the level of watershed nutrient loading which begins to cause declines in their ecological health. The primary nutrient causing the increasing impairment of the State's coastal systems is nitrogen and the primary watershed source of this nitrogen is wastewater disposal.

At present there is a critical need for state-of -the-art approaches for evaluating and restoring nitrogen sensitive and impaired embayments. Within southeastern Massachusetts alone, almost all of the municipalities are grappling with Comprehensive Wastewater Planning. These municipalities are seeking guidance on the assessment of nitrogen sensitive embayments and the available options for setting nitrogen loading thresholds and for meeting nitrogen management goals. For example, the Towns of Chatham, Falmouth, Mashpee, Wareham and Fairhaven are in the midst of determining the nitrogen sensitivity of their embayments as part of wastewater planning and have encountered problems with existing approaches. In addition, the Towns of Wareham and Bourne are concerned with non-WWTF related nitrogen issues, and the Town of Orleans' Nutrient Management Project and the Slocums/Little River Project in Dartmouth are moving forward towards nitrogen planning aimed at nutrient remediation. DEP and SMAST are currently involved with each of these nitrogen planning efforts. The present effort by DEP and SMAST aims at creating a more quantitative, site-specific, and consistent approach and efficient and expansive collaboration for addressing the critical nutrient issues relative to coastal resources.

Project Objectives

The primary objectives of the Massachusetts Estuary Project are to:

- develop an embayment working group for program prioritization and rapid transfer of results;
- determine the nutrient sensitivity of each embayment;
- determine and fill in "data-gaps" required for management modeling;
- collect needed site-specific watershed and embayment data for each embayment to parameterize the Linked Watershed-Embayment Management Model;
- conduct the scientific portion of nutrient TMDL's, through the use of Linked Approach including development of site-specific ecological thresholds, using models which are both accepted and directly validated for each system;

- conduct bacteria data collection in the embayments which have identified bacterial contamination in support of bacteria TMDL development;
- provide immediate and on-going access to results for DEP managers;
- keep each embayment's model "alive" to address future regulatory needs. The embayment model for a particular community will be useable at anytime should a community request a specific model run to evaluate a nutrient management alternative.

<u>Overview of Approach</u>
A general overview of the Linked Watershed-Embayment Management Modeling Technical Approach is provided here. A complete description and sensitivity analysis of the approach has been performed (Howes, Ramsey & Kelley 2001) and is available through the DEP Program Manager or can be downloaded directly from the DEP Estuaries Project Web Site. The Watershed-Embayment Management Model was selected over other available watershed nitrogen loading approaches based upon its (a) ability to predict embayment nitrogen distributions (associated with habitat quality) over a range of estuarine types and watershed loads, (b) accounting for both watershed and embayment processes and (c) utility in conducting evaluation of alternative nitrogen management alternatives.

SMAST has been developing nutrient related TMDL methodologies for coastal systems since the mid 1980's. SMAST researchers with their collaborators have developed a quantitative approach for determining an embayment: (1) nitrogen sensitivity, (2) nitrogen threshold loading levels and (3) quantitatively evaluating effects of changes in loading rate (predictive scenario runs on management alternatives). The approach is fully field validated (model results are confirmed by direct measurement) and unlike many approaches accounts for nutrient sources and their spatial distribution, nitrogen attenuation and recycling, and variations in tidal hydrodynamics. The validation requires that the parameterized model predict the average nitrogen concentrations at multiple points within the estuary (as derived from independent long-term measurements). The approach allows for direct and immediate analysis of management options and recommendations suggested by DEP or the DEP/SMAST Team. To apply this methodology a variety of field data collections and models must be employed.

The scientific component of a TMDL analysis (DEP will use this to complete the TMDL process) for each embayment is planned to be completed in 2 years, however, this requires that a baseline water quality monitoring program is underway. The baseline data includes warm weather sampling of nutrients (inorganic and organic), dissolved oxygen, chlorophyll, etc. (see Section B.1). The major time limitation is the need to collect three years of baseline nutrient data on each of the 89 embayments to support full nitrogen management planning. The collection of data on parameters requiring the use of more complex protocols (nitrogen recycling, hydrodynamics, etc.) will be conducted in parallel with the more basic "monitoring" sampling in order to maximize efficiency (lower costs) and provide evaluation of various proposed draft nutrient management solutions as the project progresses (rather than having to wait until the full project is completed). This approach allows the DEP and the Towns' work on management planning and long-range facilities planning as the project moves forward.

The overall technical aspects of the project (estuarine monitoring and assessment, modeling and synthesis) will be under the direction of Dr. Brian L. Howes, Manager of the Coastal Systems Program at SMAST-UMD, who will work closely with the DEP Project Manager, Brian Dudley (SERO). The University will serve as the prime technical center for this effort, although technical specialists with proven capabilities and experience within the region will be integrated into the project as required. This effort will require a variety of technical specialists at SMAST who will directly oversee their area of expertise and will be responsible for data collection and synthesis. It is envisioned that these specialists will be in place for the duration of the Project (i.e. the same individuals will be conducting the work throughout). This will provide the consistency and efficiency to the Project. The technical aspects of the project will be coordinated through the Technical Team which is composed of each of the technical leaders (surface water flow, land-use, modeling, watershed delineation, eelgrass mapping, etc.) and the DEP Program Manager. The overall technical staff, technical leaders and support staff, comprise the overall Project Team.

The general project tasks for TMDL analysis of each embayment will include data collection focusing on: watershed land-use and nitrogen source analysis, watershed nitrogen attenuation, regeneration of nitrogen within the embayment (recycling load), embayment nutrient distributions, field data collection and development of a hydrodynamic model, habitat indicators (eelgrass/macrophytes, benthic animals, summer oxygen minimum and duration). These parameters provide the data base for synthesis of nitrogen dynamics within the system, enabling construction of a water quality numerical model, site specific thresholds development and overall evaluation of the current and potential future ecological health of each embayment system. The synthesis, model and evaluation will then support management and restoration planning for each system.

The basic components of the Linked Watershed-Embayment Approach:

Nitrogen Related Water Quality Monitoring

(this baseline water quality monitoring data is to be provided external to the Estuary Project, but the Project will work with the Massachusetts Watershed Initiative (MWI) to initiate monitoring programs to fill existing data gaps)

Hydrodynamic Modeling

- bathymetric survey
- data collection on tidal exchange, salinity, validation by Acoustic Doppler Current Profiling (ADCP) of velocity

- quantitative numerical modeling & validation

Watershed Nitrogen Loading
- confirmation of delineation
- data collection on stream flow & nitrogen load (annual)
- land-use data (from Town Planning or CCC or other agency)
- watershed nitrogen model (present, build-out, tidal flow, and "best case")

Quantitative Watershed-Embayment Nitrogen Model
- nitrogen regeneration within embayments
- system predictive model, with validation

Habitat Assessment
- dissolved oxygen (high frequency measurements in targeted areas)
- macrophyte surveys (eelgrass & macroalgae) & incorporated historical data
- benthic infauna community (indicators of stress)

Synthesis of Modeling and Habitat Assessments
- determination of embayment nitrogen loading tolerances (spatially)
- projection of embayment health under build-out, best case potential loadings and hydrodynamic alteration
- evaluation of soft and hard nitrogen management options (initial screening)

Information Transfers
- monthly meetings with Planning Committee
- quarterly presentations and discussions with Advisory Committee
- quarterly presentations and discussions with Executive Office of Environmental Affairs (EOEA) Watershed Team
- public meetings and workshops
- reports and data displays

The tasks required to fulfill all of the data needs and goals of the project are detailed below:

B. ESTUARIES PROJECT TASKS

The Estuaries Project has 3 basic types of tasks:

- Review and evaluation of existing data, particularly from water quality monitoring programs
- Collection of habitat data or data to implement the Linked Watershed-Embayment Management Model
- Hydrodynamic and water quality modeling and synthesis

The specific tasks to be undertaken in order to implement the Linked Watershed-Embayment Management Approach were detailed in the previous section and fall into 7 functional categories as follows:

(1) review of nitrogen related water quality monitoring data
(2) hydrodynamic modeling
(3) watershed nitrogen loading
(4) nitrogen regeneration within embayments
(5) linked watershed-embayment nitrogen modeling
(6) habitat assessment
(7) synthesis of modeling and habitat assessments

Each one of the 7 task categories is developed in its own section B.1 – B.7, below. The site-specific details, field protocols, data sheets and chain of custody forms are provided in the Appendices (I-XXII). Protocols which cross all task categories are generally presented in an B-I.

B.1 Review of Nitrogen Related Water Quality Monitoring Data

Overview:
The Estuaries Project requires three years of baseline nutrient related water quality data on an embayment prior to the implementation of its full field data collection, modeling and thresholds development program. These data are needed both to guide field sampling and to validate the water quality model.

At present, the SMAST Team has reviewed coastal monitoring programs throughout southeastern Massachusetts as to applicability of data to the Estuaries Project. Programs typically consist of trained volunteer monitors, although some are fully conducted by professional staff. Almost all of the present programs are associated with the SMAST Coastal Systems Program for technical guidance and sample analysis. In almost all cases nutrient analyses have been conducted within the Coastal Systems Analytical Facility at SMAST and all potentially acceptable bacterial analyses have been conducted in DEP certified laboratories (primarily the Barnstable County Health Laboratory).

In almost all programs, SMAST has been responsible for training guidance, development of sampling methodologies, preparation of field sampling gear, and database preparation. In many of the programs, SMAST also conducts the assessments and prepares the monitoring reports. This existing association will facilitate the evaluation and incorporation of monitoring data by the Estuaries Project Technical Team.

The review and evaluation criteria for monitoring data (and all other data) is detailed in B-II. Briefly, the Technical Team scientists will be responsible for review of existing monitoring data relative to the quality assurance criteria detailed in this section of the QAPP. Of course, there may be some site specific exceptions which permit data inclusion, but for the most part the Technical Team will use the criteria below to ensure consistency throughout the monitoring database.

In addition, the SMAST Team will be responsible for identification of gaps in monitoring data needs for participating embayments and will work together with DEP and MWI to assist participating municipalities in establishing monitoring programs to acquire the necessary long term data as appropriate.

Background:
Long-term population growth and associated increases in nitrogen loads has resulted in the increased eutrophication of estuaries, not only along the Southeastern Massachusetts shoreline, but along many of the world's coastlines. To address the ecological problems associated with this increase in nutrient loads, new TMDL methodologies have been developed to provide the quantitative approaches needed to

model current and future nitrogen loads and their environmental impacts. Fundamental to these models is the availability of long-term high quality monitoring data that takes into account year to year variations in key environmental variables, and on a time scale suitable to identify any trends that may follow changes in land use and/or discharge along the coastline. This baseline data is therefore essential to the development of appropriate nitrogen management and land use strategies for coastal ecosystems.

The primary goal of the **Review of Nitrogen Related Water Quality Monitoring Data Task** is to assemble and review all available long-term water quality monitoring data suitable for incorporation into the Estuaries Project. In many cases, this data has become available in recent years through the use of citizen-based water quality monitoring programs operating in Southeastern Massachusetts under the technical guidance of the Coastal Systems Program at SMAST. These water quality monitoring programs are staffed with trained volunteers, given both technical hands-on training of equipment use and sample collection, as well as fundamental information on ecological processes upon which sampling techniques were based. The goal of these programs is to collect research quality data using techniques appropriate for use by trained citizens; the techniques were developed to answer basic research questions and have been tested against more sophisticated (and expensive) approaches utilizing the tools of basic ecological research (Taylor, C.T. and B.L. Howes, 1994).

Each individual monitoring program within southeastern Massachusetts generally maintains the same goals of providing reliable water quality data to assist environmental managers to:

- Establish baseline water quality,
- Evaluate nitrogen loading inputs,
- Characterize and identifying sources of pollution,
- Document long-term environmental trends in water quality,
- Evaluate the relative success of clean-up efforts,
- Facilitate implementation of management recommendations

<u>Data Sought from Water Quality Monitoring Programs</u>:
This focus is also driven by the Regulatory Agencies, including EOEA's Watershed Initiative, as well as the Public's concern relating to nutrient issues. Regulation of nutrients is changing relative to watershed-based water quality management and the public interest in clean water. As well, management of nutrients continues to be at the top of the US EPA's Agenda.

In addition to nutrient measurements some of the monitoring programs collect parallel measurements of fecal coliform levels. Almost all of this bacterial data has been collected by Division of Marine Fisheries (DMF) and will be assembled with their help for use by the Estuaries Project. Limited additional bacterial data has been collected by water quality monitoring programs. Bacterial contamination is the primary cause of embayment closures to shell fishing and swimming. Review of existing coliform data from state and local programs as well as ongoing monitoring programs will determine the need for additional measurements of fecal bacteria within specific estuaries within the Estuary Project study area. As available (and appropriate) this information will be evaluated for incorporation into Estuaries Project database **(see B-II)**.

The overall information and data sets desired from nutrient and bacterial related water quality monitoring efforts are as follows:

- Sampling and analytical protocols, QAPP if available
- Current site locations (with differential GPS as available)
- Volunteer training materials and procedures
- D.O./temperature/salinity/secchi depth data
- Dissolved and particulate nutrients data
- Bacterial data and laboratory contact information

The following sections detail the levels of quality assurance sought by the Estuaries Project, both for field and laboratory components of nutrient and bacterial monitoring programs. The field program includes both the procedures for sample collection and any field sample processing. The laboratory program includes sample holding, analytical and QA/QC procedures, chain of custody procedures and data transmission.

Guidelines for Acceptable Water Quality Monitoring Sampling Approaches: Samples are collected routinely for basic parameters (**B-I for guidance Field Sampling Protocols**):

- dissolved oxygen
- temperature
- salinity
- water clarity
- water samples for laboratory nutrient analysis
- weather/tide observations

Sampling stations should be placed along the long axis of an embayment and within major coves or tidally restricted basins. On a prescribed date selected based on tidal regime, generally 0600-0900 hrs during the 3 hours around mid-ebb tide, all samplers take samples at all stations throughout a given embayment. This simultaneous sampling schedule is critical to allow site to site comparisons of data. The critical seasonal interval for water quality sampling is June – mid September, when lowest dissolved oxygen levels can be identified and nutrient related water quality is typically at its annual minimum. Additional cold season samples are also useful for to derive an annual assessment of water quality. Similarly, additional samples during periods of overcast weather when reduced sunlight and photosynthesis yield important process information to assess the nutrient sensitivity of an embayment.

Water samples should be collected from near the surface and bottom at deeper water stations (>1.5m). This vertical sampling allows for an evaluation of water column stratification and its associated nutrient and D.O. affects. Surface water samples should be collected at a depth of 15 centimeters below the surface and bottom water samples from a depth of 30-50 centimeters above the bottom. These depths have been determined by SMAST as representative. Collection of a sample 15 cm below surface prevents entrainment of the overlying air into D.O. samples and of floating material into nutrient samples. Sampling 30-50 cm above bottom prevents stirring of the bottom sediments and subsequent contamination of the nutrient sample.

It is important that a specific volunteer or professional sampler be identified for each sampling event for each station. Ideally the Monitoring Coordinator assigns each sampling station to an appropriate volunteer and conducts a joint visit to each site prior to sampling. Each station must have a unique identification code.

Station selection should seek locations that are representative of embayment water quality conditions and not just focus on small localized “hot spots”. Stations should be placed to give good geographic coverage throughout the inner and outer (where possible) portions of an embayment. Sample stations can include central basins sampled by boat (best) or boatyard docks, town landings and piers. An offshore reference station needs to be sampled for each embayment (several embayments can be associated with a single reference), ideally located by a navigational marker. Offshore stations need to be outside of the influence of the ebb tidal plume from adjacent embayments. All sampling stations need to be identified on a U.S.G.S. Quadrangle sheet or Nautical Chart, and ideally have either lat/long. Coordinates by GPS (**see Appendix I - XX**).

Bacterial sampling can be conducted in parallel with the nutrient sampling, although typically samples are only collected from the surface (-15 cm). In addition, storm water bacteria sampling may be conducted which focuses upon land-based point inputs, primarily from direct storm water inflows. This sampling generally centers upon rainfall events. Sampling is usually conducted during daylight hours and should be timed to capture the first flush of rainfall discharge from storm water discharge pipes. Additional samples may also be collected upstream and downstream from the discharge pipe within river systems. The Estuaries Project bacterial sampling will focus primarily on comparison of dry versus wet weather bacterial distributions and the synthesis of existing long-term data sets **(B-III**). Samples need to be collected as per protocols in **B-I**.

To be acceptable to the Estuaries Project, all samples must be collected by trained staff or specially trained volunteers.

B.1.1 Data Quality Objectives

Data quality objectives have been selected as criteria for the **Review of Nitrogen Related Water Quality Monitoring Data Task** in order to fit with the goals of the Water Quality Monitoring Task and the concentrations and natural variability found within the tidal estuarine environments throughout southeastern Massachusetts. The methods and approaches which render data acceptable for inclusion of data into the Estuaries Project must meet the required levels of precision, accuracy, field blank cleanliness (analyte free), and detection limits. Although site-specific exceptions may be made after review by the Technical Team (B-II), the minimum performance criteria for the basic physical sampling is given in **Table B.1-1**, for the nutrient sampling in Table **B.1-2** and the bacteria sampling in **Table B.1-3**, below.

Table B.1-1 Water Quality Program, field parameters measured & data objectives

Parameter	Method	Range	Sensitivity	Precision	Accuracy	Calibration
Temperature[a]	Thermometer	-5°C to +40°C	0.5°C	±0.5°C	1°C	Certified thermometer over temperature range[b]
Temperature	Thermister	-5°C to +40°C	0.1°C	±0.1°C	0.2°C	Factory calibration & Certified Thermometer
Salinity	Conductivity Meter	0-35 ppt	0.1 ppt	±0.1 ppt	0.2 ppt	Certified Conductivity Standards
Salinity[c]	Hydrometer	1.000 to 1.050/ Specific Gravity	0.5 ppt	±1 ppt	1-2 ppt	Conductivity Meter & certified stds
Dissolved Oxygen	Modified Winkler Titration	0-16 ppm	0.5 ppm	±0.5 ppm	1 ppm	Dissolved gas standards
Dissolved Oxygen	Hach OX2P Oxygen Meter	0-16 ppm	0.1 ppm	±0.1 ppm	0.2 ppm	Dissolved gas standards
Water Clarity	Secchi Disk disappearance/ meters	0-15 m	1 cm	±10 cm	20 cm	NA

[a] Not preferred method for measuring temperature (Thermister Method is preferred). However, this method is acceptable if it is only used for calculating oxygen saturation for monitoring purposes.
[b] Calibration uses regression of field thermometer vs. certified thermometer with 5 temperature points and an $R^2 > 0.99$ and no pair of temperature points should exhibit a difference greater than ±1.0 degree.
[c] Not preferred method for measuring salinity (Specific Conductivity Method preferred). This method should not be used to determine stratification unless differences > 2 ppt.

Note: Field staff or trained volunteers collect water samples that are analyzed for the parameters listed in Table B.1-1 & B.1-2 and also record observations about weather and embayment conditions during sampling.

The nutrient sampling program must use accepted analytical methods for salt water analysis. These methods are accepted by the best marine research laboratories in the United States. Where EPA or Standard Methods techniques are available, they should be employed. Minimum performance criteria for water chemistry assays are listed in **Table B.1-2**, although the methods used in the program generally exceed these minima. The acceptable criteria for field blank cleanliness is generally a reading less than the detection limit. In occasional instances where high sensitivity methods are employed, the field blank must be less than 10% of the sample value.

Table B.1-2 Minimum Objectives for Nutrient Monitoring Parameters

Parameter	Matrix[a]	Field Precision	Laboratory Precision	Accuracy	Detection Limit
Nitrate + Nitrite	1	<30% RPD[b]	<20% RPD	75%-125% of matrix spike	0.25 uM[c]
Ammonium	1	<30% RPD	<20% RPD	75%-125% of matrix spike	0.25 uM
Total Phosphorus	1,2	<30% RPD	<20% RPD	75%-125% of matrix spike	1 uM
Orthophosphate	1	<30% RPD	<20% RPD	75%-125% of matrix spike	0.1uM
Chlorophyll *a*	1	<30% RPD	<20% RPD	75%-125% of matrix spike	0.1 ug/L
Total dissolved N	1	<30% RPD	<20% RPD	75%-125% of matrix spike	1 uM
Particulate C& N	1	<30% RPD	<20% RPD	75%-125% of matrix standard	1 uM

[a] 1 = saltwater, 2 = freshwater
[b] RPD = relative percent difference
[c] uM = micromolar, to convert to mg N/L multiply X 0.014, to convert to mg P/L X 0.031.

Table B.1-3 Bacterial Monitoring Parameters

Parameter	Matrix[a]	Sample Volume/ Container	Maximum Holding Time	Field Processing/ Preservation[b]	Units[c]
Fecal Coliform	1, 2	100 ml sterilized polyethylene	6 hours	Collect, label, store on blue ice in cooler	1 CFU./100ml
Enterococci	1	100 ml sterilized polyethylene	6 hours	Collect, label, store on blue ice in cooler	1 CFU./100ml
E. Coil	2	100 ml sterilized polyethylene	6 hours	Collect, label, store on blue ice in cooler	1 CFU./100ml

[a] 1 = saltwater   , 2 = freshwater
[b] field samples need to be held at 4oC until analysis at laboratory
[c] CFU = colony forming units
Note: Bacterial parameters should be assayed by Barnstable County Health Laboratory, New Bedford Health Laboratory or other DEP Certified Laboratory.

Appropriate sample bottles and filters need to have been employed in sample collection and proper QA samples, generally 5%-10% of field samples and 10% laboratory duplicates need to have been run. Matrix spike and recovery procedures need to have been run where appropriate.

Precision

The precision of each laboratory chemical assay needs to have been determined from duplicate assays of five standards. The field precision is from duplicate assay of five blind field duplicates. The precision is calculated as the relative percent difference (RPD). An additional estimate of precision is determined from the R^2 of the linear regression of each set of standards (N>5).

Accuracy

Accuracy of laboratory assays is determined from the analysis of standards for the standard curves, analysis of the matrix spikes and use of Performance and Evaluation Samples (commercially available). Accuracy is determined as the RPD of the assay of five standards run as samples within a series of analytical runs. This is compared to the RPD of five sets of Performance and Evaluation Samples. In addition, the accuracy of the method within the sample matrix is determined from the RPD of five matrix spikes experiments (standard additions), where appropriate.

Measurement Range

The usable measurement range for each chemical assay is only within the linear range as determined from least squares linear regression of laboratory standards (the upper limit and lower limit are set by the upper and lower standard concentrations). Concentrations above the linear range require standard dilutions for acceptable analysis. Since high values can be readily diluted and re-assayed the same day, the upper range of measurement is variable. Sample dilutions attempt to bring the concentration of the diluted sample into the middle of the linear range for the assay. The natural range for any analyte is typically less than 1000 fold.

Bacterial assays require a priori determination of dilutions. For fecal coliform analysis by membrane filtration, only 100 colonies can be counted per plate. Therefore, if more than 100 colonies per 100 mL are anticipated (based on previous experience) a dilution series by the laboratory will be requested (1X, 10X, 100X).

Representativeness

The goals of the monitoring programs are to provide data needed to evaluate overall water quality conditions throughout the sub-embayments and to determine changes over the long-term. Through the use of trained volunteers, we can effectively collect the substantial amount of spatial and temporal water quality data. The number and locations of sample stations is specific to each embayment and depends in part upon the embayment's size and shape, access, and navigational passages. Sampling is to be conducted throughout each estuary from its headwaters to its mouth under the same conditions of tide and weather. This is possible due to the coordinated efforts of a large number of volunteers. The data collected by the volunteers is of sufficient quality to represent environmental conditions since (1) volunteers are trained each year and are constantly checked by the Coordinator, (2) volunteers collect physical data and D.O. which are performed in the field and (3) all nutrient assays are conducted at the SMAST laboratory.

Comparability

The results from each individual monitoring program will be directly comparable to each other. All of these programs use the same training and field sampling approaches and the Coastal Systems Analytical Facility at SMAST. The results are also comparable to many national programs, both volunteer and research, since the timing and distribution of sampling within the estuaries and the level of analysis is based upon understanding the whole system. As long the methods requirements meet those set forth in this QAPP, the data from any program should be able to be integrated into the Estuaries Project.

Completeness

The ultimate goal of the Water Quality Monitoring Program Task is to obtain comparable data from each estuarine ecosystem, enabling both inter- and intra-estuarine comparisons using consistent and reliable methods of sample collection and analysis. Completeness is gauged as the number of actual measurements divided by the number of planned measurements times 100%.

B.1.2 Training certification

Monitoring Program coordinators need to provide the Technical Team with sampling techniques and training materials.   Volunteers should be taught the monitoring program's objectives and their role and responsibilities. The seriousness of the enterprise and the need for completeness of sample collection should be emphasized. Volunteers need to have received a formal hands-on training session prior to each field season. Specifically, volunteers need to be instructed in the importance of taking accurate and timely measurements and following the written field protocols provided. They should have been given a demonstration of the protocol and been observed collecting the samples and performing the tests. Retraining sessions should be held at the beginning of each sampling season. Ideally coordinators conduct individual follow up with field checks on new volunteers and seasoned volunteers are teamed with newly trained volunteers to assure consistent sampling technique. Volunteer assessment should be checked by evaluation of data against previous sample data from earlier assessments. The program coordinators should have a contact database for all volunteers. In reviewing data from water quality monitoring programs, the Estuaries Project will ascertain that field and laboratory approaches are related to a formal QAPP or sampling plan.

B.1.3 Documentation and Records

For acceptance into the Estuaries Project Database, monitoring programs need to have records of their standardized field datasheets **(example B-I)**. The nutrient data requires that Chain of Custody forms (COC) be extant.

Data will be reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, may be used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

B.1.4 Data Acceptance Requirements

The level of repeatability of the data collected by the monitoring programs and the chemical assays conducted by the SMAST Coastal Systems Analytical Laboratory are presented in **Table B.1- 4**. In some cases they are more rigorous than the minimum requirements put forth in **Tables B.1-1, B.1-2, B.1-3**.

Table B.1-4 Acceptance criteria for Duplicate samples

Parameter	Acceptable % difference	Acceptable absolute difference
Temperature: Thermometer Thermister	[a]	 1.0C 0.2C
Salinity: Conductivity Meter Hydrometer	[a]	 0.2 ppt 1 ppt
Dissolved Oxygen: Hach Winkler DO Meter	[a]	 1 ppm 0.2 ppm
Water Clarity	[a]	0.2 m
Nitrate + Nitrite coastal water	20 %	0.5 µM
Ammonium coastal water	20%	0.5 µM
Orthophosphate coastal water	20%	0.5 µM
Chlorophyll *a*	20%	0.5 µM
Total dissolved N	20%	0.5 µM
Particulate N & C coastal water	20%	2 & 10 µM
Total Phosphorus	20%	1 uM
Fecal Coliform	30%	NA
E. Coil	30%	NA
Enterococci	30%	NA

[a] Acceptable percent difference not applicable, absolute acceptable difference takes precedence.

B.1.5 Data Acquisition Requirements

For the water quality monitoring program, U.S.G.S. topographic maps or nautical charts (or suitable location information) should have been used to identify site locations for the samplers. Printed scanned copies with marked site ID’s need to have been provided to each volunteer. The exception is where sampling markers or moorings are placed by the project coordinator.

B.1.6 Data Management

Data from field observations should be recorded on standardized data sheets (**B-I**) on-site at the time the measurements are taken. Sampling personnel check that all data is accurate and legible before transferring it to the monitoring coordinator and/or laboratory supporting the specific monitoring program.

Data entry into the Estuaries Project database requires data entry checks by two laboratory personnel and the QA/QC checks are completed by the Project QA Officer (after checks by the specific program's monitoring coordinator). Final use of the data by the Estuaries Project will be after review by the Technical Team.

B.2 Hydrodynamic Modeling

The Linked Watershed-Embayment Water Quality Model is based, in part, upon a site-specific numerical model of each embayment. The hydrodynamic model requires spatial data on the system configuration, as well as bathymetry and time-series tidal data. The model is calibrated based upon predicting tidal records at the inner tide gage locations and is validated based upon comparison of modeled versus observed (ADCP) current velocities over tidal cycles at key locations within appropriate embayments.

To ensure the Estuary Project provides the DEP with an efficient approach which results in a final product that provides the basis for sound engineering and management decisions, the project team has developed a phased hydrodynamic and water quality modeling approach. The approach focuses a high level of analyses and modeling on the more complex estuarine systems with simpler evaluations for some of the smaller embayments. A complex embayment is one with multiple tributary systems or with deep water that may periodically undergo stratification. Typically, a simple embayment has a single basin and single inlet and is relatively small (1 km in length).

The hydrodynamic task is divided into (a) field data collection and (b) modeling.

B.2.1 Data Quality Objectives for Measurement Data

The data quality objectives have been selected to fit with the goals of the Hydrodynamic Modeling Task and the natural variability of the tidal characteristics of the estuarine environments of southeastern Massachusetts. The methods and approaches establish the criteria for evaluating both data collected by the Estuaries Project and existing data being evaluated by the Technical Team for inclusion into Project database **(see B-II)**. All data must meet the required levels of precision, accuracy, and detection limits. The minimum performance criteria for the hydrodynamic instrument measurements are given in **Table B.2-1** below.

Table B.2-1
Hydrodynamic Program, field parameters measured & data objectives

Parameter	Method	Accuracy	Precision	Sampling Frequency	QC Samples	Required % Data Recovery[2]
Water Elevation	Strain Gage pressure sensor	±0.12 ft	±0.12 ft	@10 min. intervals for 40 days	Calibrated at known temp and atmos. pressure prior to and after each deployment	>75%
Depth Measurement (Bathymetry)	Single beam Echo sounder	±0.5 ft	±0.5 ft	2 soundings per second across transects 250-500ft apart	Comparison with soundings with survey rod	100%
Horizontal Position	Trimble Pro XR Differential Global Position System	± 2 ft in the horizontal	± 2 ft in the horizontal	1 position reading per second	Visual check with known points on rectified map	95%
Current speed and direction	Acoustic Doppler Current Profiler	±0.3 ft/sec	±0.3 ft/sec	1 measure per 5 seconds across a transect, repeated each hour for 13 hrs	Factory calibrated. Internal testing of compass, tilt sensors, beam integrity	>85%

[1] The ability to determine the change (or difference) in a measured parameter.

[2] % Data Recovery is calculated as the # of successful instrument days (days in which an instrument performs to specifications) divided by the number of total instrument days (# instruments times days of deployment) in a deployment. However, depending upon which instrument "fails", the total deployment may still be rejected, for example the reference station always need to have >90% instrument success.

Precision

The precision of the physical determinations is established by multiple measurements at each calibration point (standards). In addition, precision is generally factory determined and provided with the instrument. Field precision is from duplicate assay of multiple field duplicates measurements. For the bathymetric measurements, transects are crossed to provide multiple measurements of the same site during the survey. For the current speed and direction, multiple measurements are made at the same site. The precision is calculated as the relative percent difference (RPD). An additional estimate of precision is determined from the R^2 of the linear regression of the calibration standard measurements.

Accuracy
Accuracy is determined from the analysis of known physical standards (levels, flows, locations). Most accuracy determinations are provided by the manufacturer, but the Project also checks the accuracy of the instruments during each field survey.

Measurement Range
The usable measurement range for each physical measurement is within the calibration determined by the factory and checked by the Project under standard conditions.

Representativeness
The goals of the hydrodynamic program are to provide data and modeling of flushing and circulation throughout the sub-embayments of each estuarine system, so that the data and model provide a valid representation of the dynamics of the real physical system. The number and locations of gauges and transects for bathymetry or current determination is specific to each embayment and depends in part upon the embayment's size and shape, and channels. Sampling is conducted throughout each estuary from its headwaters to its mouth, meaning from the inland extent to the tidal outlet to the ocean.

Comparability
The results from the hydrodynamic data collection and modeling of each individual embayment will be directly comparable among the 89 embayments. The Estuaries Project hydrodynamic program will use the same techniques, instrument requirements, modeling approach and technical personnel for all of the embayments. This is to help insure that the modeling effort for each individual system is directly comparable to the other systems in the study and also to past studies using this methodology.

Completeness
The requirement of the Estuaries Project is to obtain comparable data from each of 89 estuarine systems, enabling both inter- and intra-estuarine comparisons using consistent and reliable methods of data collection and modeling. Completeness for the Hydrodynamics field and modeling program is gauged as the number of parameterized and validated hydrodynamic models (1 per embayment) divided by the number of tasked embayments (up to 89) times 100%. Completeness of data collection for a single hydrodynamic parameter within a single estuary is gauged as the number of actual measurements of the individual parameter divided by the number of planned measurements times 100%.

B.2.2 Documentation and Records

Field observations and operational notes will be recorded in waterproof field notebooks on-site at the time the measurements are taken. The "data" from the physical measurements are collected and stored digitally within each of the instrument systems employed. These data are then downloaded to PC's at the laboratory and kept in duplicate. The hydrodynamic modeling field team will check that all data is accurate and legible before providing a copy of the field notes and digital data to the Massachusetts Estuaries Project Technical Coordinator. Data is reviewed by the hydrodynamic program leader and the Project QA/QC Officer and the hydrodynamic field team is contacted if information is missing, questionable or incomplete. The technical coordinator maintains copies of the field notebooks, hard copies as well as computer back-up disks of entered data and digital copies of raw field data. After downloading and archiving data from instruments with self-contained memory buffers, the instruments memory buffer is cleared. Copies of data notebooks will be filed by embayment in the Massachusetts Estuaries Project library at SMAST maintained by the Technical Director and the Technical Coordinator.

B.2.3 Sampling Process Design

The basis for running the hydrodynamic model is the collection of data for measurable physical parameters (tidal effect on water level in the embayment, bathymetry of the embayment, velocity of surface water flowing through the embayment for model validation). The rationale supporting which parameters are measured is based on an understanding of the hydrodynamic function of coastal embayments as well as the data needs as defined by the hydrodynamic model of choice. Similarly, measurement locations and frequencies are also defined by the understanding of hydrodynamic circulation in an embayment. As such, tidal gage locations are typically established in such a way that it becomes possible to clearly quantify the driving head (offshore gauge) and its resultant effects on water flow through the system (gauges within the tributary sub-embayments). Tidal gages are generally placed at the headwaters of the embayment, a central location in the main body of the embayment, and offshore to establish the embayment boundary condition. Hydrodynamic data collection will focus on the warm weather months, but will not be restricted to the "summer". Tidal hydrodynamics of estuaries are not impacted significantly by season, as are water quality measurements.

A bathymetric survey of the embayment is performed along pre-established transects typically spaced 250-500 feet apart to generate a sufficiently detailed picture of the embayment bottom. Additionally, high-resolution surveying is performed along longitudinal transects mirroring the primary channel(s) in the embayment as well as the embayment mouth or in any areas where rapid changes in bathymetry occur. Location is checked by periodic measurement of known geo-referenced points during a survey.

Acoustic Doppler Current Profiling (ADCP) of the embayment will be performed for validation of the embayment hydrodynamic model. ADCP measurements are made along a transect for a complete tidal cycle to capture both flood and ebb tidal currents. ADCP measurements will be obtained along transects at critical transitions within the embayment. ADCP transect runs will be performed at the embayment mouth and additional locations as the need is identified, specifically at the mouth of key tributary sub-embayments. The decision for performing ADCP transect runs in an embayment will be based on the size and complexity (simple versus complex embayments as discussed above in introduction to section B.2) of the embayment being modeled as well as channel geometry and water depth. Multiple ADCP transects will be performed in complex embayments and typically one transect in each simple embayment system. However, not all small simple embayments can support ADCP measurements due to shallow depth (<1 meter) or very low velocities.

B.2.4 Sampling Methods Requirements

Bathymetric Survey

Review Available Bathymetric Data and Collection of Additional Data:
Although NOAA digital bathymetry is available for southeastern Massachusetts, the NOAA depth measurements were made in the1930s. Although it is likely that bathymetric conditions within many areas of the systems have shown negligible change over the past 60-to-70 years (as determined from recent bathymetric surveys), the region adjacent to the inlets and some of the shallower areas need to have an updated bathymetric survey for this study. Significant alterations of embayment bathymetry since the NOAA charting typically result from natural inlet dynamics and dredging programs.

The Estuaries Project hydrodynamic program will collect depth data while the tide gages are collecting data within a given embayment. The depth measurements will be referenced to the measured local instantaneous water level; the local water level at all locations within a system will be referenced to the Town's vertical datum using water level measurements recorded by the tide gages (i.e., tide-corrected bathymetry measurements).

The bathymetry survey will be performed using a shallow draft boat, capable of traversing the shallow regions of the harbor adjacent to the inlet. Bathymetry transects running parallel to each other will be spaced approximately 250-500 feet apart depending upon the embayment size and structure. Detailed measurements will be obtained at the constriction points in the harbor entrance channel and a longitudinal transect running along the channel axis.

The bathymetric data will be acquired utilizing a portable bathymetric data acquisition system. A fathometer with depth resolution to 0.10 ft., will be used in conjunction with a differential geographic positioning (DGPS) system. This system records depth as a function of survey location. DGPS offers unparalleled positioning precision for the cost, typically yielding absolute horizontal accuracy to within 2 meters over 95 percent of the time. An integrated survey software package will be used to record depth and DGPS data simultaneously to a laptop computer. In addition to data recording, the survey software is also a powerful data editing and graphics package that allows data to be corrected for tidal deviations before being output to a plotter. This system will be available to the Estuary Project through SMAST.

Positions will be recorded in Massachusetts State Plane 1983 coordinate system (X-Y) at an approximate rate of one value every two seconds. Depending upon boat speed during the survey (estimated at 3-5 knots), position measurements will be made approximately every 10-15 feet along each survey line. Depth values are recorded continuously (approximately every 0.5 seconds, or every 3 feet along the survey line).

Acoustic Doppler Current Profiler Surveys:
In addition to bathymetric data collection, the level of numerical modeling to be conducted in the more complex systems warrants model validation using tidal current data. Cross-sectional profiles of currents will be measured using an Acoustic Doppler Current Profiler (ADCP) over tidal cycles. This will be in association with other parts of the field program, but is conducted in parallel with the tide gauge measurements and bathymetric surveys.

ADCP measurements are made along a transect for a complete tidal cycle to capture both flood and ebb tidal currents. ADCP measurements will be obtained along transects at critical transitions within the embayment. ADCP transect runs will be performed at the embayment mouth and additional locations as the need is identified, specifically at the mouth of key tributary sub-embayments. The decision for performing ADCP transect runs in an embayment will be based on the size and complexity of the embayment being modeled as well as channel geometry and water depth. Multiple ADCP transects will be performed in complex embayments and typically one transect in each simple embayment system. However, not all small simple embayments can support ADCP measurements due to shallow depth (<1 meter) or very low velocities.

Tide Data Collection:
Measurements of tidal elevation will be made at 6-8 locations within the complex embayments and 2-5 locations within the more typical and simpler estuaries. Precise knowledge of tidal elevation time histories at strategic points is required to understand the flushing characteristics throughout the system. As the tide rises in the offshore system to southeastern Massachusetts embayments (Nantucket Sound, Cape Cod Bay or Buzzards Bay), water floods into the adjacent embayment and is distributed through to the upper regions. Characteristics of the embayments, such as inlet size, depth, and bottom roughness (friction), distort the tidal wave as it travels through the system. Tidal distortion may include a reduction in the range of the tide (damping) and/or a delay in the time of occurrence of low and high tides. The extent of tidal damping through the system affects the volume exchange, and hence the flushing characteristics, between the Sound and the remote portions of the system. Measurement of the tidal elevation time-series at key locations will provide information to calibrate and verify the two-

dimensional numerical model, which will be used to evaluate flushing characteristics and compute residence times.

The system forcing tides, or the offshore tides will be measured using two tide gages offshore of the embayment entrance. The two tide gages will be installed on a pipe anchor in approximately 15-20 feet water depth, preferably, but in less water depth if extensive shallow water exists in the vicinity of the tidal inlet. The gauges will be placed at depths deep enough to ensure that the gauge is submerged at all stages of the tide. Accurate measurement of the forcing tide is critical, because the forcing tide provides the basis for evaluating flushing characteristics within adjacent embayment. Therefore, two gages are used to both for quality assurance purposes and to ensure 100% data return. The forcing tide measurements are input directly to the hydrodynamic model as a forcing boundary condition.

Measurement of the tidal response in portions of each embayment quantifies the extent of tidal damping through the connecting channels and coves. Spatial distributed placement of gauges within each system allows for detailed analysis of tidal damping throughout each embayment system. Each gauge will be installed to an existing pier piling or other stable structure such that the recording sensor remains submerged at all tide stages. Exact location of each gage will be determined during a pre-survey site visit. Standard operating procedure is to obtain permission(s) from private land owners prior to tide gauge installation on their property (if required). If no fixed structures are available the gauge will be placed using a pipe anchor similar to the offshore gauge placement.

The vertical elevation of each tide gauge will be measured relative to the Town's vertical datum, as used in the bathymetry survey. If Town datums are not available benchmark data will be retrieved from equivalent sources (e.g. USGS). The Project Team assumes that each municipality will provide the location and position (both horizontal and vertical) of local benchmarks nearest to each tide gage. The Project Team will survey the gauges into the Town datum.

Hydrodynamic Model Development:
The Project Team's technical approach for evaluating estuarine hydrodynamics includes model development and calibration. The Surface Water Modeling System (SMS) will be utilized to model both hydrodynamics and water quality (an overview of the SMS package will be provided upon request). The SMS package provides a user-friendly grid generation program and post-processing software for the RMA-2 model developed by Resource Management Associates (King, 1990). The RMA-2 model is a two-dimensional, depth-averaged finite element model, capable of simulating hydrodynamics in complex river and estuary systems. The model has been standardized by the U.S. Army Corps of Engineers and is widely accepted for a broad range of estuarine applications. RMA-2 has been used for numerous hydrodynamic studies under SMAST on Cape Cod.

To develop the model grid, the Project Team will use the bathymetry data collected as part of the hydrodynamic program and cross check it to existing bathymetry information NOAA and other studies as available). Bathymetry data will be converted to the Massachusetts State Plane 1983 coordinate system (X-Y) and a map will be prepared for incorporation into the State's, regional agency's and Town's GIS. A model grid will be developed with knowledge of the system's tributary sub-embayments, bathymetry, potential regions of nutrient loading, and regions where structural modifications are proposed.

The Project Team's modeling approach utilizes a finite element model developed by Resource Management Associates (RMA-2 Model) that solves the full two-dimensional depth-averaged hydrodynamic equations. It allows for variable computation cell sizes to take advantage of limited bathymetric information. This type of model was developed to handle complex flow patterns associated with systems like those associated with Pleasant Bay, Popponesset Bay, Three Bays, Wareham River, etc. Output from the model provides complete depth-averaged, two-dimensional current velocities for all computational nodes as a function of time within the estuary system. Our modeling approach is a four-part process:

- <u>Development</u>: Set-up the model for each embayment system. Input shoreline positions, bathymetry data, and specify boundary conditions (i.e., offshore forcing tides).
- <u>Calibration</u>: Ensure model predictions are consistent with natural processes using a thorough comparison to measured field stage data.
- <u>Validation</u>: Comparison of calibrated model to independent direct measurements of flows as determined from the ADCP field program.
- <u>Application</u>: Use the calibrated model to evaluate hydrodynamic characteristics and to determine potential improvements to flushing associated with engineering alternatives.

Flushing rates and residence times are computed easily from the wealth of detailed site-specific data this model will provide. Both *local* and *system* residence times will be computed. Local residence times represent the average time required for a parcel of water in a sub-embayment to be flushed out of the sub-embayment, and will be computed as the volume of water in each sub-embayment divided by the volume of water entering the sub-embayment over an average tidal cycle (tidal prism). System residence times represent the average time required for a parcel of water to be flushed out of the estuary from the sub-embayment, and will be computed as the volume of water in the estuary divided by the tidal prism of the sub-embayment. The draft and final report will assess the significance of tidal flushing on water quality from both local and system residence time perspectives.

Since the flushing analysis will utilize a numerical hydrodynamic model, results can be incorporated into a water quality model to indicate nutrient and/or other constituents (pollutants) impact to the estuarine system **(see Section B.5)**. By incorporating the data collected for other portions of this project, the two-dimensional model can provide the basis for a water quality model (RMA-4) that incorporates the estuarine hydrodynamics and point and non-point source nutrient inputs. In addition, the hydrodynamic model can be used to evaluate potential improvement of flushing rates as a result of channel dredging and/or other engineering modifications (e.g. alterations to culverts).

Reporting:
The hydrodynamic modeling effort will be a chapter in the synthesis report for each embayment. Calibration plots will be presented showing the accuracy of the computations with respect to the measured data. Tables of system (and local) residence times will be presented for each of the Southeastern Massachusetts' study area embayments. In addition, the tidal constituents (amplitude and phase) from both the measured and computed data will be presented. Time series plots showing the measured versus model water elevations at various locations will be presented. A discussion of the system tidal versus non-tidal (or residual) processes will be presented to provide some context of the overall tidal processes within the Southeastern Massachusetts' study area embayments. Finally, the report will analyze all generated information to describe the hydrodynamics of the system to provide DEP and stakeholders with a concise understanding of the important hydrodynamic features of these systems, and how they potentially impact water quality within the study area embayments.

The model used by the Project Team, the RMA-2 numerical model, interfaces with a larger user-interface software package called SMS (Surface water Modeling System). The SMS package is a user interface, and allows a simpler method of changing model parameters as well as provides practical graphics presentation capabilities to view results. Graphical representation of results will be provided in embayment specific reports.

Bathymetric data in the form of a map for each of the Southeastern Massachusetts' study area embayments will be provided in a digital format compatible with the ArcView GIS system.

B.2.5 Sample Handling and Custody Requirements

All data is collected digitally in the hydrodynamic modeling effort and as a result there are no associated sample handling requirements for this portion of the effort. Data management is required (see below)

B.2.6 Analytical Methods Requirements

All measurements are by autonomous field instrumentation **(see table B.2-1)**, there will be no water or sediment samples collected for this task for laboratory analysis.

B.2.7 Quality Control Requirements

Bathymetric Survey:
Bathymetry is typically surveyed in a grid pattern that provides duplicate measurements, termed crossings, at multiple points within the survey area. The two measurements at the crossings are compared to check the precision of the data collection. If the difference between the two measurements is greater than 15 cm, then the region must be resurveyed. Periodic comparisons of the fathometer to a sounding rod are performed and agreement must be within 4 cm.

Tide Gauges:
Water elevation measurements from individual tide gauges are factory calibrated and the calibration checked prior to each deployment. In addition, in the field during the deployment process all gauges for an embayment are bound together with the pressure ports at the same elevation and lowered vertically to a known depth of at least 5 feet for approximately 1 hour, sampling at 1 sec intervals. After downloading the data from each instrument the water pressure readings are corrected for atmospheric pressure and density (based on measured salinity) and converted to depth. A comparison of water elevation readings from each tide gage provides a measure of the precision and accuracy of each gauge and the comparability between gauges.

Velocity (Acoustic Doppler Current Profiler, ADCP):
Velocity measurements are collected across a series of transects once every hour throughout a tidal cycle, while the tide gauge data is being collected. During the peak flow conditions within the tidal cycle, ebb and flood, velocities across the inlet transect are surveyed twice in sequence. Comparison of the two sets of velocity measurements across the transect gives a quantitative measure of the repeatability of the ADCP velocity measurements. The two velocity measurement sequences run along the prescribed transect are spaced less than 5 minutes apart. In addition, the RDI ADCP outputs two data quality parameters for each velocity measurement. A correlation value provides a measure of the acoustic signal to noise ratio for each ensemble of acoustic pings. The second parameter is percent good, which defines the percentage of acoustic pings within an ensemble that passed the data rejection criteria. Correlation and percent good values are indications of data quality.

Qualitative Numerical Modeling and Validation

Comparison of Findings with Previous Flushing Analyses:

Some flushing studies have been conducted in Southeastern Massachusetts' embayments. These will be evaluated for their applicability to the present effort **(see B-II)**. Not all previous studies use methods that support numerical or quantitative modeling. In addition, even studies using the same protocols as the Estuaries Project, may not have collected sufficient field data to provide a consistent approach (for example less deployed tide gauges, or bathymetry based upon NOAA charts only).

Evaluation of Hydrodynamic Model results:
The quality control procedures for the hydrodynamic modeling consist of two approaches. First, a check of the model-predicted flushing rates relative to the embayment volume multiplied by the tide range. Second, a comparison of tidal prism from model predictions versus independently measured current and volumetric flow measurements provided by the ADCP. Calculated tidal prism from the embayment area and tide range is an independent determination of the flood and ebb volume. In the rare cases where an ADCP survey is not possible due to the embayment structure (e.g. inlet is too shallow) the tidal prism calculation will be used to validate the hydrodynamic model.

The first methodology involves summing the flow across the mouth of each embayment for every modeled time step and comparing this numerically predicted tidal prism with the mean embayment volume multiplied by the tide range (simplified tidal prism computation). This comparison is made for all embayment systems. For complex tidal embayments, where ADCP surveys are required, an additional model validation technique is performed. For these systems, the tidal prism volume measured using the ADCP current measurements are compared to model-predicted flow across the same transects. In this manner, a comparison between predicted and measured tidal flow can be made for the total tidal exchange over the complete tidal cycle, as well as for the time-varying nuances of the flow. The comparison should yield an average RPD of <5%.

B.2.8 Instrument Calibration and Frequency Procedures

Bathymetric Survey:
Single beam echosounders are typically calibrated by performing a bar check. A rigid vertical bar or weighted disk with tick marks every 1-foot is lowered directly below the transducer to a depth of 5 feet. The draft setting in the echosounder is adjusted until the depth reads 5 feet. The bar/disk is then lowered to the maximum depth that will be surveyed (rounded to an even foot) and the sound velocity setting is adjusted until the echosounder reads the appropriate depth. The bar/disk should be returned to 5 feet to check the depth since the sound velocity setting may have changed. If the depth reading is still 5 feet, than the echosounder is calibrated. If the reading has changed, the above procedure is repeated until the echosounder readings match the depth of the bar/disk. Bar checks are typically performed before each series of field surveys.

Periodic field checks are performed during each survey, both through multiple readings at the same point where transects cross and using a sounding rod. These field performance checks are used to indicate that the echosounder is in calibration.

Tidal Gauges (pressure transducers) and Current Velocity (ADCP):
The tide gauges used to measure time-series tidal elevations are factory calibrated. The tide gauges measure depth through strain gage pressure sensors. The gauge that the Estuaries Project typically employs is from Richard Brancker Research Ltd, Canada. A Druck Pressurements hydraulic deadweight tester is used in factory calibration to give a direct NIST traceable standard. The sensors are calibrated at eight points and a cubic fit to the data is used to determine the calibration coefficients.

Laboratory checks of transducer calibration are performed by (a) measuring the depth and salinity of the water over a gauge at deployment and recovery, (b) prior to deployment setting all gauges for an embayment at a known depth at high frequency sampling, and (c) periodic calibration of gauges in the SMAST Test Tank.

Velocity measurements are collected by an Acoustic Doppler Current Profiler (ADCP) manufactured by RD Instruments Inc. Prior to each deployment a series of tests are run to check the acoustic signal, signal processing subsystems, integrity of the 4 transducers, and error in the compass. If the error in the compass exceeds 5° or the battery has been changed since the last calibration, the compass is recalibrated. To calibrate the compass, the ADCP the instrument is rotated 360° in three different planes. The ADCP and RDI software uses the first two rotations to recalculate the compass matrix and the third rotation to verify the calibration.

Qualitative Numerical Modeling and Validation:
The calibration of the numerical model is to ensure that the model accurately predicts the observations from each portion of each embayment using data from the field measurement program. For each embayment, numerous model simulations are required (typically 20+), specifying a range of friction and eddy viscosity coefficients, to calibrate the model. Calibration of the hydrodynamic model requires a close match between the modeled and measured tides in each of the sub-embayments where tides were measured (i.e., from the tide gauge deployments). Initially, the model is calibrated to obtain visual agreement between modeled and measured tides. Once visual agreement is achieved, an approximate five-day period (10 tide cycles) is modeled to calibrate the model based on dominant tidal constituents. The five-day period is extracted from a longer simulation to avoid effects of model spin-up, and to focus on average tidal conditions. Modeled tides for the calibration time period are evaluated for time (phase) lag and height damping of dominant tidal constituents.

B.2.9 Data Acquisition Requirements

For the hydrodynamic modeling program, U.S.G.S. topographic maps are used to identify tidal gauge sites and ADCP transect locations. Printed scanned copies with marked site ID's are provided to each field team.

For the bathymetric survey and tide gauge placements local benchmarks are needed and have always been provided by the Town's. If a Town cannot provide a datum, benchmark data will be retrieved from equivalent sources (e.g. USGS). The Project then surveys in the sampling locations within the embayment, relative to the provided Town datum.

If necessary for the hydrodynamic modeling program, rainfall data is obtained by the hydrodynamic modeling Technical Leader/SMAST scientists at the end of each sampling season. Rainfall data (date and amount) is from the Town of Falmouth gauge, Cranberry Station in Wareham, City of New Bedford. The Town of Falmouth rainfall data is processed and QA/QC's by Dick Payne at the Woods Hole Oceanographic Institution. The Cranberry Experiment Station Gauge was placed by NOAA and is maintained by the University of Amherst. The City of New Bedford Gauge is used in the NOAA network. The gauge used as reference for any specific embayment is selected based upon proximity. If site-specific rainfall is deemed necessary in the future, then Li Cor tipping bucket rain gauges may be deployed.

B.2.10 Data Management

The flow of data and information is relatively direct for this Project Task. The field notes and digital data are collected by the field personnel and copied upon return to the laboratory with copies held at (a) the originator of the data, (b) the model lead, (c) the SMAST Project Library (via the Technical Coordinator).

As the data is received by the modeling lead and the Technical Manager at SMAST, the data is evaluated for completeness and quality. The data is then used to calibrate and validate the hydrodynamic model. The calibrated model is then stored (at a minimum) on CD ROM by the hydrodynamic lead and the Project Technical Manager in the SMAST Project Library.

B.2.11 Preventative Maintenance for Field Equipment

The *echosounder transducer* is rinsed in fresh water after use to avoid corrosion and damage form salt build up. Routine visual inspection of the connectors, cabling and polyurethane transducer is performed to avoid leakage. The belts of the chart recorder are checked for wear and potential failure.

The tide gauges and Acoustic Doppler Current Profiler (ADCP) are routinely inspected prior to deployment. The pressure housings and sensors are inspected for potential corrosion and leakage. Any evidence of corrosion is cleaned and an inhibitor is applied to the surface. The o-rings, providing a water-tight seal to the pressure cases, are cleaned and checked prior to each deployment, and flattened o-rings are replaced. Replacement parts for the tide gages and ADCP are kept in stock. The ADCP transducers are visually inspected for peeling or nicks of the polyurethane transducers. All equipment is rinsed in fresh water and stored based upon manufacturers specifications field deployments. The equipment is stored in dry heated storage between deployments.

Performance of the numerical modeling and associated validation does not have associated preventative maintenance for field equipment.

B.3 Watershed Nitrogen Loading

The watershed nitrogen loading program of the Estuaries Project is based upon 3 components:

- Land-use determined by GIS analysis
- Nitrogen Source Loads determined from field data and the watershed model
- Attenuation of Nitrogen determined from stream discharge measurements

These components require both field data collection, incorporation of previously collected land-use GIS databases and watershed nitrogen load modeling. Technical Team members have been pivotal in the development of these techniques over the past decade. The Estuaries Project will apply a standardized consistent watershed nitrogen loading model to all 89 embayment systems in southeastern Massachusetts.

B.3.1 Data Quality Objectives for Measurement Data

The data quality objectives have been selected to fit with the goals of the Watershed Nitrogen Loading Program of the Estuaries Project. The only field data collection under this program is the stream flow and stream nitrogen load measurements. The data quality objectives for these stream terms have been selected to account for the variability of stream discharge and nutrient concentrations typical of the small rivers and streams of southeastern Massachusetts. The data quality objectives were selected based upon the results of a limited number of annual investigations of stream nutrient transport in southeastern Massachusetts (e.g. Howes and Teal 1995, CDM and Howes 2000). The methods and approaches establish the criteria for evaluating both data collected by the Estuaries Project and existing data being evaluated by the Technical Team for inclusion into Project database **(see B-II**). All data must meet the required levels of precision, accuracy, and detection limits.

The stream nutrient sampling uses accepted methods for low level analysis. These methods are accepted by the best research laboratories in the United States. Where EPA or Standard Methods techniques are available, they are employed by the SMAST laboratory. All methods have been intercalibrated with a variety of methods and with various certified laboratories (freshwater only) and marine laboratories. Minimum performance criteria are listed in **Table B.3-1**, although the methods used in the program generally exceed these minima. The acceptable criteria for field blank cleanliness is generally a reading less than the detection limit. In occasional instances where high sensitivity methods are employed, the field blank must be less than 10% of the sample value.

Table B.3-1 Minimum Objectives for Stream Nutrient Assays

Parameter	Matrix[a]	Field Precision	Laboratory Precision	Accuracy	Detection Limit
Nitrate + Nitrite	1	<30% RPD[b]	<20% RPD	75%-125% of matrix spike	0.25 uM
Ammonium	1	<30% RPD	<20% RPD	75%-125% of matrix spike	0.25 uM
Total Phosphorus	1	<30% RPD	<20% RPD	75%-125% of matrix spike	1 uM
Orthophosphate	1	<30% RPD	<20% RPD	75%-125% of matrix spike	0.1uM
Total dissolved N	1	<30% RPD	<20% RPD	75%-125% of matrix spike	1 uM
Particulate C& N	1	<30% RPD	<20% RPD	75%-125% of matrix standard	1 uM

[a] 1 = Freshwater
[b] RPD = Relative Percent Difference
Note: These parameters are measured by the Coastal Systems Analytical Facility at SMAST

In embayments where bacterial contamination is an identified issue, parallel stream water samples may be collected for analysis.

Table B.3-2 Stream Bacterial Assays

Parameter	Matrix[a]	Sample Volume/ Container	Sample Holding Time	Field Processing/ Preservation[b]	Detection Limit
Fecal Coliform	1, 2	100 ml sterilized polyethylen e	6 hours	Collect, label, store on blue ice in cooler	1 CFU*./100ml
Enterococci	1	100 ml sterilized polyethylen e	6 hours	Collect, label, store on blue ice	1 CFU./100ml
E. Coil	2	100 ml sterilized polyethylen e	6 hours	Collect, label, store on blue ice	1 CFU./100ml

[a] 1 = saltwater, 2 = freshwater
[b] Holding temperature will be <10 Celsius
*CFU – Colony Forming Unit
Note: Bacterial parameters measured through Barnstable County Health Laboratory, New Bedford Health Laboratory or other DEP Certified Laboratory.

Analytical requirements for stream nutrient assays:
Complete standard curves are generated for each analytical run. If more than a 10-fold range of concentrations are encountered in the samples, then both a high and low standard curve is created. In all cases the standards are prepared new each day and are chosen to give at least 5 points over the sample concentration range. Standards

well above the sample range are not used. Nitrate+Nitrite (run in duplicate) by auto-analysis has additional standards run before and after every five (5) samples. Failure of these additional standards (run as samples) to agree within 10% of their known value halts the assay line for complete recalibration and the re-running of the last sample set.

For nitrate+nitrite, dissolved ammonium, total dissolved nitrogen, ortho-phosphate, and total phosphorus, non-automated assays are all run in duplicate (at a frequency of at least 10% of the samples) with a <5% tolerance between duplicates required for acceptance. After completion of analyses, remaining sample is frozen, for possible reanalysis if required.

Analytical requirements for stream bacterial assays:
The bacterial assays will be conducted by a DEP Certified laboratory (Barnstable County Health Laboratory). The Estuaries Project requirements will follow those of certification. The data requirements are a detection limit of 1 CFU per 100 mL, unless prior data indicates a high level (>100 CFU) of Fecal Coliform bacteria are present at a specific site. In that case a dilution will be conducted at 10 and 100 fold to ensure capture of the population count. Duplicate samples will be conducted on 10% of the field samples and these need to have an RPD of <25% (N=5).

<u>Precision</u>
The precision of each chemical assay is determined by from duplicate assays of five standards. The field precision is from duplicate assay of five blind field duplicates. The precision is calculated as the relative percent difference (RPD). An additional estimate of precision is determined from the R^2 of the linear regression of each set of standards (N>5).

<u>Accuracy</u>
Accuracy is determined from the analysis of standards for the standard curves, analysis of the matrix spikes and use of Performance and Evaluation Samples (commercially available). Accuracy is determined as the RPD of the assay of five standards run as samples within a series of analytical runs. This is compared to the RPD of five sets of Performance and Evaluation Samples. In addition, the accuracy of the method within the sample matrix is determined from the RPD of five matrix spikes experiments (standard additions), where appropriate.

<u>Measurement Range</u>
The usable measurement range for each chemical assay is only within the linear range as determined from least squares linear regression of laboratory standards. Concentrations above the linear range require standard dilutions for acceptable analysis. Since high values can be readily diluted and re-assayed the same day, the upper range of measurement is variable. Sample dilutions attempt to bring the concentration of the diluted sample into the middle of the linear range for the assay. The natural range for any analyte is typically less than 1000 fold.

Bacterial assays require a priori determination of dilutions. For fecal coliform analysis by membrane filtration, only 100 colonies can be counted per plate. Therefore, if more than 100 colonies per 100 mL are anticipated a dilution series by the laboratory will be requested (10X, 100X). The determination to conduct dilutions will be based upon prior data from a specific stream under wet and dry weather flows.

Representativeness
The goals of the stream sampling program is to provide nutrient loads from streams to coastal embayments. The sampling point will be selected as near to the embayment as possible and to avoid tidal influence. Since the stream data is compared directly to its contributing watershed, the watershed is adjusted to account for nutrient sources which would be captured by the stream prior to the gauging site.

Comparability
The results from each stream sampling program will be directly comparable to each other. In addition, since these are accepted methods, they will be directly comparable to other studies conducted by U.S.G.S. and other groups.

Completeness
The ultimate goal of the stream sampling sub-task is to obtain data for comparison to its sub-watershed nitrogen load and comparable data for each estuarine system in southeastern Massachusetts. This both provides the needed site-specific data and enables both inter- and intra-estuarine comparisons using consistent and reliable methods of sample collection and analysis. Completeness is gauged as the number of actual measurements divided by the number of planned measurements times 100%.

B.3.2 Documentation and Records

Stream flow and nutrient data will be recorded on field data sheets to be kept in notebooks for each embayment **(B-I).** Data will be recorded on-site at the time the measurements are taken and in laboratory notebooks at the Coastal Systems Analytical Facility (both data and chain of custody forms). Sampling personnel check that all data is accurate and legible before passing the field data sheets to the SMAST laboratory. As the data is received by the SMAST laboratory, it is reviewed and the samplers are contacted to clarify any numbers, issues or if any information is missing. In addition, the stream Technical Lead (Roland Samimy) will check that all data is accurate and legible before making copies for Technical Coordinator and SMAST Project Library. All data is reviewed by the Technical Manager. The nutrient sampling portion of the program requires that Chain of Custody forms (COC) be filled out as the samples are delivered at SMAST. Each COC is checked as samples are received. The stream flow and nutrient data will be stored on CD-ROM in the SMAST Project Library with copies distributed to the Stream Technical Lead and the Technical Manager.

All data entry is checked by two laboratory personnel and the QA/QC checks are completed by the Project QA Officer (A.4 Project Organization and Responsibilities.)

Nutrient Analytical data:
Raw data is maintained in duplicate notebooks. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards. The results will be reported in terms of concentration, as means and standard errors. All data are subject to 100% check at all stages by everyone. All data reported are reviewed to check for errors in transcription, calculation, or computer input. If data points are judged to be aberrant, the reserved sample will be reanalyzed. Data are also reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, are used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

The watershed loading model is held in spreadsheet format, which includes the land-use and loading data for each sub-watershed to an embayment. The model will be held on CD-ROM and in paper copy at three locations: (a) Cape Cod Commission, (b) Technical Coordinator, SMAST, (c) Technical Manager in the SMAST Project Library.

B.3.3 Sampling Process Design

The design of the Watershed Nitrogen Loading task is aimed at providing spatially resolved nitrogen loading data for input into the Linked Watershed-Embayment Model. To accomplish this task a GIS based land-use analysis is conducted by the Technical Lead using watershed delineations provided by or confirmed by the U.S.G.S. These data are combined with direct measurements of nitrogen discharge by streams to parameterize the Watershed Loading Model component of the Linked Model.

Phosphorous loading to freshwater systems (ponds/streams) will not be determined as it is not the focus of the Estuaries Project in and of itself. The Estuaries Project focuses primarily upon the sources, sinks, and transfers of nitrogen within the watershed-embayment complex. Nitrogen is the nutrient for managing eutrophication in Massachusetts coastal embayments, while phosphorus is the primary nutrient for management of eutrophication of freshwater systems. In specific cases where it is necessary to determine phosphorous loading in support of other analyses or evaluations, loading may be determined. Some examples of cases where support may be requested:

- NPDES Permiting
- Nitrogen source reduction for embayment restoration, where P load to eutrophic freshwaters will also be effected. Source reduction may be by relocation of discharges or reduction in discharged load.
- Cases where a regulatory agency has a priority

In the event that phosphorus loading determinations are undertaken, a project specific plan will be developed to meet site specific needs. However, the analysis will follow the format of the nitrogen loading analysis for the embayments. This site specific project plan will be appended to the relevant embayment specific Appendix QAPP under this umbrella QAPP for the Estuaries Project.

Watershed Land Use Analysis:
Watershed land-use will be based on a parcel by parcel analysis using GIS. The land-use data will use the most recent data available, not older than 5 years. The preferred land-use data will be based upon town assessors database and will include all parcels. The watershed delineations will be based upon the U.S.G.S West Cape Model for Cape Cod embayments (Masterson and Barlow 1994, Masterson et al 1997). The sub-watersheds for each major tributary sub-embayment will undergo land-use analysis. In addition, each watershed will be partitioned into regions which nutrients flow directly to the embayment via groundwater, regions which discharge to freshwater ponds, and regions where nutrients flow to streams and are transported via surface water streams to the embayments.

GIS analysis will be supported by field surveys of major potential contributors (i.e. schools, hotels, apartment buildings, etc.).

Watershed Stream Flow and Nitrogen Load:
The goal of the stream gaging component of the Estuaries Program is to quantify the nutrient load and freshwater inflow from major streams which discharge to each estuary. These data will be used to:

- Validate the USGS watershed discharge modeling results
- Quantify the surface water nitrogen load
- Determine site-specific nitrogen attenuation values for the surface water flows to each embayment (comparison of watershed model to stream nitrogen discharge results).

Nutrient loading to an embayment through a stream is in part dependent on quantifying surface water flows (Q, volumetric discharge) and the associated nitrogen concentration in that discharge volume. For the purpose of this stream gaging protocol, flow will be calculated from continuous measurements of water level, stream cross sectional area, and periodic measurements of velocity. Stream water levels will be measured (15 minute intervals) using a Global Waters Water Level Logger: WL-15 or equivalent. The gauges will be vented to the atmosphere. Stream cross sectional areas will be measured using a top-setting wading rod. Permanent markers will establish the cross-section location. A Marsh McBirney Flow-mate Model 2000 or equivalent current meter will be used to measure stream velocities. The summation of the products of stream subsection areas of the stream cross-section and the respective measured velocities will represent the computation of stream flow (Q). A rating curve will be developed for each gauge to transform level data to discharge rates. High and low flow hydrologic regimes will be sought for development of the rating curve for each stream within the study area.

Station Location:
Selection of stream gaging station locations will be based on:

- Accessibility
- Lack of tidal influence
- Section of stream providing a generally straight channel
- Streambed is free of aquatic growth and relatively smooth
- Unchanging natural control
- Stream channel does not go dry during low flow periods
- Gage site is not influenced by backwater effects (culverts, dams, confluences)
- Stable channel cross section

It will not be likely that all the above listed criteria will be able to be satisfied by all sites being considered, however, attempts will be made to find gauging sites that meet as many of the listed criteria as possible.

Ingress and egress to a potential site will be field verified and ownership of the site will be investigated. Permission to access a potential site will be gained from the owner of the site prior to using the site as a stream gauging station location.

Tidal influence on stream flow will be assessed prior to selection of a gaging station location. The assessment of tidal influence will initially be based on observation of stream habitat flora. Observations will be made in the field to determine the presence of freshwater plant species. Should the site under consideration be selected, a water level indicator will be installed to record stream levels and lack of tidal influence will be confirmed via instrument measurement. Should a slight tidal influence be present, numerical filtering techniques will be applied to the data to screen the tidal influence out of the data.

All stream gauging locations will be selected in stream reaches that are not influenced by backwater effects resulting from the presence of stream confluences, drainage culverts, dams or other naturally occurring or artificial structures. The gauging location will be situated down-gradient from culverts and dams and far enough up-gradient from a confluence that water level not be effected. In the absence of stage and discharge data at a potential gauge site or concurrent stage at the stream confluence, the gauging site selected will be the one located furthest away from the known confluence.

Stream Cross Section Measurements:
After having identified an acceptable stream cross section where velocity measurements will be made, the selected cross section will be waded with a top setting wading rod in order to establish the profile of the cross section. The stream channel profile will be established before each run of velocity measurements.

A measuring tape will be manually stretched across the width of the stream channel and, while facing up-stream, the left and right banks of the channel will be noted in feet using the measuring tape. The transect will be marked with permanent markers to which the tape measure will be affixed on each sampling occasion. Water depth across the width of the stream will be measured in 0.5 foot increments using the top setting wading rod. Water depth will be measured in meters. Total stream channel cross sectional area will be the summation of the total number of segment cross sectional areas.

The stream cross section location will also be described in the field record book in order to maintain a record of changes in the channel bottom or bank characteristics.

Stream Water Level Measurements:
Stream water level measurements will be obtained using a Global Waters Water Level Logger (WL-15) or some equivalent instrument. The factory calibrated water level loggers will be prepared in the laboratory for deployment in selected streams by checking that the instrument is properly sealed to prevent malfunctions resulting from moisture build up in the instrument casing. Deployments will typically be continuous for approximately one year.

The water level instrument will typically be encased in a PVC tube, open ended on the bottom so that the instrument cable can run freely and capped on the top so that moisture cannot degrade the instrument communication port. The PVC encased instrument will be mounted to a convenient and permanent natural or artificial structure and the water level probe held in the desired location in the stream reach using either a stilling well or placement on a flat weight (ca. 40 lbs) in shallow streams. The instrument cable will be run as unobtrusively as possible so as to be hidden from view and to not become an obstacle. The water level probe will be placed at the deepest point in the stream channel so as to remain submerged during low flow seasons and mean sea level will be used as the vertical datum to which the probe is referenced. The water level probe will be weighted down appropriately so as to prevent the probe from migrating down stream during increased flow rates.

Water level data will be down loaded monthly in the field via lap top computer. Water level data will be field verified each month against either an in-stream surveyed staff gage or by making a manual water level measurement of height of water over the water level probe using a tape measure. Measured height of water over the in-stream water level probe will be compared to water level data record to confirm that data record is comparable.

Stream Water Velocity Measurements:
Stream water velocity measurements will be taken, at a minimum, each time the WL-15 water level logger is down loaded. Additional velocity measurements may be taken in between instrument down loads depending on weather conditions in order to capture high or low flow events. Nutrient samples for total nitrogen will be collected on each visit to the gauge site. Bacterial samples will also be collected to determine stream loads to embayments associated with the wet and dry weather embayment sampling for bacterial contaminants (see B-III).

Field data sheet for collection of velocity data have been developed and will be used to record velocity measurements, stream depths, and distance from the right or left bank where a velocity measurement is taken. In the absence of a field sheet, the same information can be recorded in a field notebook (as used by the USGS).

Stream Flow Calculation:
Determination of stream flow will be calculated and based on the measured values obtained for stream cross sectional area and velocity (Rantz et al. 1982). Stream discharge will be represented by the summation of individual discharge calculations for each stream subsection for which a cross sectional area and velocity measurement were obtained. Velocity measurements across the entire stream cross section WILL NOT be averaged and then applied to the total stream cross sectional area.

The formula that will be used for calculation of stream flow (discharge) is as follows:

$$Q = \Sigma(A * V)$$

where by:

Q = Stream discharge (m^3/day)
A = Stream subsection cross sectional area (m^2)
V = Stream subsection velocity (m/s)

Thus, each stream subsection will have a calculated stream discharge value and the summation of all the sub-sectional stream discharge values will be the total calculated discharge for the stream.

Nitrogen discharge is calculated using the paired discharge and nitrogen concentration data to determine the mass flux of nitrogen through the gauging site. These data are expressed as nitrogen mass per unit time (kg/d). The mass flux over the period of interest (month, season, year) is determined by integrating the area under the appropriate interval of the daily mass flux versus date graph. The water samples for assay of nitrogen concentration will be collected weekly during May – September and weekly to biweekly over the rest of the year. The samples will be collected and analyzed at the Coastal Systems Analytical Facility at SMAST meeting the requirements of Section B.1 and B.3.6. The stream samples will be assayed for nitrite+nitrate, orthophosphate, ammonium, particulate organic carbon/nitrogen and total phosphorus.

Watershed Nitrogen Loading Model
The Watershed Nitrogen Loading Model consists of identifying all of the land-uses within the sub-embayments of an estuarine system. Each nitrogen source is assigned a nitrogen loading term (Howes et al. 2001) based upon:

- Seasonality
- Occupancy
- Land-use Type
- Area
- Location relative to freshwater pond watersheds
- Location relative to groundwater watersheds
- Location relative to stream watersheds

The individual loads are composited within each sub-embayment. Attenuation is determined from the modeled unattenuated stream nitrogen load versus the directly measured stream nitrogen load.

B.3.4 Sampling Methods Requirements

Watershed Land Use Analysis:
Sampling is not required as part of this analysis.

Watershed Stream Flow and Nitrogen and Bacterial Loads:
As indicated in Task 2, attenuation of watershed nitrogen during surface water transport can significantly reduce the amount of watershed nitrogen entering an estuary. We will directly measure nitrogen, and phosphorus inputs of each major stream/river discharges in the embayments undergoing the full modeling effort. These direct measurements of watershed freshwater and nutrient inputs will a) serve to validate the watershed delineation's, b) validate the land-use models, c) help to calibrate the hydrodynamic models applied to estuarine circulation in Tasks discussed below. These direct measurements are also applied to the system nitrogen loading models.

The use of the surface water inflow data to validate the loading and hydrodynamic models used for all 89 targeted embayments in the Massachusetts Estuaries Project contrasts with many other studies that rely solely on land-use data. Unfortunately the land-use only studies have often resulted in overestimates on nitrogen loading and distribution and lead to improper or ineffective management options. The use of directly measured nitrogen discharges for rivers and streams is essential to properly determine watershed nitrogen loads and to rank the nitrogen sources, and to minimize uncertainties and provide for effective watershed management decisions.

Surface water inflow volume and mass transport of nitrogen and phosphorus will be determined using site-specific flow discharge relationships and continuous records of water levels. Phosphorus sampling will only be conducted when there is a special request from DEP related to a freshwater eutrophication problem within a specific embayment watershed. Nutrient samples will be collected for inorganic and organic nitrogen and phosphorus concentrations at weekly intervals over a 14-16-month period, encompassing 2 summer seasons. Total nitrogen (not just inorganic forms) is required to accurately determine the input through this pathway. Instruments will be maintained weekly. We have recently successfully deployed a similar array of instruments within the Wareham River Estuary.

Water samples will be collected directly from the stream by syringe (60 cc) and filtered (0.45 um) into 60 cc acid leached bottles for analysis of dissolved nutrients. Additional 1 liter samples will be collected in acid leached bottles for particulate analysis and for total phosphorus **(see Table B-3.1**). Sample handling is similar as for water quality monitoring task B.1.

Bacterial samples are collected in parallel with the nutrient samples. Samples are collected directly in sterile 250 mL polyethylene bottles provided by the certified laboratory. Samples will be collected directly from the stream by plunging the bottle mouth downward and bringing horizontal facing the flow at several inches depth. The bottle is left with a 30-50mL headspace to allow mixing by shaking in the laboratory. Bottles are transported, dark and on blue ice at <10C to the laboratory in less than 6 hr after collection. Cooler temperatures are checked using a field thermometer which has been calibrated to the certified thermometer in the laboratory. Additional details on bacterial sampling are given in B-I.

Bacterial loads will only be determined in embayments which have an identified bacterial problem. Embayments with identified bacterial problems are those on the 303(d) list for bacterial contamination or those determined based upon review of existing bacterial data (primarily DMF data). In the latter case, an embayment will be receive bacterial analysis based upon review by the Technical Team and recommendation to DEP.

Table B.3-3. Stream Nutrient Monitoring Parameters

Parameter	Matrix[a]	Sample Volume/ Container	Maximum Holding Time	Processing/ Preservation	Units
Nutrients:					
Nitrate + Nitrite	1	60 ml polyethylene acid-washed	28 days (frozen)	Field filter, store dark at -20°C in Lab[b]	μg/l
Ammonium	1	60 ml polyethylene acid-washed	24 hours (4C)	Field filter, store on ice in dark	μg/l
Total Phosphorus	1	60 ml polyethylene acid-washed	28 days (acidified)	Whole water, acidify, store dark at 4°C in Lab	μg/l
Orthophosphate	1	60 ml polyethylene acid-washed	24 hours (4C)	Field filter, store on ice in dark	μg/l
Total dissolved N	1	1L polyethylene acid-washed	24 hours	Field filter, store on ice in dark	μg/l
Particulate C& N	1	1L polyethylene acid-washed	28 days	Collect on ashed Filter in Lab, Dry and Store in dessicator	μg/l
Bacteria					
Fecal Coliform	1	250 mL polyethylene sterile	6 hrs (<10C)	Collect and transport at <10C to Lab	CFU/100mL
E. Coli	1	250 mL polyethylene sterile	6 hrs (<10C)	Collect and transport at <10C to Lab	CFU/100mL
Enterococcus	1	250 mL polyethylene sterile	6 hrs (<10C)	Collect and transport at <10C to Lab	CFU/100mL

[a] Matrix 1 = Freshwater
[b] USGS Central Laboratory had determined that freezing filtered samples for nitrate+nitrite is acceptable, without acidification (Avanzino and Kennedy 1993).

Watershed Nitrogen Loading Model
Sampling for the Loading Model is covered in the above sub-sections of B.3.4. The bacterial loads are calculated in a similar manner to the nutrient loads discharged from the streams.

B.3.5 Sample Handling and Custody Requirements

Sampling under the Watershed Nitrogen Loading Task is limited to instrument measurements for determination of stream flow and manual collection for nutrient sampling. It is the nutrient sampling that has sample handling and chain of custody requirements.

Watershed Delineation
No sample handling is associated with this sub-task.

Watershed Land Use Analysis
No sample handling is associated with this sub-task.

Watershed Stream Flow and Nitrogen and Bacterial Loads
Sampling associated with stream sub-task is related to the need for nutrient measurements to couple with the flow measurements to determine the nitrogen load transported by a stream. Nitrogen loading based on stream flow is calculated as a

function of flow rate. Bacterial loads will only be determined in embayments which have an identified bacterial problem. Embayments with identified bacterial problems are those on the 303(d) list for bacterial contamination or those determined based upon review of existing bacterial data (primarily DMF data). In the latter case, an embayment will be receive bacterial analysis based upon review by the Technical Team and recommendation to DEP. DEP will make the ultimate judgment as part of their TMDL process. Sample handling requirements are presented in **Table B.3-3**

All samples will be assayed by the Coastal Systems Analytical Facility at SMAST, which requires Chain of Custody forms before accepting samples. A copy of the form is then given to the stream Technical Leader (R. Samimy) and a copy is kept on file in the Facility.

Watershed Nitrogen Loading Model
No sample handling is associated with this sub-task. Samples for parameterizing the model are collected under the “Stream Flow and Nitrogen and Bacterial Loads” sub-task.

B.3.6 Analytical Methods Requirements

Sampling under the Watershed Nitrogen Loading Task is limited to instrument measurements for determination of stream flow and manual collection for nutrient sampling.

Watershed Delineation
No sample handling is associated with this sub-task.

Watershed Land Use Analysis
No sample handling is associated with this sub-task.

Watershed Stream Flow and Nitrogen Load
Watershed stream flow is considered in the context of taking physical measurements. As such, nutrient loading to near shore waters is in part dependent on quantifying surface water flows (Q) to the embayment under investigation. For the purpose of this stream gaging effort, flow will be calculated from measurements of water level, stream cross sectional area, and velocity. Stream water levels will be measured using a Global Waters Water Level Logger: WL-15 or equivalent. Stream cross sectional areas will be measured using a top-setting wading rod. A Marsh McBirney Flow-mate Model 2000 or equivalent current meter will be used to measure stream velocities. The summation of the products of stream subsection areas of the stream cross-section and the respective measured velocities will represent the computation of stream flow (Q).

Refer to **B-I** for the detailed stream gaging protocol that describes gaging station location, stream cross section measurement, water level measurement, stream velocity measurement, and stream flow calculation.

Nitrogen loading to embayments through stream discharge requires both determination of stream flow and collection and analysis of stream water samples. Stream samples will be assayed for nitrate+nitrite, ammonium, total dissolved nitrogen, particulate nitrogen/carbon, ortho-phosphate and total phosphorus. The analytical methods and quality control samples are listed in **Table B.3-4**, below.

Analytical procedures used in this program have been tailored to the specific chemical environment of coastal streams and estuaries, i.e. variable salinity and analyte concentration ranges of 1000 fold. The procedures used are those commonly employed by the SMAST Coastal Systems Program for research on coastal processes. The analytical methods are being or have been used by SMAST in the measurement of water quality in a variety of monitoring programs such as the USGS Namskaket Marsh Project (required intercalibration with USGS Central Lab), MWRA-HOM Program, Falmouth PondWatch, Pleasant Bay Alliance, USAID Water Quality Program-Jamaica, MCZM Wetlands/Stormwater Monitoring Program, Assabet River TMDL Study, RIDEM-Greenwich Bay Study, WHOI Nantucket Harbor Monitoring Program, Martha's Vineyard Coastal Pond Monitoring Program (MVC), and many others. These programs over the past 15 years have QAPP's and most of them have required acceptance by either EPA or Massachusetts DEP.

Watershed Nitrogen Loading Model
No sample handling is associated with this sub-task.

B.3.7 Quality Control Requirements

The Watershed Nitrogen Loading Task has quality control requirements both for its land-use analysis, stream sampling and watershed nitrogen loading model.

Watershed Land Use Analysis
Although the GIS analysis will use local and regional databases. These databases will use assessors data rather than MassGIS and are maintained by Towns and the Cape Cod Commission and Martha's Vineyard Commission (project partners). It is envisioned that the data will be less than 5 years old. There will be a QA effort based upon ground-truthing the GIS information. This will primarily take the form of checking that the major sources are properly referenced and properly represented spatially. In addition, there will be an effort to check major changes in land-use that may have occurred since the specific database was established. Note that this is over and above the ground-truthing that has already taken place by most planning departments and agencies that oversee the databases.

Watershed Stream Flow and Nitrogen Load
The stream nitrogen loading measurements require water level, water velocity and nitrogen assays. The water level precision should be an RPD of 1%. The velocity will checked in a control flume and should be within 5% of that determined using the factory calibration **(see details B-II).**

The nutrient analyses used in the stream program follow standard laboratory procedures. However, not all analytes are amenable to matrix spikes (eg. PC/PN). In the analysis of field samples, for each chemical assay, a complete standard curve is generated for each analytical run. In addition, reagent blanks and standards are prepared and analyzed with each new batch of reagent. These blanks are compared to previous data on blanks to evaluate the potential of contamination and the standard curve compared to previous records. If this initial blank and standard curve are deemed satisfactory, samples using the new reagent batch can then analyzed.

Calibration blanks are prepared and analyzed simultaneously with the creation of each standard curve which is created for each sample series. If more than a 10 fold range of concentrations are encountered in the samples, then both a high and low standard curve is created. In all cases the standards are prepared new each day and are chosen to give at least 5 points over the sample concentration range. Least Squares Linear Regression is used to calculate the standard relationship and a minimum $R^2 = 0.99$ is required for acceptance. Standards well above the sample range are not used. In addition to the R2 criterion, each curve will be visually inspected to determine that each standard, especially the lower standards, lie close to the curve. Nitrate+Nitrite (run in duplicate) and Particulate C & N by autoanalysis have additional standards run before and after every five (5-6) samples. Failure of these additional “check” standards (run as samples) to agree within 10% of their known value halts the assay line for complete recalibration and the re-running of the last sample set. These “check” standards are used to adjust the calculated sample values for instrument efficiency. For all assays, “check” standards are run at the end of each run and compared to the standard curve.

For nitrate+nitrite, dissolved ammonium, total dissolved nitrogen, ortho-phosphate, and total phosphorus are all assayed in duplicate at a frequency of more than 15% of the samples and with a <5% tolerance between duplicates required for acceptance. After completion of analyses, remaining sample is frozen, for possible reanalysis if required (and appropriate). For the particulate analyses (PN, PC), only field duplicates and laboratory standards can be assayed as the analysis consumes the entire sample.

Spiked samples are periodically analyzed as analytical checks in dissolved ammonium, nitrate+nitrite, total dissolved nitrogen and ortho-phosphate assays. Spiked samples are not widely run, as the standards are made up in the same matrix as the samples. Greater numbers of spiked samples are sometimes run as unknowns” similar to field duplicates. Recovery of spikes must be within 15%-20% of expected to meet QA. Spikes for PN/PC samples are not available. Therefore, PC/PN at known concentrations is added directly to filters. This is done during machine calibration as an internal QA check after every fifth field sample assayed.

As available (eg. PC/PN not available, TC is not appropriate for PC evaluation) Performance and Evaluation Samples for the nutrient assays will be purchased and run during the course of this study. These data will be used to evaluate the accuracy of the SMAST laboratory.

Table B.3-4. Stream Analytical Procedures/Quality Control Samples

Parameter	Essential or Correlative data	Method	Detection Limits	QC Samples	Acceptable %Recovery
Temperature	Correlative	Thermometer -5 °C to 40°C	0.5 C	Field Dups ± 1C	
Salinity	Correlative	Specific Conductivity Meter	0.1 ppt	Field Dups ± 0.2ppt	
Dissolved Oxygen	Correlative	Modified Winkler Titration/Hach OX2P	0.5 ppm	Field Dups ± 0.5 ppm	
Fecal coliform	**	Standard Method Membrane Filtration with m-FC Difco Agar	1 fc/100 ml	Lab Dups 30%"	
Enterococci	**	Standard Method 1600 w/ mEI media, EPA	1 /100 ml	Lab Dups 30%"	
E. Coli	**	Standard Method 1600 w M-tech media, EPA KF Strep Media	1 /100 ml	Lab Dups 30%" Trip Blanks	
Nitrate + Nitrite-	Essential	LACHAT Autoanalyzer[a] (Cd Reduction)	0.1 µM	Lab/Field Dups ± 10%	85%-115% of spike
Ammonium-	Essential	Indophenol[b]	0.1 µM	Lab/Field Dups ± 10%	85%-115% of spike
Orthophosphate-	Essential	Molybdenum Blue[c]	0.05 µM	Lab/Field Dups ± 10%	85%-115% of spike
Total Dissolved Nitrogen	Essential	Persulfate digestion[d]	0.5 µM	Lab/Field Dups ± 20%	80%-120% of spike
Particulate Nitrogen & Carbon -	Essential	Elemental analysis[f], 440.0	0.5 µM	Field Dups ± 20%	95%-115% of check std
Total Phosphorus	Essential	Persulfate Digestion	0.5 uM	Lab/Field Dups ± 20%	80%-120% of spike

** samples to be collected only where bacterial contamination has been identified.

a Standard Methods 19th Edition, Method 4500-NO3-F using Lachat Autoanalysis procedures based upon:
Wood, E., F. Armstrong and F. Richards. 1967. Determination of nitrate in sea water by cadmium copper reduction to nitrite. J. Mar. Biol. Ass. U.K. 47:23-31.
Bendschneider, K. and R. Robinson. 1952. A new spectrophotometric method for the determination of nitrite in sea water. J. Mar. Res. 11:87-96.

b Standard Methods 19th Edition, Method 4500-NH3-F and Schneider, D. 1976. Determination of ammonia and Kjeldahl nitrogen by indophenol method. Water Resources 10:31-36.

c Standard Methods 19th Edition, Method 4500-P-E Murphy, J. and J. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27:31-36.

d Standard Methods 19th Edition, Method 4500-Norg-D D'Elia, C.F., P.A. Steudler and N. Corwin. 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. Limnol. Oceanogr. 22:760-764.

e Parsons, T.R., Y. Maita and C. Lalli. 1989. Manual of Chemical and Biological Methods for seawater analysis. Pergamon Press, 173 pp.

f Perkin-Elmer Model 2400 CHN Analyzer Technical Manual.

g Standard Methods 19th Edition, Method 4500-P-B.5, persulfate digestion and assay as orthophosphate.

Watershed Nitrogen Loading Model
The watershed loading model will be checked in sub-watersheds where the stream discharge can be expected to be unattenuated (for example as was done in upper Mashapaquit Creek in Falmouth). These circumstances are predictable, but do not occur in each embayment. However, they are frequent enough that we should be able to perform this type of confirmation at least once in each embayment cycle. The predicted nitrogen load should be within 10% of the measured load.

B.3.8 Instrument Calibration and Frequency Procedures

Sampling under the Watershed Nitrogen Loading Task is limited to instrument measurements for determination of stream flow and nutrient analysis.

Stream Flow and Nitrogen Load
Instrumentation deployed or utilized as part of the stream gauging program are factory calibrated. The factory calibration is checked for the Marsh McBirney Flow mate 2000 velocity meter by placing the velocity probe into a test tank containing still water. The velocity meter probe is mounted on a sled that runs the length of the test tank at a constant speed. The speed of the sled is varied in order to check the velocity meter function at low, medium, and high flow rates. Sled runs should be conducted at speeds that capture the range of flow rates that are encountered in the field program. Four sled speeds have been traditionally used in previous SMAST studies to check the calibration of the velocity meter (2.0 cm/s, 20cm/s, 40cm/s, and 80cm/s). Multiple repetitions at a selected sled speed are performed. A three to ten minute time interval is typically used between runs to allow the water in the test tank to return to still conditions. Potassium permanganate is introduced to the tank between the runs at higher speeds to check that the water in the test was sufficiently still to begin the next run.

The velocity meter calibration check is begun by running the test tank sled at the lowest check speed of interest and then increasing the speed of the calibration check runs incrementally until the highest check speed is reached. Afterwards, the lowest speed is re-run to check that instrument drift is not occurring. If a drift of more than 5% is encountered the instrument is sent back to the manufacturer for maintenance.

Water level loggers are factory calibrated prior to the start of the field season. Calibration for these sensors is the same as for the tide gauges in Section B.2. In addition, each probe is field verified each time a velocity profile is being run by measuring the height of water over the probe with a measuring tape and comparing the manual measurement with the instrument measurement. Manual measurements are subsequently plotted against instrument measurements and simple linear regression analysis is performed on the data to determine the linear relationship. The calibration is acceptable if the $r^2 > 0.98$.

Laboratory analytical instruments are calibrated for each analytical run and standards are run as part of the Facility's analytical process **(see B.3.6 & B.3.7)**. The instruments are also serviced by factory representatives if they fall outside of factory specifications. Balances and spectrophotometers are checked weekly with calibration standards.

B.3.9 Data Acquisition Requirements

For the location of stream sites, U.S.G.S. topographic maps are used to identify site locations (sites are GPS referenced for input into GIS).

Rainfall data is needed as corroborating data for the stream program. This data (date and amount) is obtained by the Stream Technical Lead from: is from the Town of Falmouth (via the WHOI WEB site), OTIS Air Force Base, Massachusetts Cranberry Station in Wareham, City of New Bedford, and other sources as they are identified.

Daily temperature and wind records may be required for some studies and they can be obtained from the same sites. Temperature and wind data are sampled at high frequency, generally continuously and then integrated into max/min and average statistics. The selected meteorological sites are all used for research or forecasting purposes.

B.3.10 Data Management

Watershed land-use will be presented both in maps and in spreadsheet formats. The GIS information, spreadsheets and any associated digital records will be help on CD-ROM with copies with the Land-use Technical Lead (Ed Eichner), the Technical Coordinator (R. Samimy) and with the Technical Manager (B. Howes) in the SMAST Project Library.

Stream flow and nutrient data will be recorded on field data sheets and kept in embayment specific notebooks **(B-I).** Data is recorded using the field data sheets while on-site at the time the measurements are taken and in laboratory notebooks at the Coastal Systems Analytical Facility (both data and chain of custody forms are filed). The stream Technical Lead will be asked to check that all data is accurate and legible before making copies for Technical Coordinator and SMAST Project Library. All data is reviewed by the Technical Manager. The nutrient sampling portion of the program requires that Chain of Custody forms (COC) be filled out as the samples are delivered at SMAST. Each COC is checked as samples are received. The stream flow and nutrient data will be stored on CD-ROM with copies held by the Analytical Facility, the Stream Technical Lead and the Technical Manager at the SMAST Project Library. Hard copies of data are also maintained by the same persons.

Nutrient Analytical data:
Raw data is maintained in duplicate notebooks. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards. The results will be reported in terms of concentration, as means and standard errors. All data are subject to 100% check at all stages by the Estuaries Project Technical Director (B. Howes), the technical lead in N-regeneration (D. Schlezinger), the Coastal Systems Lab Manager (P. Henderson), and the Lab Coordinator for water quality monitoring (D. Goehringer). All data reported are reviewed to check for errors in transcription, calculation, or computer input. If data points are judged to be aberrant, the reserved sample will be reanalyzed. Data are also reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, are used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

The watershed loading model is held in spreadsheet format, which includes the land-use and loading data for each sub-watershed to an embayment. The model will be held on CD-ROM and in paper copy at three locations: (a) Cape Cod Commission, (b) Technical Coordinator, SMAST, (c) Technical Manager in the SMAST Project Library.

B.3.11 Preventative Maintenance for Field Equipment

The only field equipment used in the watershed nitrogen loading task is associated with the stream flow measurements.

Watershed Land Use Analysis
No field equipment associated with this sub-task.

Watershed Stream Flow and Nitrogen Load
Preventative maintenance on the water level loggers deployed in streams for the continuous measurement of stream water height is limited due to the nature of the instrument itself. Field maintenance requires checking the installation to confirm that sediment is not accumulating on top of the water level probe. Additionally, batteries that power the water level loggers must be replaced every three months for proper function of the instrument.

When a water level logger is retrieved from a stream at the end of a measurement period, it is brought back to the coastal systems lab and inspected for moisture accumulation. The probe is placed in a test tank at SMAST to confirm that it is recording water level accurately and precisely. The probes are cleaned and the logging portion of the instrument is wrapped in a breathable plastic baggy to add an extra layer of protection against the elements.

The current meter is calibrated at the factory and periodically checked in a research flume (at WHOI) during the field season. Batteries are replaced every two months to ensure adequate power in the field. The instrument is stored dry as per manufacturer specifications and no special storage procedures are recommended by the company. When not in use all field equipment is stored in dry heated storage.

Watershed Nitrogen Loading Model
No instruments are associated with this sub-task.

B.4 Nitrogen Regeneration Within Embayments

Overview: In addition to “new” nitrogen entering the estuary from the surrounding watershed, nitrogen is recycled within the sediments and watercolumn. This recycled nitrogen adds directly to the eutrophication of the estuarine waters in the same fashion as watershed inputs. In some systems that the Estuaries Project Technical Team have previously investigated, recycled nitrogen can account for about half of the nitrogen supply to phytoplankton blooms during the warmer summer months. It is during these warmer months that estuarine waters are most sensitive to nitrogen loadings. **Failure to account for this recycled nitrogen generally results in significant errors in determination of threshold nitrogen loadings.** In addition, since the sites of recycling can be different from the sites of nitrogen entry from the watershed, both recycling and watershed data is needed to determine the best approaches for nitrogen mitigation.

The organic rich nature and relatively shallow waters of coastal systems like many of those on Cape Cod result in sediments having a significant role in system biogeochemical cycles. Organic matter deposition to sediments, hence benthic respiration, tends to decrease with increasing depth of overlying waters due to interception by watercolumn heterotrophic processes. The result is that Harbor respiration rates are typically many times higher than in the adjacent offshore waters. With stratification of harbor waters, sediment metabolism plays a major role in bottom water oxygen declines (an ecosystem structuring parameter).

The critical period for determining sediment nitrogen regeneration is during the warmer summer months (July-August) when the systems are most sensitive to nitrogen inputs. This is also the period of minimum dissolved oxygen and habitat quality and therefore the critical period for management. Sediment nitrogen regeneration will be determined throughout each embayment during this most sensitive summer interval (July-August) for parameterizing the site-specific water quality model.

B.4.1 Data Quality Objectives for Measurement Data

The data quality objectives have been selected to fit with the goals of the Sediment Regeneration Program of the Estuaries Project. The field data collection under this program involves water quality samples and observations during sediment collections. Data is also collected during the sediment incubations at a shore-side field lab and in the analysis of sampled waters at the SMAST Facility. The data quality objectives have been selected to account for the spatial and seasonal nature (summer) of sediment regeneration rates typical of the estuarine systems of southeastern Massachusetts. The methods and approaches establish the criteria for evaluating both data collected by the Estuaries Project and existing data being evaluated by the Technical Team for inclusion into Project database **(see B-II)**. All data must meet the required levels of precision, accuracy, and detection limits.

The sediment regeneration program uses accepted methods for low level analysis in saltwater. These methods are accepted by the best marine research laboratories in the United States. EPA or Standard Methods techniques are employed by the SMAST laboratory when available. All methods have been inter-calibrated with a variety of methods and with various certified laboratories (freshwater only) and marine laboratories. Minimum performance criteria are listed in **Table B.4-1**, although the methods used in the program generally exceed these minima. The acceptable criteria for field blank cleanliness is generally a reading less than the detection limit. In occasional instances where high sensitivity methods are employed, the field blank must be less than 10% of the sample value.

Table B.4-1. Minimum Objectives for Sediment Regeneration Parameters

Parameter	Matrix[a]	Field Precision	Laboratory Precision	Accuracy	Detection Limit
Nitrate + Nitrite	1	<20% RPD[b]	<10% RPD	85%-115% of matrix spike	0.25 uM
Ammonium	1	<20% RPD	<10% RPD	85%-115% of matrix spike	0.25 uM
Orthophosphate	1	<20% RPD	<10% RPD	85%-115% of matrix spike	0.1uM
Dissolved organic N	1	<20% RPD	<10% RPD	85%-115% of matrix spike	1 uM
Dissolved Oxygen[b]	1	$\pm$0.25 mg/L	$\pm$0.1 mg/L	1% of air equilibration	0.2 mg/L
Temperature	1	$\pm$0.25 C	$\pm$0.1 C	$\pm$0.2 C	-10C – 40C
Salinity	1	$\pm$0.2 ppt	$\pm$0.1ppt	$\pm$0.2 ppt	0.3 ppt
1 – saltwater					

[a] 1 = saltwater
[b] dissolved oxygen is kept above 4 mg/L in these studies
Note: These parameters are measured by the Coastal Systems Analytical Facility at SMAST

Analytical requirements for sediment regeneration nutrient assays:
Complete standard curves are generated for each analytical run. If more than a 10-fold range of concentrations are encountered in the samples, then both a high and low standard curve is created. In all cases the standards are prepared new each day and are chosen to give at least 5 points over the sample concentration range. Standards well above the sample range are not used. Nitrate+Nitrite (run in duplicate) by autoanalysis has additional standards run before and after every five (5) samples. Failure of these additional standards (run as samples) to agree within 10% of their known value halts the assay line for complete recalibration and the re-running of the last sample set.

For nitrate+nitrite, dissolved ammonium, dissolved organic nitrogen, and ortho-phosphate, non-automated assays are all run in duplicate (at a frequency of at least 10% of the samples) with a <5% tolerance between duplicates required for acceptance.

After completion of analyses, remaining sample is frozen, for possible reanalysis if required. Oxygen analyses are performed within the headspace overlying the sediments using a stirred oxygen electrode. The electrode is calibrated at known oxygen concentrations, at the incubation temperature and salinity prior to and after each measurement. The calibrated electrode reading must be within 0.2 mg/L of the standard for a headspace measurement to be accepted.

Precision

The precision of each laboratory chemical assay needs to have been determined from duplicate assays of five standards. The field precision is from duplicate assay of five blind field duplicates. The precision is calculated as the relative percent difference (RPD). An additional estimate of precision is determined from the R^2 of the linear regression of each set of standards (N>5).

Accuracy

Accuracy is determined from the analysis of standards for the standard curves and use of Performance and Evaluation Samples (commercially available). Accuracy is determined as the RPD of the assay of five standards run as samples within a series of analytical runs. This is compared to the RPD of five sets of Performance and Evaluation Samples. In addition, the accuracy of the method within the sample matrix is "checked" using the results and RPD of five matrix spikes experiments (standard additions) for comparison to the results and RPD of the standards, where appropriate.

Measurement Range

The usable measurement range for each chemical assay is only within the linear range as determined from least squares linear regression of laboratory standards. Concentrations above the linear range require standard dilutions for acceptable analysis. Since high values can be readily diluted and re-assayed the same day, the upper range of measurement is variable. Sample dilutions attempt to bring the concentration of the diluted sample into the middle of the linear range for the assay. The natural range for any analyte is typically less than 1000 fold.

Representativeness

The goal of the sediment nitrogen regeneration program is to provide nutrient inputs from sediments to the overlying waters of coastal embayments. The sampling points will be selected to encompass the tributary sub-embayments and to be representative of system sediment distribution. Sampling will focus on summer when embayments are most sensitive to nitrogen inputs and regeneration rates are highest.

Comparability

The results from each sediment nitrogen regeneration program will be directly comparable to each other. In addition, since these are accepted methods, they will be directly comparable to other studies conducted by EPA in other regions and other groups.

Completeness
The ultimate goal of the sediment regeneration task is to obtain data for determination of summer nitrogen inputs from sediments for the water quality model and to provide comparable data for each estuarine system in southeastern Massachusetts. This both provides the needed site-specific data and enables both inter- and intra-estuarine comparisons using consistent and reliable methods of sample collection and analysis. Completeness is gauged as the number of actual measurements divided by the number of planned measurements times 100%.

B.4.2 Documentation and Records

Field data associated with the collection of the sediment cores will be recorded on field data sheets to be kept in embayment specific notebooks **(B-I).** Data will be recorded on the field data sheets on-site at the time the measurements are taken. Similarly, data collected during the incubation of the sediments at the shore-side facility is recorded in field notebooks. Data associated with the handling and analysis of the resulting nutrient samples is kept in laboratory notebooks at the Coastal Systems Analytical Facility (both data and chain of custody forms are kept on file).

Nutrient Analytical data:
Raw data is maintained in duplicate laboratory notebooks. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards.

B.4.3 Sampling Process Design

Sediment nitrogen regeneration will be determined throughout each embayment during the most sensitive summer interval (July-August) for parameterizing the site-specific water quality model. Rates of oxygen uptake and nutrient release are made incubating undisturbed sediment cores for ca. 24-36 hours at *in situ* temperature.

Sediment cores (15 cm id) will be collected by SCUBA divers or in very shallow waters from a small boat. Cores are maintained from collection through incubation at *in situ* temperatures. Temperature control is maintained through mixed circulating water baths and constant temperature monitoring.

Bottom water (1-2 meters above bottom) is collected by submerging a 20 liter acid leached polycarbonate container from the region of each core site. The container is capped and returned to the field laboratory, filtered (ca. 1 um) and used to replace the headspace water of the flux cores prior to incubation. The water overlying the sediment is gently mixed with a magnetic stirrer and the headspace is sealed with a gas-tight closure fitted with sampling ports during incubation. Bottom water samples for water quality assays (nitrate+nitrite, ammonium, dissolved organic nitrogen, particulate organic nitrogen/carbon, ortho-phosphate, chlorophyll a/pheophytin a, salinity) are collected, held and assayed as in Section B.1. These data provide interpretive information for the sediment program, but become part of the water quality “monitoring” database.

The time series measurements of total dissolved nitrogen, nitrate+nitrite, ammonium and ortho-phosphate and dissolved oxygen made on the water overlying each sediment core sample allows calculation of the rates of nutrient and oxygen exchange. Exchange rates are determined from linear regression of analyte concentrations through time. The rate of oxygen uptake is similarly determined in order to support (1) evaluation of the sensitivity to oxygen depletion of each embayment area under periodic stratification, (2) ranking of sediments as to organic matter deposition rates (not possible using organic content), and (3) parameterization of nitrogen models. Water column oxygen uptake rates will also be determined at each core site on at least three dates.

Sampling sites within an embayment are distributed relatively uniformly from the upper tributary sub-embayments to the tidal inlet. When collecting a sediment sample, divers avoid small localized disturbed areas (mooring, rocks, single large shells, etc.). An attempt is made to collect samples that are representative of the condition of a general area, based upon visual survey by the SCUBA divers and observations from the boat when possible. During sampling the location is noted both using land marks on an aerial photo or USGS topographic map and by GPS. Temperature of bottom water and sediment characteristics are recorded (descriptions of macrophytes, infaunal burrows, epifauna, and sediment oxidation conditions, grain size, organic content) being made in the field and again in the laboratory as appropriate.

Typically up to 24 sites will be measured in the more complex systems and between 4-12 in the more typical and simple systems. Duplicate sediment samples are collected and incubated at 10% of the sites within an embayment.

The results allow the spatial pattern and rate of nutrient inputs from the sediments to the water column to be entered into the nutrient model. From our experience, sediment regeneration during the summer is a large and important source of nutrients Ramsey et al. 2000, Howes and Taylor 1990) supporting both phytoplankton and macroalgal blooms in embayments throughout Southeastern Massachusetts.

B.4.4 Sampling Methods Requirements

The concept in determining sediment nutrient regeneration rates is to collect an undisturbed sediment sample and incubate it under in situ conditions to allow natural exchange of nutrients between the sediment and overlying water under controlled conditions. The approach and methods which we employ in this program were also used by Estuaries Project Technical Team members for numerous estuarine studies including the MWRA HOM Program (Combined Work/Quality Assurance Project Plan, MWRA Enviro. Quality Dept. Misc. Rpt. No. ms-36).

Benthic nutrient flux cores (6" diameter) are collected by diver and maintained at in situ temperatures until returned to the laboratory. All of the sediment incubations will be performed immediately upon return. Estuary Project Technical Team members have all of the equipment required for this purpose and have routinely conducted these incubations in a variety of field conditions (including a remote interior site in Antarctica). Baffles and appropriate anti-mixing procedures are used during the transport of the cores. While much effort is generally spent in achieving highly accurate chemical assays (accuracy to 10%) to determine flux rates, handling of the sediment cores themselves (the source of the fluxes) is generally not well controlled and yet can create several fold errors in rates. In fact, our long experience in these measures in a variety of coastal sediment systems indicates that core handling can be a major source of error in benthic nutrient flux measures. For these reasons, incubations are conducted at a shore-side site to avoid overland transport of sediment samples.

Upon arrival at the shore-side field laboratory sediment cores are inspected for any surface disturbance or large megafauna (for example crabs or fish) which cause rejection of these cores. Acceptable flux cores are then sealed from the atmosphere with machined core tops fitted with magnetic stirrers that gently mix the overlying water without disturbing the sediment surface. Oxygen will be determined using an Orbisphere meter and electrode (the probe fitted through an opening in the core top) calibrated at 100% and 50% of atmospheric equilibration at the temperature and salinity of the headspace water of the cores. The headspace of the cores from each of the seven stations will be replaced with 0.22 micron filtered water (collected from each core site). Subsamples of the filtered water will be incubated to control for oxygen and nutrient changes in the headspace not associated with sediment flux. In all cases the incubation will continue until a significant flux is detected or to 36 hours. A “significant flux” is defined as one where the least squares regression of the headspace analyte concentration over time has a slope different from zero. The headspace will be set so as to maximize the signal and minimize the incubation time (ideally 18 hours).

At least four to five time points (plus time zero) will be conducted per core incubation. Dissolved oxygen will not be allowed to decline to less than 50 percent of air equilibration. Since oxygen disappearance rates may exceed those of other solutes, we will continue the incubations after completion of the oxygen uptake assay by aerating the headspace until the solute flux assays are completed. At each time point, headspace water will be removed through a port in the gas tight headspace with equal replacement with the setup water; samples are immediately filtered (Millipore 0.22 micron in-line filtration) into acid leached 60cc polyethylene bottles upon removal **(Table B.4-2).** Our system allows water removal without even brief pressure changes to the headspace (negative pressures can increase fluxes in some incubation systems). All fluxes will be adjusted for water removals and measured activities within the headspace water.

Table B.4-2. Sediment Regeneration, Nutrient Parameters

Parameter	Matrix[a]	Sample Volume/ Container	Maximum Holding Time	Field Processing/ Preservation	Units
Nitrate + Nitrite[b]	1	60 ml polyethylene acid-washed	28 days (frozen)	Field filter, store dark in lab -20°C	μg/l
Ammonium	1	60 ml polyethylene acid-washed	24 hours (4C)	Field filter, store on ice in dark	μg/l
Orthophosphate	1	60 ml polyethylene acid-washed	24 hours (4C)	Field filter, store on ice in dark	μg/l
Dissolved Organic Nitrogen	1	1L polyethylene acid-washed	24 hours	Field filter, store on ice in dark	μg/l
Dissolved Oxygen	1	none	none	Direct DO Meter Assay	mg/l
1 – seawater					

[a] 1 = saltwater
[b] USGS Central Laboratory had determined that freezing filtered samples for nitrate+nitrite is acceptable, without acidification (Avanzino and Kennedy 1993).
Note: These parameters are measured by the Coastal Systems Analytical Facility at SMAST

Ammonium, nitrate + nitrite and ortho-phosphate and dissolved organic nitrogen (and oxygen) will be analyzed for each of the time point sample volumes. Temporal changes in headspace concentrations will be used to calculate flux rates. The time-course measures will be used to ensure calculations from linear increases.

Samples for ammonia, nitrate/nitrite, and phosphate will be analyzed against reference standards having nutrient concentrations bracketing those of the samples. Standards will be analyzed daily, and checked for linearity (r^2 >0.99) and acceptability of blanks. All standards and blanks are run in duplicate. The dissolved oxygen meter will be calibrated against air-saturated water and the calibration will be checked prior to each oxygen measurement. Deviations from 100% saturation will be noted and appropriate corrections will be applied to the data following the manufacturer's manual. Nutrient samples will be analyzed in conformance with the same standards as applied to the nutrient water quality monitoring program (B.1) and stream program (B.3).

B.4.5 Sample Handling and Custody Requirements

Measurements of benthic nutrient flux will be conducted by the measurement of oxygen and nutrient flux across the sediment/water interface in cores collected from throughout each embayment system. Cores are collected by diver and maintained at in situ temperatures on board the vessel until return to the shore-side field laboratory. Incubations will be performed at a "field" laboratory very near the ship landing in order to prevent disturbance to the cores in transit. All of the sediment incubations will be incubated immediately upon return to the remote field laboratory. The potential for disturbance to the sediment matrix of the cores due to transport over land (even a short distance) requires this procedure. It is nearly impossible to prevent vibrational mixing of the surficial sediment matrix during long distance transport over land. The problem with benthic flux measurements is that both disturbed and undisturbed cores yield linear rates, the only difference being that highly disturbed cores sometimes show less inter-core variance. Baffles and appropriate anti-mixing procedures will be used during the transport of the cores. While much effort is generally spent in achieving highly accurate chemical assays (accuracy to 1%) to determine flux rates, handling of the sediment cores themselves (the source of the fluxes) is generally not well controlled and yet can create several fold errors in rates. In fact, our long experience in these measures in a variety of coastal sediment systems indicates that core handling is the single major source of error in benthic oxygen and nutrient flux measures.

Sample analyses are performed for most parameters by the Coastal Systems Analytical Facility at SMAST. Samples are transported to the laboratory in coolers on ice. The methods employed are the standard methods of research level environmental laboratories. The methods used by the laboratory have been through many EPA and other agency reviews as part of QAPP procedures over the past 2 decades (5 years at SMAST, 15 years Woods Hole Oceanographic Institution).

Samples are logged-in upon delivery to the SMAST Coastal Systems Laboratory based upon field logs and Chain of Custody forms prior to signature by the authorized laboratory staff member. Staff are on-call 24 hours when field teams are sampling, both to assist in any sample handling issues which might arise and to allow drop-offs and assay within the proscribed holding times. During log-in, sample integrity and clarity of label are checked and any unusual sample characteristics (identified by visual inspection or information from sample courier) noted on the COC and in the appropriate laboratory notebook. All frozen and/or archived samples are stored in a freezer (-20^{o}C) accessible only to authorized laboratory personnel. The laboratory analysts are responsible for the samples from arrival to analysis and data entry.

Some of the sampling data is observational or collected by instrument (i.e. dissolved oxygen and therefore the information enters the laboratory via field data books. However, the nutrient sampling requires the transport of water samples to laboratories and therefore has additional documentation and handling requirements to ensure sample and information integrity.

All samples collected for nutrient analysis are labeled in the field with Embayment name, program name (i.e. Sed Flux), Sample ID, date (m/d/y), time of collection, and any other specialized information. Identical information is recorded on a data sheet/chain of custody, which also include notes as to environmental conditions, problems encountered, names of personnel, etc. Samples are all held on ice in coolers from collection through transport to SMAST. Upon reaching the SMAST laboratory, all samples are cross-checked to the COC's and recorded by lab personnel. Copies of the sample list, COC's and data sheets are made and kept by the laboratory, the sediment regeneration Technical Lead, the Technical Coordinator and in the SMAST Project Library.

B.4.6 Analytical Methods Requirements

Sampling under the Sediment Regeneration Task includes analysis of headspace water samples for nutrients and dissolved oxygen measurements by electrode in the sediment incubations. In addition, field water quality samples collected from the fill water sites are analyzed under requirements of Section B.1 and are part of the water quality monitoring database.

Sediment incubation water samples will be assayed for nitrate+nitrite, ammonium, dissolved organic nitrogen, and ortho-phosphate by the Coastal Systems Analytical Facility at SMAST. Headspace dissolved oxygen will be assayed during the incubations using a YSI meter with a stirred BOD oxygen electrode. The analytical methods and quality control samples are listed in Table B.4-3, below.

Analytical procedures used in this program have been tailored to the specific chemical environment of coastal waters, i.e. variable salinity and analyte concentration ranges of 1000 fold. The procedures used are those commonly employed by the SMAST Coastal Systems Program for research on coastal processes. The analytical methods are being, or have been, used by SMAST in the measurement of water quality in a variety of monitoring programs such as: the USGS Namskaket Marsh Project (required intercalibration with USGS Central Lab), MWRA-HOM Program, Falmouth PondWatch, Pleasant Bay Alliance, USAID Water Quality Program-Jamaica, MCZM Wetlands/Stormwater Monitoring Program, Assabet River TMDL Study, RIDEM-Greenwich Bay Study, WHOI Nantucket Harbor Monitoring Program, Martha's Vineyard Coastal Pond Monitoring Program (MVC), and many others. These programs over the past 15 years have QAPP's and most of them have required acceptance by either EPA or Massachusetts DEP.

B.4.7 Quality Control Requirements

The nutrient analyses used in the sediment regeneration program follow standard laboratory procedures. In the analysis of incubation water samples, for each chemical assay, a complete set of standard curves is generated for each analytical run. In addition, reagent blanks and standards are prepared and analyzed with each new batch of reagent. These blanks are compared to previous data on blanks to evaluate the potential of contamination and the standard curve compared to previous records. If this initial blank and standard curve is deemed satisfactory, samples using the new reagent batch can then analyzed. Calibration blanks are prepared and analyzed simultaneously with the creation of each standard curve that is created for each sample series. If more than a 10-fold range of concentrations is encountered in the samples, then both a high and low standard curve is created. In all cases the standards are prepared new each day and are chosen to give at least 5 points over the sample concentration range. Least Squares Linear Regression is used to calculate the standard relationship and a minimum $R^2 = 0.99$ is required for acceptance. Standards well above the sample range are not used. Nitrate+Nitrite (run in duplicate) by autoanalysis has additional standards run before and after every five (5-6) samples. Failure of these additional "check" standards (run as samples) to agree within 10% of their known value halts the assay line for complete recalibration and the re-running of the last sample set. These "check" standards are used to adjust the calculated sample values for instrument efficiency.

Nitrate+nitrite, dissolved ammonium, dissolved organic nitrogen, and ortho-phosphate are all assayed in duplicate at a frequency of more than 15% of the samples and with a <5% tolerance between duplicates required for acceptance. After completion of analyses, remaining sample is frozen, for possible reanalysis if required (and appropriate).

Spiked samples are periodically analyzed as analytical checks in dissolved ammonium, nitrate+nitrite, dissolved organic nitrogen and ortho-phosphate assays. Spiked samples are not widely run, as the standards are made up in the same matrix as the samples. Greater numbers of spiked samples are sometimes run as unknowns" similar to field duplicates. Recovery of spikes must be within 15%-20% of expected to meet QA.

As available Performance and Evaluation Samples (Ultra Scientific Inc.) for the nutrient assays will be purchased and run during the course of this study. These data will be used to evaluate the accuracy of the SMAST laboratory.

Table B.4-3. Analytical Procedures/Quality Control Samples

Parameter	Site	Method	Detection Limits	QC Samples	Acceptable %Recovery
Temperature	Core Headspace*	Thermister -10 °C to 40°C	0.1 C	Field Dups	
Salinity	Core Headspace	Specific Conductivity Meter	0.1 ppt	Field Dups $\pm$ 0.25ppt	
Dissolved Oxygen	Core Headspace	Dissolved Oxygen Electrode/Meter	0.1 ppm	Field Dups $\pm$ 0.5 ppm	
Nitrate + Nitrite-	Core Headspace	LACHAT Autoanalyzer[a] (Cd Reduction)	0.1 µM	Lab/Field Dups $\pm$ 10%	85%-115% of spike
Ammonium-	Core Headspace	Indophenol[b]	0.1 µM	Lab/Field Dups $\pm$ 10%	85%-115% of spike
Orthophosphate-	Core Headspace	Molybdenum Blue[c]	0.05 µM	Lab/Field Dups $\pm$ 10%	85%-115% of spike
Dissolved Organic Nitrogen	Core Headspace	Persulfate digestion[d]	0.5 µM	Lab/Field Dups $\pm$ 20%	80%-120% of spike

* Core Headspace – water overlying the sediment cores during incubation, Core Site – field location during core collection.

a Standard Methods 19th Edition, Method 4500-NO3-F using Lachat Autoanalysis procedures based upon:
Wood, E., F. Armstrong and F. Richards. 1967. Determination of nitrate in sea water by cadmium copper reduction to nitrite. J. Mar. Biol. Ass. U.K. 47:23-31.
Bendschneider, K. and R. Robinson. 1952. A new spectrophotometric method for the determination of nitrite in sea water. J. Mar. Res. 11:87-96.

b Standard Methods 19th Edition, Method 4500-NH3-F and Schneider, D. 1976. Determination of ammonia and Kjeldahl nitrogen by indophenol method. Water Resources 10:31-36.

c Standard Methods 19th Edition, Method 4500-P-E Murphy, J. and J. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Analytica Chimica Acta 27:31-36.

d Standard Methods 19th Edition, Method 4500-Norg-D D'Elia, C.F., P.A. Steudler and N. Corwin. 1977. Determination of total nitrogen in aqueous samples using persulfate digestion. Limnol. Oceanogr. 22:760-764.

B.4.8 Instrument Calibration and Frequency Procedures

The sediment regeneration program requires 2 types of instrumentation: (a) dissolved oxygen equipment for assay during the core incubation and (b) analytical instruments associated with the assay of water samples collected during the incubations.

The dissolved oxygen meter (YSI digital meter with stirred BOD probe) is calibrated during use in a humidified temperature controlled calibration vessel at the temperature of the core incubations. Calibration is conducted before each time point and deviations from calibration measured immediately after. Before each incubation, the meter is multi-point calibrated using air a 10% oxygen certified gas mix and a zero oxygen gas at anticipated field temperatures. This is done to confirm instrument function before deploying to the field site. The probe and meters are maintained according to the YSI manual.

The digital temperature meter and probe are checked with a certified thermometer prior to deployment to the field. Incubation water temperature is monitored with this thermocouple probe and with a standard thermometer (less sensitive, but also cross-referenced to a certified thermometer).

Laboratory analytical equipment (Bausch and Lomb, Genesis Spectrophotometers, Lachat Autoanalyzer, conductivity meters, etc.) is calibrated through the processing of standards in the normal analytical procedure. Meters and electrodes are multi-point calibrated. Laboratory analytical balances are under annual manufacturer service and calibration. SMAST also maintains and routinely uses certified calibration weights and thermometers. The freezer has a chart record of temperature and a temperature alarm to ensure the maintenance of frozen (nitrate+nitrite) samples below -20ºC.

Any field sampling equipment (refractometers, CTD, light meters, etc) are maintained and calibrated under the manufactures specifications and requirements with assistance from the SMAST Laboratory.

B.4.9 Data Acquisition Requirements

For the sediment regeneration program, U.S.G.S. topographic maps and aerial photographs are used to identify site locations. Printed scanned copies with marked site ID's are used by the field team.

Data on sediment types and eelgrass distribution is used, as available. The eelgrass data is available within the Technical Team (C. Costello). Sediment distribution data is sought from dredging permits and existing scientific studies.

B.4.10 Data Management

Field observations and data collected during the sediment incubations will be recorded in field data sheets to be filed in embayment specific notebooks **(B-I).** Data will be recorded on the field data sheets on-site at the time the measurements are taken and in laboratory notebooks at the Coastal Systems Analytical Facility (both data and chain of custody forms). The sediment regeneration Technical Lead will be asked to check that all data is accurate and legible before making copies for Technical Coordinator and SMAST Project Library. All data is reviewed by the Technical Manager. The nutrient sampling portion of the program requires that Chain of Custody forms (COC) be filled out as the samples are delivered at SMAST. Each COC is checked as samples are received.

The field observations, incubation data and laboratory nutrient data will be stored on CD-ROM with copies held by the Analytical Facility, the Sediment Regeneration Technical Lead and the Technical Manager at the SMAST Project Library. Hard copies of data are also maintained by the same persons.

Nutrient Analytical data:
Raw data is maintained in duplicate notebooks. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards. The results will be reported in terms of concentration, as means and standard errors. All data are subject to 100% check at all stages by everyone. All data reported are reviewed to check for errors in transcription, calculation, or computer input. If data points are judged to be aberrant, the reserved sample will be re-analyzed. Data are also reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, are used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

The determination of nutrient and oxygen exchange rates are held in spreadsheet format, which includes both the concentration data and the rate calculations and the field conditions for each site in an embayment. This will be held on CD-ROM and in paper copy at three locations: (a) Sediment Technical Leader, (b) Technical Coordinator, SMAST, (c) Technical Manager in the SMAST Project Library.

B.4.11 Preventative Maintenance for Field Equipment

SMAST laboratory staff will perform a routine inspection and maintenance of field sampling equipment prior to each use. Throughout the season spare parts and replacement equipment is available to keep field operations running smoothly in the event of equipment failure. Temperature control units used in the incubations are periodically serviced by the manufacturer and backup units are deployed to the field site for each incubation.

All equipment (Niskin Bottles, SCUBA gear, pumps, and other mechanical gear) is cleaned, freshwater rinsed and put away in good working order at the completion of a sampling event. Dissolved oxygen equipment is stored as indicated by the manufacturer (humidified membrane). Conductivity meter is rinsed in freshwater and stored as per manufacturer specifications. All mechanical and electrical gear is held in dry heated storage.

B.5 Linked Watershed-Embayment Nitrogen Model

The Linked Watershed-Embayment Nitrogen Model integrates the data and models derived from tasks described above:

- watershed nitrogen loading model (Section B.3)
- embayment regeneration of nitrogen from sediments (Section B.4)
- hydrodynamic model (Section B.2)

In addition, the Linked Model is validated using water quality monitoring data (Section B.1). The model has been compared to other available approaches and had a sensitivity analysis conducted as part of the Estuaries Project Phase I (Howes et al. 2001).

Cumulative Nitrogen Loading Assessment

The ecological health of each of Southeastern Massachusetts' embayments is the integration of the amount and distribution of nutrient inputs from their surrounding upland watersheds, the rate at which these nutrients are removed by tidal flushing and the physical structure of the embayments. This Task focuses on the rate of nutrient input from the surrounding watershed as determined in Section B.3, above.

The total nitrogen input to each embayment (Section B.3) was determined using GIS based land-use analysis and direct measurements of nitrogen discharge from streams. These parameterize a loading model which is consistent with that used by the Cape Cod Commission and the Buzzards Bay Project and has been accepted by the general estuarine community for over a decade. The loading model uses land-use distributions and loading rates specific to each land-use to determine total system loading. The land-use loading terms are all from regional studies conducted in similar aquifer soils. Attenuation of nitrogen during transport through the aquifer and surface freshwater systems of the watershed will be included in the modeling effort. This attenuation of nitrogen is a critical part of the land-use model, in that omitting this process can result in significant errors in the determined nitrogen loads.

The watershed will be divided into regions a) contributing directly via groundwater to the estuaries, b) contributing to freshwater lakes and ponds, c) contributing to streams and rivers. A full land-use loading model will be applied to each of these sub-watersheds (where they exist) to determine the spatial distribution and amount of nitrogen loading to the estuarine portions each watershed-embayment system.

In support of the loading models is data collection on land-use and its validation, physical and biogeochemical data collection on the freshwater lakes and ponds, and the spatial and areal distribution of wetlands. However, the lake/pond and wetlands data will be gathered from existing sources (See Section 5.9, below). The land-use modeling will rely heavily on GIS approaches, but field data collection will also be required. Lake and pond field data collection of stratification, nutrient and chlorophyll levels is important for determining attenuation rates. GIS work will be conducted in collaboration with Town Departments and the SMAST Project Team (and where appropriate with regional agencies CCC or MVC), with field studies directed by SMAST staff scientists.

Embayment regeneration of nitrogen from sediments (Section B.4)
The survey of nitrogen regeneration rates from sediments yields a spatial distribution of nitrogen inputs to the embayment water column from this source. These data are incorporated into the embayment portion of the Linked Watershed-Embayment Nitrogen Model.

Embayment hydrodynamic model (Section B.2)
The calibrated and validated hydrodynamic model (RMA-2) is used as the foundation to the water quality model (RMA-4).

Embayment Water Quality Model
Provides the distribution of nitrogen within an embayment relative to the watershed and sediment inputs, circulation and flushing. The concentrations are spatially and temporally distributed, with variations in concentration predicted through the tidal cycle. The model output is validated by measured nitrogen levels determined from water quality sampling programs. The nitrogen levels in the waters of an embayment (at the appropriate tide stage) are predicted by the water quality model for comparison to the levels determined by the multi-year water quality sampling program. The average percent difference between observed and predicted over the estuary should have an RPD of 5% to 10%.

B.5.1 Data Quality Objectives for Measurement Data

There is no field data collection under this task. The task is an integration of data collected under other tasks into the Linked Watershed-Embayment Model. The watershed nitrogen loading model and the embayment sediment nitrogen regeneration provide spatially applied nitrogen input terms, the water quality monitoring data provides both average summer nitrogen concentration distribution (including offshore boundary conditions) and the hydrodynamic model provides the circulation and flushing within the embayment.

B.5.2 Documentation and Records

The data used in the Linked Model will be fully documented and stored with the model on CD-ROM. However, this input data is generally in spreadsheet format (or as a digital model in the case of the hydrodynamics), so that the original base data will be stored under the individual Task categories (i.e. sediment regeneration, stream flow, etc.).

B.5.3 Linked Model Process Design

The movement or transport of water quality constituents within the waters of an estuary is the result of two primary hydrodynamic mechanisms, advection and dispersion. Advection is the transport of a constituent contained within a fluid flow, as in the case of a tidal estuary, where the flow of sea water in and out over the course of a tidal cycle carries along with it dissolved and suspended matter. Dispersion is a small-scale process that results from the random scattering of particles by the combined effects of shear within the flow (velocity gradients and eddies) and diffusion (concentration gradients and molecular motion). The Estuaries Project will use the RMA-4 Model to account for these processes in order to determine nitrogen transport and distribution within each of the embayments of southeastern Massachusetts. In the RMA-4 water quality model, the advective mechanism of constituent transport results from the hydrodynamic output of the RMA-2 model (Section B.2). Dispersion is included in RMA-4 through the use of coefficients that are set by the user. Non-primary hydrodynamic mechanisms will not be evaluated by the Estuaries Project as a source of transport of water quality constituents. However, some are incorporated into the field measurements. For example, the effects of bioturbation is incorporated into the benthic regeneration studies and the effect of tidal resuspension of nitrogen in particulate form is included in the water quality data used to validate the model. The effects of storm water inflows on estuarine transport tends to be small given the dominance of groundwater in the freshwater hydrologic balance of these systems. Overall, these secondary mechanisms appear to be very small compared to the roles of advection and dispersion in the transport and distribution of nitrogen within these small enclosed or semi-enclosed estuarine systems.

Each RMA-4 application to a specific estuary is calibrated by making adjustments to the dispersion coefficients applied in the model. Typically, values between 10 and 50 m^2/sec^{-1} are observed in relatively quiescent waters and values up to 300 $m^2\ sec^{-1}$ in moderately sized flows (Fischer et al. 1979). By adjusting the longitudinal dispersion coefficients until the model prediction match the field observations, estuary specific diffusion characteristics are determined.

Estimates for the dispersion coefficients (i.e. model calibration) required by the water quality model are determined by evaluating natural dispersion of salt within each embayment. Salinity measurement during slack and/or ebbing tide conditions along the central axis and tributary sub-embayments provides the basis for dispersion estimates. Since salt is a conservative constituent (the only source is the offshore tidal waters and there are no sinks); measurement of salt in combination with an analysis of freshwater inflow allows determination of dispersion/diffusion along the longitudinal axis of each pond. The freshwater stream discharge data is provided by the stream program (Section B.3) and the groundwater inflow is part of the USGS watershed program database.

Using dispersion relationships from salinity analysis, the nitrogen loading data, water quality and hydrodynamic models are integrated in order to generate estimate of the spatial and temporal distribution of total nitrogen resulting from site-specific hydrodynamic processes. The distributions, strengths and discharge locations of nitrogen loads from the watershed and sediment sources are distributed based upon spatial information into the model. The model is validated with both water quality data collected by the Estuaries Project and the long-term monitoring database for each embayment. The model output is validated by measured nitrogen levels determined from water quality sampling programs. The nitrogen levels in the waters of an embayment (at the appropriate tide stage) are predicted by the water quality model for comparison to the levels determined by the multi-year water quality sampling program. The average percent difference between observed and predicted over the estuary should have an RPD of 5% to 10%.

Once the Linked model is calibrated and validated for current conditions in a specific embayment, 4-5 scenarios will be conducted:

- Watershed build-out under the most likely conditions
- Removal of all wastewater inputs
- Unrestricted tidal flow through the inlet (or possibly to specific sub-embayments)
- A site-specific scenario to be determined
- And if tidally restricted wetlands are identified, restoration of tidal flow

B.5.4 Sampling Methods Requirements

There is no field sampling or equipment associated with this task.

B.5.5 Sample Handling and Custody Requirements

There is no field sampling or equipment associated with this task.

B.5.6 Analytical Methods Requirements

There is no field sampling or equipment associated with this task.

B.5.7 Quality Control Requirements

The Linked Model must agree with the observed nitrogen distribution under current conditions to an RPD of 5%-10% depending on the quality of the available long-term water quality baseline. If this is not achieved, additional water quality, input or calibration data may have to be collected. If this occurs, the same stations occupied by the baseline monitoring program will be assayed by Estuaries Project staff, focusing on June-September months. In addition, the watershed nitrogen model will be re-examined seeking missed nitrogen sources or sinks.

<u>Review of Existing Studies and Water Quality and Hydrodynamic Data.</u>
We will perform a review of all existing studies of Southeastern Massachusetts embayments and watersheds. We will review the water quality data and hydrodynamic data and models which have been previously collected for: (1) quality of sampling approach, (2) quality and capability of chemical analysis, (3) quality assurance procedures, (4) completeness, (5) applicability to the nitrogen modeling, engineering and management effort which is the focus of this project. The protocol is presented in **B-II**. The purpose of this data review is to allow incorporation of needed water quality (Section B.1) and hydrodynamic data (Section B.2) to support the Linked Watershed-Embayment Management Approach. The data may include water quality constituents, dissolved oxygen, stage records, bathymetric maps, and circulation data.

B.5.8 Linked Model Calibration

See Section B.5.3.

B.5.9 Data Acquisition Requirements

Baseline water quality data is required for the validation of the Linked Model. This data is being compiled by the Technical Manager and Technical Coordinator from the various monitoring programs in southeastern Massachusetts. The monitoring data that is currently available includes:

Coalition for Buzzards Bay
Falmouth PondWatch
Popponesset Bay Monitoring Program
Pleasant Bay Alliance
Chatham WaterWatch
Three Bays Monitoring Program
Orleans Monitoring Program
Barnstable Monitoring Program
Wellfleet Harbor Monitoring Program
Nantucket Harbor – WHOI Study
Martha’s Vineyard Monitoring Programs
Plymouth Harbor/Eel River Monitoring
Scorton Creek Monitoring Program

Additional data on groundwater inflow rates is to be provided by the USGS watershed effort that is partnered to the Estuaries Project. Data on lakes and ponds will be gathered as available from studies such as the CCC/SMAST Cape Cod lake survey or the National Seashore Lake studies, however, this data is used as correlative to the Linked Model. Wetland data will be acquired (as available) through the DEP wetland mapping program.

B.5.10 Data Management

Data will be transferred by the Technical Coordinator from the Technical Leads for: watershed nitrogen loading modeling, hydrodynamics and sediment nitrogen regeneration, to the water quality modeling Technical Lead and the Technical Manager.

As the information is received by the modeling Technical Lead and the Technical Manager at SMAST, the data is evaluated for completeness and quality. The data is then used to calibrate and validate the Linked Watershed-Embayment Model. The calibrated model is then stored (at a minimum) on CD ROM by the Technical Lead and the Project Technical Manager in the SMAST Project Library.

B.5.11 Preventative Maintenance for Field Equipment

There is no field sampling or equipment associated with this task.

B.6 Habitat Assessment

The nutrient related ecological health of an estuary can be gauged by the nutrient, chlorophyll and oxygen levels of its waters and the plant (eelgrass, macroalgae) and animal communities (infauna) which it supports. The Estuaries Project Technical Specialists will conduct surveys of these parameters during the field data collection part of the 2 year embayment cycle. Additional historic data will be used, as available, to determine trends. These data will be synthesized into an assessment of the systems present health and will also be used for projections of future conditions based upon the water quality modeling effort (Section B.5, B.7). These data will be collected in each of the 89 embayment systems in southeastern Massachusetts.

This Indicator Task involves sediment collections for benthic animals by traditional oceanographic methods (grab sampling or large cores and wet sieving), placement of continuously recording dissolved oxygen sensors at key locations for 30 days and underwater surveys for macrophyte mapping. The macrophyte mapping program will also provide a historic trend analysis for some embayments since the Technical Lead for this sub-task, C. Costello, has been conducting mapping throughout southeastern Massachusetts since 1993.

B.6.1 Data Quality Objectives for Measurement Data

The data quality objectives have been selected to fit with the goals of the Habitat Assessment Project Task of the Estuaries Project and to be relevant to the natural variability of habitat indicators both spatially and seasonally in southeastern Massachusett’s estuaries. The indicator measurements are primarily to map distribution (macrophytes) or to identify and count numbers of organisms (benthic infauna), the instrument program collects analytical data. The minimum performance criteria for inclusion into the habitat assessment program database for the relevant parameters are given in **Table B.6-1**, below.

Table B.6-1. Habitat Assessment Program, field parameters measured & data objectives

Parameter	Method	Detection Limits	Frequency	QC Samples	Acceptable %Recovery
Macrophytes	Video Survey	Individual shoots	1 survey May-Oct.	Spot checks by diver	95%
Benthic Animals	Van Veen Grab or Coring as appropriate Microscope sorting	1 animal	1 survey Aug-Oct	Spot checks by different specialist	95%
Dissolved Oxygen	Rapid Pulse Clark Electrode	0.2 mg/L	15 min. for 1-2 months, July-August	Winkler Titration of water from sensor depth	75 %
Temperature	Bead Thermistor (sensitivity of 0.1^{o}C)	NA	15 min. for 1-2 months, July-August	Calibrated to certified thermometer prior to deployment	75 %
Conductivity/ Salinity	2-electrode platinum conductivity cell 1 cm. Path length	0.1 mS/cm	15 min. for 1-2 months, July-August	Whole water collected at sensor depth	75 %
Depth	Differential Strain gauge transducer	0.02 m	15 min. for 1-2 months, July-August	Calibrated to measured tape level at beginning and end of deployment	75 %
Chlorophyll a	Fixed wavelength fluorometer, 470 nm	0.1 ug/L	15 min. for 1-2 months, July-August	Chlorophyll extraction	75 %

Precision

The precision of each chemical assay is determined by from repetitive assays in well mixed seawater of known composition under standard conditions. The precision is calculated as the relative percent difference (RPD). An additional estimate of precision is determined from the R^2 of the linear regression of each set of standard solutions (N>5).

Accuracy

Accuracy is determined from the analysis of standards for the standard curves. Accuracy is determined as the RPD of the assay of five standards solutions run as samples within a series of analytical runs. This is compared to the RPD of five sets of Performance and Evaluation Samples.

Measurement Range

The usable measurement range for each chemical assay is only within the linear range of the instrument as determined the factory calibration and field checks

Representativeness
The goal of the indicator program is to provide data needed to conduct habitat assessments throughout the sub-embayments of each embayment system in southeastern Massachusetts and to determine changes over the long-term. Benthic infauna sampling sites are paired to the sediment regeneration sites. The results of the indicator program will be compared to previous data sets.

Comparability
The results from each embayment's indicator sampling will be directly comparable to the others within the Estuaries Project. In addition, since these are accepted methods, they will be directly comparable to other studies conducted by NOAA and EPA in other regions and by other groups. The results are also comparable to many national programs and to the EPA Coastal Survey.

Completeness
The ultimate goal of the Water Quality Monitoring Program Task is to obtain comparable data from each estuarine ecosystem, enabling both inter- and intra-estuarine comparisons using consistent and reliable methods of sample collection and analysis. Completeness is gauged as the number of actual measurements divided by the number of planned measurements times 100%.

B.6.2 Documentation and Records

Field data from will be recorded in field books or on standardized data sheets **(B-I)** on-site at the time the measurements are taken. The Technical Leads will be asked to check that all data is accurate and legible before making a copy for the Technical Coordinator and the Technical Manager for the SMAST Project Library. The benthic animal samples require that Chain of Custody forms (COC) be filled out. Each COC is checked to verify the sample id's and locations. A copy of the database is maintained both at the program offices and at SMAST.

B.6.3 Sampling Process Design

The indicator program is composed of 3 basic components:

- Eelgrass and macroalgal surveys
- Benthic Animal Surveys
- Dissolved Oxygen and chlorophyll *a* records from key sites

Sampling will be conducted at long-term baseline water quality monitoring stations and the macrophyte surveys along transects throughout the embayment systems. Sampling will be most intense during the critical warmer months.

Mapping of eelgrass and macroalgal communities will be conducted during the summer months. SMAST has refined these survey and mapping techniques for recent studies in the Town of Chatham and for MA DEP in West Falmouth Harbor. Macroalgal mapping will include distribution. Macroalgae are a natural part of estuarine systems, but become “excessive” under nutrient enrichment. Existing data on the system collected over the past decades will be used to assess changes in distribution or community structure. For Protocol see **B-I**.

Benthic animals are a key indicator of the health of estuarine systems. Benthic sampling and analysis will be performed primarily SMAST staff, who have more than 30 years of experience in Cape Cod embayments. Samples will be collected either by Van Veen Grab (25 cm x 25 cm) or large cores (15 cm id). Samples will be collected and the animals separated using a 300 um sieve. The animals and any remaining particles on the sieve are washed with seawater into 1 gallon jars, preserved with ethanol and the final sorting of the animals conducted under a dissecting scope.

Dissolved oxygen is a critical indicator of nutrient over-enrichment and eutrophication. The problem with quantifying dissolved oxygen conditions stems from the high temporal variability of this parameter. However, determining the level of oxygen depletion and the duration of low oxygen conditions is a key indicator and one with regulatory implications. Therefore, the Estuary Project will deploy ENDECO/YSI 6600 sensor systems in the target embayments throughout July and August of the field data collection year or possibly 2 years. We have extensive experience with using these instruments and they are a routine part of SMAST field Programs. The sensors will also measure temperature, salinity and chlorophyll a. They will be placed within “areas of concern” and other areas throughout each system, as indicated from the long-term monitoring baseline. The sensors will be deployed on fixed moorings generally within the upper reaches of embayments or where baseline water quality monitoring suggests that D.O. depletion may be occurring. The sites will be selected based upon (1) measured dissolved oxygen levels of <4mg/L by water quality monitoring programs or (2) indications based upon algal blooms and circulation that a low dissolved oxygen environment may exist. Sensors will be placed 0.3 m above the sediment surface and will sample at 10-15 minute intervals. Membrane fouling and sensor maintenance will follow manufacturer specifications, but membranes and batteries will be replaced every 30 days.

These water quality and habitat data sets will be synthesized and integrated with the modeling efforts, for both hind and forecasting of habitat quality changes linked to watershed management.

B.6.4 Sampling Methods Requirements

Macrophyte Survey:
Overview: The State of Massachusetts has protected wetlands for over 30 years. During this time, eelgrass bed and *Zostera marina*, has been a relatively unknown wetlands resource. Recognizing this lack of information, the Department of Environmental Protection Wetlands Conservancy Program has conducted a statewide mapping inventory of eelgrass resources over the past 8 years. This mapping inventory was completed using 1:20,000 scale color aerial photography metric and extensive field surveys. The eelgrass resources have been compiled on a 1: 10,000 scale digital orthophoto base map. There are currently over 26,000 acres of eelgrass meadows in Massachusetts. This eelgrass meadow spatial data represents an accurate statewide inventory of the eelgrass resources. Currently, the data is used in project review and project permitting.

During the summer months of 2002, the DEP Wetlands Conservancy Program will conduct field surveys in the prioritized embayments as identified by Phase III of the Massachusetts Estuaries Project. This work will be conducted during the scheduled fieldwork of the Program's ongoing eelgrass monitoring efforts.

The purpose of this study is to continue the project of collecting eelgrass site information in areas where water quality conditions would be expected to adversely impact the eelgrass resources. Data will be recorded and displayed on a digital base map that will include the accurate location of field note information and graphic representation of specific sampling points. Transects will be surveyed by differentially-corrected GPS to provide accurate coordinates for subsequent monitoring efforts. High-resolution underwater digital videography (GPS stamped) will be collected and stored for the specific point and transect sites. This digital imagery will be included in the database and will be available for distribution.

The overall objectives of the Macrophyte sub-task and field protocols are provided in **B-I**.

Benthic Infauna Community:
Sampling of sediments are routinely conducted by the SMAST laboratory for infaunal sampling. Samples are collected by benthic grab, generally Van Veen grab, or diver collected cores), sieved (0.300 mm) and sorted according to species by SMAST Coastal Systems Program benthic ecologists familiar with the needs of the research. There is seasonality in benthic animal populations with the minimum numbers and diversity generally found at the end of the summer (particularly is there is summer hypoxia). Therefore, sampling will focus on late summer and early fall to capture samples

indicative of potential summer stresses. Each station will be located both by visual data on USGS topographic charts and by GPS. All of the procedures employed are standard methods and are currently in use in our laboratory.

Moored instrumentation:
Moorings will be placed at key sites within each embayment to record dissolved oxygen, salinity, temperature and chlorophyll levels. Locations will be identified both using visual references and GPS coordinates.

Dissolved Oxygen: Calibrated oxygen sensors are kept in a protective cap from the time of calibration until field deployment. Humidity is maintained near 100% within the protective cap through additions of distilled water. Sensors are prevented from becoming immersed until deployment thus preventing the growth of performance degrading bio-films upon the sensors surfaces. When instruments are recovered, sensors are rinsed with distilled water and maintained in a 100% humidity environment until post-deployment calibrations are performed at the SMAST Coastal Systems Laboratory. Both pre and post deployment calibrations are performed within 48 hours of field deployment.

Conductivity: Whole water samples are collected after the dissolved oxygen sample in a 1 liter amber bottle after being rinsed with 100 mL of sample. Samples are held in a sealed bottle until analysis by bench top conductivity meter within 48 hours. The meter is calibrated using three certified calibration standards before each use and with a single calibration standard after each use.

Temperature: There is no sample handling requirements for temperature. Pre and post deployment the temperature sensor is checked using a mixed water bath and a certified thermometer.

Chlorophyll: Whole water samples are collected after the dissolved oxygen sample in a 1 liter amber bottle after being rinsed with 100 mL of sample. Samples are held on blue ice and filtered within 12 hours of collection. The sensor operates on fluorescence. The laboratory analysis uses acetone extraction and fluorometric assay, as in section B.1.

B.6.5 Sample Handling and Custody Requirements

Macrophyte Survey:
The macrophyte (eelgrass and macroalgae) survey data is collected digitally in the field and transported to the DEP Mapping Laboratory on disc. No analytical samples are collected, however, when necessary specimens are collected to confirm identification. These samples are collected by grab, net or diver and kept in seawater in a cooler for laboratory identification.

Benthic animal survey:

Sediment samples for benthic animal analysis are wet sieved in the field and the fraction retained on the sieve is transferred to a 1 gallon polyethylene wide mouth jar. The jar is labeled with the embayment name, site id, date/time and lat/long. The samples are preserved with buffered ethanol. These data are also placed upon a Chain of Custody form as the samples move to the SMAST laboratory for sorting.

Moored Instrumentation
The data collected by the moorings is held in memory within the instrument until download in the SMAST Coastal Systems Laboratory. This data carries its own chain of custody and ID's and placement information as a header in the file. However, each instrument has an external ID reference which is entered onto a COC during transport and handling through download.

Dissolved Oxygen: Calibrated oxygen sensors are kept in a protective cap from the time of calibration until field deployment. Humidity is maintained near 100% within the protective cap through additions of distilled water. Sensors are prevented from becoming immersed during transport, thus preventing the growth of performance degrading bio-films upon the sensors surfaces. When instruments are recovered, sensors are rinsed with distilled water and maintained in a 100% humidity environment until post-deployment calibrations are performed. Both pre and post deployment calibrations are performed within 48 hours of field deployment.

Chlorophyll and conductivity: The field samples collected for QC of these instruments are entered onto a COC form and the samples processed through the SMAST Analytical Facility as for other water quality samples.

B.6.6 Analytical Methods Requirements

The macrophyte mapping sub-task does not require analysis. Identifications will be confirmed using the Marine Biological Laboratory Museum collection.

The benthic infaunal samples are assayed at the SMAST Facility. The field collected samples are dyed with a vital stain and preserved with ethanol. The samples are hand sorted under a binocular dissecting microscope and the animals placed in vials of ethanol for later identification and counting. After a sample is sorted, a different technical member checks the sample for "missed" organisms. The harvested organisms are then divided by species and identified based upon standard keys and local museum collections. Most of the identifications are confirmed using the Marine Biological Laboratory Museum collection and the Woods Hole Oceanographic benthic collection. The most used keys are the Woods Hole key to the invertebrates and Gosner's key of invertebrates from Cape Hatteras to the Gulf of Maine. The technical staff conducting the identifications are recognized experts, but confirmations are requested as needed from outside experts in Woods Hole. The sorted organisms are then archived by SMAST.

Moored Instrumentation
The moored instruments are performance checked weekly by collection and analysis of samples from the sensor depth for dissolved oxygen, conductivity, temperature and chlorophyll. Samples associated with the moorings will be assayed at the SMAST Facility.

Dissolved Oxygen: Winkler titrations for dissolved oxygen form the criterion for determining instrument performance. Assays are conducted in the SMAST Coastal Systems Analytical Facility. Triplicate 300 mL dark BOD bottles are filled by peristaltic pump. The inlet tubing is placed adjacent to the dissolved oxygen sensor and after flushing the pump and tubing with three volumes of water the outlet tubing is inserted to the bottom of a BOD bottle. 1 liter of water is allowed to overflow the bottle before the stopper is inserted. Once collected, oxygen samples in BOD bottles are fixed by first adding Manganous sulfate and alkaline iodide azide powders (Hach Company, Loveland, CO) to the sample. After replacing the stopper the bottle is shaken for 3 minutes allowed to rest for 30 seconds and shaken for another three minutes to ensure full reaction of dissolved oxygen with the combined reagents. The precipitate produced by the reaction is allowed to settle to the bottom third of the bottle before the sulfamic acid powder reagent is added. Following addition of the sulfamic acid the sample is shaken until all of the precipitate is dissolved. Sample collection is repeated if at any time air bubbles are introduced into the sample bottle. Samples are stored on blue ice (10C) water sealed in the dark and analyzed within 24 hours of collection. Although Standard Methods indicates that 8 hours is the preferred holding time for dissolved oxygen samples, marine research and monitoring programs (for example the MWRA HOM Program) have determined that fixed samples of coastal waters can be held for more than 24 hours without loss of signal. Holding experiments conducted by the University of New Hampshire (Ted Loder pers. comm.) indicate a loss of less than 1 uM per day for dark water sealed samples at 10^{o}C. Experiments by the SMAST Coastal Systems Group support the UNH findings.

Oxygen determinations are made on 100 mL sub samples analyzed by potentiometric titration using an ABU91 Autoburette (Radiometer America Inc., Westlake, OH). The instrument is calibrated once daily prior to sample analysis by titrating a 100 mL sample of known concentration.

Conductivity: Samples are collected in parallel with the dissolved oxygen water samples, transported at 10^{o}C in the dark in a cooler and assayed in the SMAST Coastal Systems Analytical Facility. Conductivity samples are analyzed on a YSI 3900 Bench top Conductivity meter equipped with a 1 cm cell. Prior to sample analysis the meter is calibrated using a three-point calibration method with a range of standards that brackets the expected sample range. Following calibration the slope of the calibration line is noted and if it differs by more than 2% from the expected slope of 100, then the calibration procedure is repeated until the criterion is met. Samples are analyzed after equilibrating to room temperature.

Temperature: A visual inspection of the mercury column within the certified thermometer is performed prior to use. If the mercury column is separated, the thermometer is not used until continuity of the mercury column is restored and the thermometer recertified. The certified thermometer is used for comparison to the sensor on the YSI/Endeco 6600 sonde in the laboratory during pre and post deployment check out.

Chlorophyll: Whole water samples are filtered and analyzed for Chlorophyll a +Pheophytin a by collection of phytoplankton on membrane filters (0.45 um Millipore) and cold extraction under 90% acetone in the dark. Assay is by fluorometric analysis. Standardization uses "pure" chlorophyll a (Sigma Scientific) and quantification using the trichromatic equations on a scanning spectrophotometer.

B.6.7 Quality Control Requirements

Macrophyte Survey:

Macrophyte survey data will be checked using diver observations at multiple points within an embayment. In addition, the areas with macroalgae will be observed by divers to confirm species and density. Divers will use a percent cover approach to macrophyte density and checks will be performed only occasionally (<5% of transects). The primary QC check will be the detailed revisiting of "point 3" in the video transects as explained in B-I (Eelgrass Survey Protocols). Video transects will also have "cross-over" points where a second determination is made of the same location.

Benthic Animal Survey:

Triplicate grabs will be collected at each site within an embayment. Duplicates will be fully sorted and identified. If the samples differ by more than 30%, the third replicate sample will be sorted. The species identifications will be periodically checked by an independent expert on local fauna, on about 5% of the samples. However, all species of uncertain identification will be confirmed by an independent expert. Cross checks will also be made using museum collections (WHOI and MBL).

Moored Instrumentation:

Dissolved Oxygen: During instrument deployment triplicate BOD bottles are collected by peristaltic pump at the precise depth of the dissolved oxygen sensor to validate sensor operation. Oxygen determinations by Winkler titration are made on sub-samples of the collected BOD bottles according to the above protocol. Instrument output is corrected to the titration data and data between field data validation samplings is adjusted linearly. If instrument and titration values differ by more than 10% then the calibration data is re-examined. If the differences between the types of data cannot be rectified the data is invalidated and the sampling location is re-occupied. The D.O. unit is calibrated in the laboratory pre and post deployment, the in situ samples are collected to validate sensor operation in the field.

Salinity: During instrument deployment whole water samples are collected by peristaltic pump at the precise depth of the conductivity sensor to validate sensor operation. Sample values are compared to the instrument record following instrument recovery. If differences greater than 5% exist between the collected samples, additional field samples are collected and analyzed. If the difference is found in the second set of samples the instrument record the data is invalidated until recalibration is performed.

Temperature: Quality control of temperature is performed at time of calibration. During calibration the sensor is placed in a mixed water bath with a certified thermometer. The sonde sensor must agree with the standard thermometer to within 0.2^{o}C before the sonde can be deployed to the field.

Chlorophyll: The *in situ* response of phytoplankton to excitation wavelengths varies according to many factors that cannot be accounted for individually. The data record will be corrected to a 2 hour (8 measurements) average and differences between discreet samples will be interpolated linearly. Post-hoc screening of the data will exclude any data that is more than $\pm$2 standard deviations from the mean of the previous 8 measurements. Analysis of water samples by acetone extraction and fluormetric analysis will be standardized using “pure” chlorophyll a (Sigma Scientific) and quantification using the trichromatic equations on a scanning spectrophotometer. Calibration follows the protocols for the Turner AU-10 fluorometer for chlorophyll analysis.

B.6.8 Instrument Calibration and Frequency Procedures

Macrophyte Survey
The GPS unit on the linked video system is checked using know reference points at the beginning and end of a day’s survey.

Benthic Infauna Community
Not instruments are used in this analysis.

Moored Instrumentation:
Instruments are deployed for 1 month between laboratory calibrations and downloads. If a 2 month deployment is desired, it will consist of back to back 1 month deployments.

Dissolved Oxygen: Two days before calibration of dissolved oxygen sensors the electrolyte solution and Teflon membrane are replaced according to the manufacturers specifications. Sensors are examined to ensure that no air bubbles are trapped beneath the membrane and that the entire membrane surface is uniform, tight and smooth. With protective cap partially filled with distilled water and loosely affixed to the instrument the instrument is allowed to operate at a normal duty cycle (15 minutes) until the instrument record indicates the sensor is stable over several hours. Following this initial stabilization period, a single point calibration is performed at 100% oxygen saturation in water-saturated air (100% humidity in the protective cap) at the expected average deployment temperature. The calibration is verified before deployment at ambient room conditions. The procedure is repeated following deployment to determine sensor drift.

Conductivity:
After calibrating the oxygen electrode the conductivity cell is calibrated. Single point calibrations are performed prior to every deployment. The sensor is rinsed with deionized water and dried with compressed air. The sensor is lowered into a factory provided 50.0 mS KCl standard and allowed to remain for at least one minute to allow temperature equilibration. While in the "Specific Conductance" mode the sensor output is observed until the readings are stable and then accepting the displayed value finishes the calibration. The cell constant is then checked. The nominal cell constant for this type of sensor is 5.0. If the cell constant resulting from the calibration procedure differs by more than 0.2 the calibration is repeated following probe maintenance. The probe is replaced if the procedure fails twice.

Temperature:
Prior to deployment the temperature probe is compared to a certified thermometer at a temperature near the middle of the range of temperatures expected during deployment (typically 20 ^{o}C - 30 ^{o}C) . Any deviations from the certified thermometer are recorded to correct temperature data following deployment. The probe must agree within 0.2^{o}C before it can be deployed.

Chlorophyll:
Chlorophyll probes are routinely calibrated to 0% fluorescence by blocking the light path to the detector. Further calibration is performed using field samples, which have been filtered and extracted as described in section B.6.6.

B.6.9 Data Acquisition Requirements

Existing historic data required for the trend analysis of eelgrass, is held within the Project Technical Team. This eelgrass data is primarily held within the DEP eelgrass mapping program (C. Costello) and consists of mapping conducted state-wide since 1993.

Current benthic infaunal information will be collected by the Estuaries Project by direct sampling and analysis. Historic data will be used for comparison to present data to determine trends. If the historic data was collected using different methods, then qualitative statements can still be made. For example, the shift from a filter feeding community to a deposit feeding community would be detected even if different methods were employed.

Regional light and rainfall data will be acquired by the Stream Technical Lead from: the Town of Falmouth (via the WHOI WEB site), OTIS Air Force Base, Massachusetts Cranberry Station in Wareham, City of New Bedford, and other sources as they are identified.

B.6.10 Data Management

Data from field observations will be recorded on field data sheets to be retained in embayment specific notebooks **(B-I).** Data is entered on the field data sheets while on-site at the time the measurements are taken and in laboratory notebooks at the Coastal Systems Analytical Facility (both data and chain of custody forms). The appropriate sub-task Technical Lead will be asked to check that all data is accurate and legible before making copies for Technical Coordinator and SMAST Project Library. All data is reviewed by the Technical Manager. The nutrient sampling portion of the program requires that Chain of Custody forms (COC) be filled out as the samples are delivered at SMAST. Each COC is checked as samples are received.

The indicator data sets will be presented both in maps and in spreadsheet formats. The GIS information, spreadsheets and any associated digital records will be held on CD-ROM with copies with the Habitat Assessment Technical Leaders , the Technical Coordinator (R. Samimy) and with the Technical Manager (B. Howes) in the SMAST Project Library.

The macrophyte survey data will follow the QAPP for DEP's on-going mapping program (which we have partnered with), C. Costello. Copies of maps and resultant spatial information will be held in the SMAST Project Library.

The benthic animal data will be held in spreadsheet format for each embayment on CD-ROM in the SMAST Project Library and with the Technical Coordinator.

Water column analytical data associated with the mooring program consists of raw data and synthesized results. Raw data is maintained in duplicate notebooks in the Analytical Facility. Data reduction involves the process of converting raw numbers into data that have direct chemical meaning or can be compared statistically. Calculation to concentration is done in an adjacent column for easy comparison. The calculation is based upon the regression equation calculated from the chemical standards. The results will be reported in terms of concentration, as means and standard errors. All data are subject to 100% check at all stages by everyone.

All data reported are reviewed to check for errors in transcription, calculation, or computer input. If data points are judged to be aberrant, the reserved sample will be reanalyzed. Data are also reviewed for adherence to analytical protocols and to pre-established criteria (e.g., holding times, surrogate recoveries, initial and continuing calibration, matrix spikes, laboratory duplicates, blank contamination). Students t-test for paired samples, analysis of variance, are used for interpretation. Data is transcribed only for the statistical analysis and each point is checked for accuracy. Sample logs associated with field and laboratory custody and tracking are maintained in the project files.

The synthesized mooring data is held in spreadsheet format for site within an embayment. The mooring time-series and check data will be held on CD-ROM and in paper copy at three locations: (a) mooring sub-task Technical Lead (D. Schlezinger, SMAST), (b) Technical Coordinator, SMAST, (c) Technical Manager in the SMAST Project Library.

B.6.11 Preventative Maintenance for Field Equipment

Macrophyte Survey
All appropriate equipment is rinsed with freshwater and stored dry. The survey system is shipped in proper cases. The equipment is the property of the DEP Eelgrass Mapping Program and is maintained at their facility.

Benthic Infauna Community
Not instruments are used in this analysis. Field equipment (Van Veen Grab, cores, sieves) are rinsed in freshwater and stored dry in non-temperature controlled storage.

Moored Instrumentation:
Moored instrumentation is typically laboratory calibrated and maintained at 30 day intervals. When not in use the instruments are held in dry heated storage at the SMAST Coastal Systems Laboratory.

Dissolved Oxygen:
Once a dissolved oxygen sensor has stabilized following a pre-deployment membrane and electrolyte change the “DO charge” value is read from the instrument menu. High charge indicates the presence of AgCl deposits on the silver anodes of the sensor, which compromise the probe response to changing oxygen concentrations. A DO charge greater than +60 is used as the criteria for maintenance. The membrane and electrolyte are removed and the sensor is dried. 15-micron sanding disks, provided by the manufacturer are used to remove the deposits. Following this reconditioning procedure the entire calibration procedure is repeated.

Conductivity:
A brush provided by the manufacturer is inserted into both sensor holes 10-15 times to remove any deposits.

Temperature:
There is no preventative maintenance for the temperature probe.

Chlorophyll:
Prior to deployment the wiper assembly is wiped clean with a soft cloth and proper function is ensured by initiating three wiping cycles. If the wiper assembly does not stop opposite the LED sensors the wiper is replaced. If the new wiper assembly does not stop opposite the LED sensors, then the entire sensor is replaced and the procedure is repeated.

B.7 Synthesis of Modeling and Habitat Assessments

This task collects no additional data but integrates the findings and data from tasks B.1 through B.6. The habitat assessments and thresholds development will follow the guidelines being prepared by the Technical Team for review by DEP before July 1, 2002. The basic concept will be to evaluate the present indicators of water quality and the results of the Linked Watershed-Embayment Model to:

- Determine the present habitat quality in different regions of each embayment
- Determine the temporal trend in habitat health
- Determine the primary causes for the present habitat quality
- Determine likely future habitat quality from the modeling scenarios
- Determine multiple thresholds for differing levels of habitat quality
- Evaluate habitat quality improvement from unrestricted tidal exchange
- Evaluate tidal restoration for identified tidally restricted wetlands
- Recommend restoration alternative which derive from the synthesis

The thresholds and assessment will link nitrogen loading rates to embayment nitrogen levels to habitat quality. Multiple thresholds are necessary, since it is not always possible to produce the highest level of habitat quality throughout every embayment. For example, some systems have naturally nutrient enriched conditions and naturally have not supported eelgrass beds.

B.7.1 Data Quality Objectives for Measurement Data

No data are collected under this task.

B.7.2 Documentation and Records

No data are collected under this task.

B.7.3 Sampling Process Design

No samples are collected under this task.

B.7.4 Sampling Methods Requirements

No samples are collected under this task.

B.7.5 Sample Handling and Custody Requirements

No samples are collected under this task.

B.7.6 Analytical Methods Requirements

No samples are collected under this task.

B.7.7 Quality Control Requirements

No samples are collected under this task.

B.7.8 Instrument Calibration and Frequency Procedures

No samples are collected under this task.

B.7.9 Data Acquisition Requirements

All data is acquired in earlier Project tasks.

B.7.10 Data Management

All synthesis and results will be presented in Estuaries Project Embayment Reports or in specific Technical Memoranda.

B.7.11 Preventative Maintenance for Field Equipment

No samples are collected under this task.

C. ASSESSMENT AND OVERSIGHT

C.1 Assessment and Response Actions

Review of the Estuaries Project field activities and data documentation is the responsibility of the Technical Manager. However, the Technical Manager will be assisted by the Project Technical Team in the review of all field and laboratory activities. The Technical Team will also serve as the evaluation body for the inclusion of previous data collection and water quality monitoring data for inclusion into the Estuaries Project database. The Technical Team, the QA/QC Officer, and the DEP Project Officer will conduct an annual review of the Project Approach, performance and objectives of the overall Project. The results of this review will be presented to the Planning and Steering Committees for discussion. Problems encountered which require modifications of approach will be part of this review and if the approach is altered the proper modifications to the Estuaries Project QAPP will be made.

C.2 Reports

Given the scope and long-term nature of the Estuaries Project, two types of reports are generated: (a) Technical Memoranda addressing specific issues raised by the various oversight committees or addressing the acceptability of data sets or setting technical guidelines, and (b) Embayment Specific Synthesis Reports which detail the field data collected by the Project: the embayment hydrodynamics, watershed loading and water quality modeling results; assessment of present embayment nutrient related health and identified bacterial contamination issues; the synthesis of the Linked Modeling results including the results of 4 scenario model runs; and site specific thresholds results. The Embayment Reports are produced in the second year of the 2-year cycle to complete an embayments analysis.

The Technical Memoranda are produced as issues arise and are distributed to the Technical, Planning and Steering Committees as appropriate. The Embayment Reports are distributed sequentially to these same committees for review and approval. The final version of each report will address comments which arise during review and will also indicate any issues relating to the modeling effort or parameterization data. In addition, any recommendations as to means for improving or streamlining the approach will be put forward.

In addition to reports, the Estuaries Project will also provide data for outreach effort (as funds allow) including for posters, fact-sheets and newsletters.

D. DATA VALIDATION AND USABILITY

D.1 Data Review, Validation / Usage

As part of the data review and validation, all field and lab data will be reviewed and discussed by the Program Coordinator and Science advisors from SMAST to determine if the data meets the QAPP objectives (**see B-II** for additional detail on data acceptance criteria). Historical data or data collected by the Estuaries Project will be screened for "flaws" based on (a) its quality relative to criteria established in the Project QAPP, (b) comparison of data to associated parameters that are known with "certainty", and (c) biogeochemical cross-checks (for example a PC/PN ratio of >25 is suspect). When a potential problem datum is identified, a secondary procedure of checking the field and laboratory notebooks, calculations, and data entry is performed. Errors in data entry will be corrected, and any outliers will be flagged for further review or discarded. Data which remain "at issue" will be maintained in the database, and will be discarded only if they fall more than 2 standard deviations away from the mean of the other appropriate data points. Discarded data will be documented. Upon completion of data entry and data checks, the data will be summarized with the intent to develop findings, conclusions and recommendations.

The Massachusetts Estuaries Project Technical Team will review all project data prior to its use in water quality modeling, system synthesis or thresholds development. The team will render an opinion and judgment regarding data acceptability, generally using the criteria in the 4 data classes, described below: (1) collected under a QAPP meeting the requirements of the Estuaries Project QAPP, (2) collected under a QAPP but not meeting the requirements of the Estuaries Project, (3) collected without an approved QAPP, but data is traceable and methodologies documented and meet requirements of Estuaries Project QAPP, and (4) collected without an approved QAPP and data is not traceable or methods are undocumented. Data will be deemed to be:

- Fully useable, to be fully incorporated into the Project database;
- Useable only as supporting data, additional Project data collection is required;
- Useable only as qualitative supporting information (anecdotal);
- Not useable in any fashion for this Project.

Verification of monitoring data sets can occur in several different ways. Ideally, the data set being considered for inclusion into the Massachusetts Estuaries Project will have been collected under an approved Quality Assurance Project Plan (QAPP), with limits meeting the requirements of the Estuaries Project QAPP. Approval of QAPPs would typically be rendered by the Massachusetts Department of Environmental Protection (DEP) or the U.S. Environmental Protection Agency (EPA). Attempts will be made by the Estuaries Project to collect QAPPs for each data set which could provide useable data to the Project. These QAPPs will be kept in the Estuaries Project library for future reference should the need arise. Should this scenario be the case, it will be recommended to the Technical Team that the data set be included into the Estuaries Project. If it is determined that the data was collected with an approved QAPP but detection limits do not meet the requirements of the Estuaries Project QAPP, data will be considered unacceptable unless further review by Technical Team deems any special considerations to allow use.

In the absence of a DEP or EPA approved QAPP, the person or organization responsible for collecting the data and the lab that was responsible for analysis of samples will be sought out for specific information regarding data collection practice and analysis. Collection of samples or measurement data, in addition to the analysis of samples by a lab, at a minimum must have been performed in accordance to a set of standard operating procedures specific to the parameter measurement or sample type being collected.

Should a data set under consideration be collected in the absence of a DEP or EPA approved QAPP and the data is not traceable back to the person or organization responsible for the collection of the data, data almost certainly will be unacceptable after review by Technical Team. These data will be treated as anecdotal information.

Having a QAPP does not necessarily ensure that data will be used by the Estuaries Project. The documentation that the QAPP was followed and the QC checks performed will also be evaluated by the Technical Team as part of the data review process.

Ultimately, all data being considered for use in the Massachusetts Estuaries Project will be judged worthy relative to quality control criteria set forth in the present Project QAPP. Criteria for acceptance of data in each of the Estuaries Project elements (hydrodynamic modeling, watershed nitrogen loading, nitrogen regeneration, linked watershed embayment nitrogen model, habitat assessment, synthesis of modeling and habitat assessments) are presented in respective sections. Additionally, data being considered for inclusion in the estuaries project must meet the criteria for precision, accuracy, and sensitivity (including instrument detection limits) as defined in the overall project QAPP.

To Reiterate, the Massachusetts Estuaries Project Technical Team will review all project data prior to its use in water quality modeling, system synthesis or thresholds development. The team will render an opinion and judgment regarding data acceptability, generally using the criteria in the 4 data classes given above, data will be deemed to be:

- Fully useable, to be fully incorporated into the Project database;
- Useable only as supporting data, requiring Project data collection;
- Useable only as qualitative supporting information (anecdotal);
- Not useable in any fashion for this Project.

D.2 Data Review, Validation

Data entry is checked by the Program Coordinator and two laboratory personnel and the QA/QC checks are performed by the Project QA Officer. Data will be reviewed by the Project Technical Coordinator before being entered into the Project database and Library. Data sheets will be checked against the spreadsheet on a regular basis and against a final print out. Linked spreadsheet programs have been developed to facilitate the data synthesis and display aspects of the Estuaries Project. Automatic calculations have been integrated into the linked spreadsheets as appropriate to minimize the possibility of human error. However, test data is checked to confirm that the equations are functioning properly. If an unusual or unbelievable recording is noted, the laboratory or field personnel responsible for collecting the data or entering the data will be called to discuss the data. Technical staff collecting samples or measurements in the field are also instructed to take replicate samples if an unusual reading is recorded in the field.

Upon completion of data entry and data checks, the following will be calculated for each parameter: averages, minimum value, maximum value, standard deviation, and any other required calculation.

D.3 Reconciliation with Data Quality Objectives

If data requirements and quality indicators are not being met in accordance to the specifications presented in the QAPP, equipment and techniques will be reassessed and improved, sampling personnel retrained and related specifications may be revised for the next sampling season. Any changes will be brought forward in the annual Project review and annual QAPP updates. Limitations due to equipment failure, sampling performance, or techniques will be explained in final reports and other summary reports as needed.

All of the methods to be used by the Estuaries Project have been employed in similar studies of southeastern Massachusetts embayments over the past decade. The QAPP criteria are based upon these applications of portions of or the full Linked Watershed-Embayment Nitrogen Management Approach. However, it is likely that as the Project progresses that it will be possible to stream-line data collection approaches. This will require a through Technical Review by the Technical Team and DEP and a revision of the QAPP. Changes will only be considered if they maintain the consistency of approach for all 89 embayment systems.

The Technical Manager with assistance from the Project Technical Team will be responsible for review of existing monitoring data and estuarine process data to determine suitability for inclusion into the water quality modeling, synthesis and development of site specific thresholds. Decisions regarding data incorporation will be made by the Estuaries Project Technical Team (which includes DEP Project Officer).

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The Massachusetts Estuaries Project

Quality Assurance Project Plan

MA Estuaries Project QAPP Appendices A.I-XXIII

Embayment Specific Sampling

MASSACHUSETTS ESTUARIES PROJECT

LISTING OF APPENDIX QAPPs A.I - XX

Appendix A-I	CC/Mashpee/Barnstable: Popponesset Bay
Appendix A-II	CC/Chatham: Sulpher Springs/Bucks Creek
Appendix A-III	CC/Chatham: Muddy Creek
Appendix A-IV	CC/Chatham: Bassings Harbor/Ryders Cove/Frost Fish Creek
Appendix A-V	CC/Chatham: Stage Harbor system
Appendix A-VI	CC/Chatham: Taylors Pond
Appendix A-VII	CC/Falmouth: Bournes Pond
Appendix A-VIII	CC/Falmouth/Mashpee: Hamblin/Jehu Ponds, Quashnet River
Appendix A-IX	CC/Falmouth: Great/Perch Ponds
Appendix A-X	CC/Falmouth: Green Pond
Appendix A-XI	Wareham: Agawam/Wareham/Broad Marsh Rivers, Marks Cove
Appendix A-XII	CC/Falmouth: Little Pond
Appendix A-XIII	N/Nantucket: Nantucket Harbor
Appendix A-XIV	CC/Falmouth: West Falmouth Harbor
Appendix A-XV	CC/Barnstable: Three Bays
Appendix A-XVI	MV/Martha's Vineyard: Edgartown Great Pond
Appendix A-XVII	CC/Falmouth: Oyster Pond
Appendix A-XVIII	N/Nantucket: Sesachacha Pond
Appendix A-XIX	BB/New Bedford: Acushnet River, New Bedford Inner Harbor
Appendix A-XX	BB/Bourne: Eel Pond, Back River

Watershed Code:

CC – Cape Cod
BB – Buzzards Bay
MV – Martha's Vineyard
N – Nantucket

MA Estuaries Project QAPP Appendices A.I-XX
Embayment Specific Sampling

Introduction

Phase III of the Estuaries Project is the implementation of the Linked Watershed-Embayment Model which was selected after evaluation under Phase I. The Estuaries Project will implement this Linked Approach in each of the 89 embayments throughout Southeastern Massachusetts over six years or as funding allows. Embayments will be addressed generally following a 2 year cycle, where year 1 is primarily data collection and year 2 is primarily modeling and synthesis. However, the cycle will be flexible to meet the needs of the municipalities and DEP.

The initial 20 embayments for which the approach is to be implemented were selected based upon prioritization by the DEP/SMAST in Phase II. Prioritization will occur on an annual basis. Embayments 1-20 differ from the general 2 year cycle, in that embayments 1-10 had most of the field data collected prior to the Estuaries Project initiation of Phase III. Therefore, embayments 1-10 enter the cycle in a quasi-year 2, since some minor field data collection is required to complete some of them but most just require the modeling and synthesis elements of the Approach. Embayments 11-20 generally require significant field data collection and full modeling and synthesis. Embayments 1-10 are currently scheduled for completion by June 2003 and embayments 11-20 by June 2004, although specific embayments will be completed prior to these dates.

All data not collected under the Estuaries Project has been reviewed for consistency to Estuaries Project Protocols following the guidelines in B-II. All accepted data used to parameterize the water quality model has been collected since 1990 and all chemical and biological data since 1997. The basic guideline is that all data, historic or new, must conform to the Estuaries Project QAPP for quality and completeness. In addition, relative to estuaries whose baseline water quality monitoring data was collected by municipalities or non-governmental monitoring programs, the Estuaries Project Staff will collect limited water quality samples during summer. These samples will be assayed for the suite of nutrient, plant pigment and associated parameters to parallel the baseline data series. Project water quality sampling will generally be performed at 3-4 sites within each embayment on 1-2 occasions during July/August. Additional samples for oxygen and plant pigments will be performed at 2-5 locations. Comparison of these “check” samples to the long-term baseline and on-going monitoring program data series will provide an additional level of QA.

MA Estuaries Project QAPP
Appendix A-I Popponesset Bay
Towns of Mashpee and Barnstable
Prioritization Rank: Round 1 - #1

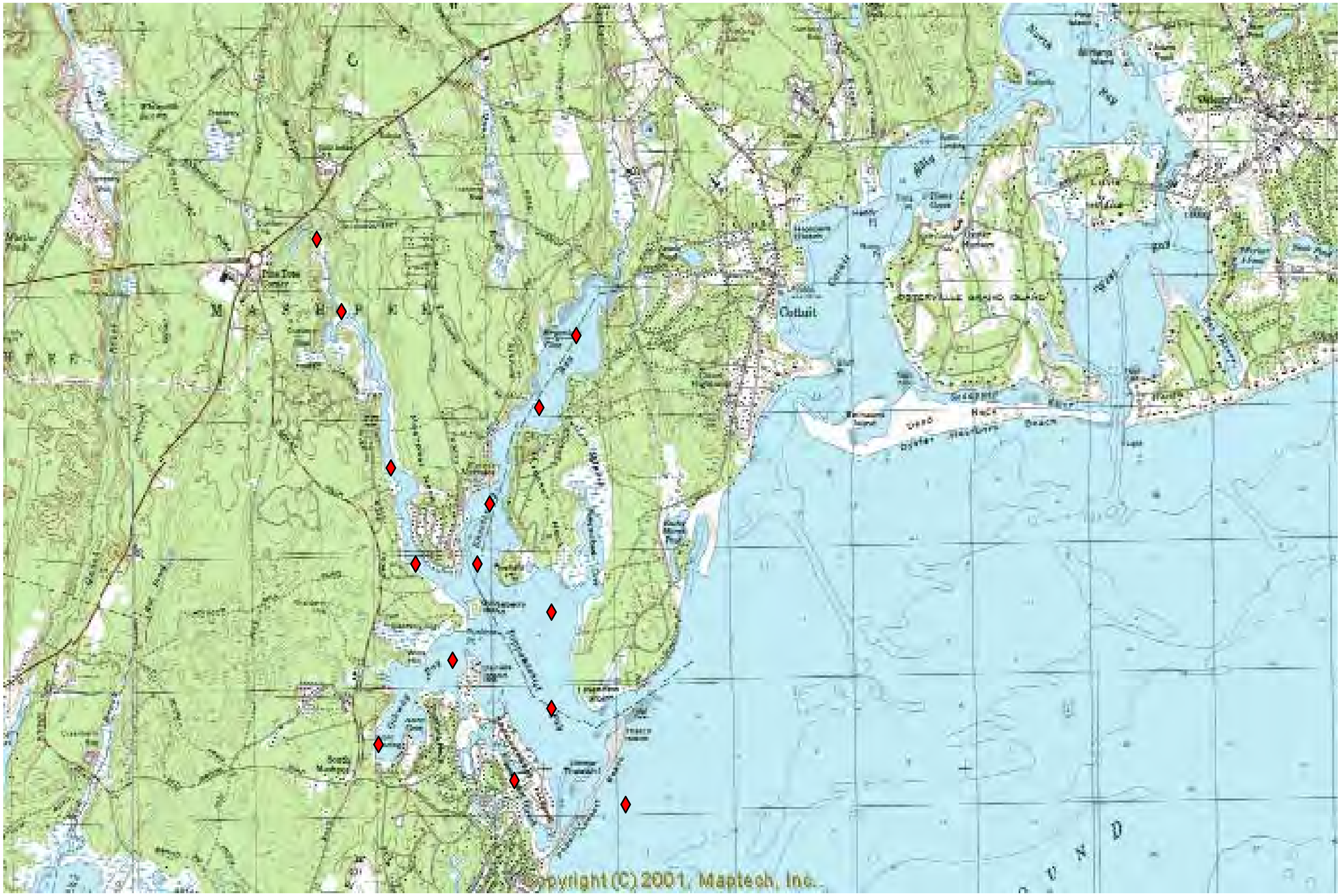
Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Popponessett Bay, Mashpee & Barnstable: All field data collection is complete. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay's QAPP (Williams and Howes, 2001). All technical design and analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Estuary Project required field data is complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. Water quality modeling is will include additional scenario runs over the Estuaries Project Standard protocol, due to funding from the Town of Mashpee. There is one minor adjustments from the Estuary Project approach to field data collection in that the benthic regeneration samples were collected several times throughout the embayment, but in clusters. Regarding dissolved oxygen measurements in this system, a maximum of 6 dissolved oxygen meters were deployed in the upper half of the estuary for continuous measurements during the months of July and August.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1



◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations   Figure 3

Tide Gauge Location ADCP Transects

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Popponesset Bay (1)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	2	Weekly	100	10	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	8	Once/Embayment	16	16	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	5 **	60 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	8	Once/Embayment	8	16	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-II Sulfur Springs/Bucks Creek
Town of Chatham
Prioritization Rank: Round 1 - #2

Figure 1. Location Map

Figure 2. Nutrient Sampling Locations

Figure 3. Benthic Regeneration and Stream Discharge Sampling Locations

Figure 4. Hydrodynamic Data Collection Sites: Tide Gauges and ADCP transects

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Sulfur Springs, Chatham*:* All field data collection is complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Pleasant Bay Alliance QAPP. All technical design are acceptable and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Estuary Project required field data is complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated) due to the embayment's basic configuration and the lack of suitable channel cross section needed for accurate ADCP application. DO records will not be collected on this shallow intertidal system.

Regarding dissolved oxygen measurements in this system, 1 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Sulfur Springs / Bucks Creek (2)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	7	Once/Embayment	7	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	1 **	12 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	0	Once/Embayment	0	0	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-III Muddy Creek
Town of Chatham
Prioritization Rank: Round 1 - #3

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Muddy Creek. Chatham & Harwich*:* All field data collection is complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Pleasant Bay Alliance QAPP. All technical design are acceptable and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Estuary Project required field data is complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated) due to the embayment's basic configuration and the lack of suitable channel cross section needed for accurate ADCP application. An additional analysis will be included as to the management alternatives of (a) opening the culvert between Muddy Creek and Pleasant Bay and (b) repairing the dike at mid-system to improve flushing of the lower system and restore the freshwater habitat of the upper system. A D.O. mooring will be placed in the lower portion of this system to help refine the thresholds analysis.

Since Muddy Creek has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Muddy Creek System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This “paired” sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Muddy Creek (3)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:	Benthic Coring	a,b,c,d	Time Course Incubation	2	Once/Embayment	2	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	2	Once/Embayment	2	2	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-IV The Bassing Harbor System
Bassing Harbor/Ryders Cove/Frost Fish Creek
Town of Chatham
Prioritization Rank: Round 1 - #4

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Bassing Harbor System, Chatham*:* Almost all field data collection is complete to allow modeling and synthesis, except for a nitrogen attenuation study of Frost Fish Creek. Water quality monitoring data was collected and analyzed following the Pleasant Bay Alliance QAPP. All technical design details are acceptable and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. All of the standard Estuary Project required field data is complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary

Project Technical Team members. This work has been conducted as part of Chatham's Comprehensive Wastewater Planning effort.

The Estuaries Project will continuing sampling of stream discharge and nitrogen loading from Lovers Lake/Stillwater Pond into Ryders Cove through the summer of 2002 in collaboration with the Chatham Water Quality Laboratory (R. Duncanson). An additional eelgrass survey will be conducted in 2002 (previous was 2000), due to the projected rate of decline in this system and 4 DO records will be collected, to refine the site specific thresholds analysis.

Additions to the Estuaries Project Standard Approach are as follows:

(1) This system requires a nitrogen attenuation study of the Frost Fish Creek System. This is a tidal creek-salt marsh and will require measurements of net nitrogen discharge to Ryders Cove. The protocol will be the same as employed in the DEP/SMAST study of Mashapaquit Creek in West Falmouth Harbor.
(2) The benthic regeneration survey of the Bassing Harbor System was conducted in both summers of 2000 and 2001.
(3) An analysis of well withdrawals on watershed nitrogen loading will be performed based upon the modeling study of Earth Tech (currently under review).

Regarding dissolved oxygen measurements in this system, a maximum of 5 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Since Bassing Harbor / Ryders Cove / Frost Fish Creek has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Bassing Harbor System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This "paired" sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

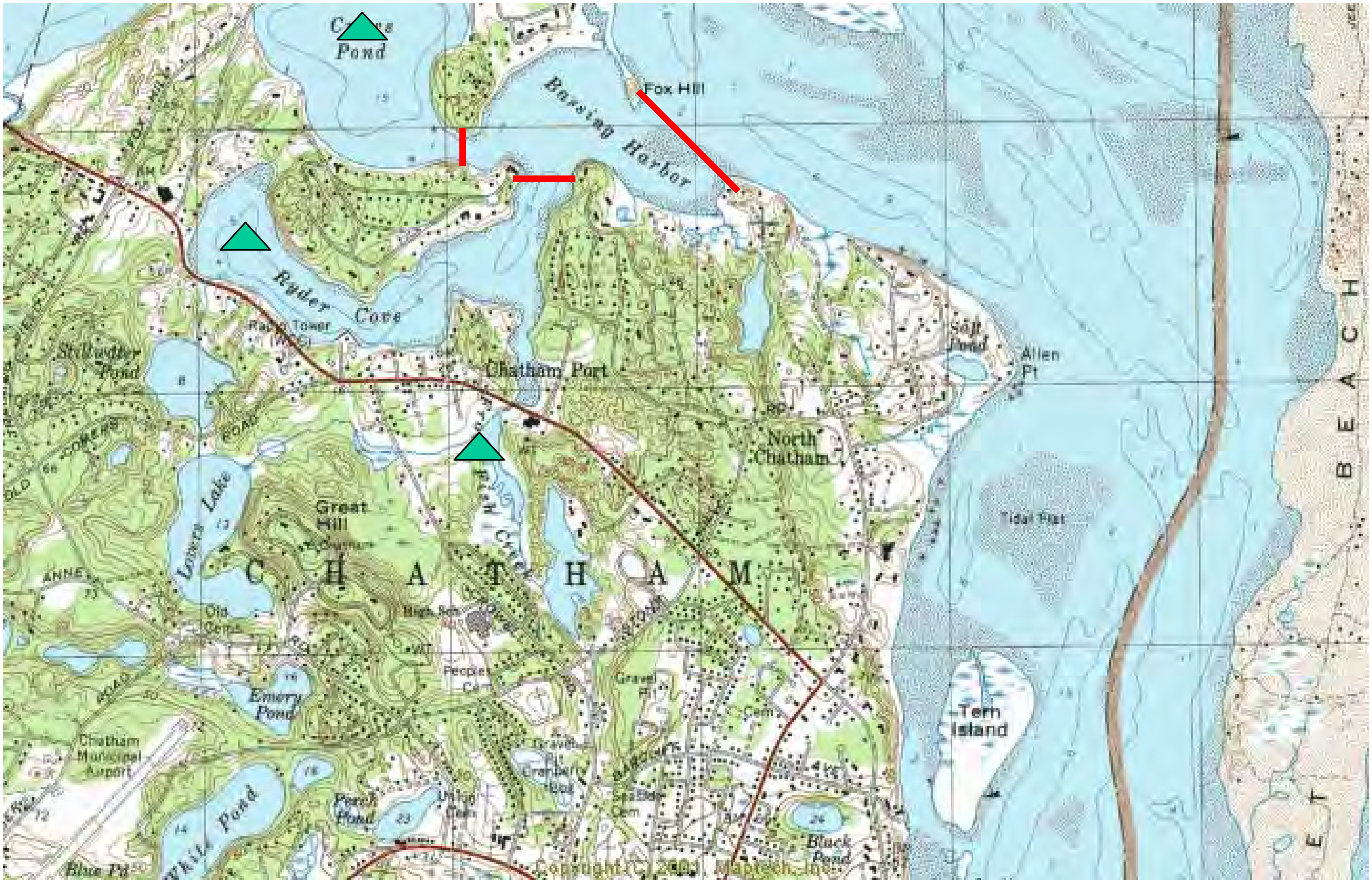
Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations   Figure 3



Tide Gauge Location ADCP Transects

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Bassing Harbor / Ryders Cove / Frost Fish Creek (4)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	2	Weekly	100	10	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	26	Once/Embayment	26	3	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	4 **	48 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	4	Once/Embayment	4	6	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-V Stage Harbor System
Town of Chatham
Prioritization Rank: Round 1 - #5

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Stage Harbor, Chatham: All field data collection is complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Pleasant Bay Alliance QAPP. All technical design details are acceptable and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Estuary Project required field data is complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. An additional eelgrass survey and 4 D.O. records will be conducted in 2002 to support the thresholds analysis.

Regarding dissolved oxygen measurements in this system, a maximum of 5 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location   ADCP Transects

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Stage Harbor (5)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	15	Once/Embayment	15	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	3 **	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	5	Once/Embayment	5	10	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-VI Taylor's Pond
Town of Chatham
Prioritization Rank: Round 1 - #6

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Taylors Pond, Chatham*:* Data is mostly complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Pleasant Bay Alliance QAPP. All technical design details are acceptable and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Initial water quality modeling discovered that previously determined watershed nitrogen loads during summer were greatly overestimated due to a failure to account for water withdrawal from the Town well field. An analysis of well withdrawals on watershed nitrogen loading will be performed based upon the groundwater modeling study of Earth Tech (currently under review). The Project will then re-parameterization the Taylors Pond water quality model to account for summer water withdrawals. The land-use analysis will have to be conducted and the modeling performed, prior to synthesis and reporting.

Acoustic Doppler Current Profiling (ADCP) will not be performed, due to the embayment's basic configuration and the lack of suitable channel cross section needed for accurate ADCP measurements.

Regarding dissolved oxygen measurements in this system, a maximum of 1 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

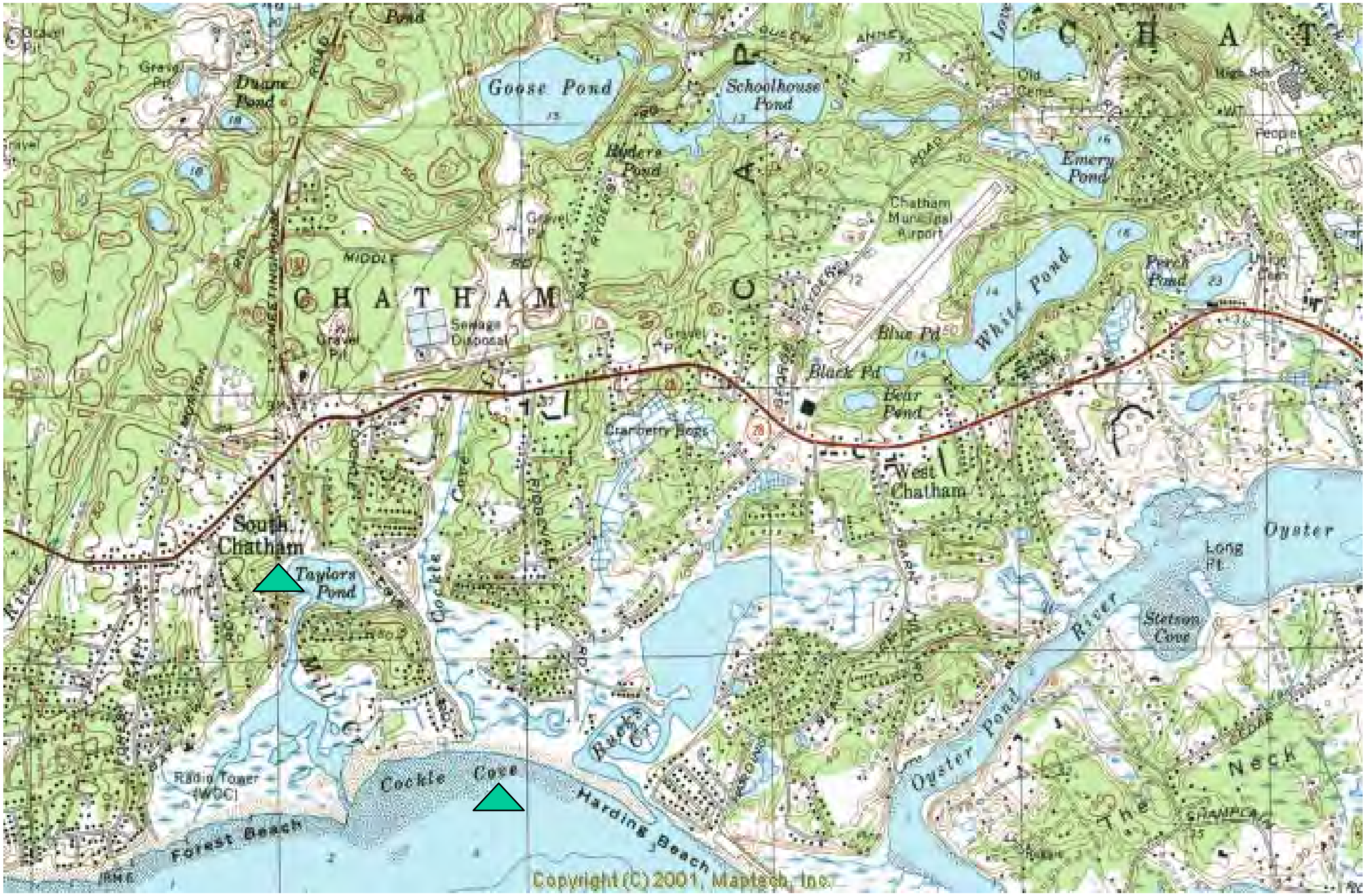
Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3



Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Taylors Pond (6)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:	Benthic Coring	a,b,c,d	Time Course Incubation	5	Once/Embayment	5	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	1 **	12 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	1	Once/Embayment	1	2	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-VII Bournes Pond
Town of Falmouth
Prioritization Rank: Round 1 - #7

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Bournes Pond, Falmouth*:* Data is mostly complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Falmouth PondWatch Program. Estuary Project required field data is nearly complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. An additional eelgrass survey and oxygen records will be conducted in 2002 to support the thresholds analysis.

While benthic regeneration rates have been determined for this system, the spatial distribution is not as extensive as appropriate for the Estuaries Project Approach. Therefore, additional benthic regeneration sampling will be conducted in 2002. These data enhance the water quality model and update the previous synthesis to be consistent with the Estuaries Project. An additional eelgrass survey and 2-3 D.O. recordings will be conducted in 2002 to support the thresholds analysis. Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated by field observations), due to the embayment’s basic configuration and the lack of suitable channel cross section needed for accurate ADCP measurements.

Regarding dissolved oxygen measurements in this system, a maximum of 2 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations △ Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Bournes Pond (7)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	10	Once/Embayment	10	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	7	Once/Embayment	7	7	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-VIII Hamblin/Jehu Ponds
Including Quashnet River
Towns of Falmouth and Mashpee
Prioritization Rank: Round 1 - #8

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Quashnet-Hamblin Pond-Jehu Pond, Mashpee & Falmouth*:* Data is mainly complete to allow modeling and synthesis. Two summers of water quality monitoring data will be included as collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST. All technical design details and the analytical aspects of the monitoring were conducted by the Coastal Systems Program at SMAST. Additional water quality data is anticipated to be provided by WBNERR through its association with the five year NSF-LMER (National

Science Foundation's Land Margin Ecological Research) program. Existing Estuary Project required field data was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members.

Field data will be collected during 2002 on (1) stream flow and nitrogen load, (2) benthic animals, (3) additional D.O. records (in addition to the WBNERR data, and (4) an eelgrass survey will be conducted to support the thresholds analysis.

Regarding dissolved oxygen measurements in this system, a maximum of 2 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

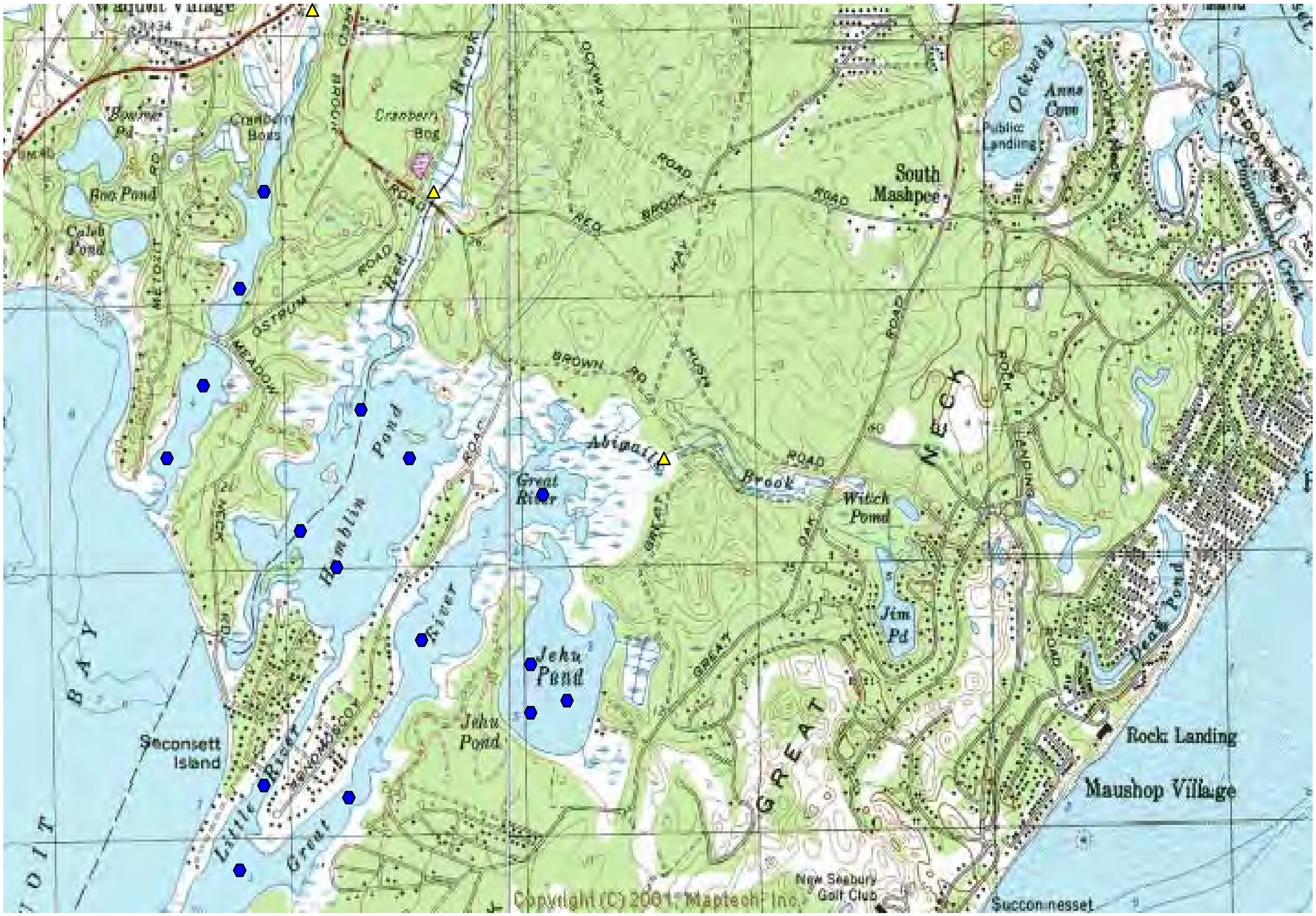
Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated by direct field observations) due to the embayment's basic configuration and the lack of suitable channel cross section needed for accurate ADCP measurements.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage Locations   Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Hamblin / Jehu Ponds / Quashnet River (8)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	14	Once/Embayment	14	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	10	Once/Embayment	10	10	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-IX Great/Perch Ponds
Town of Falmouth
Prioritization Rank: Round 1 - #9

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Great/Perch Pond, Falmouth: Data is mostly complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Falmouth PondWatch Program. Estuary Project required field data is nearly complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. An additional eelgrass survey and 2-3 D.O. recordings will be conducted in 2002 to support the thresholds analysis.

While benthic regeneration rates have been determined for this system, the spatial distribution is not as extensive as appropriate for the Estuaries Project Approach. Therefore, additional benthic regeneration sampling will be conducted in 2002. These data enhance the water quality model and update the previous synthesis to be consistent with the Estuaries Project. An additional eelgrass survey will be conducted in 2002 to support the thresholds analysis.

Regarding dissolved oxygen measurements in this system, a maximum of 2 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location — ADCP Transects

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Great / Perch Ponds (9)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	12	Once/Embayment	12	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	7	Once/Embayment	7	7	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection.
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-Invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-X Green Pond
Town of Falmouth
Prioritization Rank: Round 1 - #10

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Green Pond, Falmouth*:* Data is mostly complete to allow modeling and synthesis. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Falmouth PondWatch Program. Estuary Project required field data is nearly complete and was collected following the procedures of this Estuaries Project QAPP and was performed by Estuary Project Technical Team members. An additional eelgrass survey and 2-3 D.O. recordings will be conducted in 2002 to support the thresholds analysis.

While benthic regeneration rates have been determined for this system, the spatial distribution is not as extensive as appropriate for the Estuaries Project Approach. Therefore, additional benthic regeneration sampling will be conducted in 2002. These data enhance the water quality model and update the previous synthesis to be consistent with the Estuaries Project. An additional eelgrass survey will be conducted in 2002 to support the thresholds analysis. Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated by field observations), due to the embayment's basic configuration and the lack of suitable channel cross section needed for accurate ADCP measurements.

Regarding dissolved oxygen measurements in this system, a maximum of 3 dissolved oxygen meter will be deployed in the upper half of the estuary for continuous measurements during the months of July and August. Specific deployment site is to be determined.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Green Pond (10)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	9	Once/Embayment	9	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	3 **	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct
	Benthic Infauna	n	Grab	6	Once/Embayment	6	6	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-Invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XI Acushnet River/New Bedford Inner Harbor
City of New Bedford
Prioritization Rank: Round 1 - #11

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

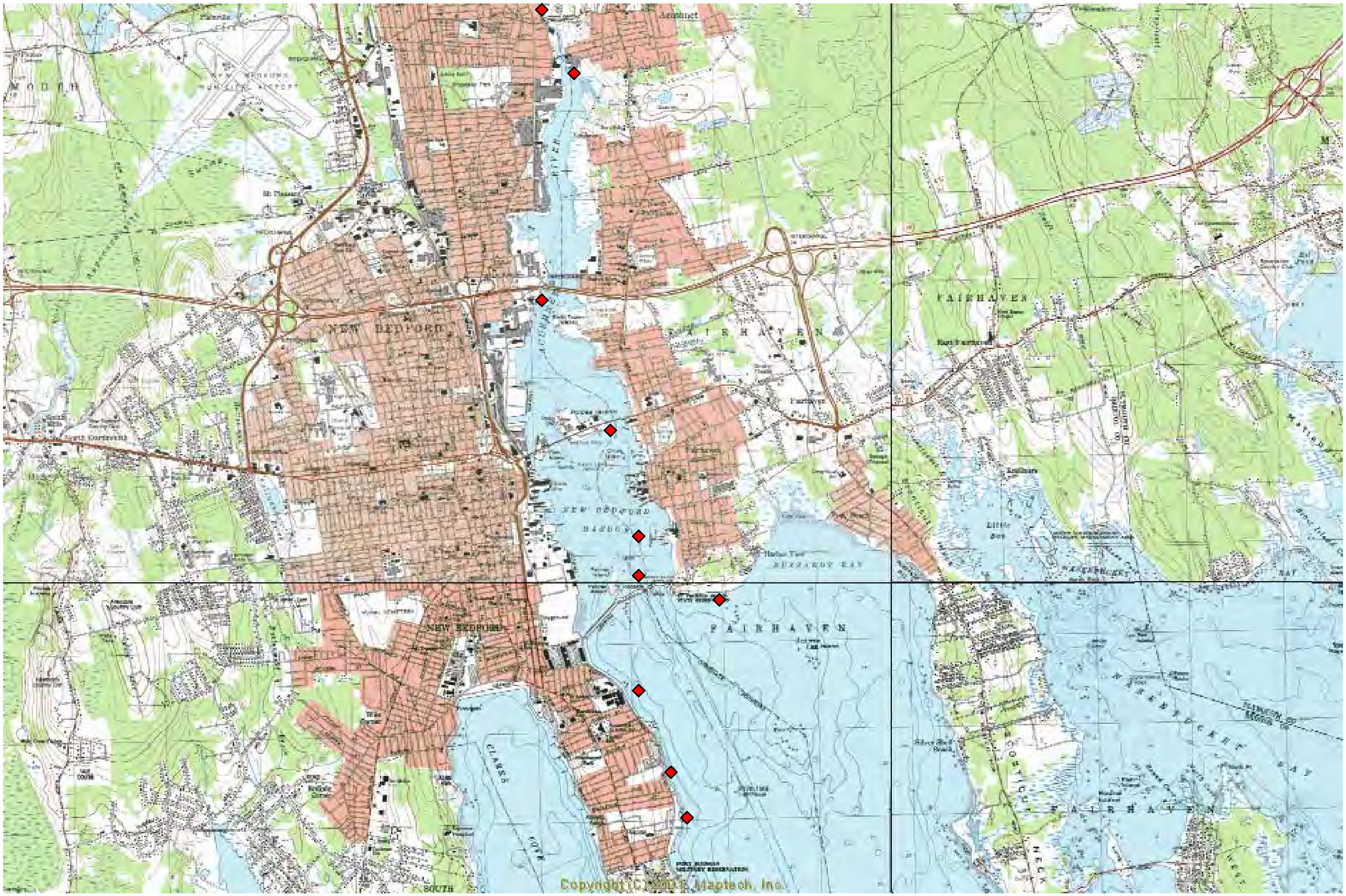
Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Acushnet River-Inner New Bedford Harbor (on 303d list-pathogens), New Bedford-Fairhaven & Acushnet: Some Estuaries Project Approach data is available for this system and there is a 10 year record of nutrient related water quality data. Extensive studies have been conducted on this system relating to the PCB clean-up and the CSO discharges. In addition, recent work by Applied Science Associates Inc (ASA) under EPA contract will provide some useful hydrodynamic data (Kim et al., 2001). These studies will provide the habitat assessment data required for the Estuaries Project (eelgrass, macroalgae, benthic animals). These data were all collected under approved QAPP's. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP (Howes and Williams 2001). All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program. Dissolved oxygen moorings to complete the habitat assessment will be placed at 2-3 locations (1-2 in the upper and 1 in the lower basin, during summer 2002). Specific deployment sites are to be determined.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model (with ADCP validation, ASA did not collect ADCP data) which will require placement of tide gauges (ASA study had only 1 gauge), (2) conduct a benthic regeneration survey, (3) update and make consistent with the Project Approach the land-use and watershed nitrogen loading model (we incorporate the data in the Buzzards Bay Project study), (4) expand the Acushnet River discharge data on flow and nitrogen load to allow determination of nitrogen attenuation within the upper watershed, and (5) conduct the water quality modeling, thresholds analysis and synthesis. Confirmation of previous eelgrass mapping will be conducted during 2002.

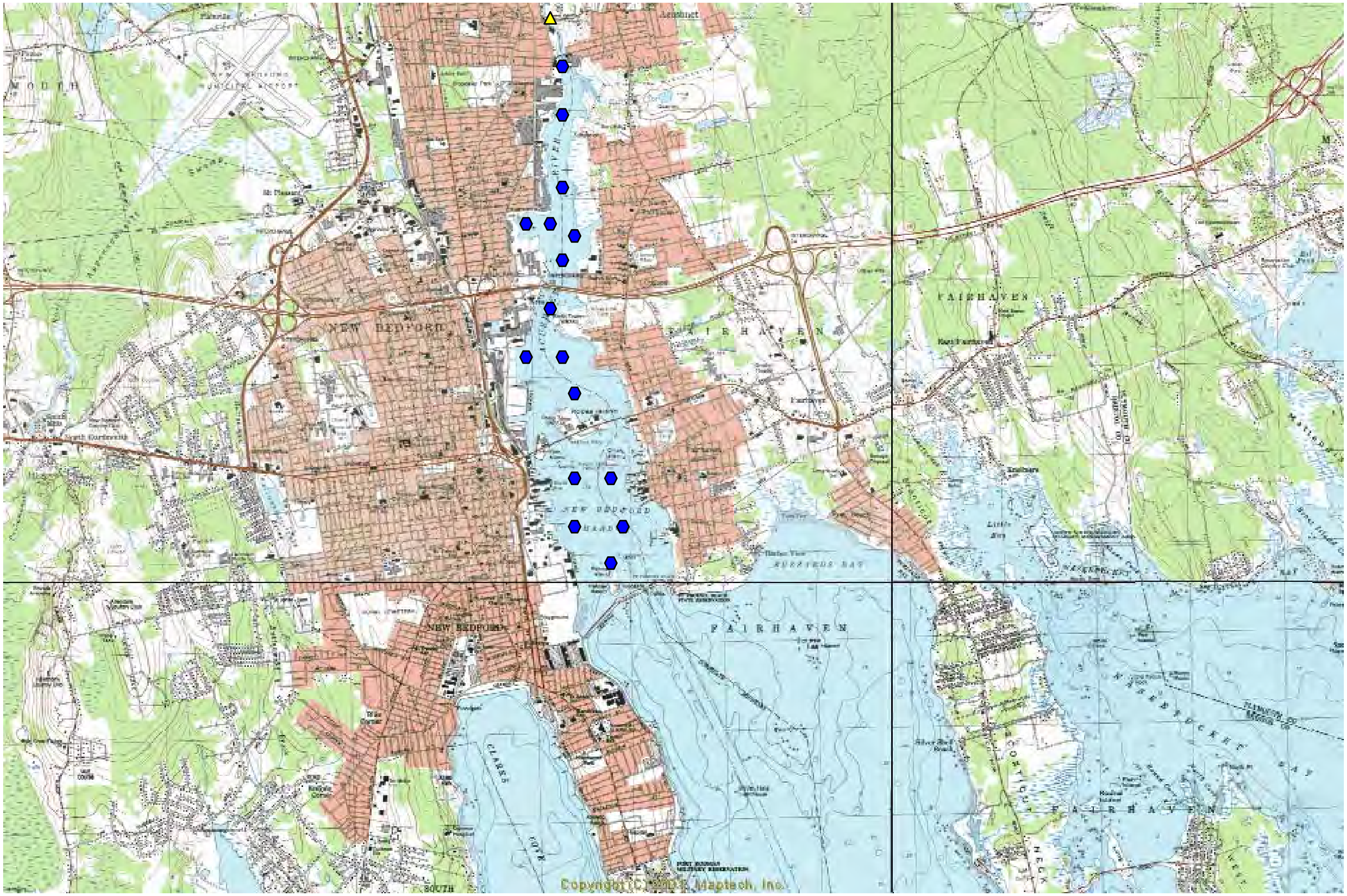
Massachusetts Estuaries Project Round 1 Prioritization

Figure 1



◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations △ Stream Gage Locations

Figure 3

Tide Gauge Location ADCP Transect

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Acushnet River / New Bedford Inner Harbor (11)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	14	Once/Embayment	14	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	4 **	48 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	3	Once/Embayment	3	6	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection

** Moored Instruments in the systems

*** Number of Winkler Titrations

**** Parameters measured at 15 minute interval

NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.

Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XII Little Pond
Town of Falmouth
Prioritization Rank: Round 1 - #12

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Little Pond, Falmouth: There is an extensive historical data set on the nitrogen cycling in Little Pond (1985-1995). Much of the data to support modeling and synthesis needs to be updated and will require field data collection by the
Estuaries Project. The previous data collection on benthic regeneration and stream discharge was not collected under a QAPP, but was collected by Estuaries Project staff and is fully consistent with Estuary Project protocols as specified in the present QAPP. Water quality monitoring data (1987-2001) has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP (Howes and Williams 2001). All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Falmouth PondWatch Program.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model which will require placement of tide gauges (previous data is prior to the new inlet); (2) conduct a benthic regeneration survey; (3) update the existing land-use and watershed nitrogen loading model; (4) collect benthic infaunal data within the upper, mid and lower basins to compare to historic data; (5) two dissolved oxygen meters will be deployed in the mid and lower basins of the estuary for continuous measurements, specific deployment sites are to be determined; and (6) conduct the water quality modeling, thresholds analysis and synthesis. Confirmation of previous eelgrass mapping will be conducted during 2002.

Acoustic Doppler Current Profiling (ADCP) will not be performed, due to the embayment's basic configuration and the lack of suitable channel cross section.

Note: This system is being evaluated, as part of the Falmouth Comprehensive Wastewater Planning effort. The focus is to consider installing sewers throughout much of the eastern and northern watershed.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2

Benthic Coring Locations Stream Gage Locations Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Little Pond (12)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	7	Once/Embayment	7	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	6	Once/Embayment	6	3	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XIII Nantucket Harbor
Island of Nantucket
Prioritization Rank: Round 1 - #13

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Nantucket Harbor (on 303d list-pathogens), Nantucket*:* Nantucket Harbor was the site of a precursor study to the Estuaries Project (WHOI Nantucket Harbor Study 1990-1995). This included each aspect of the Estuaries Project data collection, including DEP's eelgrass mapping program (it was one of the first reference sites). While there was not a QAPP, the work is fully compliant with this QAPP. However, the water quality modeling and thresholds analysis was not conducted.

The existing data includes eelgrass mapping, macroalgal surveys, infaunal analysis, benthic regeneration, multiple tide gauges, bathymetry, D.O. records (4 sites, within each of the main basins), current records, validated land-use analysis, stream flow and nitrogen loads.

Estuaries Project sampling will include (1) deployment of tide gauges and (2) ADCP transects.
Water quality monitoring data has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST.

Since Nantucket Harbor has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Nantucket Harbor System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This “paired” sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts
Department of
Environmental
Protection

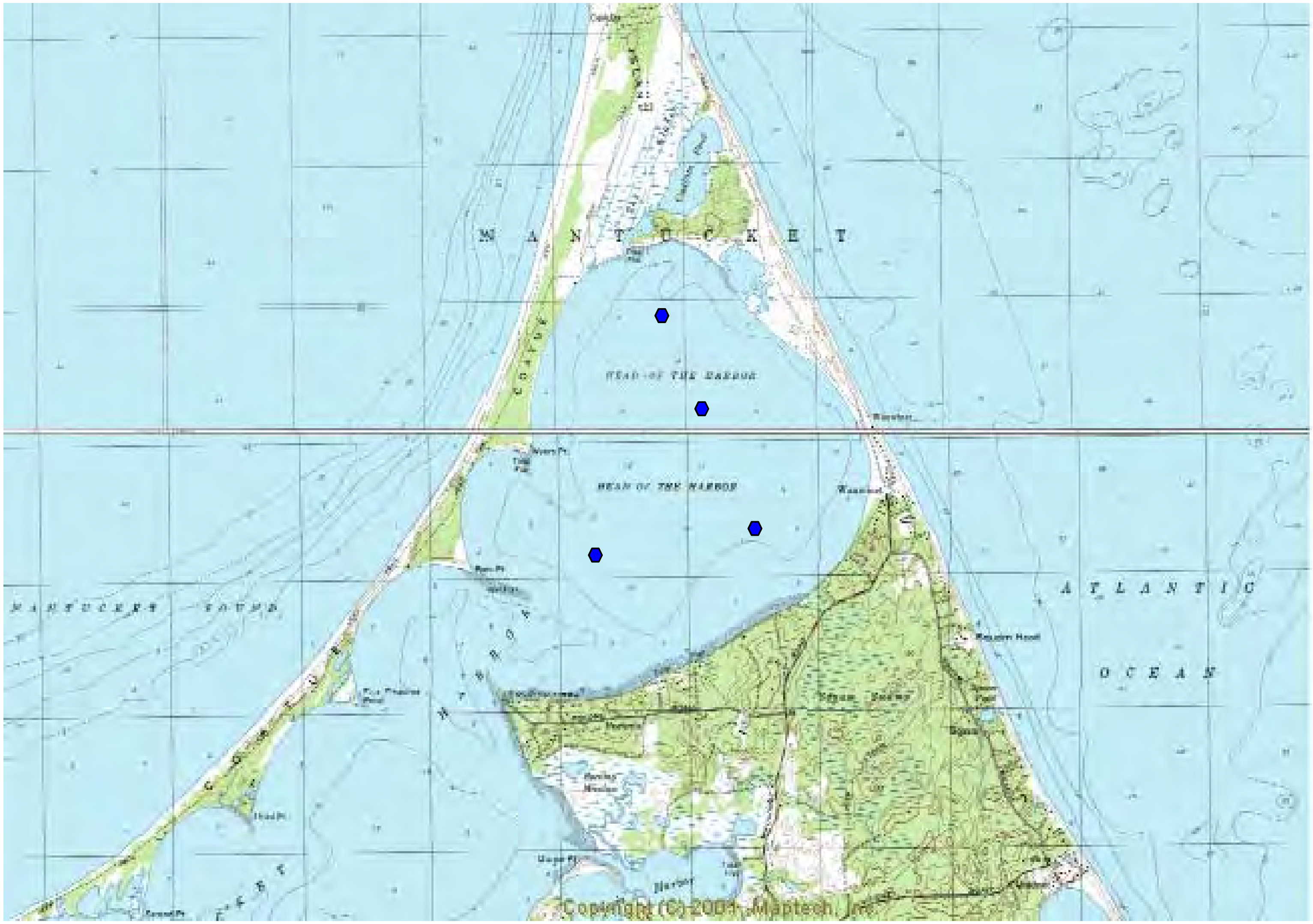
Figure 1

◆ Nutrient Sampling Locations

Figure 2

◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage Locations

Figure 3

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Tide Gauge Location — ADCP Transect

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Nantucket Harbor (13)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	8 (isco)	1	daily	100	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	24	Once/Embayment	24	6	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	4 **	48 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab		Once/Embayment	4	8	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XIV West Falmouth Harbor
Town of Falmouth
Prioritization Rank: Round 1 - #14

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

West Falmouth Harbor, Falmouth*:* This system has seen intense activity as part of the Falmouth WWTF permit renewal and system upgrade. Several of the key elements of the Linked Approach have been collected in this effort by DEP/SMAST. However, the full Linked Watershed-Embayment Management Model has not been applied to date.

Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring and Falmouth PondWatch Programs.

The existing data which will be used is fully compliant with this QAPP and was collected and analyzed by present Estuaries Project Technical Team members (and are included in DEP's West Falmouth Harbor Report). These data sets include: (1) benthic infaunal surveys, (2) eelgrass (and macroalgae) mapping and historical reconstruction, and (3) stream nitrogen loading and wetlands attenuation.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based upon existing data and conduct ADCP measurements at the inlet; (2) update the existing land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect dissolved oxygen records to complete the habitat assessment (1 in Snug Harbor and 1 in the outer Harbor), (4) re-map eelgrass distribution to enhance thresholds analysis; and (5) conduct the water quality modeling, thresholds analysis and synthesis.

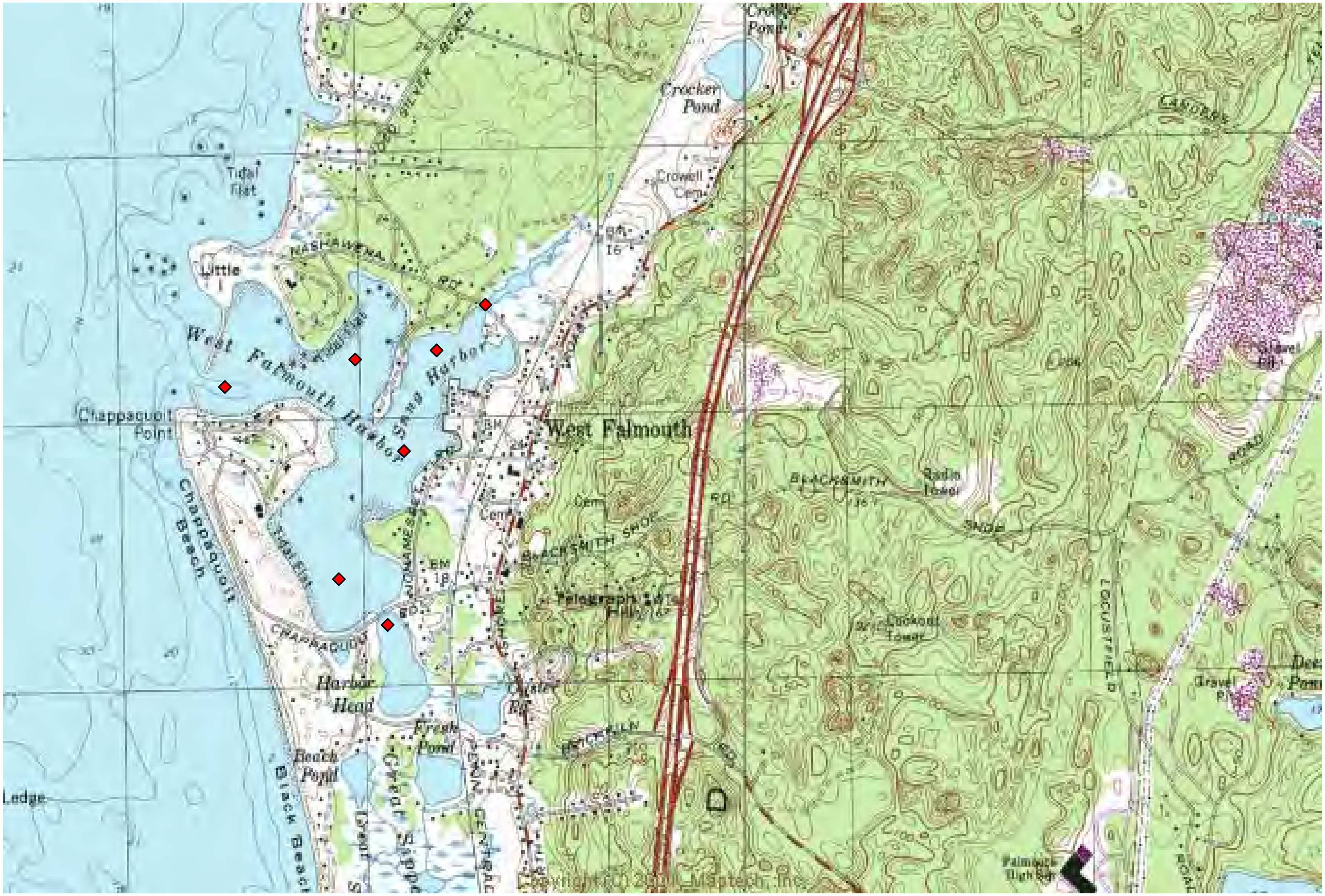
Note: West Falmouth Harbor represents a critical site for evaluating nitrogen thresholds. We have a continuous record of nitrogen levels as the Falmouth WWTF plume has been discharging to the Harbor and causing accelerated eutrophication. Eelgrass distribution is changing rapidly and the last mapping was conducted in 1999.

Massachusetts Estuaries Project Round 1 Prioritization

smast
University of Massachusetts Dartmouth
The School for Marine Science and Technology

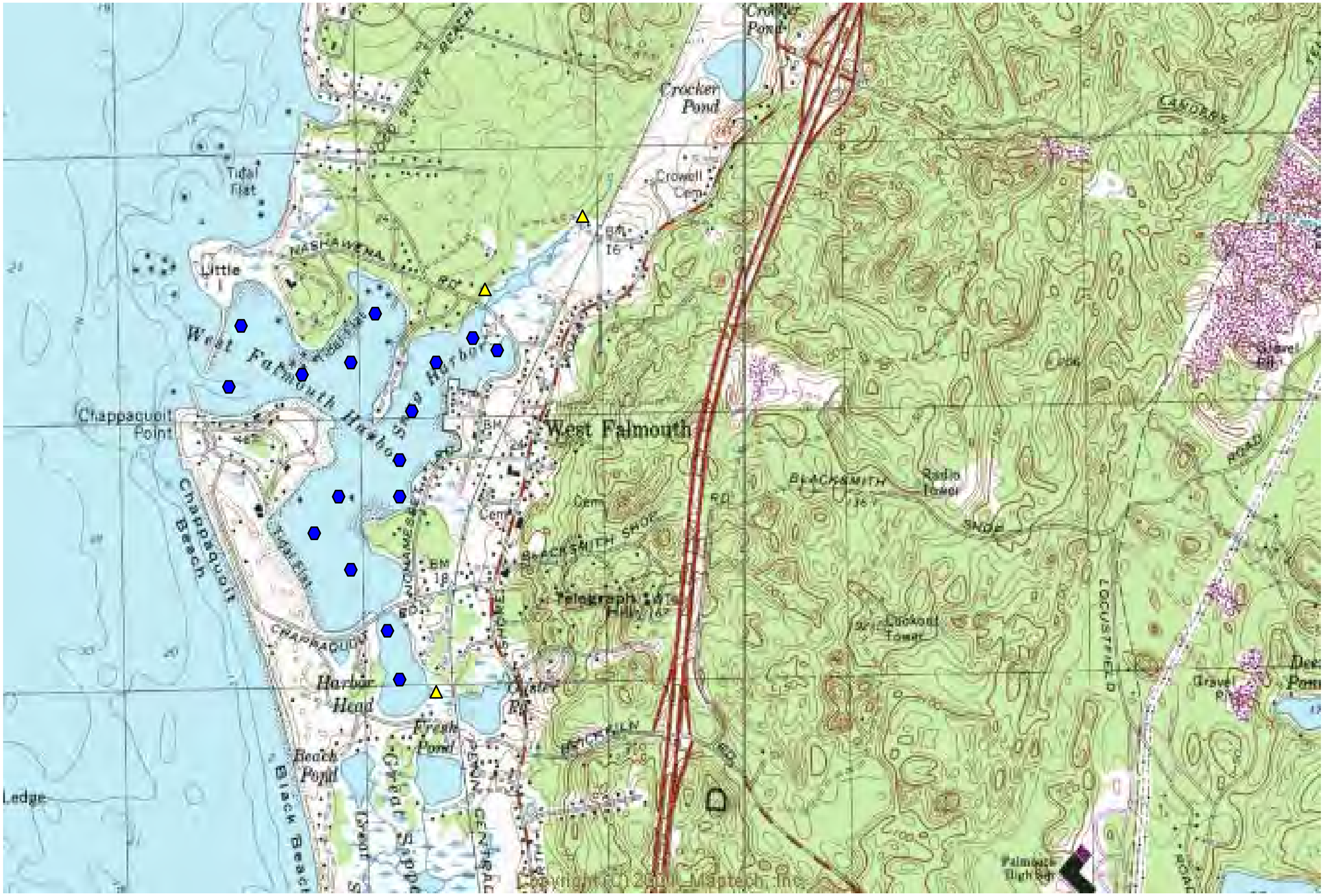
Massachusetts
Department of
Environmental
Protection

Figure 1



◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location ADCP Transect

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
West Falmouth Harbor (14)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	15	Once/Embayment	15	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	0	0	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	6	Once/Embayment	6	2	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XV Three Bays System
Town of Barnstable
Prioritization Rank: Round 1 - #15

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Three Bays (on 303d list-pathogens), Barnstable*:* Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Three Bays Preservation Monitoring Program. This program has technical staff (including SMAST staff) performing the sampling.

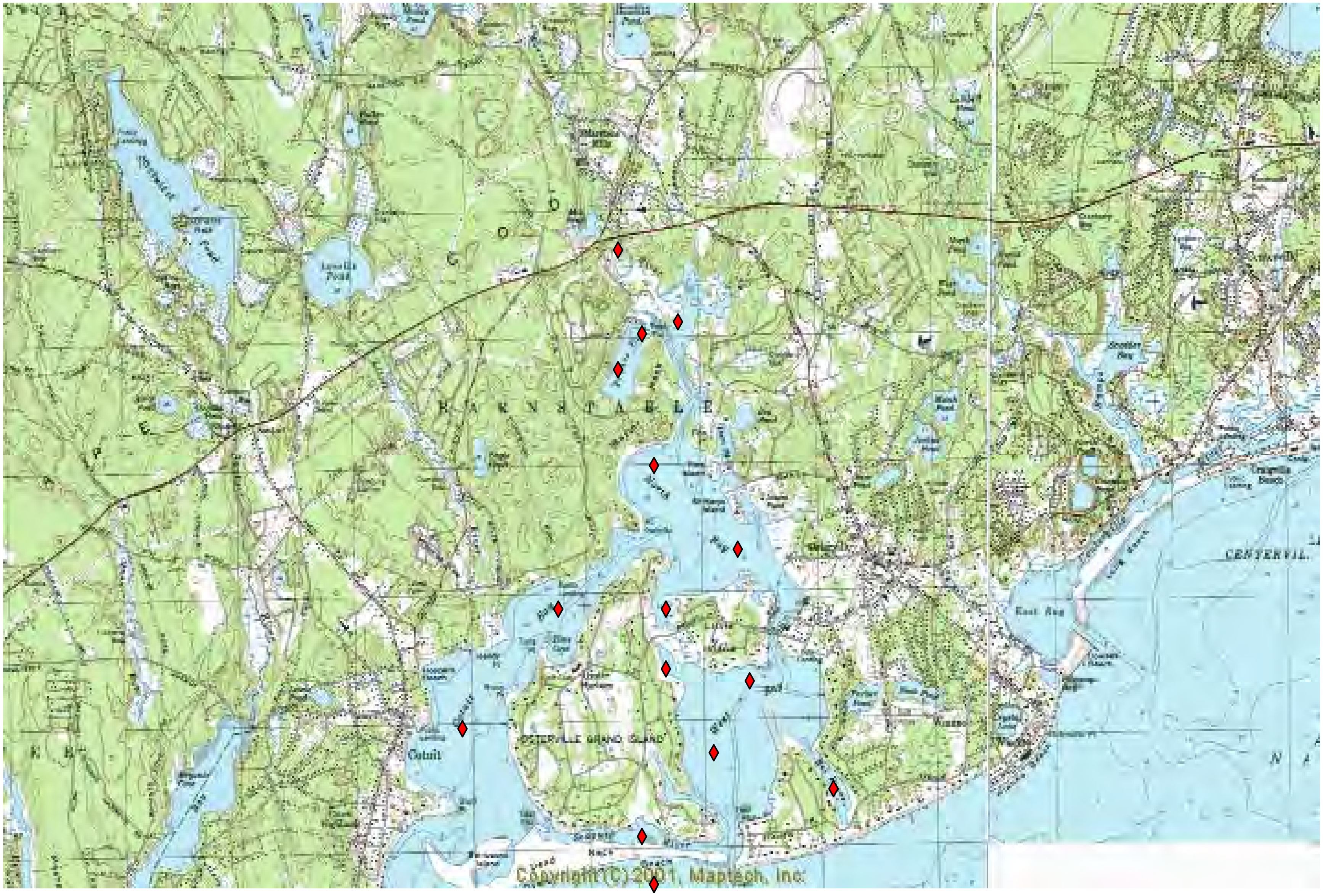
The existing data for the Linked Approach which will be used is fully compliant with this QAPP and was collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) stream flow and nitrogen loading from the Marstons Mills and Little Rivers, (2) dissolved oxygen records from 4 sites (2 in Princes Cove, upper and mid North Bay, (3) nutrient sampling of major lakes and ponds, (4) some bathymetric and tidal data, including 2 permanent tide gauges.

Since Three Bays has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Three Bays System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This “paired” sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III.

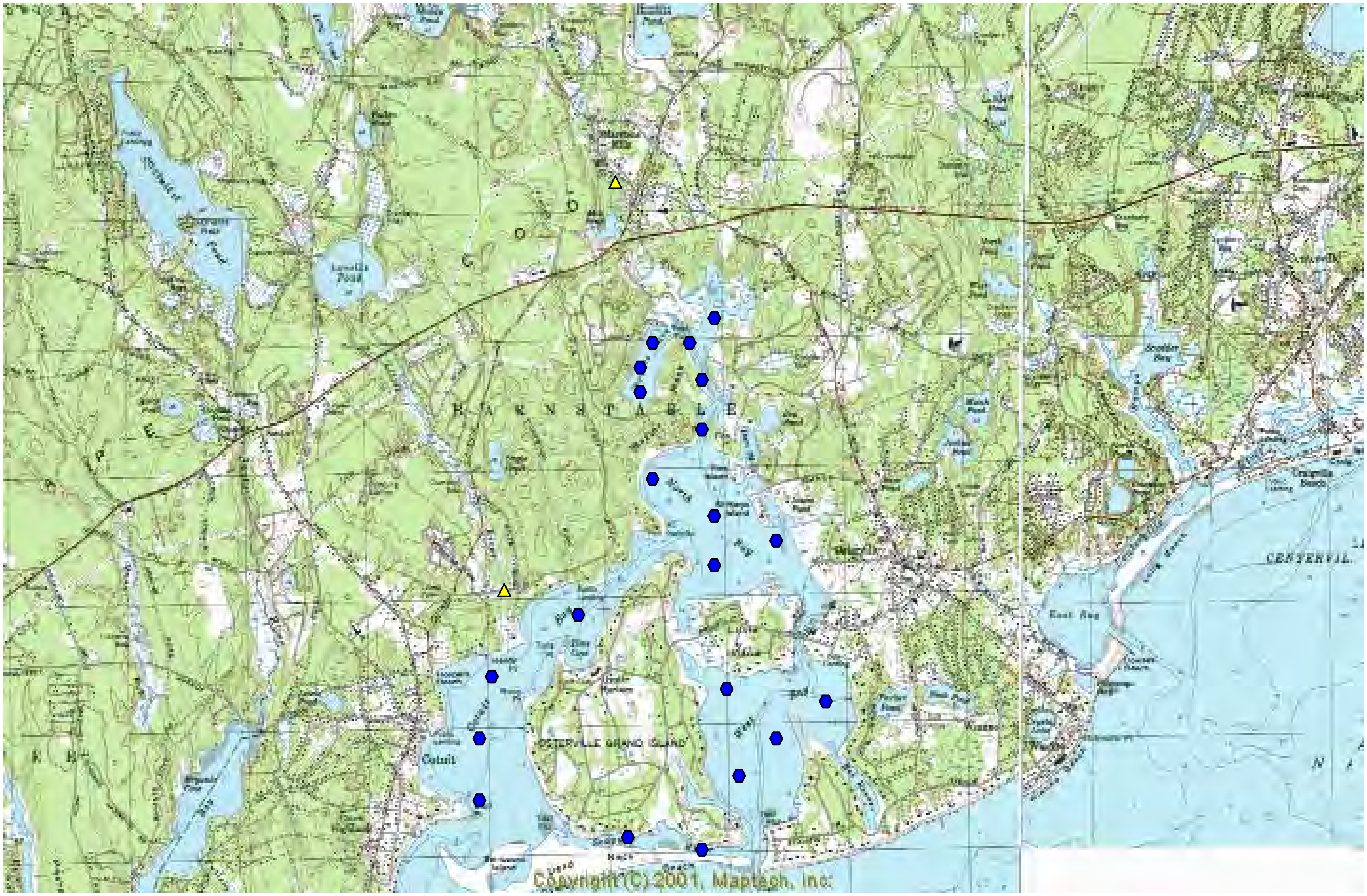
The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based which will require placement of tide gauges and conducting ADCP measurements; (2) update the existing land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect 2 additional dissolved oxygen records to complete the habitat assessment (1 lower North Bay and 1 in upper West Bay), (4) map eelgrass distribution and create historic record; (5) conduct the water quality modeling, thresholds analysis and synthesis and (6) conduct wet versus dry weather bacterial surveys within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization



◆ Nutrient Sampling Locations

Figure 2



⬣ Benthic Coring Locations △ Stream Gage Locations

Figure 3

Tide Gauge Location ADCP Transect

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Three Bays System (15)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	2	Weekly	100	10	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	19	Once/Embayment	19	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	4 **	48 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	10	Once/Embayment	10	20	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertebrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XVI Edgartown Great Pond
Island of Martha's Vineyard
Prioritization Rank: Round 1 - #16

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Edgartown Great Pond, Edgartown*:* This salt pond is closed to tidal exchange by a barrier beach. It has a "managed tidal exchange" through periodic opening by the Town of Edgartown. This system has seen intense activity as part of the Edgartown WWTF upgrade. Some useful data has been collected on key elements of the Linked Approach as part of this effort. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP (Williams and Howes, 2001, and has had its own independent QAPP, as well). All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Martha's Vineyard Commission. Monitoring is conducted by technical personnel, no volunteers are used.

The data which has been previously collected and may be used to parameterize the Estuaries Project Approach does not appear to be fully compliant with this QAPP. Therefore field data collection by Estuaries Project Technical Team members is required before inclusion into the analysis. Given the differences in protocols, the previous data will only be used to supplement Estuaries Project data. These data sets include: (1) benthic infaunal surveys, (2) eelgrass (and macroalgae) mapping (by Gaines, WHOI) and (3) D.O. records. Note there have been 2 sets of D.O. records collected for the system, the first is unacceptable as the meter was placed too close to the surface and the second data set is not yet available.

A major existing data set which is compliant with the Project QAPP and which will be incorporated fully is the MVC's land-use and watershed delineation (Martha's Vineyard Commission, 1999). This data will allow implementation of the Project's watershed nitrogen loading model.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model which accounts for the dispersion and mixing within the estuary during openings (includes tide gauges and bathymetric survey); (2) collect dissolved oxygen records (1 each in upper and lower pond) with specific sites to be determined, (3) map eelgrass distribution; (4) confirm previous infaunal community analysis; (5) conduct a benthic nitrogen regeneration survey; (6) gauge the stream into the upper pond which likely receives discharge from the WWTF plume (if possible based upon site inspection), and (7) conduct the water quality modeling, thresholds analysis and synthesis. This work will be conducted in collaboration with the Martha's Vineyard Commission through their coastal scientist, William Wilcox.

Hydrodynamic instrumentation will be deployed before, during, and after seasonal breach. Acoustic Doppler Current Profiling (ADCP) will not be performed due to the closure of the pond.

Massachusetts Estuaries Project Round 1 Prioritization

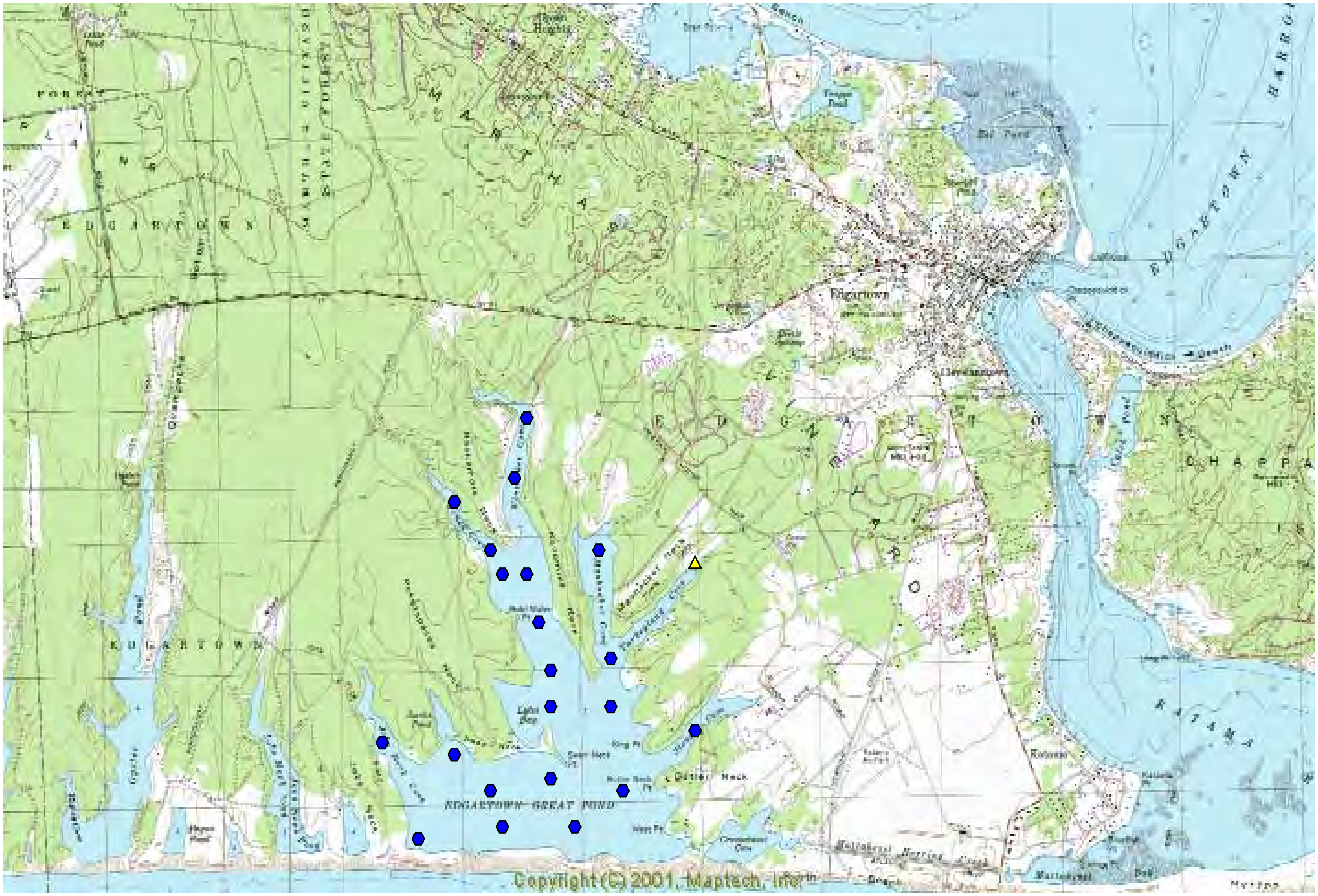
smast
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts
Department of
Environmental
Protection

Figure 1

◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Edgartown Great Pond (16)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flowNitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	19	Once/Embayment	19	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	3 **	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	10	Once/Embayment	10	20	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XVII Oyster Pond
Town of Falmouth
Prioritization Rank: Round 1 - #17

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Oyster Pond, Falmouth*:* Some useful data exist on hydrodynamics, watershed delineation and habitat parameters. However, none of these data sets is complete and each component of the Linked Approach will require some additional data collection or modeling.

This salt pond is closed to tidal exchange by a barrier beach. It has a “managed tidal exchange” through a control weir at the pond outlet. This pond has significant historical data collected by WHOI scientists that will help in assessment and management. Some data has been collected on key elements of the Linked Approach by members of the Estuaries Project Technical Team under the protocols of this QAPP.

Water quality monitoring data (1987-2001) has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Falmouth PondWatch Program.

The data which has been previously collected and will be used to parameterize the Estuaries Project Approach includes: (1) tide gauges, (2) freshwater inflow and nitrogen levels in stream flow, and (3) temporal and spatial distribution of stratification.

Supporting data on stratification of the central basin, historical records of salinity and nitrogen levels, fish populations, herring populations and basic structure are also available.

The main Estuaries Project efforts will be to (1) update the hydrodynamic model (including a bathymetric survey), (2) collect dissolved oxygen records (2 depth profile at the upper basin), (3) infaunal community analysis; (4) conduct a benthic nitrogen regeneration survey; (5) determine stream flow and nitrogen discharge to the upper pond, (6) conduct land-use analysis based upon new USGS watershed delineation, and (7) conduct the water quality modeling, thresholds analysis and synthesis.

Acoustic Doppler Current Profiling (ADCP) will not be performed, due to the embayment's basic configuration and the lack of suitable channel cross section (water is only 20-50 cm depth).

Since Oyster Pond has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

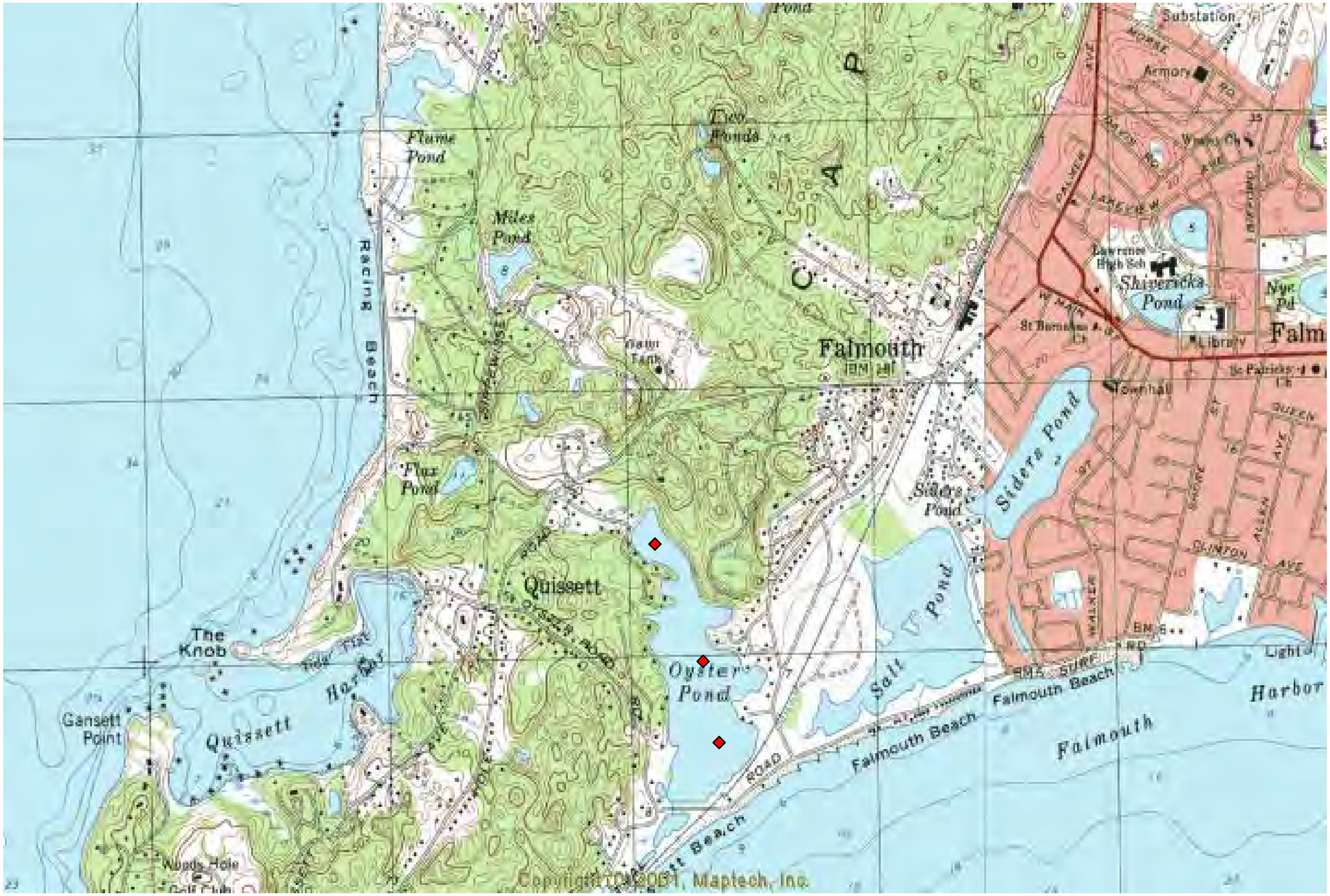
Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Oyster Pond System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This "paired" sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

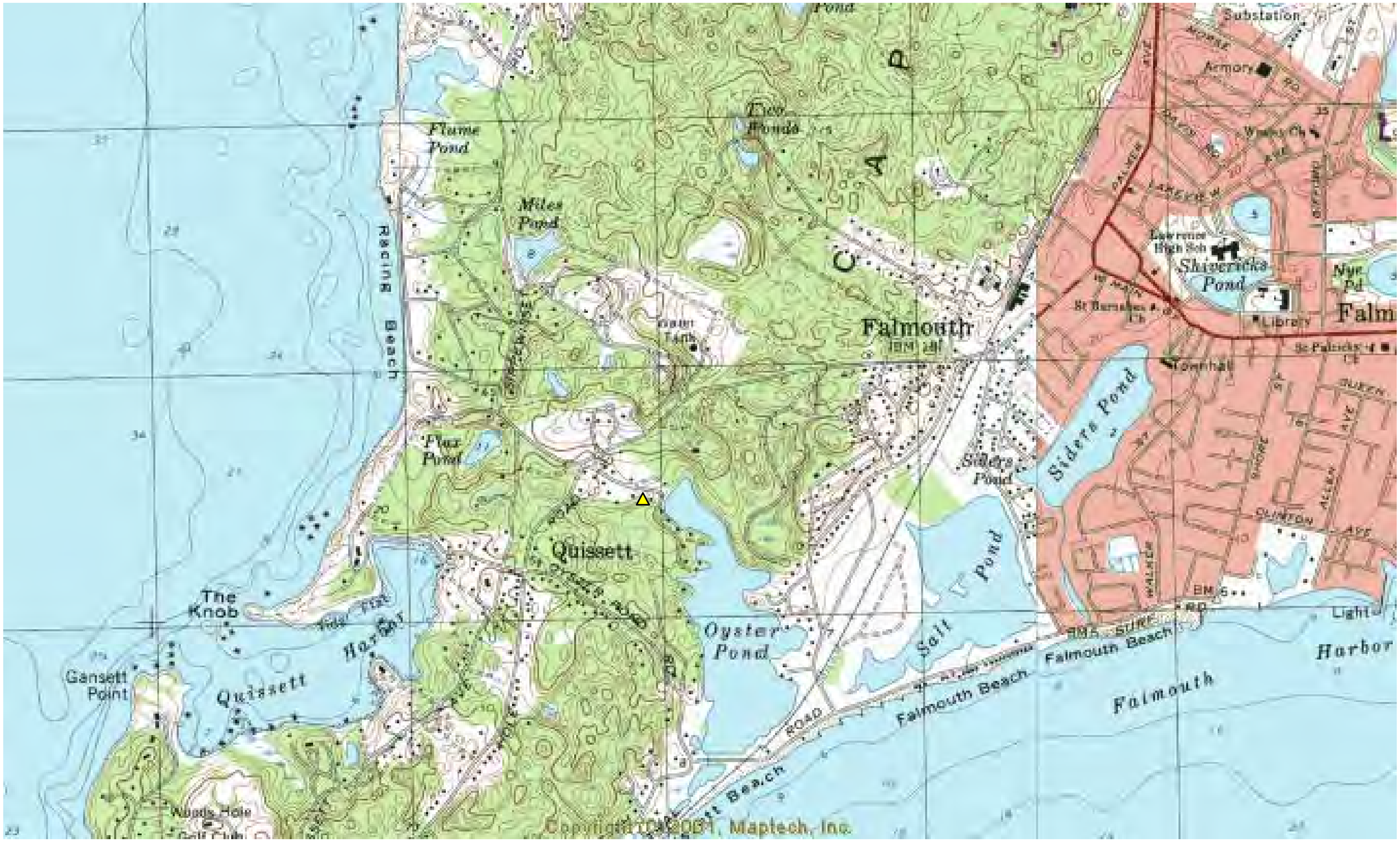
Massachusetts Department of Environmental Protection

Figure 1



◆ Nutrient Sampling Locations

Figure 2



Benthic nutrient flux is inferred from changes in hypolimnion concentrations. Coring will be performed along the edge of the pond just below water surface at this site.

Benthic Coring Locations   Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Oyster Pond (17)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	3	Once/Embayment	4	4	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	0	0	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	5	Once/Embayment	5	10	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XVIII Sesachacha Pond
Nantucket Island
Prioritization Rank: Round 1 - #18

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Sesechacha Pond (on 303d list-pathogens), Nantucket*:* This salt pond is closed to tidal exchange by a barrier beach. It has a “managed tidal exchange” through periodic opening by the Town of Nantucket. This system has seen periods of regular opening and intervals of years with no-openings. Some useful data has been collected on key elements of the Linked Approach as part of the pond management planning. Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP by Estuaries Project Technical Team members with analysis by the Coastal Systems Program at SMAST. Over the past 5 years monitoring data has been sparse and these data have not yet been evaluated for inclusion into the Estuaries Project.

Data is available on the exchange characteristics and nutrient conditions (associated with openings), watershed delineation, and habitat assessment parameters (infaunal and eelgrass). However, none of these data sets is complete and each component of the Linked Approach will require some additional data collection or modeling.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model which accounts for the dispersion and mixing within the estuary during openings (includes tide gauges and bathymetric survey); (2) collect dissolved oxygen records (in the central basin) with specific sites to be determined, (3) map eelgrass distribution; (4) conduct infaunal community analysis; (5) conduct a benthic nitrogen regeneration survey; (6) conduct land-use analysis; and (7) conduct the water quality modeling, thresholds analysis and synthesis. This work will be conducted in collaboration with the Nantucket Marine Department.

If pond is breached during the field season for management purposes, hydrodynamic instrumentation will be deployed, before, during, and after to prescribed breach.

Acoustic Doppler Current Profiling (ADCP) will not be performed due to the closure of the pond. Stream gauging will not be performed due to the lack of stream discharges.

Since Sesachacha Pond has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

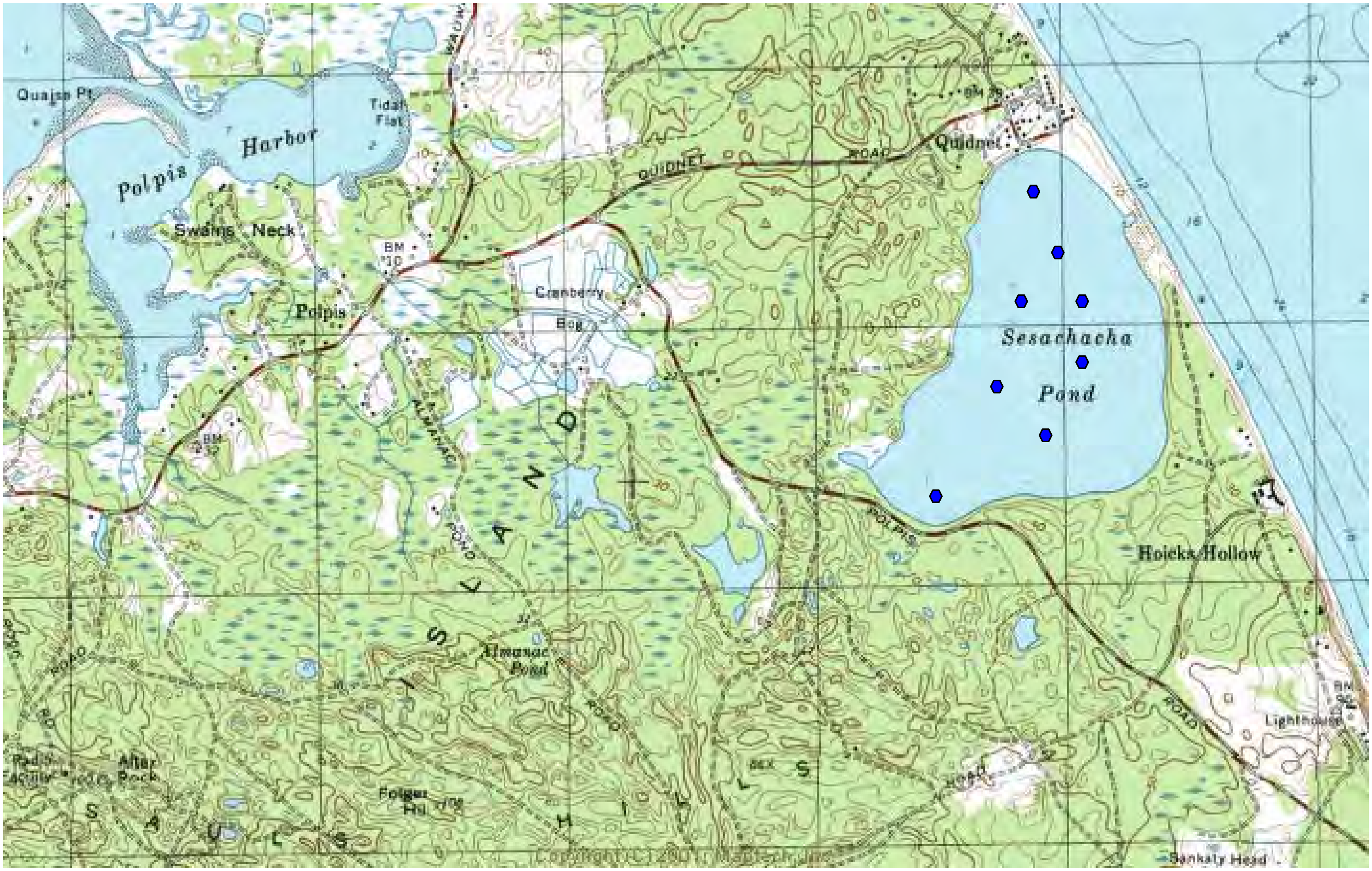
Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Sesachacha Pond System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This “paired” sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization

Figure 1

◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Sesachacha Pond (18)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	NA	NA	NA	NA	0	0	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	7	Once/Embayment	7	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	1 **	12 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	5	Once/Embayment	5	10	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XIX Agawam/Wareham/Broad Marsh Rivers Including Mark's Cove
Town of Wareham
Prioritization Rank: Round 1 - #19

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Wareham River System (Agawam and Wankinco Rivers, Broad Marsh, Marks Cove and Central Estuary), Wareham*:* This system has seen intense activity as part of the Town of Wareham's WWTF permit renewal and system upgrade. Several of the key elements of the Linked Approach have been collected in this effort by Camp, Dresser and McKee and SMAST. However, there was not a system hydrodynamic model or water quality model run as part of this process.

Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP, 1992-2001 (Howes and Williams 2001). All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program. Additional, water quality data was collected by SMAST in 2000 for the Town of Wareham.

The existing data which will be used is fully compliant with this QAPP and was collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) stream nitrogen loading and wetlands attenuation in both the Agawam and Wankinco Rivers, (2) some tide gauge records (need to be supplemented due to failure of the offshore gauge), and (3) land-use analysis (including a study of nitrogen discharge from the existing WWTF).

Some supporting data is also available: (1) a study of nutrient limitation in the Agawam River, and (2) surveys of stratification, estuarine circulation and nutrient structure of the estuary.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based in part on existing tidal data and new gauge records with ADCP measurements of currents; (2) update the existing land-use and watershed nitrogen loading model to conform with Project protocols; (3) collect dissolved oxygen records at 5 locations from the Wankinco/Agawam confluence, equidistant to the mouth of the estuary; (4) map eelgrass and macroalgal distribution; (5) conduct benthic regeneration survey; (6) conduct infaunal community survey and (7) conduct the water quality modeling, thresholds analysis and synthesis.

An additional effort (outside of Estuary Project standard protocols) may be made to use a moored acoustic current meter at the railroad bridge in the upper estuary. This decision will be made based upon a site visit (to see if a mooring is feasible) and further analysis of the extant tide records. The current meter is part of the SMAST Coastal Systems Program instrumentation inventory and will be at no cost to the Project.

Since the Acushnet River / New Bedford Inner Harbor has documented fecal coliform problems, there is data on fecal coliform distribution collected by DMF and SMAST. In addition, there has been a study using a DNA methodology to identify sources.

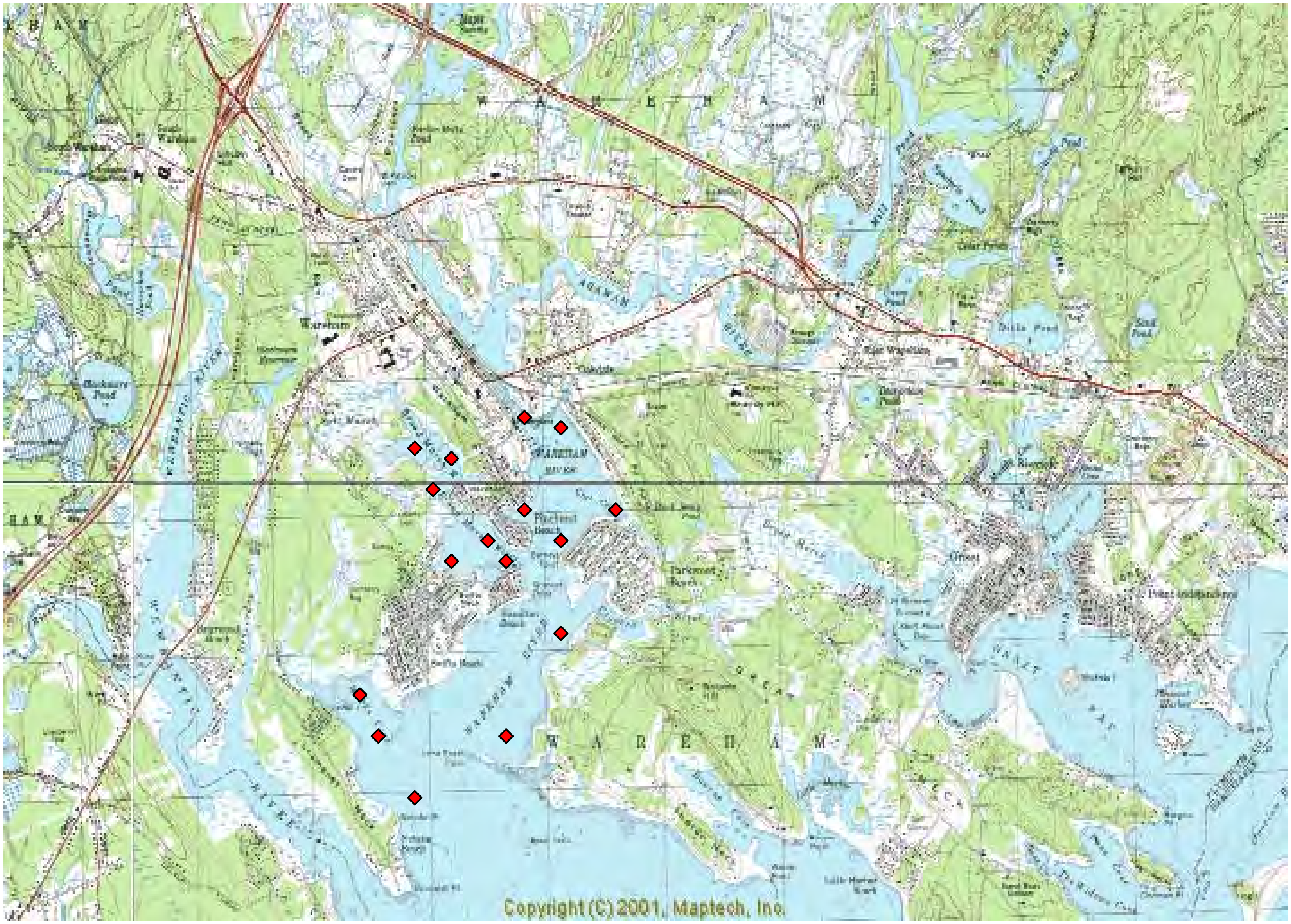
Based upon review of existing DMF bacterial data (Howes and Samimy 2002) bacterial assessment will be performed on the Acushnet River / New Bedford Inner Harbor System. Surface water (0.15 cm depth) will be collected at each of the benthic flux sites and stream gauge sites (Figure 3), during both wet weather and dry weather. This “paired” sampling will be conducted on 3-5 occasions, focusing on periods of warmer water temperatures. The sampling will follow that outlined in B-III. Wet versus dry weather bacterial surveys will be conducted within the embayment.

Massachusetts Estuaries Project Round 1 Prioritization

SMAST
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts
Department of
Environmental
Protection

Figure 1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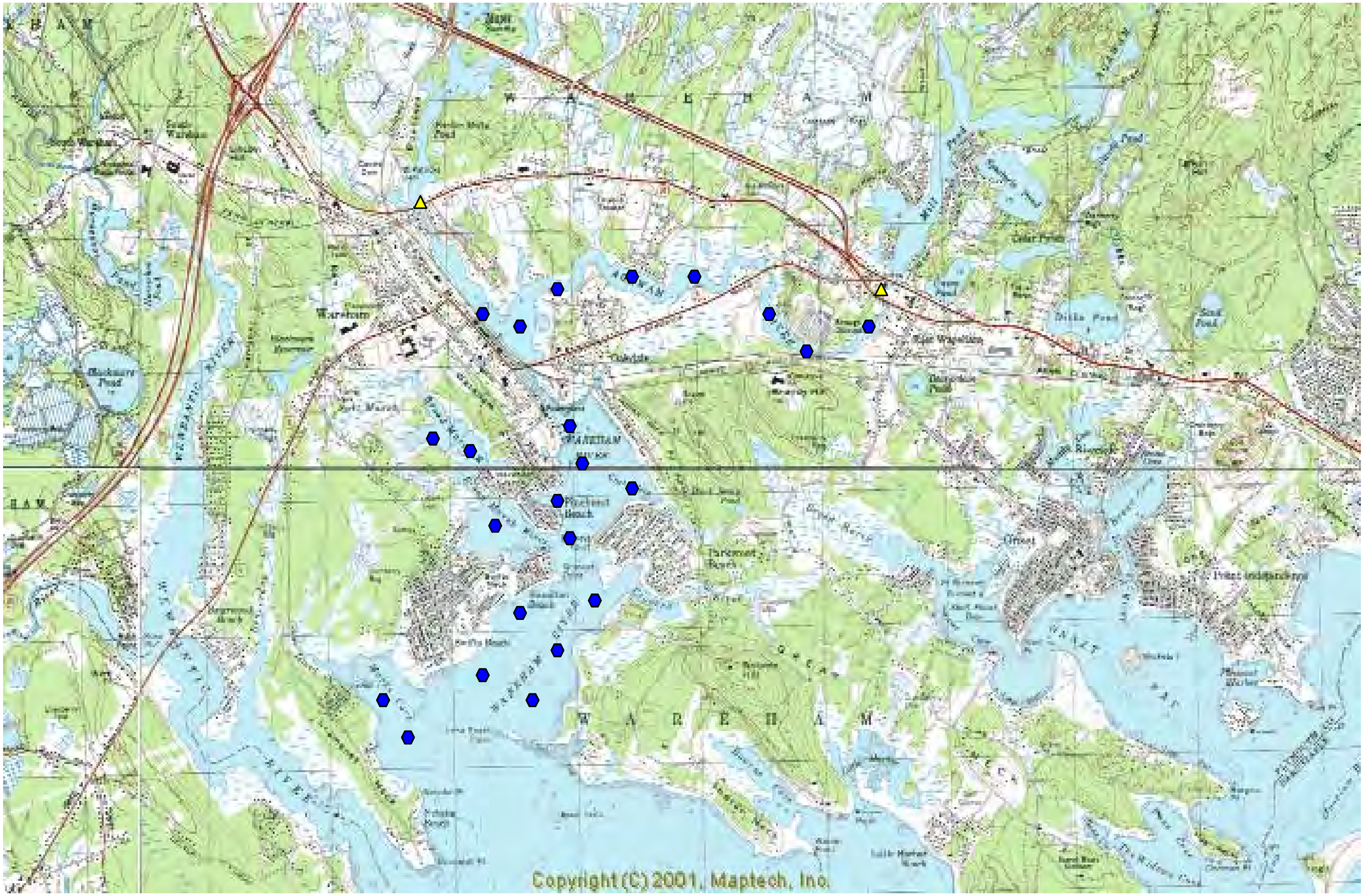
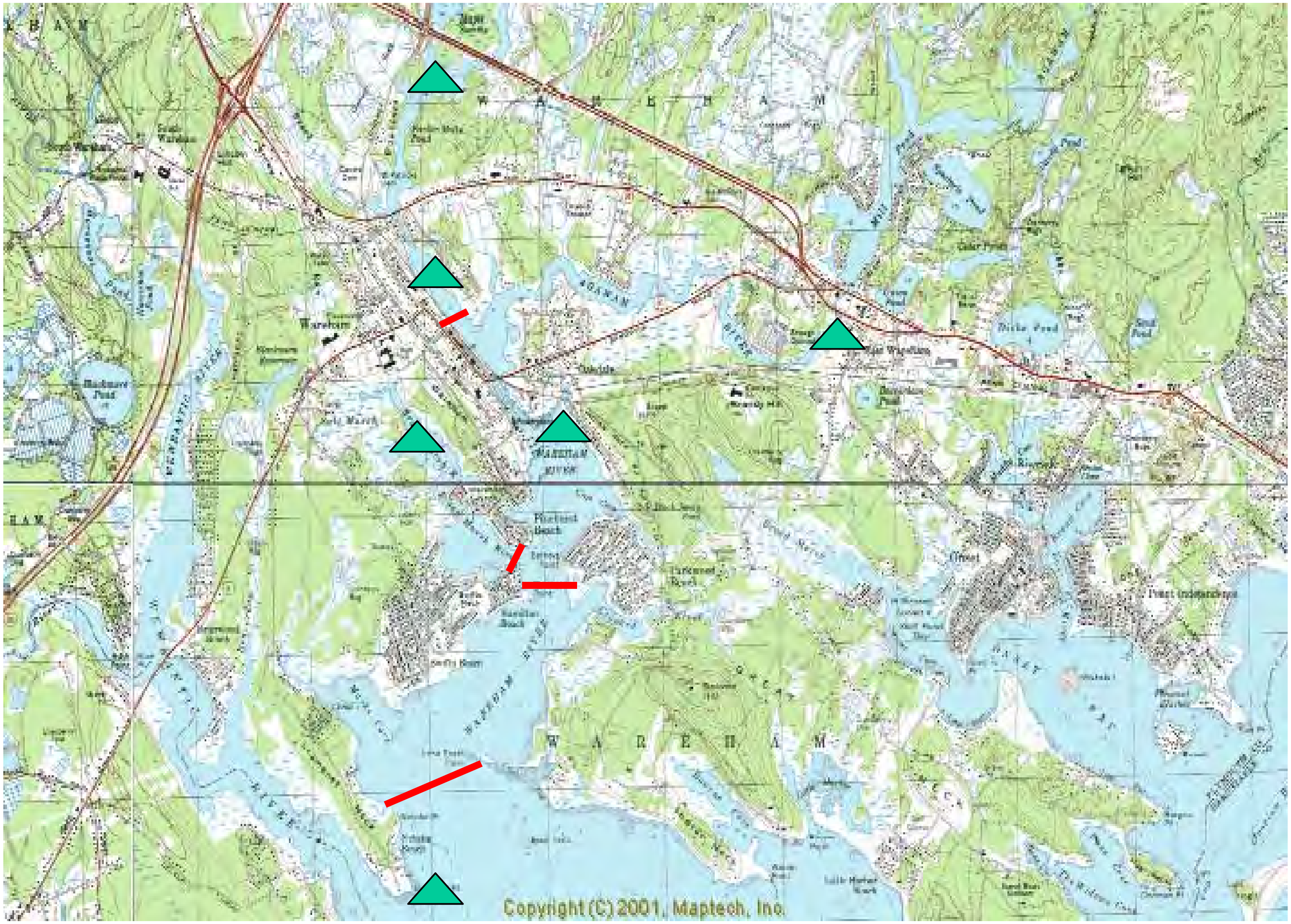
W A R E H A M
Nutrient Sampling Locations

Figure 2



Benthic Coring Locations Stream Gage Locations

Figure 3



Tide Gauge Location ADCP Transect

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Agawam River / Wareham River / Broad Marsh / Marks Cove (19)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	2	daily to every 5 days	200	20	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	23	Once/Embayment	23	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	4 **	48 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	10	Once/Embayment	10	20	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XX Eel Pond Back River
Town of Bourne
Prioritization Rank: Round 1 - #20

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Back River/Eel Pond, Bourne*:* This system has seen significant activity as part of the Town of Bourne Landfill upgrade. Several of the key elements of the Linked Approach have been collected in this effort by the Estuaries Project Technical Team in 2001. However, the full Linked Watershed-Embayment Management Model has not been applied to date.

Water quality monitoring data was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program. An additional spatial survey of oxygen was conducted by SMAST in 2001.

The existing key data which will be used is fully compliant with this QAPP and was collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) limited stream nitrogen loading and wetlands attenuation; (2) complete benthic regeneration survey; (3) tide gauges, bathymetry and hydrodynamic model and (4) some landfill nitrogen loading measurements to support the watershed nitrogen modeling.

The main Estuaries Project efforts will be to (1) update the existing land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (2) enhance the stream flow and nitrogen loading database to bring in to QAPP compliance; (3) conduct benthic infaunal survey; (4) collect dissolved oxygen records (1 mid marsh and 1 in Eel Pond), (5) re-map eelgrass distribution; and (5) conduct the water quality modeling, thresholds analysis and synthesis.

Acoustic Doppler Current Profiling (ADCP) will not be performed (unless otherwise indicated) due to the embayment's basic configuration and the lack of suitable channel cross section.

Massachusetts Estuaries Project Round 1 Prioritization

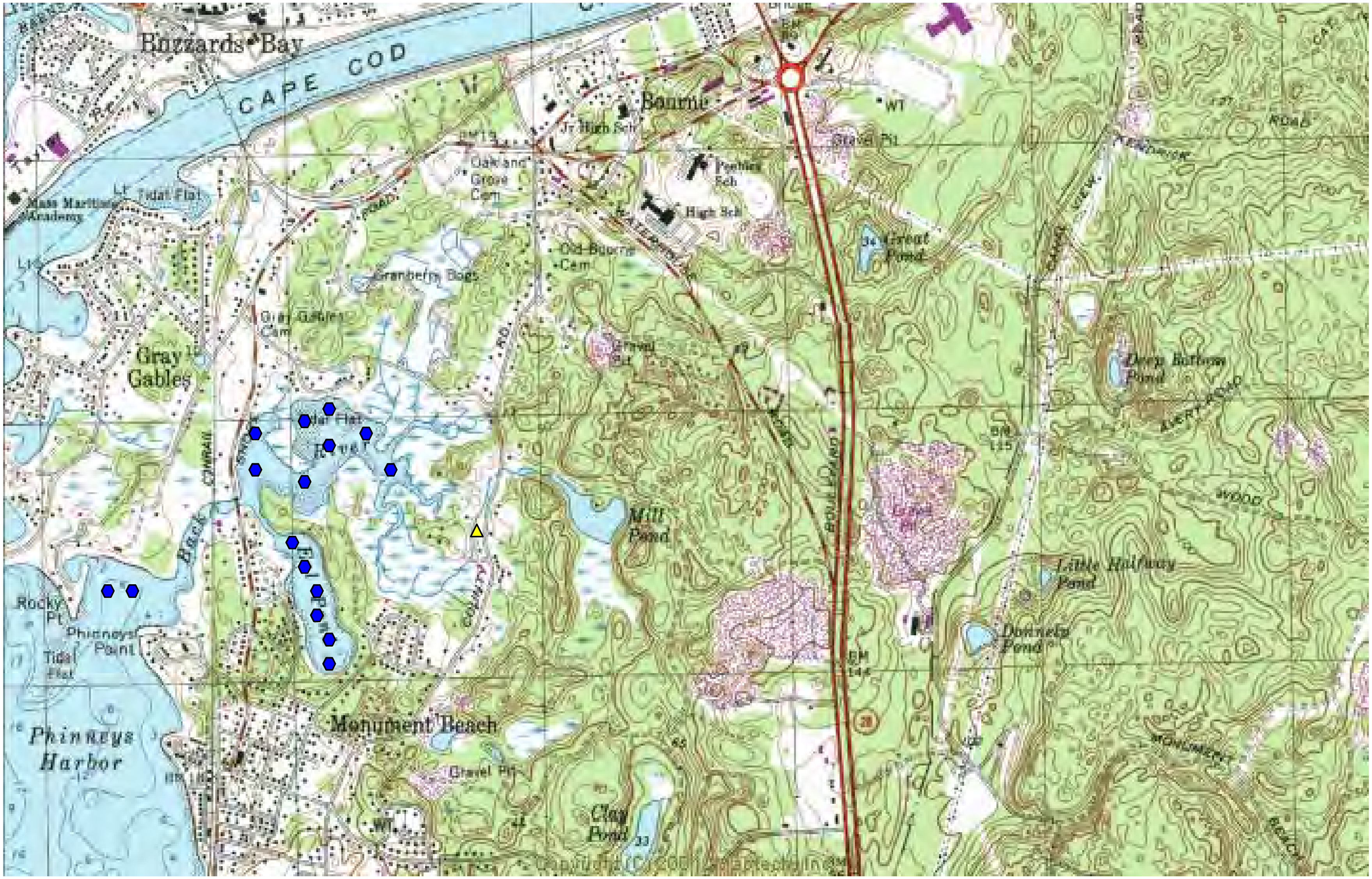
smast
University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts Department of Environmental Protection

Figure 1

◆ Nutrient Sampling Locations

Figure 2



Benthic Coring Locations Stream Gage Locations

Figure 3

Tide Gauge Location

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Eel Pond / Back River (20)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	50	5	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	13	Once/Embayment	13	3	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,l,m	NA	NA	15 minutes ****	2 **	24 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	5	Once/Embayment	5	10	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXI Namskaket Marsh
Town of Orleans
Prioritization Rank: Round 2 - #21

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Namskaket Marsh, Orleans: This estuary consists primarily of a salt marsh system exchanging water with Cape Cod Bay through a single main tidal channel. This system will likely receive some discharge of nutrient enriched groundwater originating from the Tri-Town Septage Treatment Facility. The existing plume is being tracked by USGS.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Town of Orleans Water Quality Monitoring Program. This program uses both technical staff and volunteers to perform the sampling. There are also water quality data collected by the Town of Orleans from lakes which may be in the watershed (awaiting USGS completion of delineations). These data were collected under an approved QAPP with chemical assays primarily by the NPS Laboratory, with some checks by the SMAST Analytical Facility. Additional, nitrogen process-level data exist for this system which will provide supporting information for the Estuaries Project. These data were collected by the

USGS Study of the upper marsh related to the Tri-Town Septage Treatment Plume for DEP. The data which will be incorporated includes: (1) magnitude of the nitrogen load from the Treatment Facility reaching the marsh now and projected future discharge; (2) rates of denitrification within the upper marsh creek bottoms; (3) likely responses of the vegetated marsh and creek bottoms to increased nitrogen loading.

There are additional existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and an ADCP validated hydrodynamic model of this system, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream site.

The main Estuaries Project efforts will be to (1) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (2) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (3) collect benthic cores and determine summer nitrogen regeneration rates; (4) collect a dissolved oxygen record to support the habitat assessment; (5) map eelgrass distribution and create historic record; (6) collect benthic infaunal distribution and indicator data; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

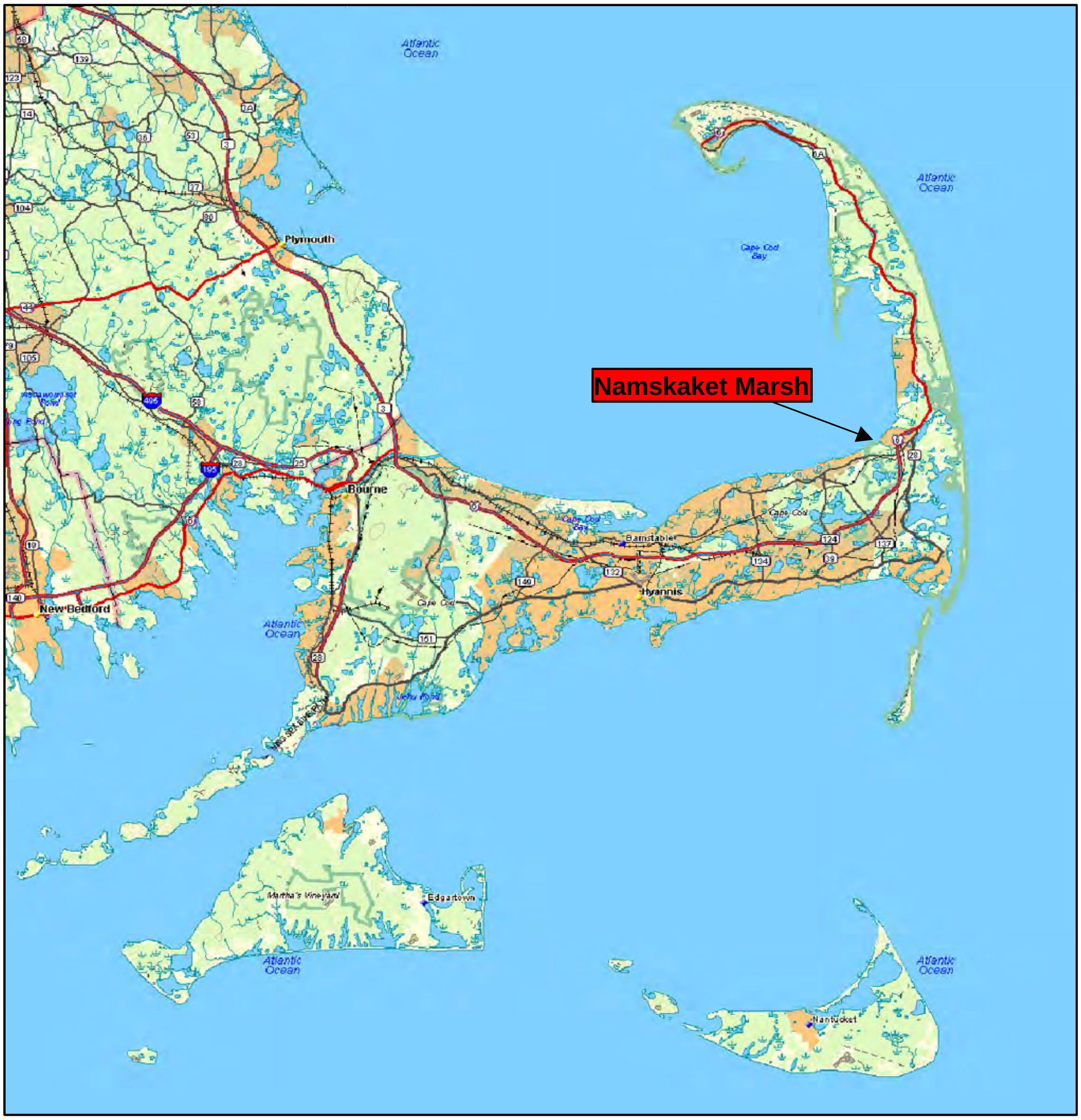
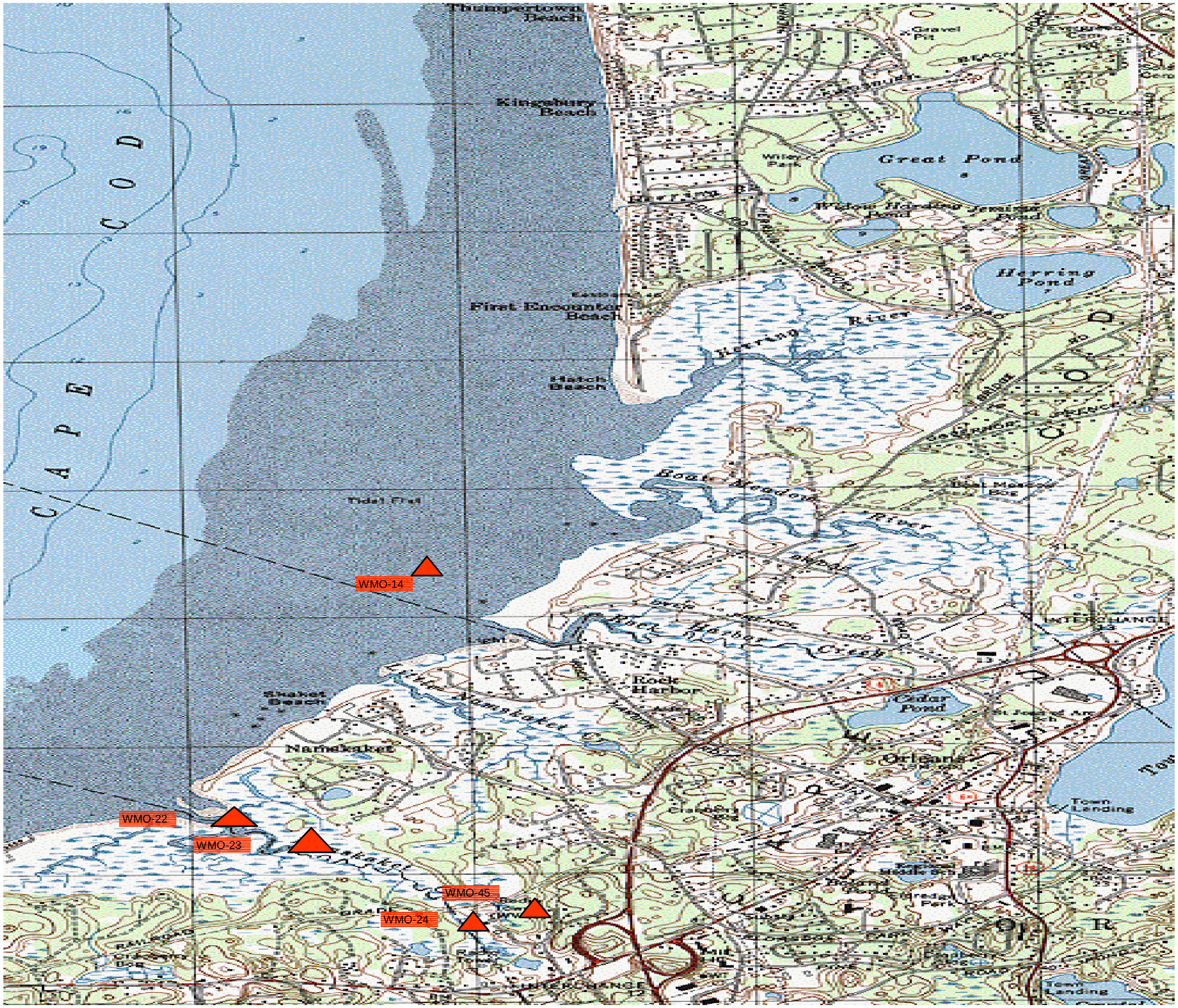
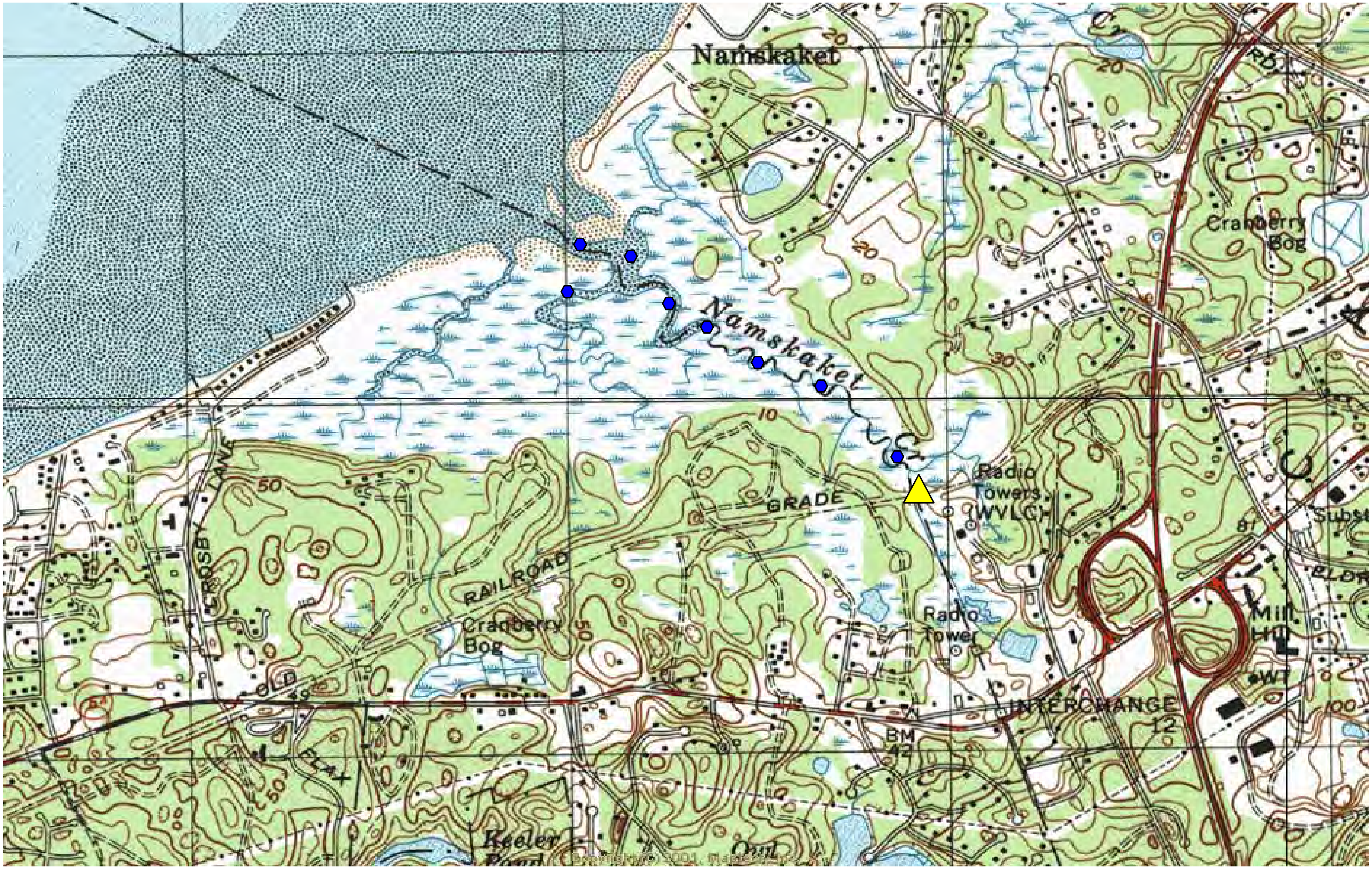

Namskaket Marsh
Atlantic Ocean
Atlantic Ocean
Cape Cod Bay
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Martha's Vineyard
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket

Figure 1



Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations △ Stream Gage/MEP Nutrient Sampling

Figure 3

Tide Gauge Location — ADCP — Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Namskaket Marsh (21)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	8	Once/Embayment	8	0 *****	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	1 **	15 minutes ****	> 2880	9 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	4	Once/Embayment	4	8	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
***** Cores will be collected in both Namskaket and Little Namskaket Systems on same day therefore QC sample listed in table for Little Namskaket Marsh
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXII Little Namskaket Marsh
Town of Orleans
Prioritization Rank: Round 2 - #22

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Little Namskaket Marsh, Orleans:
This estuary consists primarily of a salt marsh system exchanging water with Cape Cod Bay through a single main tidal channel. This system may potentially receive nutrient enriched groundwater discharges originating from the Tri-Town Septage Treatment Facility. The existing plume is being tracked by USGS.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Town of Orleans Water Quality Monitoring Program. This program uses both technical staff and volunteers to perform the sampling. There are also water quality data collected by the Town of Orleans from lakes which may be in the watershed (awaiting USGS completion of delineations). These data were collected under an approved QAPP with chemical assays primarily by the NPS Laboratory, with some checks by the SMAST Analytical Facility.

There are some existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and an ADCP validated hydrodynamic model of this system, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream site.

The main Estuaries Project efforts will be to (1) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (2) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (3) collect benthic cores and determine summer nitrogen regeneration rates; (4) collect a dissolved oxygen record to support the habitat assessment; (5) map eelgrass distribution and create historic record; (6) collect benthic infaunal distribution and indicator data; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

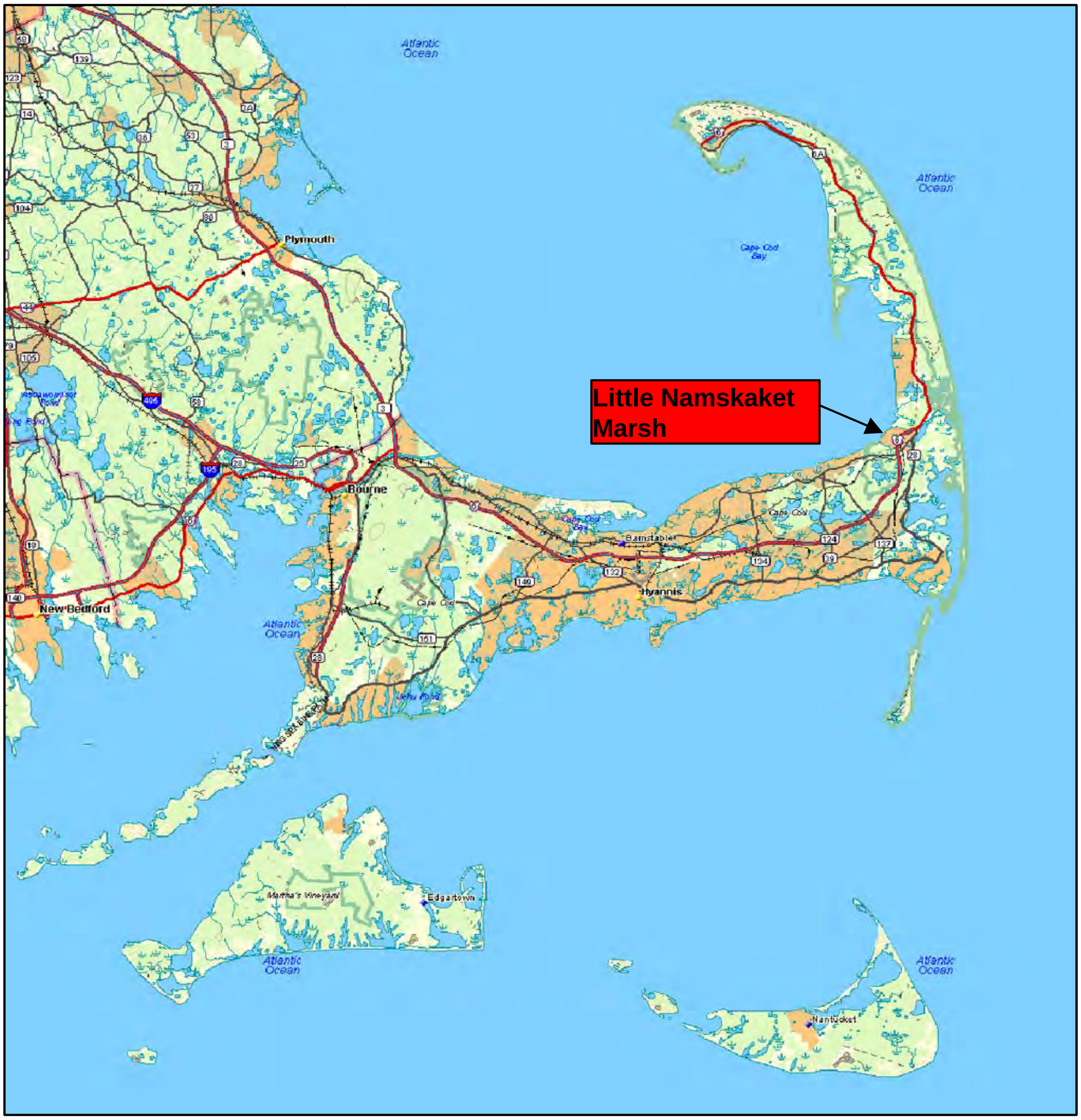
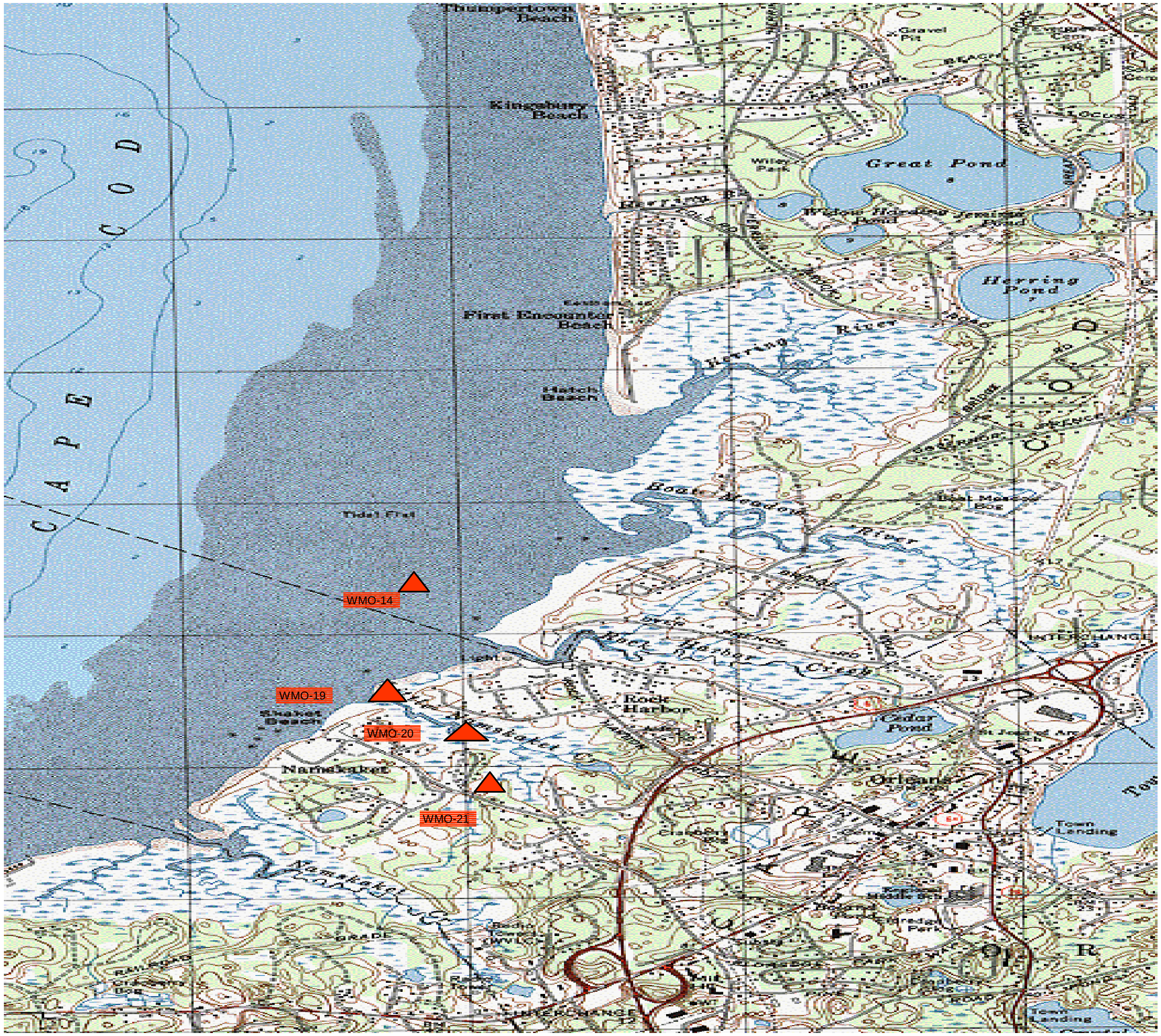
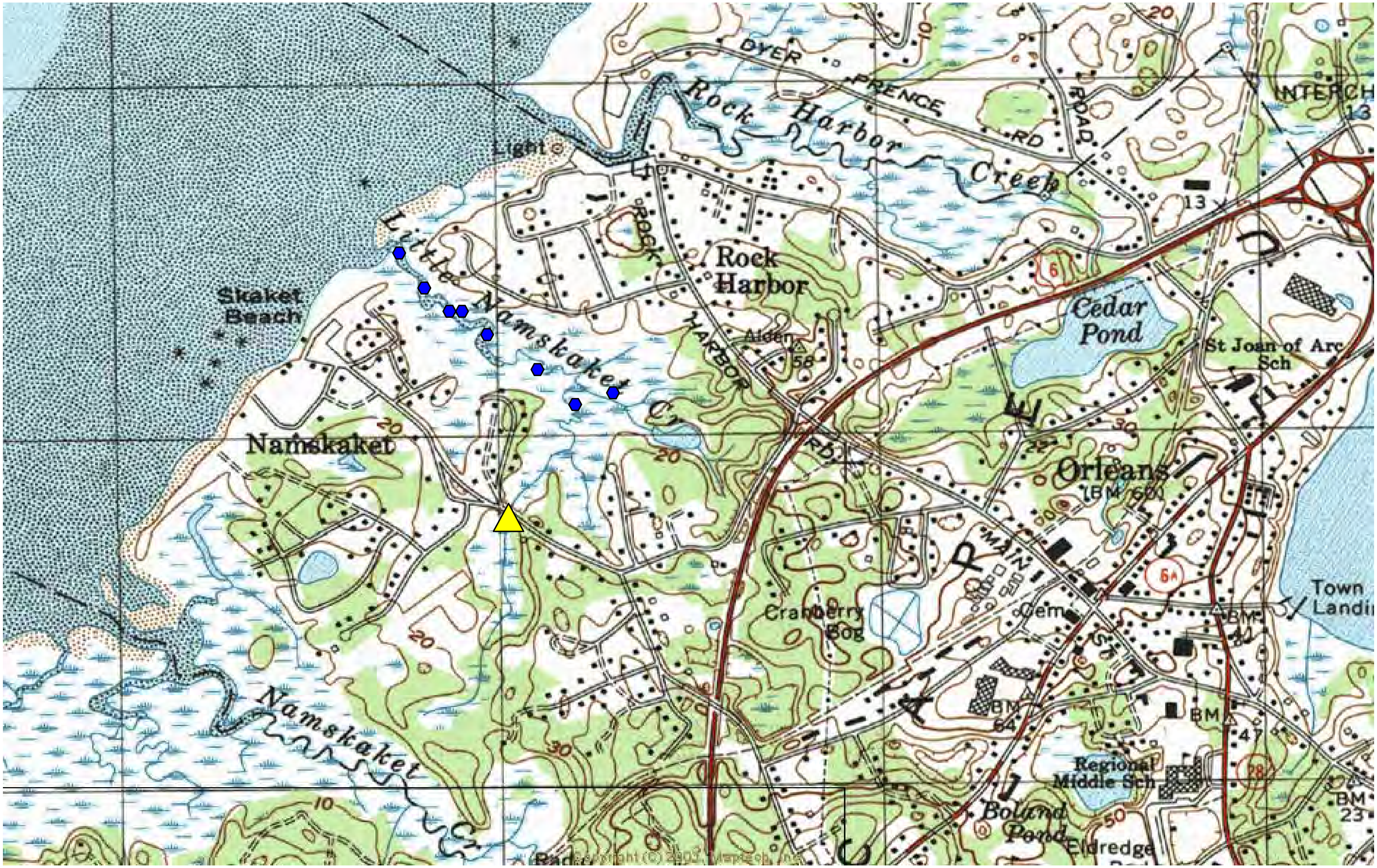

Little Namskaket Marsh
Atlantic Ocean
Cape Cod Bay
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Edgartown
Nantucket

Figure 1



▲ Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations △ Stream Gage/MEP Nutrient Sampling Location

Figure 3

Tide Gauge ADCP Dissolved Oxygen Mooring Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Little Namskaket Marsh (22)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	7	Once/Embayment	7	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	1**	15 minutes****	> 2880	9 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	4	Once/Embayment	4	4	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXIII Rock Harbor
Town of Orleans
Prioritization Rank: Round 2 - #23

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Rock Harbor, Orleans: This estuary consists primarily of a salt marsh system, with a man-made harbor in its lower reach, exchanging water with Cape Cod Bay through a single main tidal channel. The Harbor is fully populated with boat slips and moorings.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Town of Orleans Water Quality Monitoring Program. This program uses both technical staff and volunteers to perform the sampling. There are also water quality data collected by the Town of Orleans from lakes within the watershed. These data were collected under an approved QAPP with chemical assays primarily by the NPS Laboratory, with some checks by the SMAST Analytical Facility.

There are some existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and an ADCP validated hydrodynamic model of this system, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream site.

The main Estuaries Project efforts will be to (1) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (2) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (3) collect benthic cores and determine summer nitrogen regeneration rates; (4) collect a dissolved oxygen record to support the habitat assessment; (5) map eelgrass distribution and create historic record; (6) collect benthic infaunal distribution and indicator data; and (7) conduct the water quality modeling, thresholds analysis and synthesis.


Rock Harbor
Atlantic Ocean
Atlantic Ocean
Cape Cod Bay
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Martha's Vineyard
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket

Figure 1

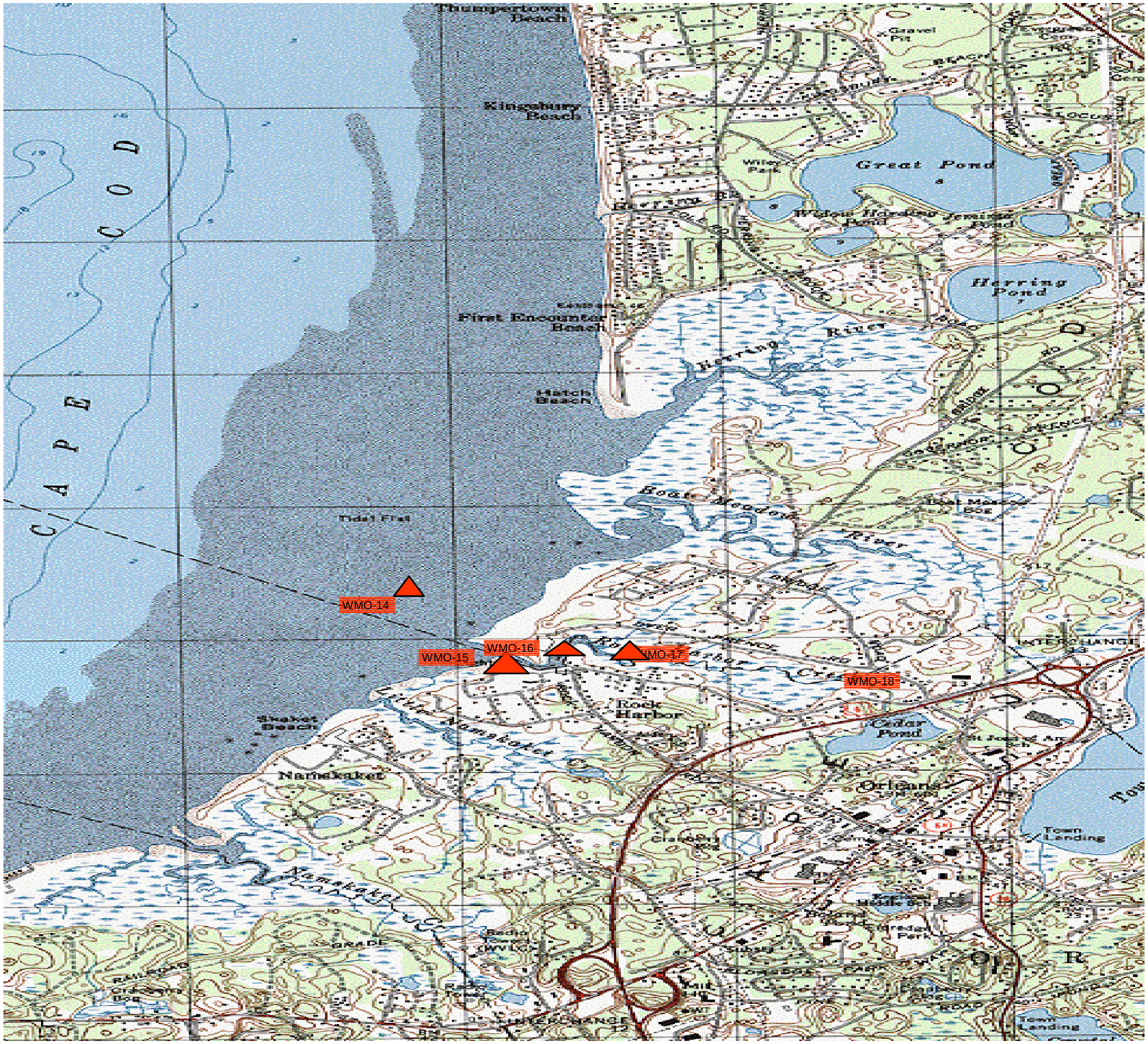

WMO-14
WMO-15
WMO-16
WMO-17
WMO-18
Historical Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling   Figure 3

Tide Gauge Location ADCP Transects Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Rock Harbor (23)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	7	Once/Embayment	7	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	1**	15 minutes ****	> 2880	9 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	4	Once/Embayment	4	4	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXIV Nauset Marsh
Town of Orleans
Prioritization Rank: Round 2 - #24

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

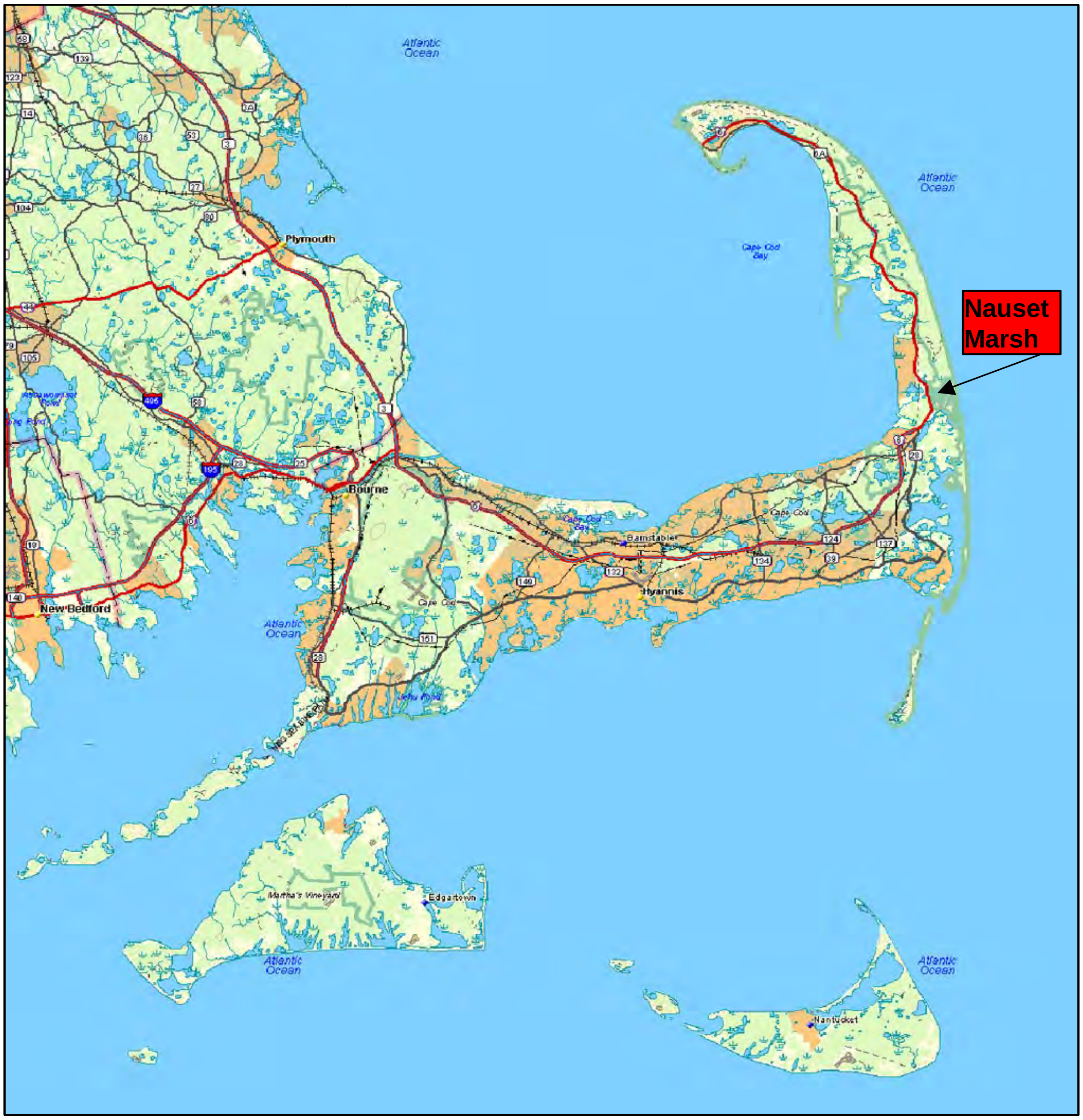
Nauset Marsh, Orleans: This estuary consists primarily of a salt marsh system (upper half) coupled to a large lagoon, Town Cove (lower half). Both sub-systems exchange tidal waters with the Atlantic Ocean through a single inlet, Nauset Inlet. This system supports significant shellfish resources. The Nauset System experienced a large red-tide bloom during the summer of 2002. The Estuaries Project is collaborating with a group from WHOI who are planning a system-wide assessment of red-tide during the project period.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Town of Orleans Water Quality Monitoring Program. This program uses both technical staff and volunteers to perform the sampling. There are also water quality data collected by the Town of Orleans from lakes potentially within the watershed (awaiting USGS delineations). These data were collected under an approved QAPP with chemical assays primarily by the NPS Laboratory, with some checks by the SMAST Analytical Facility.

There are historical data which have been assembled by the Estuaries Project which directly relate to the Linked Modeling effort: (1) Town Cove Study (Teal et al. 1983), (2) preliminary land-use analysis by the Cape Cod Commission (2000), (3) tidal circulation modeling by WHOI, 1997 (data not usable due to lack of offshore system driving gauge), (4) denitrification measurements in nearshore of upper system (Nowicki et al.).

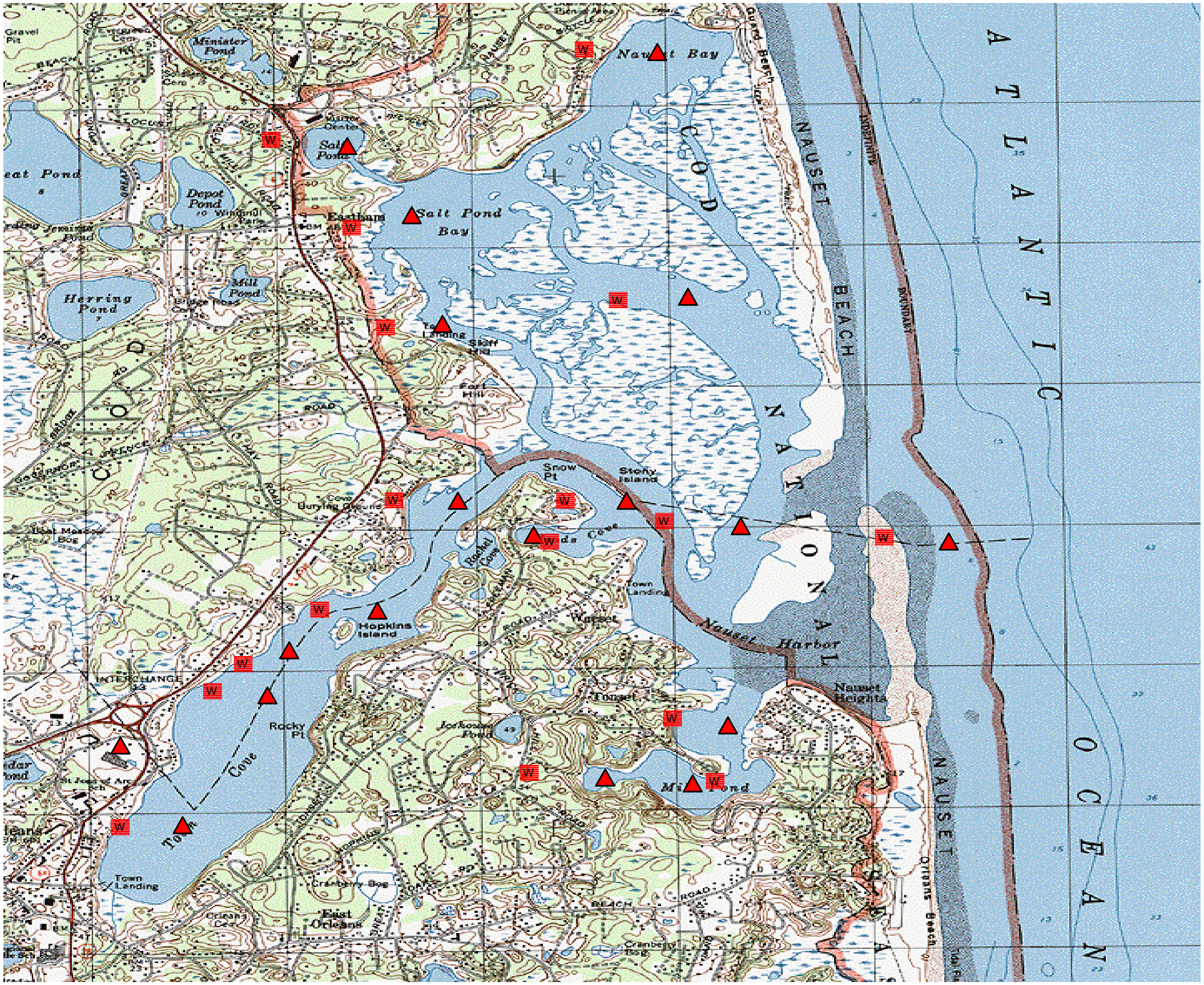
There are some existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and an ADCP validated hydrodynamic model of this system, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream site.

The main Estuaries Project efforts will be to (1) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (2) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (3) collect benthic cores and determine summer nitrogen regeneration rates; (4) collect a dissolved oxygen record to support the habitat assessment; (5) map eelgrass distribution and create historic record; (6) collect benthic infaunal distribution and indicator data; and (7) conduct the water quality modeling, thresholds analysis and synthesis.



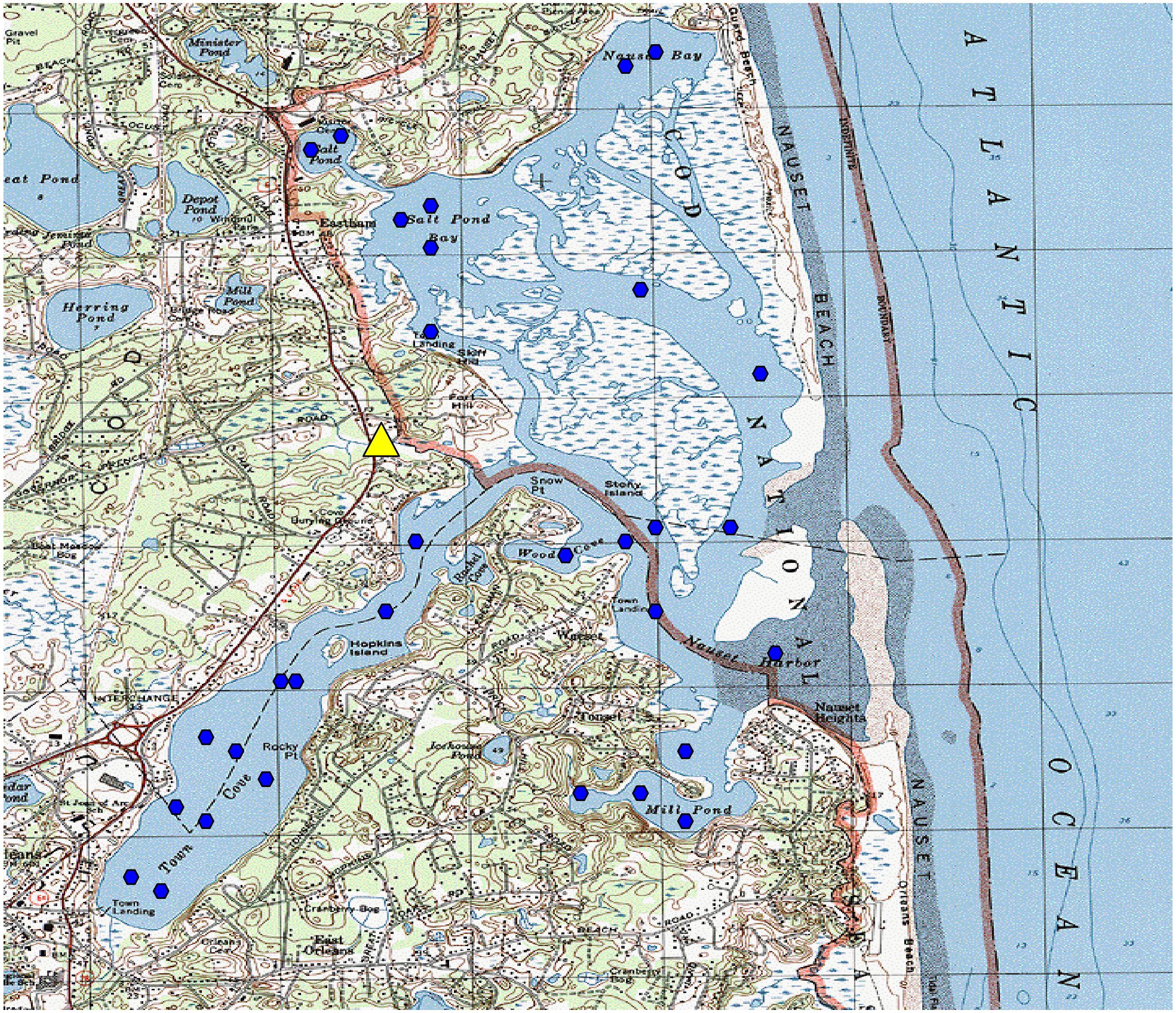
Nauset
Marsh
Atlantic
Ocean
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Edgartown
Nantucket

Figure 1

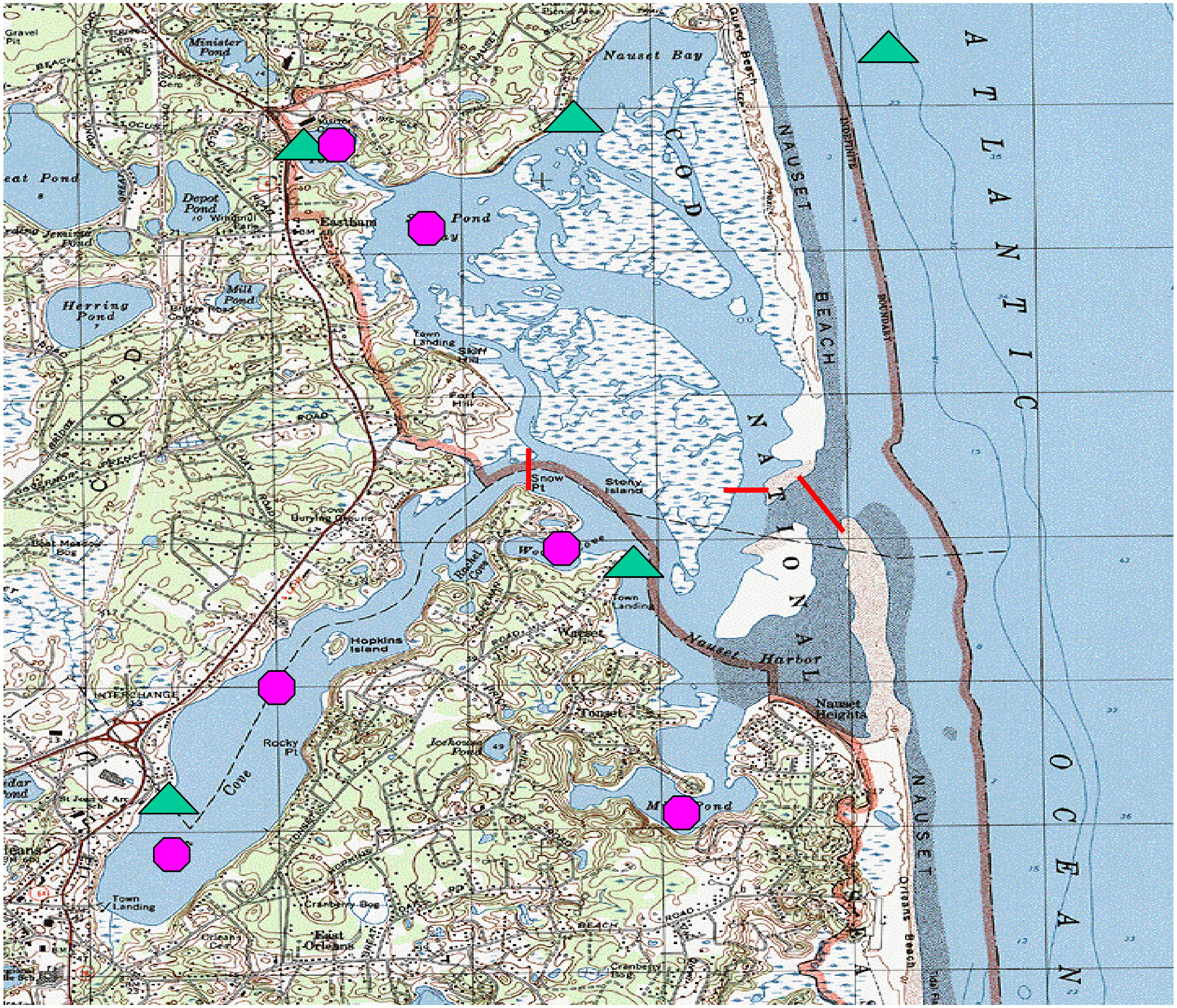


Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling   Figure 3



Tide Gauge Location ADCP Dissolved Oxygen Mooring Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Nauset Marsh (24)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	29	Once/Embayment	29	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	6**	15 minutes ****	> 2880	54 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	15	Once/Embayment	15	15	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXV Upper Pleasant Bay
Towns of Orleans/Harwich/Brewster
Prioritization Rank: Round 2 - #25

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

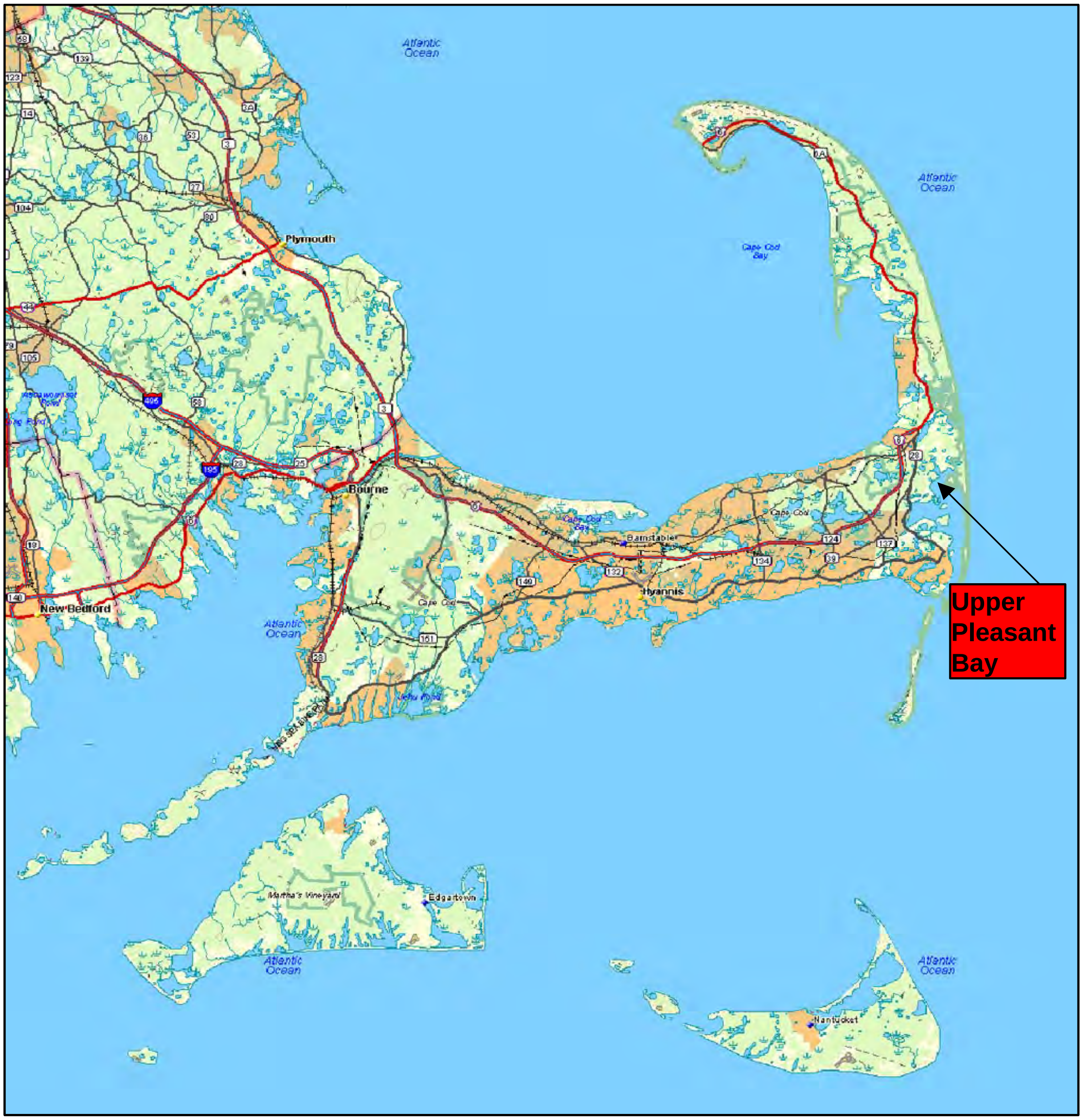
Upper Pleasant Bay, Orleans/Harwich/Brewster: This estuary consists of the upper region of Pleasant Bay, the largest enclosed embayment on Cape Cod. The system is primarily open water, although extensive salt marshes exist on the eastern shore. There are 3 terminal drowned kettle ponds which have been the focus of water quality concerns (Arey's, Lonnies, Meetinghouse Ponds). The Pleasant Bay System exchanges water with the Atlantic Ocean through a single main tidal channel within Chatham Harbor. This inlet historically has migrated, with the current inlet being the result of a relatively recent breach.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Town of Orleans Water Quality Monitoring Program. This program uses both technical staff and volunteers to perform the sampling. This water quality data set is integrated with the Pleasant Bay Alliance Monitoring Program data, which was collected under a DEP/EPA approved QAPP. There is also water quality data collected by the Town of

Orleans from lakes within the watershed. These data were collected under an approved QAPP with chemical assays primarily by the NPS Laboratory, with some checks by the SMAST Analytical Facility. The Pleasant Bay Alliance is assisting in the incorporation of historical data into the Estuaries Project Effort.

There are some existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and an ADCP validated hydrodynamic model for the River sub-system and a coarse hydrodynamic model for Upper Pleasant Bay, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream sites.

The main Estuaries Project efforts will be to (1) integrate the tributary embayment hydrodynamic models to a Project upgraded model for the central bay which will require limited placement of tide gauges and conducting ADCP measurements; (2) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (4) collect benthic cores and determine summer nitrogen regeneration rates; (5) collect distributed dissolved oxygen records to support the habitat assessment; (6) map eelgrass distribution and create historic record; (7) collect benthic infaunal distribution and indicator data; and (8) conduct the water quality modeling, thresholds analysis and synthesis.

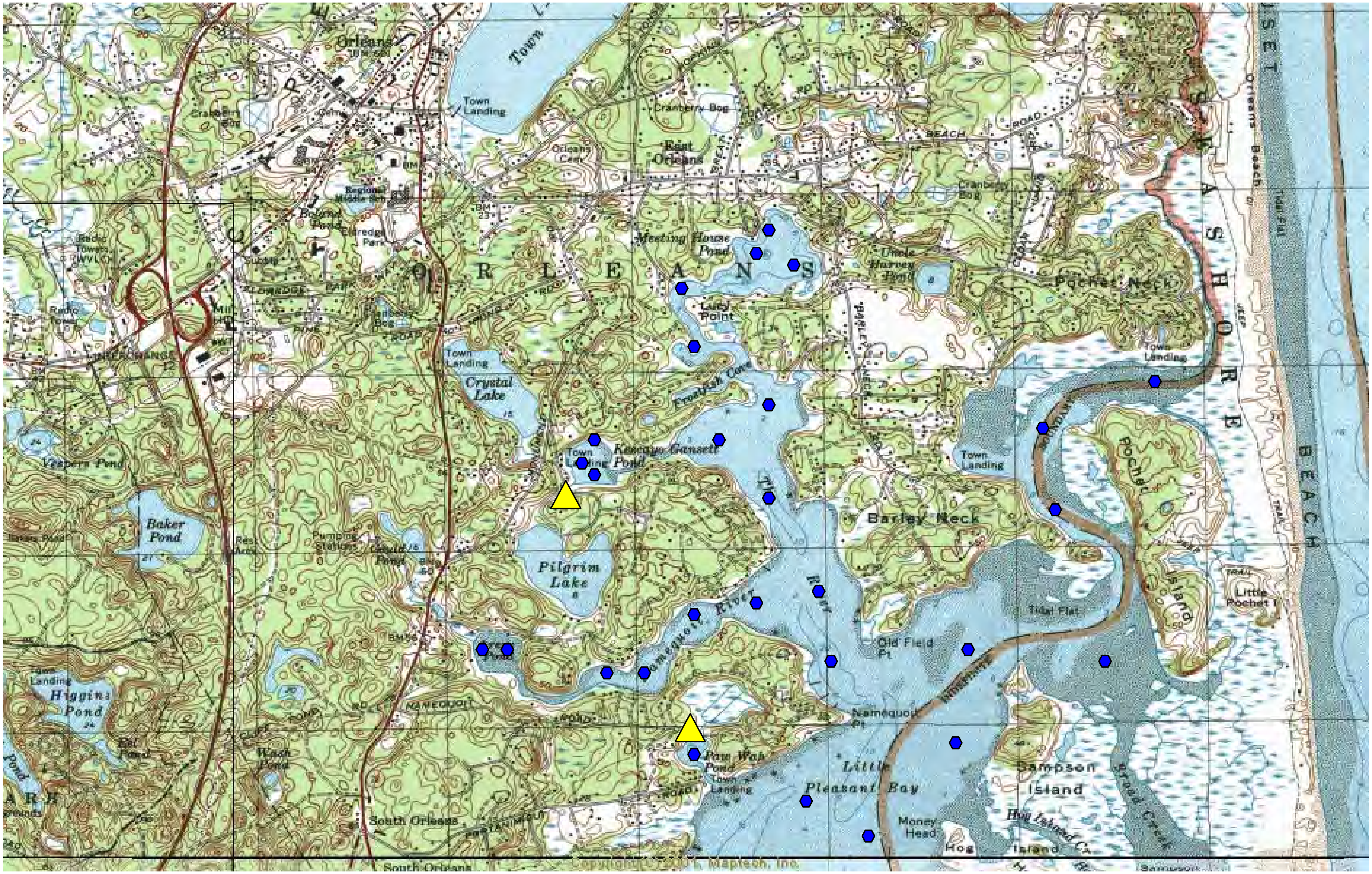


Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Upper Pleasant Bay
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket

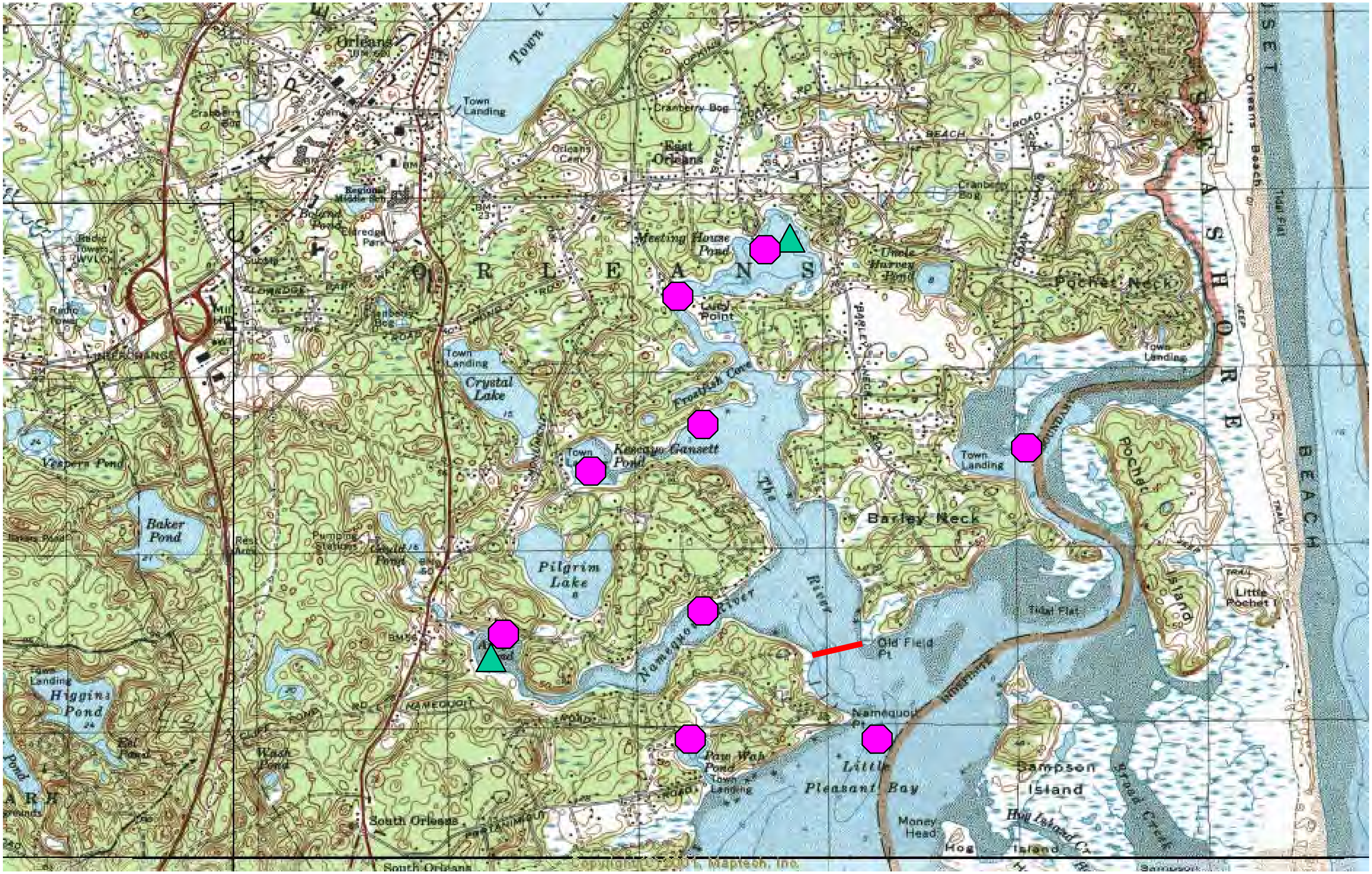
Figure 1

Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling   Figure 3



Tide Gauge ADCP Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Pleasant Bay - Upper (25)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	2	Weekly	120	12	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	26	Once/Embayment	26	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	8**	15 minutes ****	> 2880	72 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	12	Once/Embayment	12	12	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXVI Lower Pleasant Bay
Town of Orleans
Prioritization Rank: Round 2 - #26

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Lower Pleasant Bay, Orleans/Harwich/Brewster: This estuary consists of the lower region of Pleasant Bay, the largest enclosed embayment on Cape Cod. The system is primarily open water. There are 4 tributary embayments to the central bay, which have been the focus of water quality concerns (Quanset Pond, Round Cove, Muddy Creek, Bassing Harbor). The Pleasant Bay System exchanges water with the Atlantic Ocean through a single main tidal channel within Chatham Harbor. This inlet historically has migrated, with the current inlet being the result of a relatively recent breach.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed under a DEP/EPA approved QAPP for the Pleasant Bay Alliance. Analyses have been conducted by the SMAST Analytical Facility. This program uses both technical staff and volunteers to perform the sampling. The Pleasant Bay Alliance is assisting in the incorporation of historical data into the Estuaries Project Effort.

There are some existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP. These data were collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) bathymetric and tidal data and a coarse hydrodynamic model for Pleasant Bay, (2) partial record of stream flow and nutrient load at the Estuaries Project proposed stream site, (3) Estuaries Project full analysis for the tributary embayments of Muddy Creek and Bassing Harbor, which will be linked to the Pleasant Bay model.

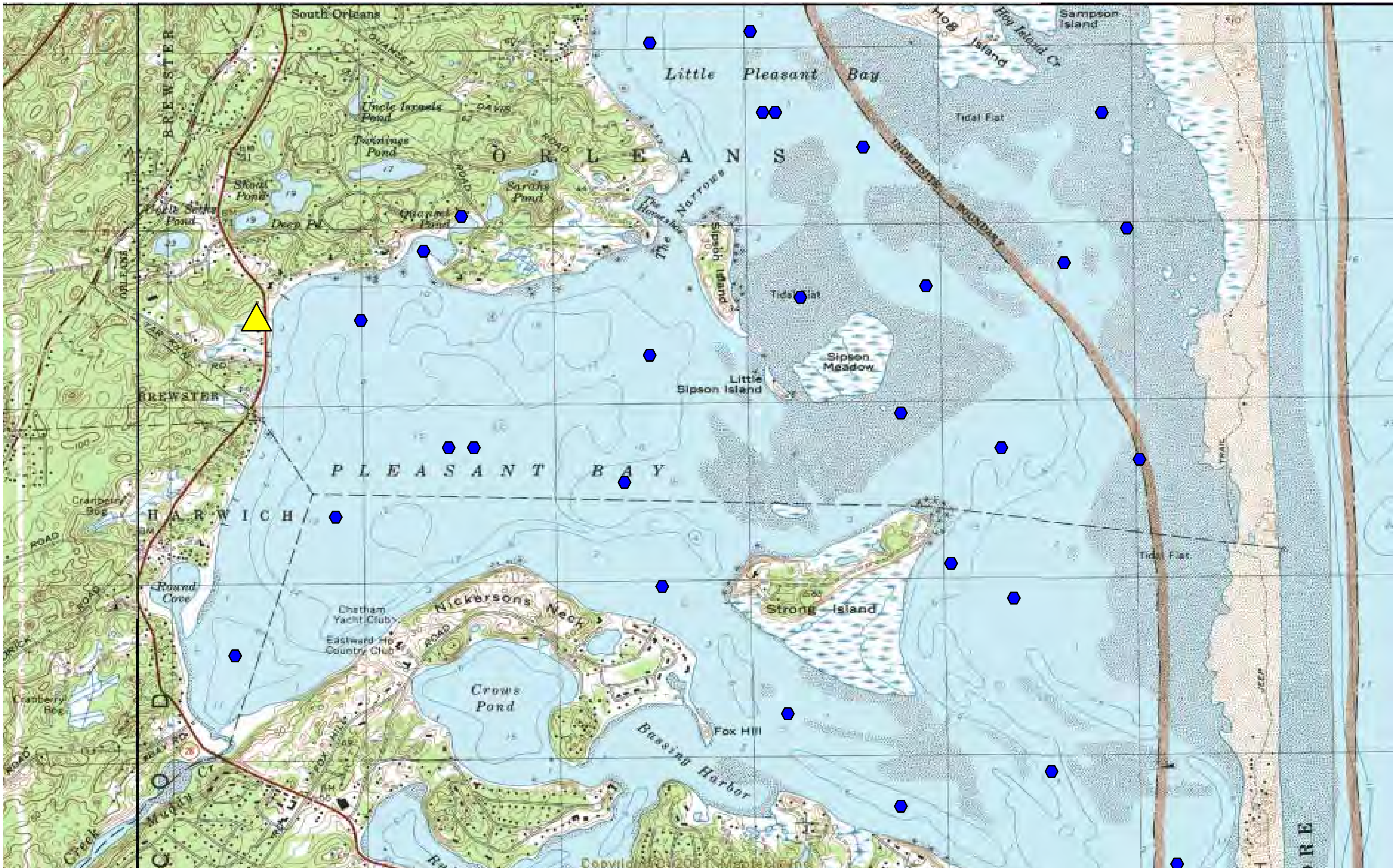
The main Estuaries Project efforts will be to (1) up-grade the current hydrodynamic model for the central bay which will require limited placement of tide gauges and conducting ADCP measurements; (2) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect stream flow/nitrogen load data to complete the requisite 14 months (building on the existing dataset); (4) collect benthic cores and determine summer nitrogen regeneration rates; (5) collect distributed dissolved oxygen records to support the habitat assessment; (6) map eelgrass distribution and create historic record; (7) collect benthic infaunal distribution and indicator data; and (8) conduct the water quality modeling, thresholds analysis and synthesis.


Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Lower Pleasant Bay
Edgartown
Atlantic Ocean
Atlantic Ocean

Figure 1

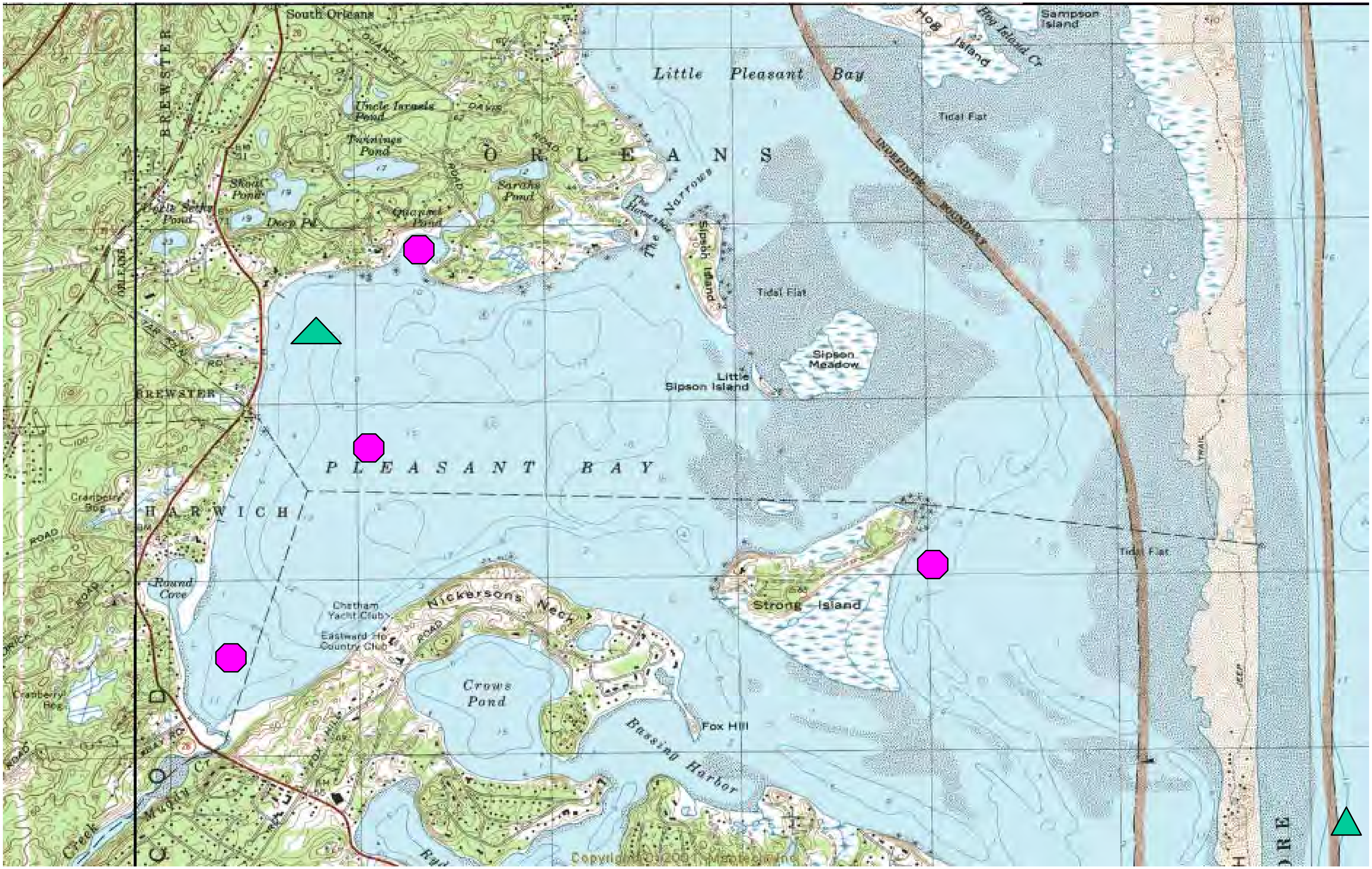
Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling Location

Figure 3



Tide Gauge ADCP Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Pleasant Bay - Lower (26)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	30	Once/Embayment	30	2	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	4**	15 minutes ****	> 2880	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	12	Once/Embayment	12	12	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXVII Lake Tashmoo
Martha's Vineyard
Prioritization Rank: Round 2 - #27

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Lake Tashmoo, Martha's Vineyard: This estuary consists of a drowned river valley separated from offshore waters by a barrier beach with a maintained tidal inlet. The system is primarily open water with limited fringing salt marsh.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed by the Martha's Vineyard Commission following the Coalition for Buzzards Bay Monitoring QAPP (and may have had its own QAPP as well). Technical design details and analytical aspects of the monitoring program were reviewed by the Coastal Systems Program at SMAST for the MVC. Most of the assays were performed by the SMAST Analytical Facility. This program uses technical staff to perform the sampling. The Martha's Vineyard Commission is a formal partner to the Estuaries Project and is assisting in the incorporation of water quality data and historical data into the Estuaries Project Effort.

At present no existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP have been identified.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based which will require placement of tide gauges and conducting ADCP measurements; (2) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect stream flow/nitrogen load data; (4) collect benthic cores and determine summer nitrogen regeneration rates; (5) collect distributed dissolved oxygen records to support the habitat assessment; (6) map eelgrass distribution and create historic record; (7) collect benthic infaunal distribution and indicator data; and (8) conduct the water quality modeling, thresholds analysis and synthesis.

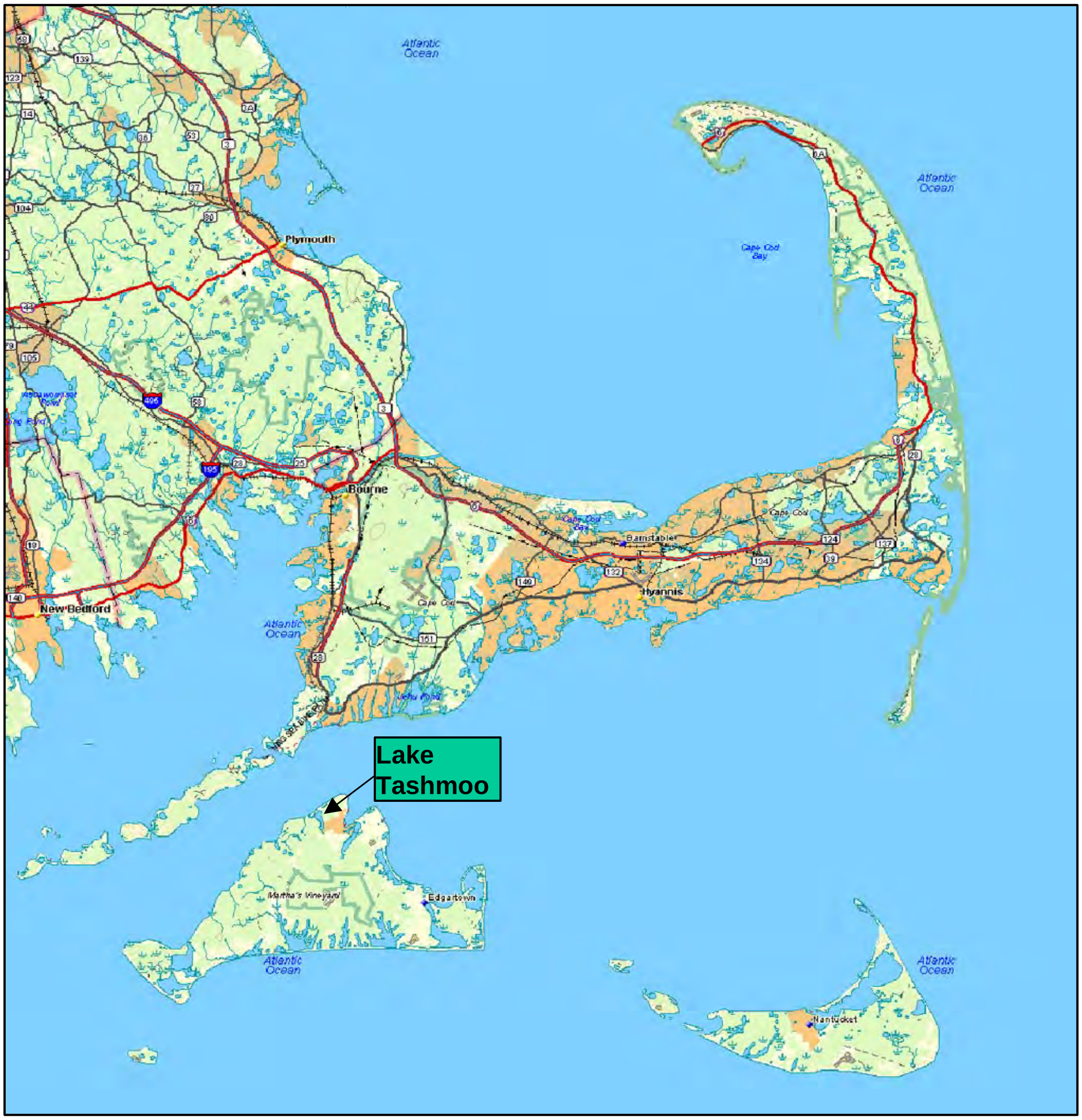
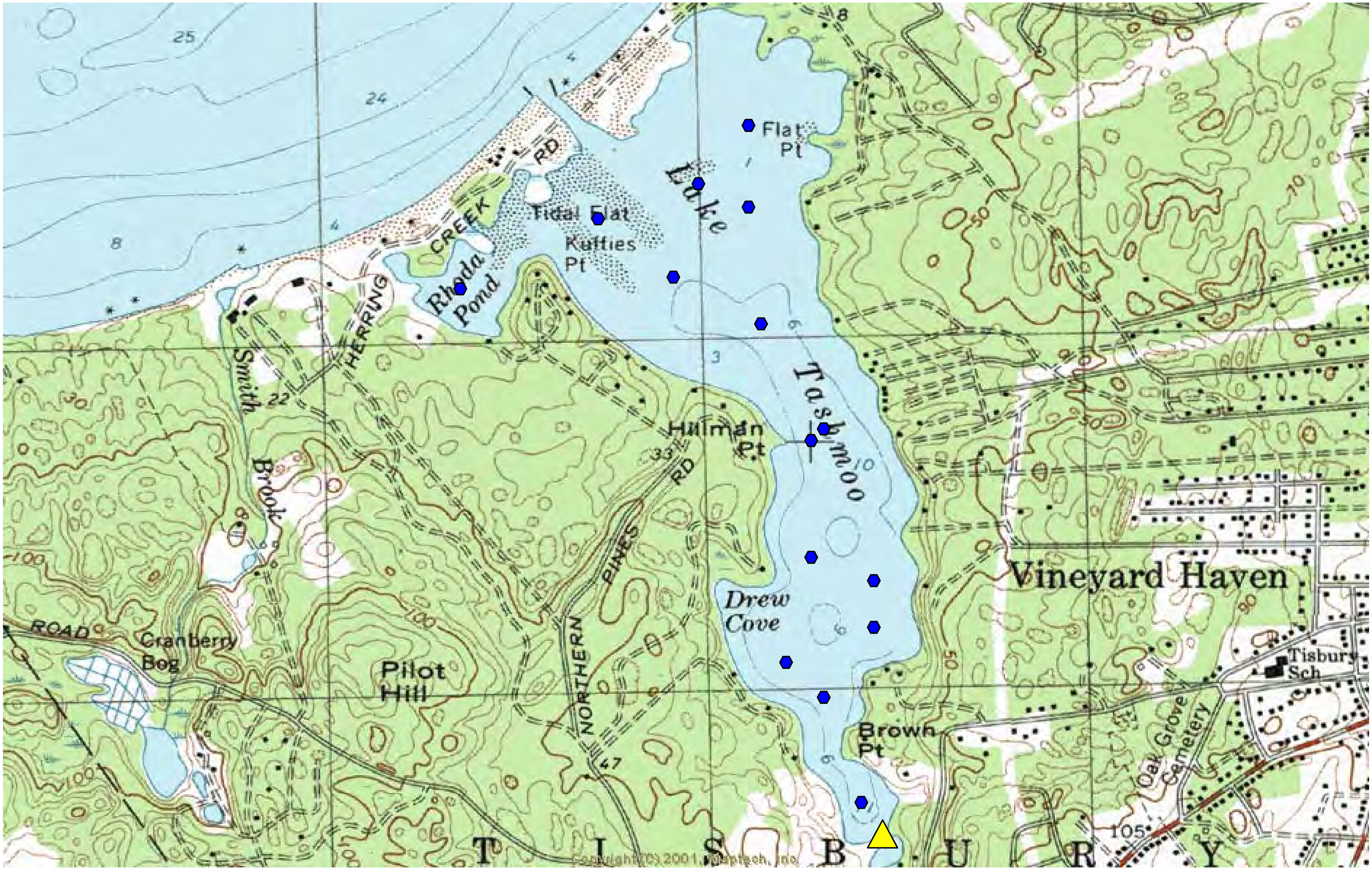

Lake
Tashmoo
Atlantic Ocean
Plymouth
Bourne
New Bedford
Barnstable
Hyannis
Edgartown
Nantucket

Figure 1

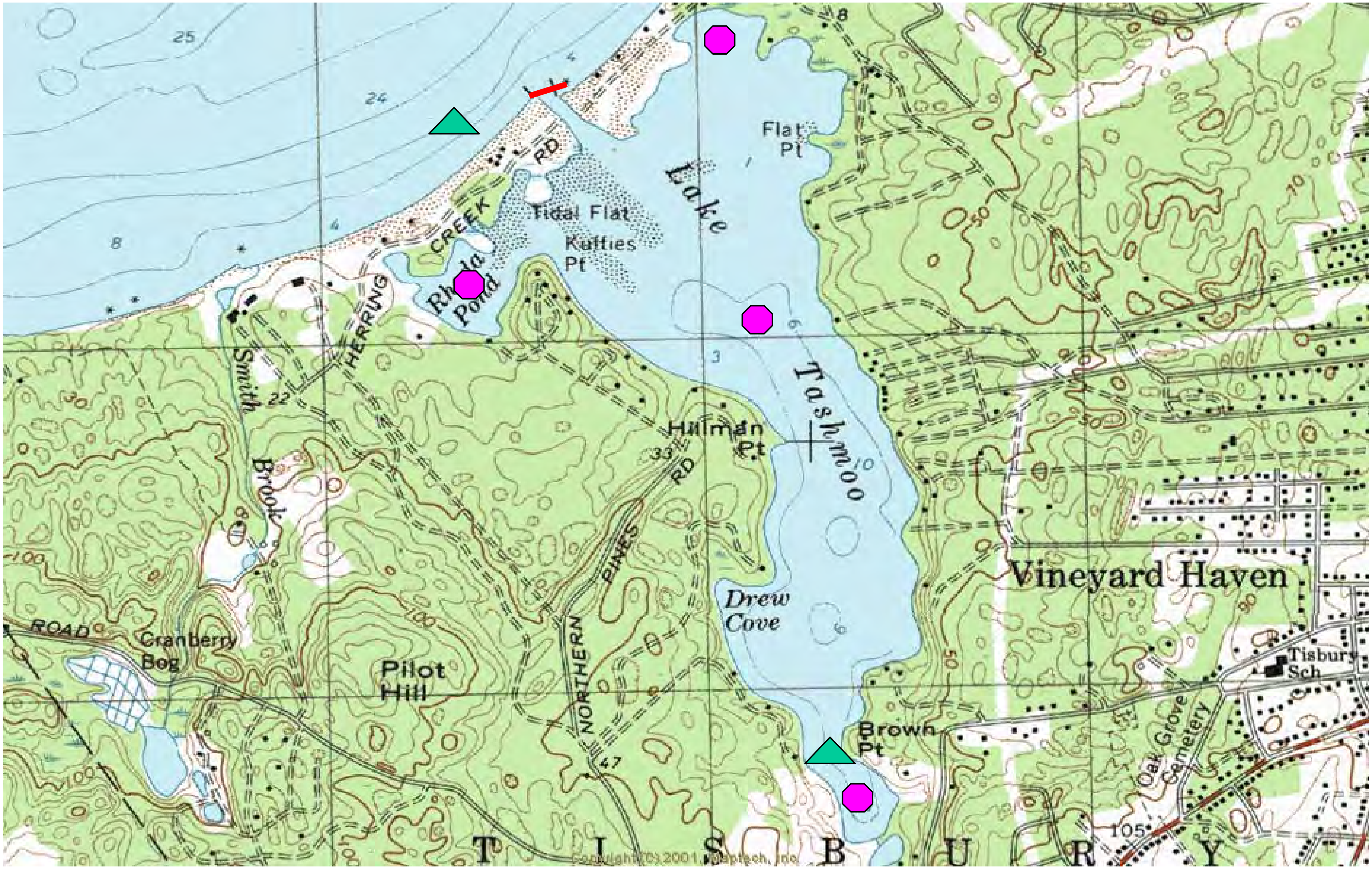
Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations △ Stream Gage/MEP Nutrient Sampling

Figure 3



Tide Gauge ADCP Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Lake Tashmoo (27)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	14	Once/Embayment	14	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	3**	15 minutes ****	> 2880	27 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	9	Once/Embayment	9	9	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXVIII Lagoon Pond
Martha's Vineyard
Prioritization Rank: Round 2 - #28

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Lagoon Pond, Martha's Vineyard: This estuary consists of a drowned river valley separated from Vineyard Haven Harbor by a causeway with a single maintained tidal inlet. The system is primarily open water with limited fringing salt marsh.

Only limited Estuaries Project data exist for this estuary. However, high quality water quality monitoring data exists which was collected and analyzed by the Martha's Vineyard Commission following the Coalition for Buzzards Bay Monitoring QAPP (and may have had its own QAPP as well). Technical design details and analytical aspects of the monitoring program were reviewed by the Coastal Systems Program at SMAST for the MVC. Most of the assays were performed by the SMAST Analytical Facility. This program uses technical staff to perform the sampling. The Martha's Vineyard Commission is a formal partner to the Estuaries Project and is assisting in the incorporation of water quality data and historical data into the Estuaries Project Effort.

At present no existing data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP have been identified.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based which will require placement of tide gauges and conducting ADCP measurements; (2) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect stream flow/nitrogen load data; (4) collect benthic cores and determine summer nitrogen regeneration rates; (5) collect distributed dissolved oxygen records to support the habitat assessment; (6) map eelgrass distribution and create historic record; (7) collect benthic infaunal distribution and indicator data; and (8) conduct the water quality modeling, thresholds analysis and synthesis.

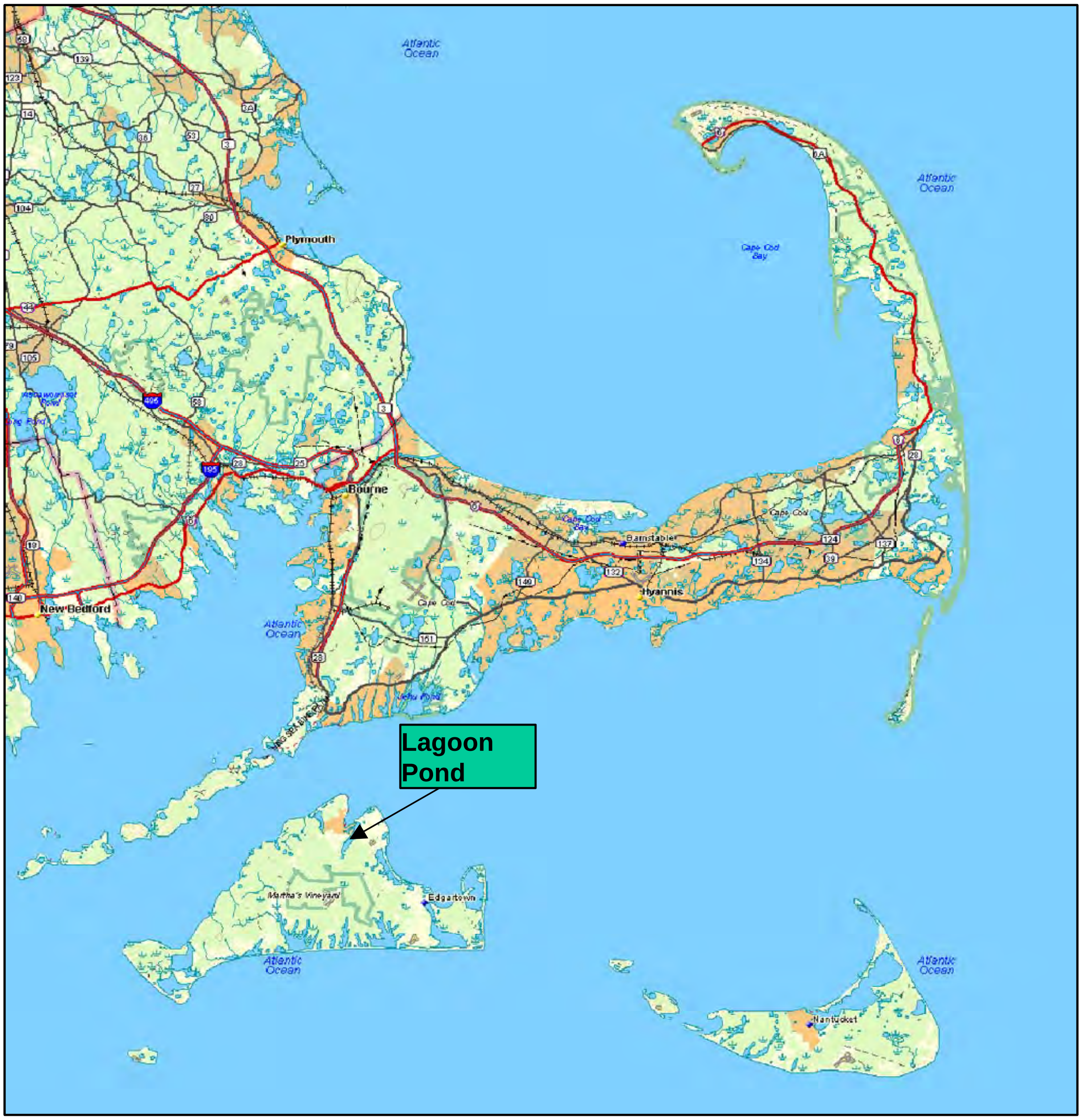
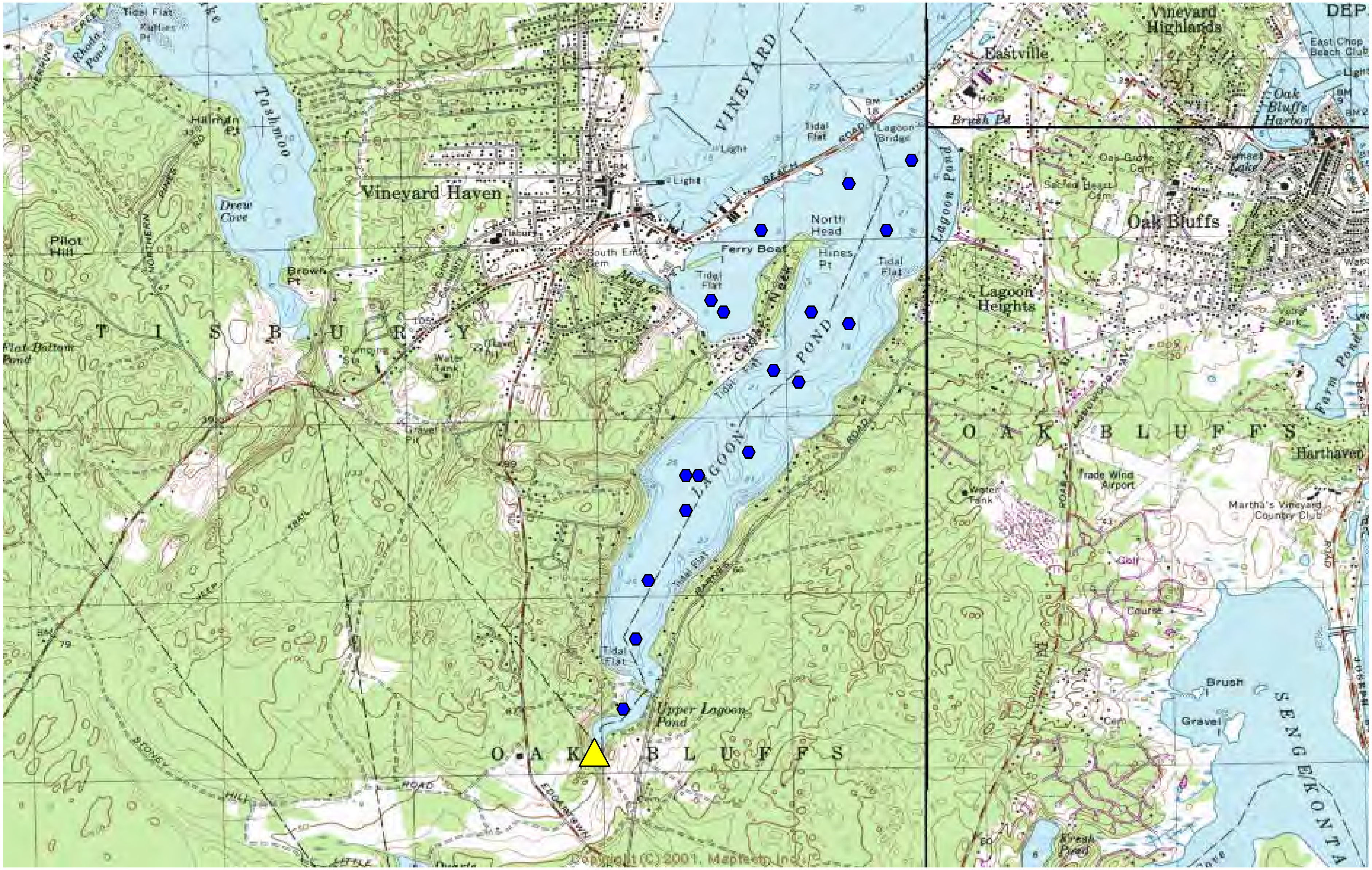

Atlantic Ocean
Atlantic Ocean
Cape Cod Bay
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Lagoon Pond
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket

Figure 1

Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling   Figure 3

Tide Gauge Location — ADCP — Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Lagoon Pond (28)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	16	Once/Embayment	16	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	2**	15 minutes ****	> 2880	18 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	9	Once/Embayment	9	9	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXIX Eel Pond
Town of Mattapoisett
Prioritization Rank: Round 2 - #29

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Eel Pond, Mattapoisett: Eel Pond is a tributary embayment to Mattapoisett Harbor. This system is separated from the Harbor by a barrier beach. Tidal exchange is currently through a channel under the old railroad bridge and a newly breached inlet directly through the barrier beach. A bicycle path is being developed on the old railroad bed which runs the length of the barrier beach. As a result of this planned construction, Eel Pond has entered a 3 year Estuaries Project analysis (instead of the usual 2 year). The first year will focus primarily on assessing inlet size and dynamics and tidal exchange relating to the Bike Path.

A high quality nutrient monitoring data set is available from the Coalition for Buzzards Bay's Monitoring Program. The monitoring data has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program.

There have been several studies conducted on Eel Pond relevant to the Estuaries Project assessment and modeling effort. These studies provide supporting data on land-use, water quality and tidal exchange (pre-new inlet) and historic changes in the barrier beach. At present existing data fully compliant with this QAPP appropriate for directly parameterizing the Linked Nitrogen Management Model has not been identified.

The main Estuaries Project efforts will be to (1) construct the hydrodynamic model, which will require limited placement of tide gauges and conducting flow measurement following stream flow protocols; (2) land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) determine stream flow and nitrogen loading/attenuation; (4) conduct benthic infaunal survey; (5) collect dissolved oxygen records; (6) map eelgrass distribution; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

Note: Inlet flows will follow stream flow method, but will be conducted in time-series over a tidal cycle at each inlet. The Acoustic Doppler Current Profiler (ADCP) will not be used. The ADCP does not yield accurate results at the water depths (0.4m) and channel dimensions associated with the Eel Pond inlets.

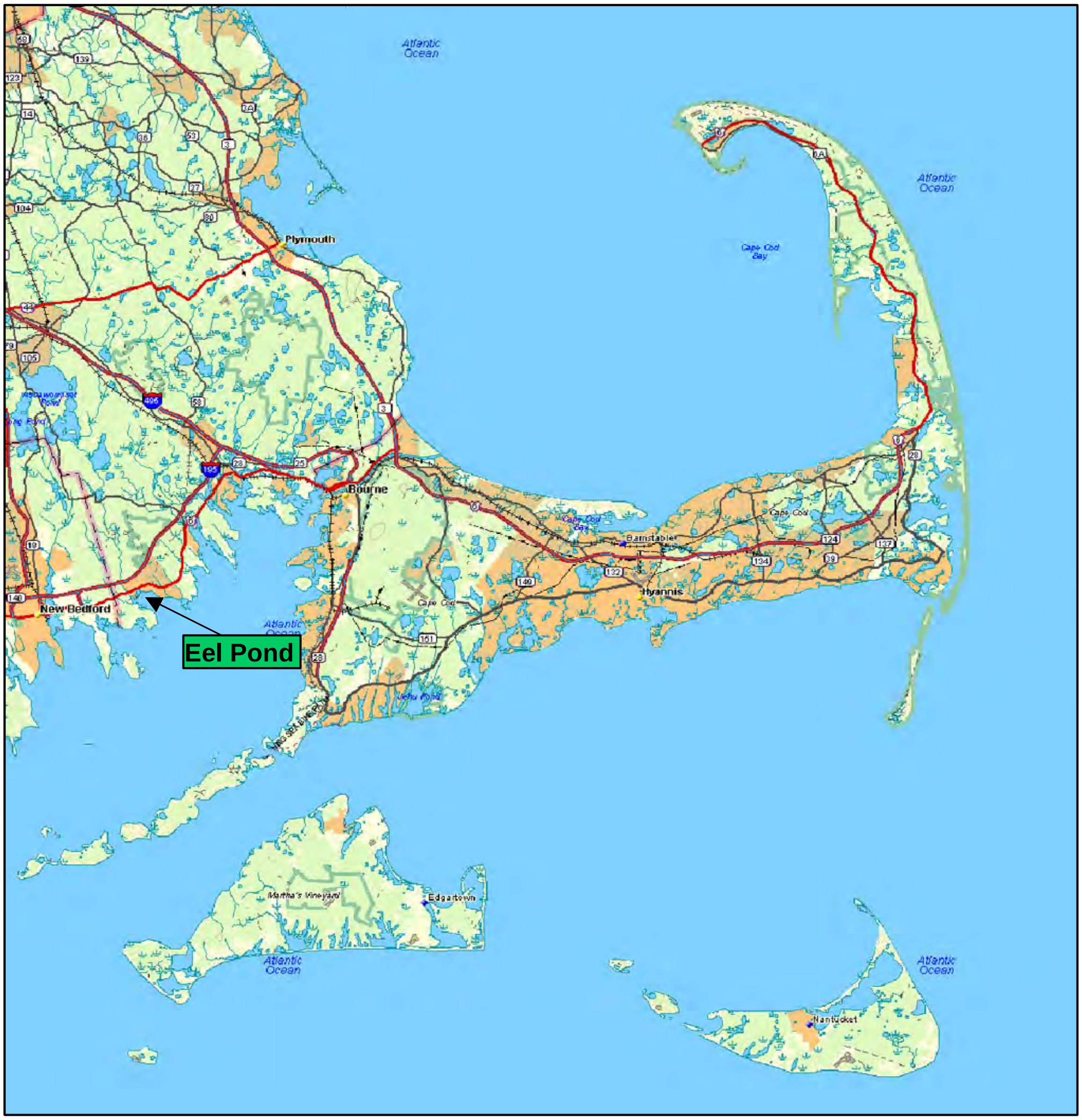

Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Eel Pond
Atlantic Ocean
Martha's Vineyard
Edgartown
Atlantic Ocean
Nantucket
Atlantic Ocean

Figure 1

Historical Nutrient Sampling Locations

Figure 2

Benthic Coring Locations Stream Gage/MEP Nutrient Sampling Figure 3

Tide Gauge ADCP Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Mattapoisett Harbor (43)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	2	Weekly	120	12	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	31	Once/Embayment	31	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	4**	15 minutes****	> 11520	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	21	Once/Embayment	21	21	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval

NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXX Aucoot Cove
Town of Marion
Prioritization Rank: Round 2 - #30

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Aucoot Cove, Marion: Aucoot Cove is a relatively open embayment with open exchange with Buzzards Bay waters. The upper region of the Cove supports an extensive salt marsh system. One of the major marsh creeks receives the discharge from the Marion Wastewater Treatment Facility which is being upgraded.

A high quality nutrient monitoring data set is available from the Coalition for Buzzards Bay's Monitoring Program. The monitoring data has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program. In addition, a system-wide high resolution nutrient related water quality dataset exists from the summer 1991, collected under a QAPP. Additional relevant data from the Wastewater Facilities Plan will be incorporated relative to wastewater nitrogen discharges, past and future.

At present existing data fully compliant with this QAPP appropriate for directly parameterizing the Linked Nitrogen Management Model has not been identified.

The main Estuaries Project efforts will be to (1) construct the hydrodynamic model, which will require limited placement of tide gauges and conducting an ADCP transect; (2) land-use and watershed nitrogen loading model based upon the USGS/Estuaries Project watershed delineation; (3) determine stream flow and nitrogen loading/attenuation and wetland attenuation; (4) conduct benthic infaunal survey; (5) collect dissolved oxygen records; (6) map eelgrass distribution; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

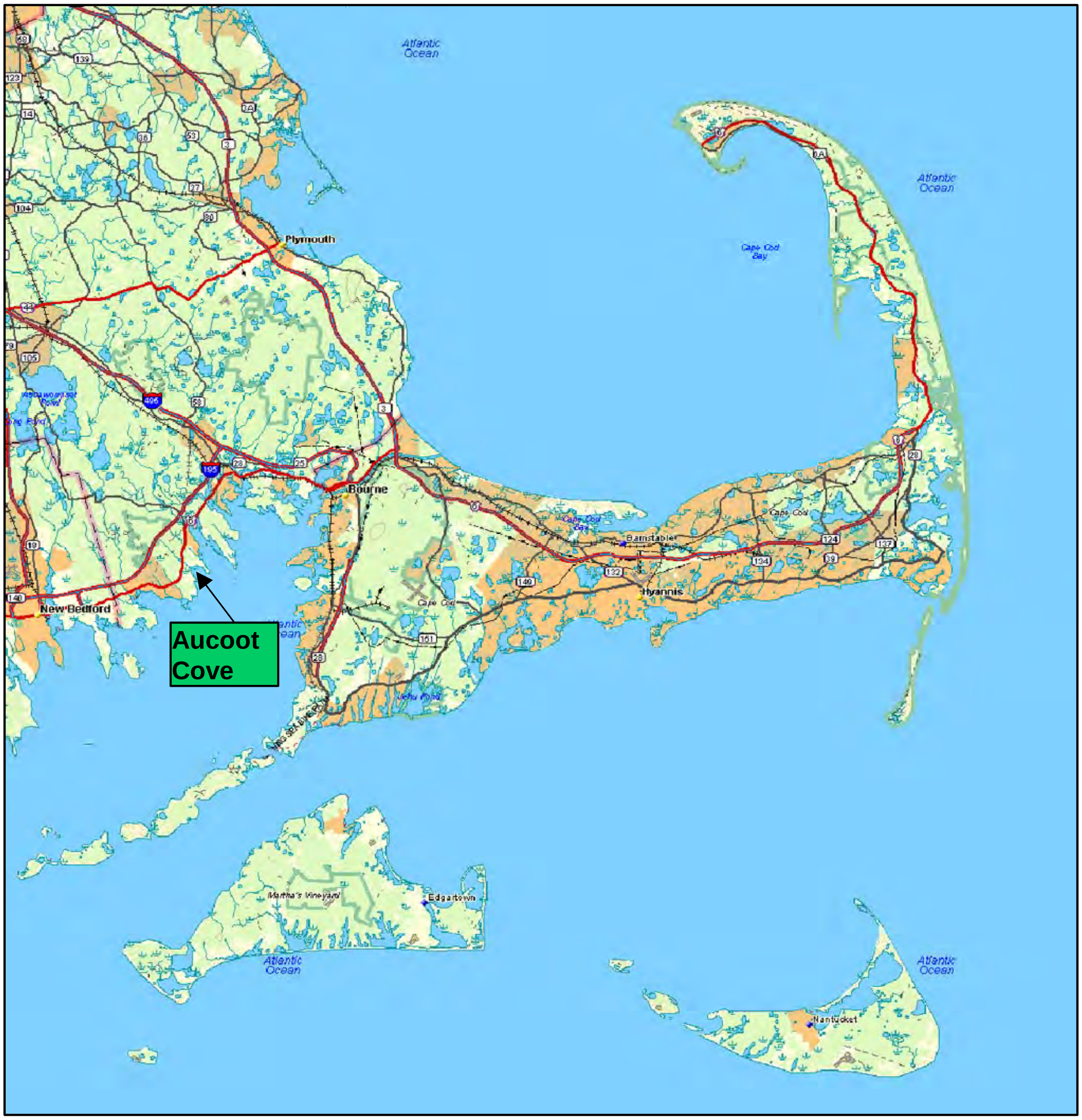
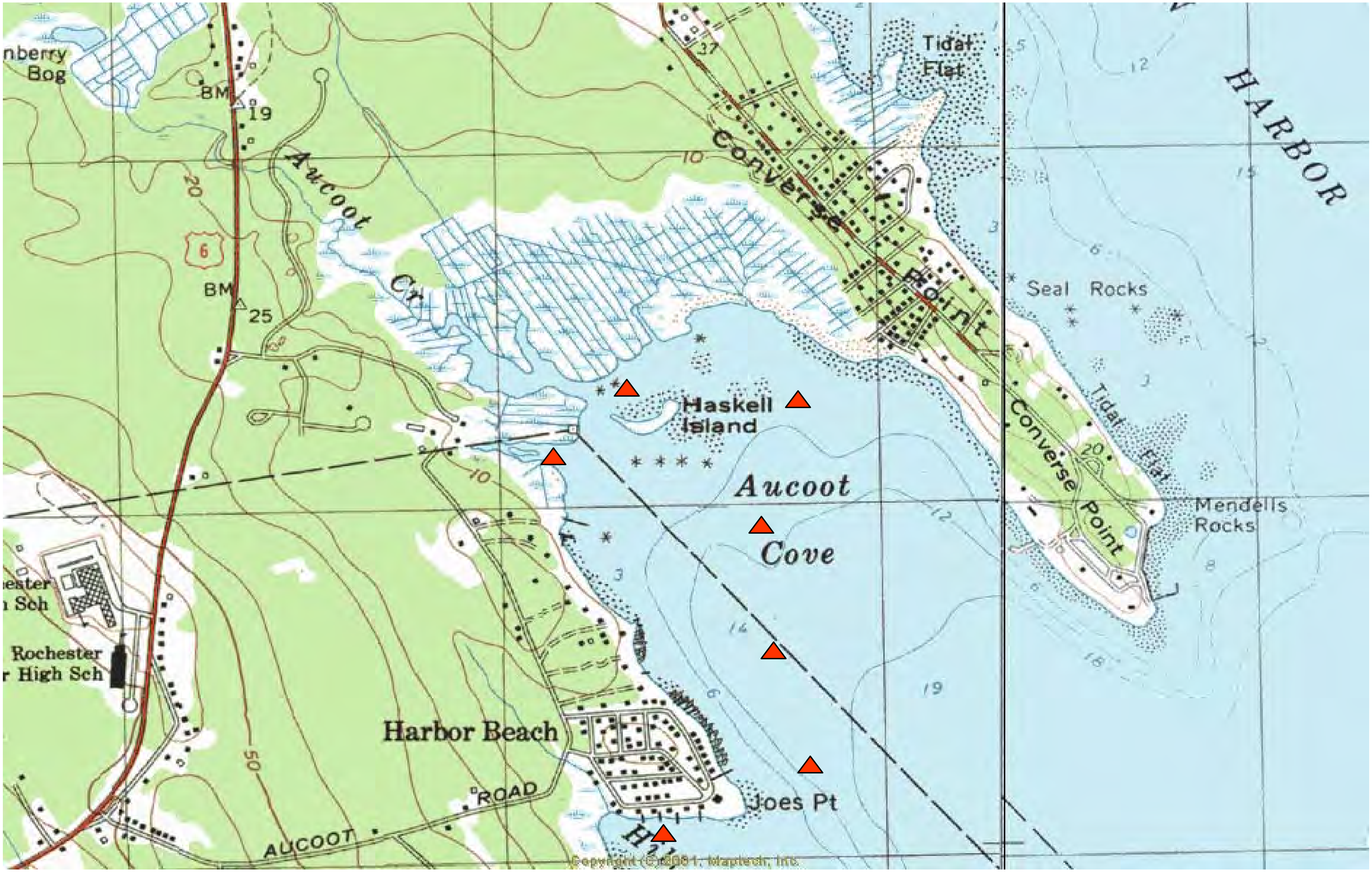
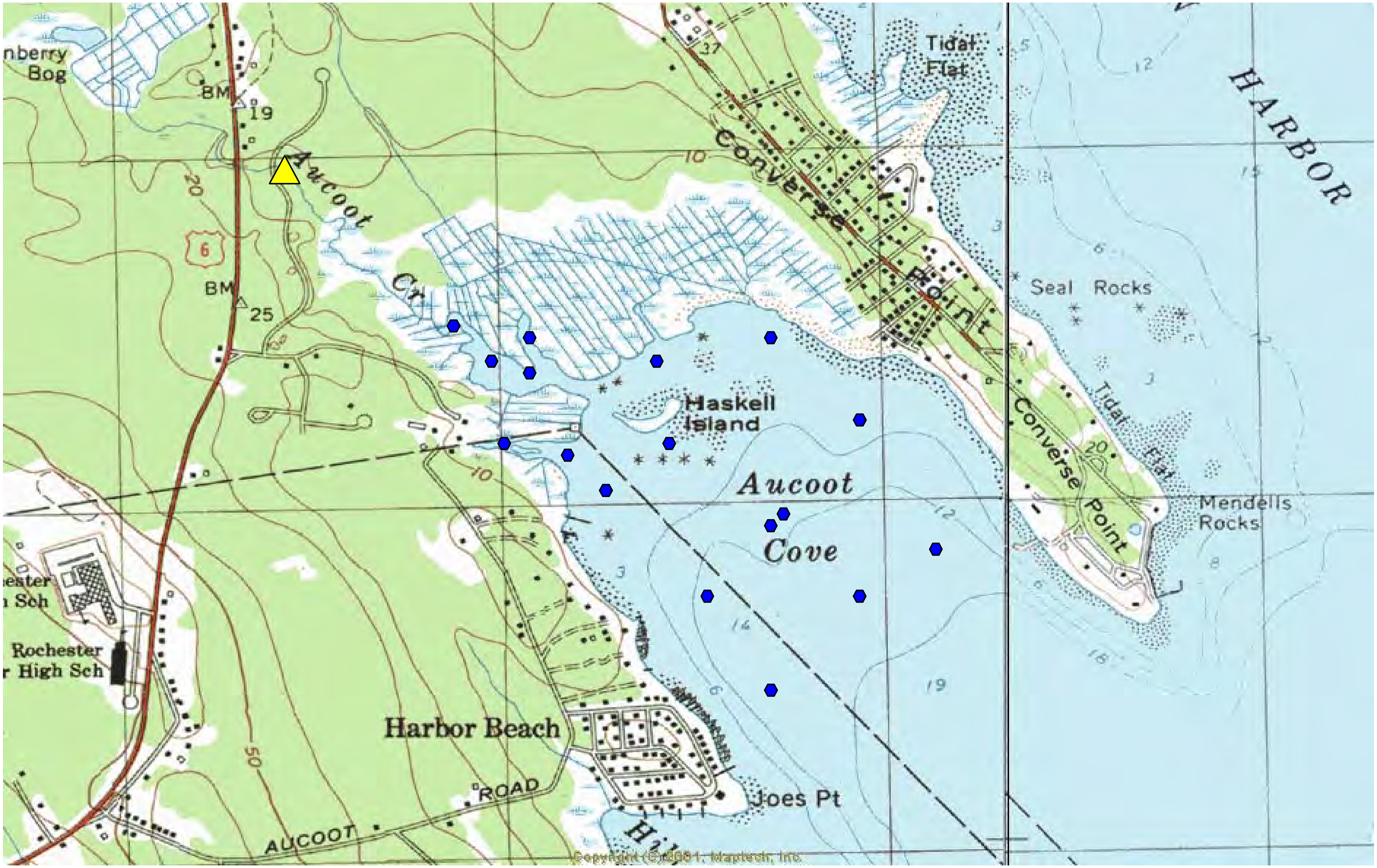

Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Aucoot Cove
Martha's Vineyard
Edgartown
Atlantic Ocean
Nantucket
Atlantic Ocean

Figure 1

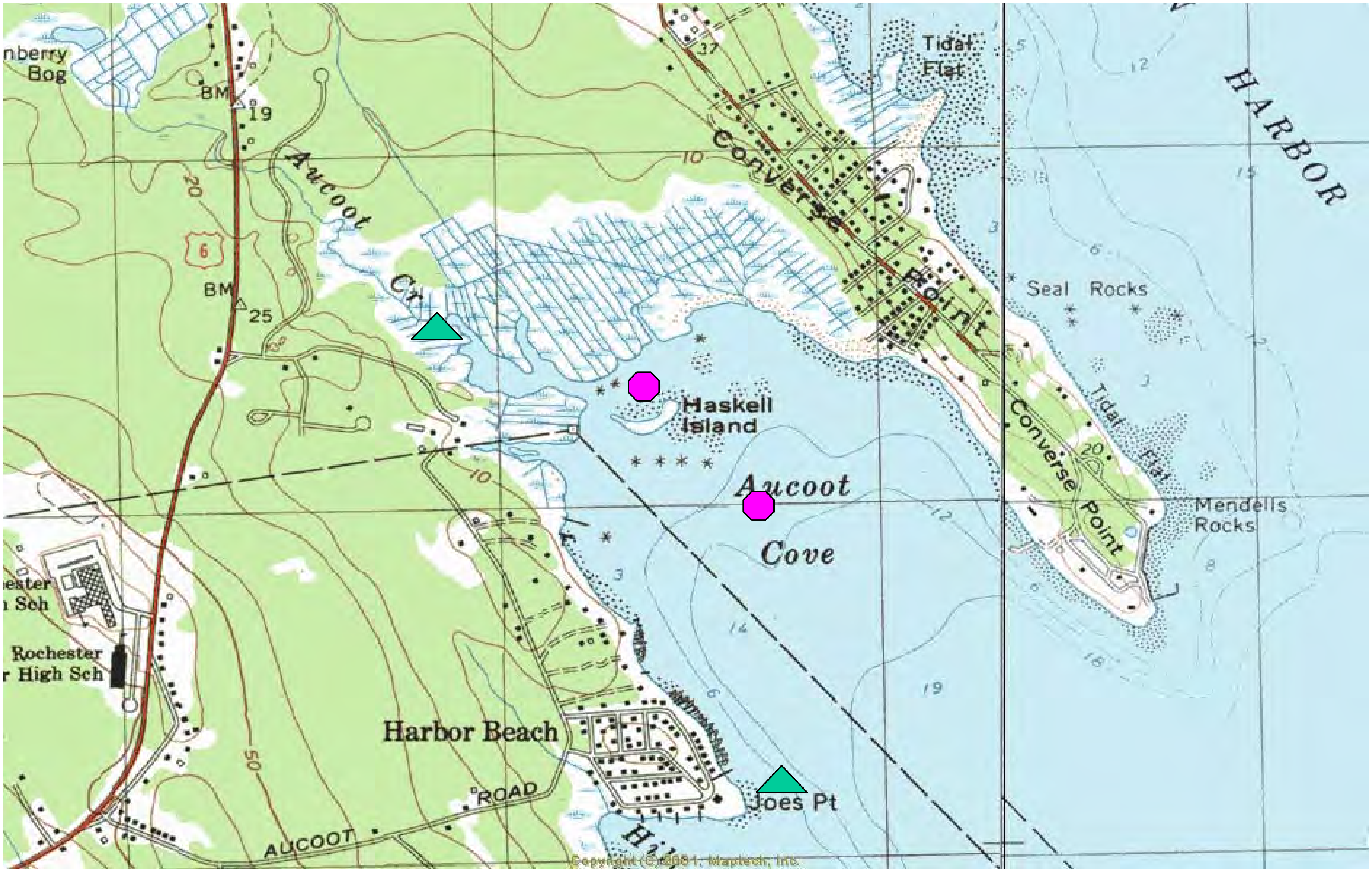


Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling Location   Figure 3



Tide Gauge   ADCP   Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Aucoot Cove (30)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:	Benthic Coring	a,b,c,d	Time Course Incubation	16	Once/Embayment	16	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	2**	15 minutes ****	> 2880	18 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	7	Once/Embayment	7	7	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:
a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXXI Madaket Harbor
Nantucket
Prioritization Rank: Round 2 - #31

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

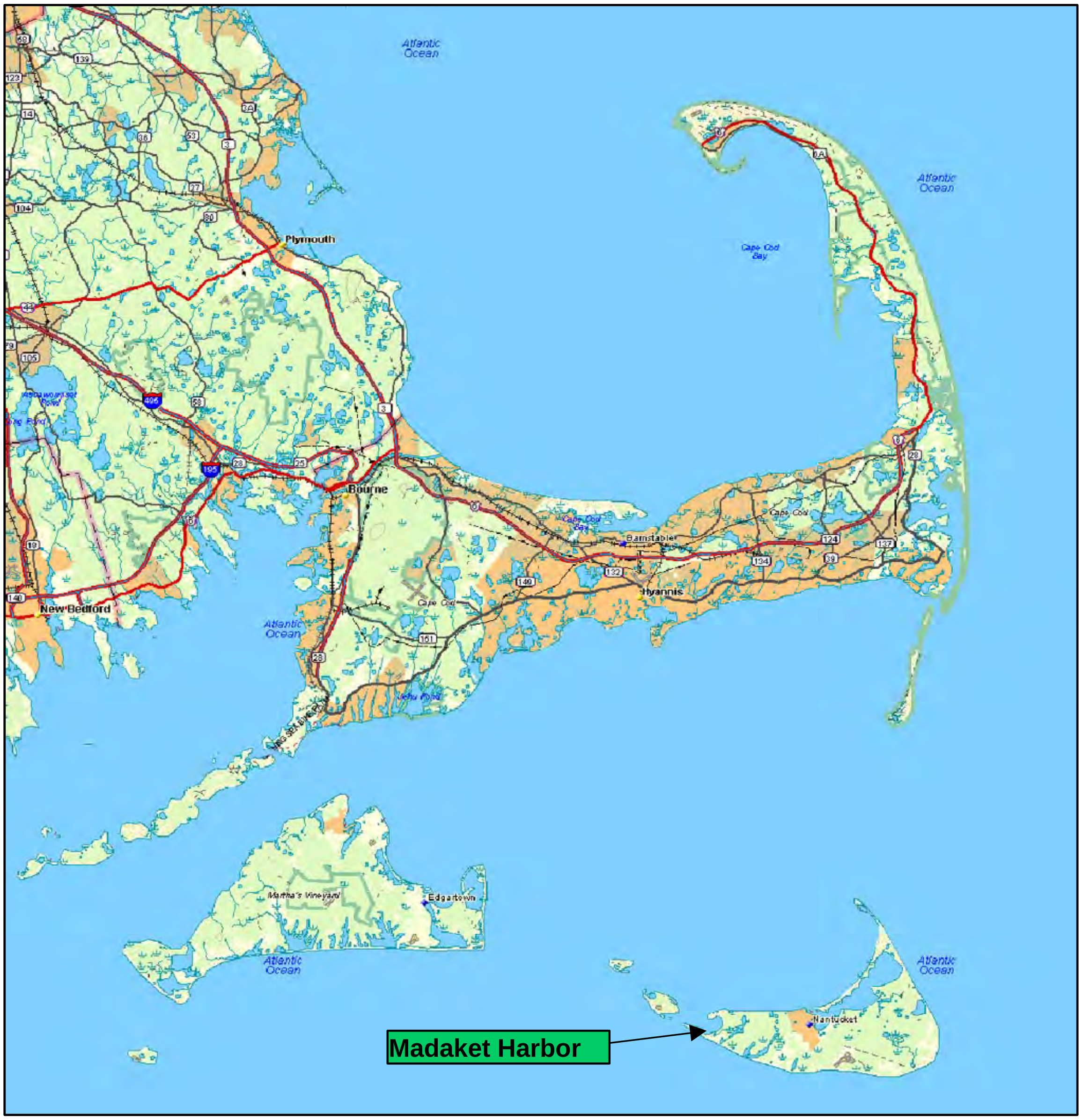
Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Madaket Harbor, Nantucket: This estuary consists of a relatively open basin (Madaket Harbor) with direct exchange with open ocean waters and a shallow enclosed basin (Hither Creek) which exchanges tidal water with Madaket Harbor and receives discharge from Long Pond. Madaket Harbor is primarily open water with limited fringing salt marsh.

Only limited Estuaries Project data exist for this estuary. However, water quality monitoring data exists from a several sources: Nantucket Marine Department sampling 2001, 2002; SMAST sampling following the present QAPP in 2002 and historical data from 1991 (consistent with the present QAPP) by WHOI. These data have been reviewed based upon the Estuaries Project QAPP as part of the prioritization process. All of the water quality data has been collected by professional staff. The Nantucket Marine Department is a formal collaborator with the Estuaries Project and is assisting in the incorporation of water quality data and historical data into the Estuaries Project Effort.

At present no existing process-level data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP have been identified. However, a circulation study was performed in 2000-2001 which provides qualitative information relevant to nutrients and will be incorporated into the Estuaries Project assessment, as appropriate.

The main Estuaries Project efforts will be to (1) establish a hydrodynamic model based which will require placement of tide gauges and conducting ADCP measurements; (2) perform land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) collect stream flow/nitrogen load data; (4) collect benthic cores and determine summer nitrogen regeneration rates; (5) collect distributed dissolved oxygen records to support the habitat assessment; (6) map eelgrass distribution and create historic record; (7) collect benthic infaunal distribution and indicator data; and (8) conduct the water quality modeling, thresholds analysis and synthesis.

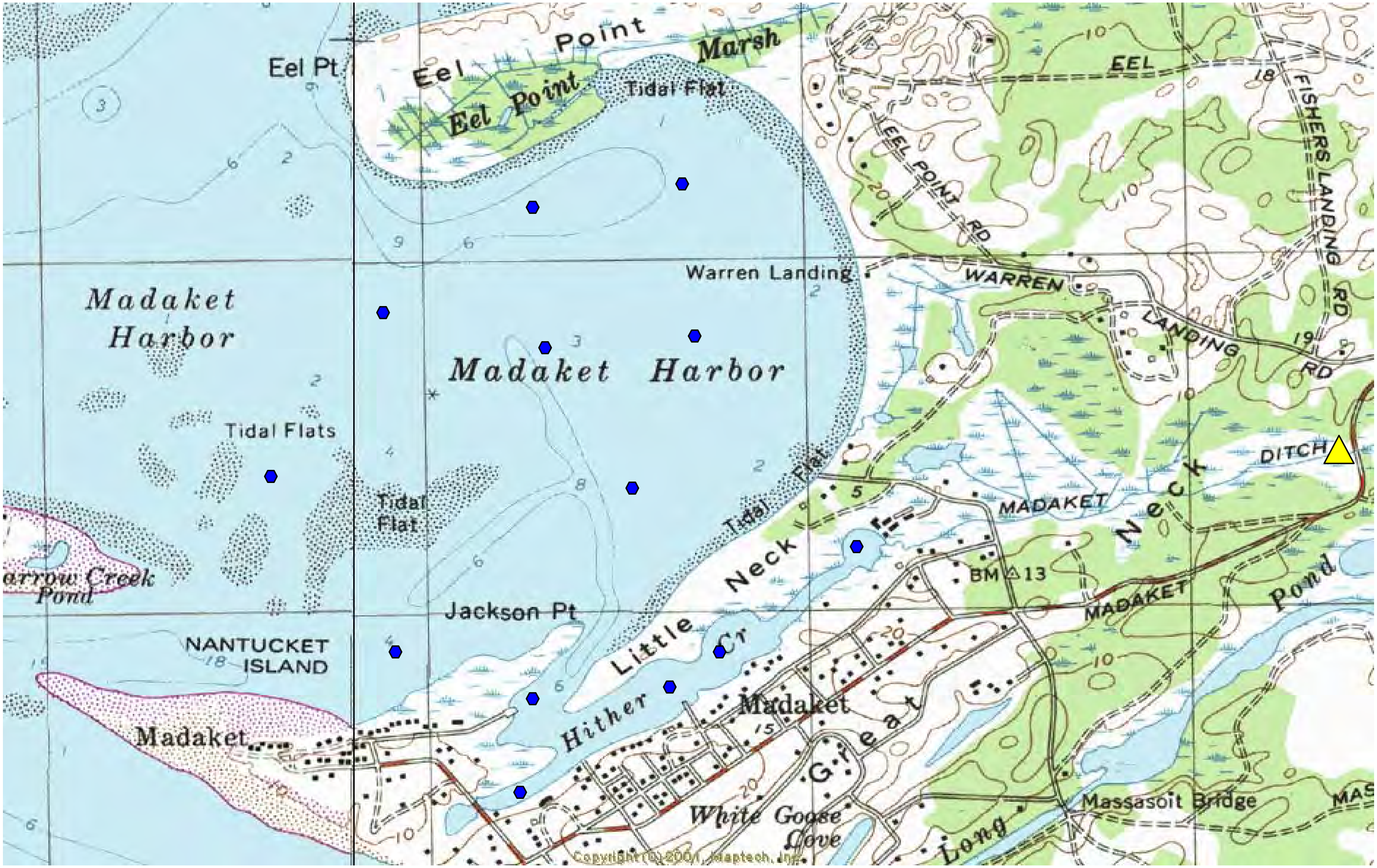


Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket
Madaket Harbor

Figure 1

Historical Nutrient Sampling Locations

Figure 2



● Benthic Coring Locations △ Stream Gage/MEP Nutrient Sampling

Figure 3

Tide Gauge ADCP Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Madaket Harbor (31)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	NA	NA	NA	NA	NA	NA	NA
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	13	Once/Embayment	13	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	2**	15 minutes ****	> 2880	18 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	8	Once/Embayment	8	8	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection.
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertebrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXXII Long Pond
Nantucket
Prioritization Rank: Round 2 - #32

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Long Pond, Nantucket: Long Pond is a man-made estuary, created opening Madaket Ditch between the Pond and Hither Creek/Madaket Harbor. This system exchanges tidal water and is currently brackish. This estuary is totally enclosed (except for the Ditch) and contains wetland resources.

Only limited Estuaries Project data exist for this estuary. However, water quality monitoring data exists from a several sources: Nantucket Marine Department sampling 2001, 2002; SMAST sampling following the present QAPP in 2002. Historical nutrient data were collected by the Nantucket Land Council in the early 1990's, which will be review and incorporated as appropriate. The recent data have been reviewed based upon the Estuaries Project QAPP as part of the prioritization process. All of the water quality data has been collected by professional staff. The Nantucket Marine Department is a formal collaborator with the Estuaries Project and is assisting in the incorporation of water quality data and historical data into the Estuaries Project Effort.

At present no existing process-level data suitable for parameterizing the Linked Approach which are fully compliant with the Estuaries Project QAPP have been identified.

The main Estuaries Project efforts will be to (1) construct the hydrodynamic model, which will require limited placement of tide gauges and conducting flow measurement following stream flow protocols; (2) land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) determine stream flow and nitrogen loading/attenuation; (4) conduct benthic infaunal survey; (5) collect dissolved oxygen records; (6) map eelgrass distribution; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

Note: Inlet flows will follow stream flow method, but will be conducted in time-series over a tidal cycle in upper Madaket Ditch. The Acoustic Doppler Current Profiler (ADCP) will not be used. The ADCP does not yield accurate results at the shallow water depths and small channel dimensions associated with the Long Pond tidal exchange channel (Madaket Ditch). There will also be a recording gauge at this site to allow assessment of the magnitude and frequency of saltwater inflow to Long Pond.

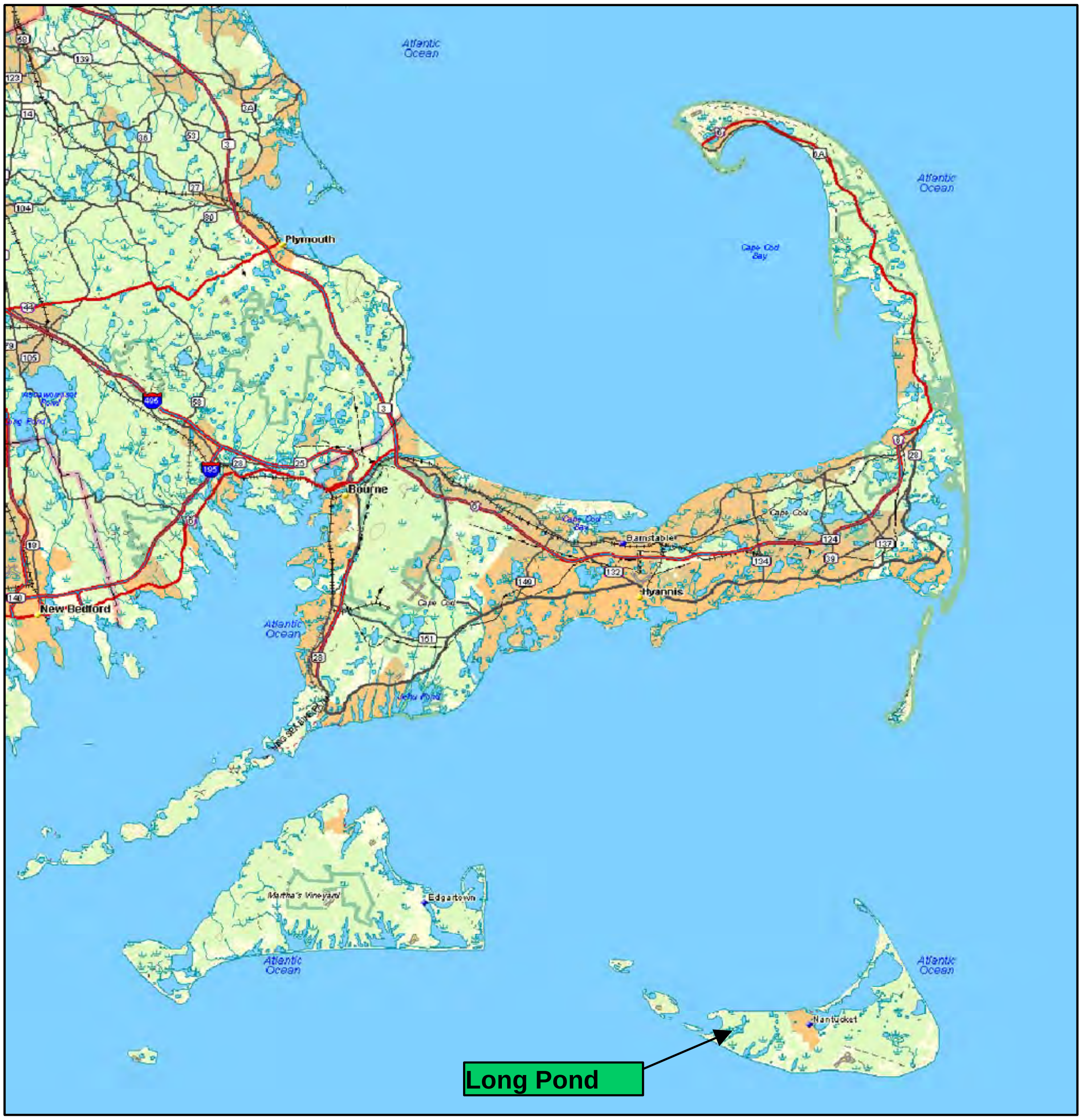
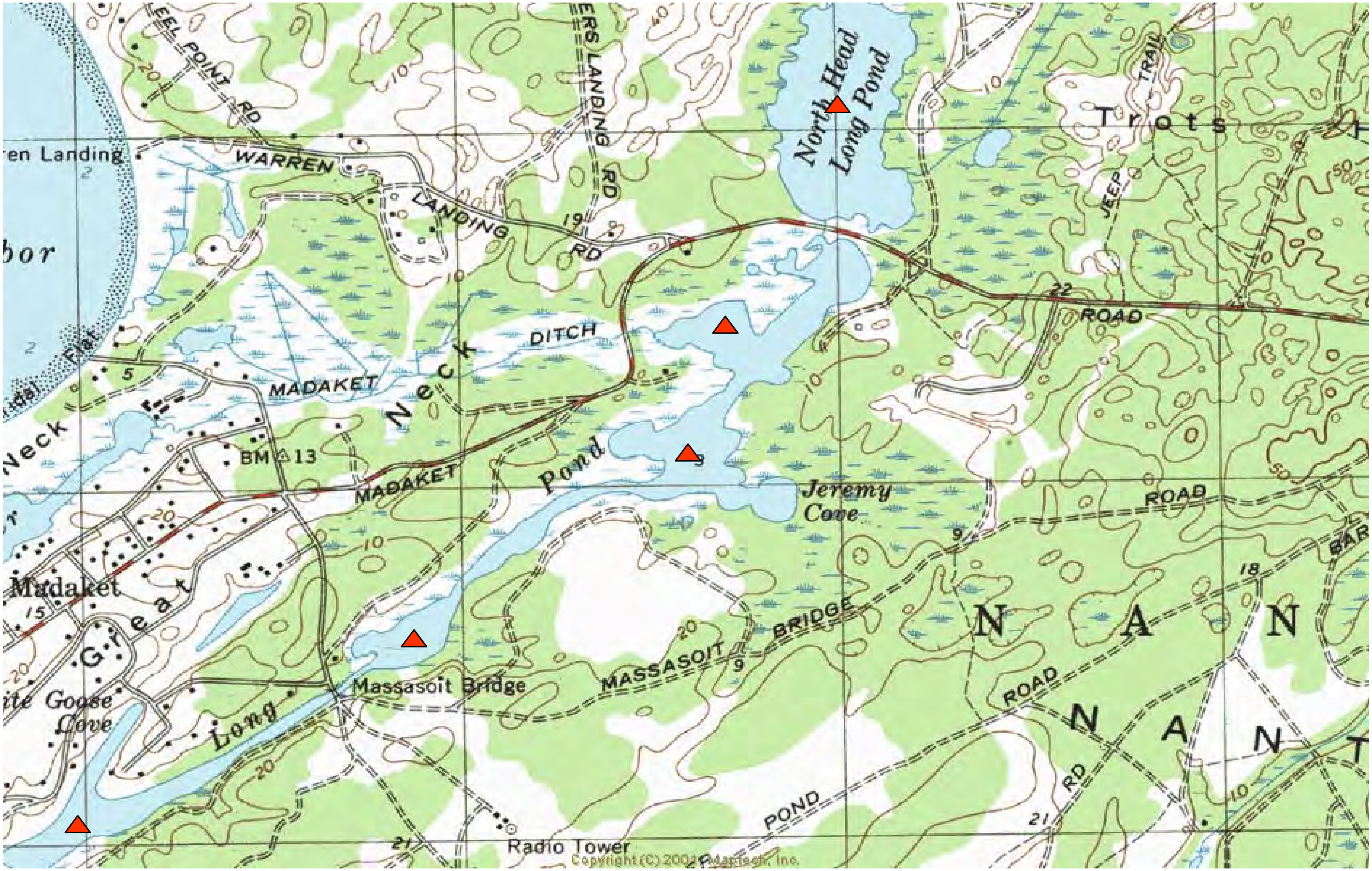
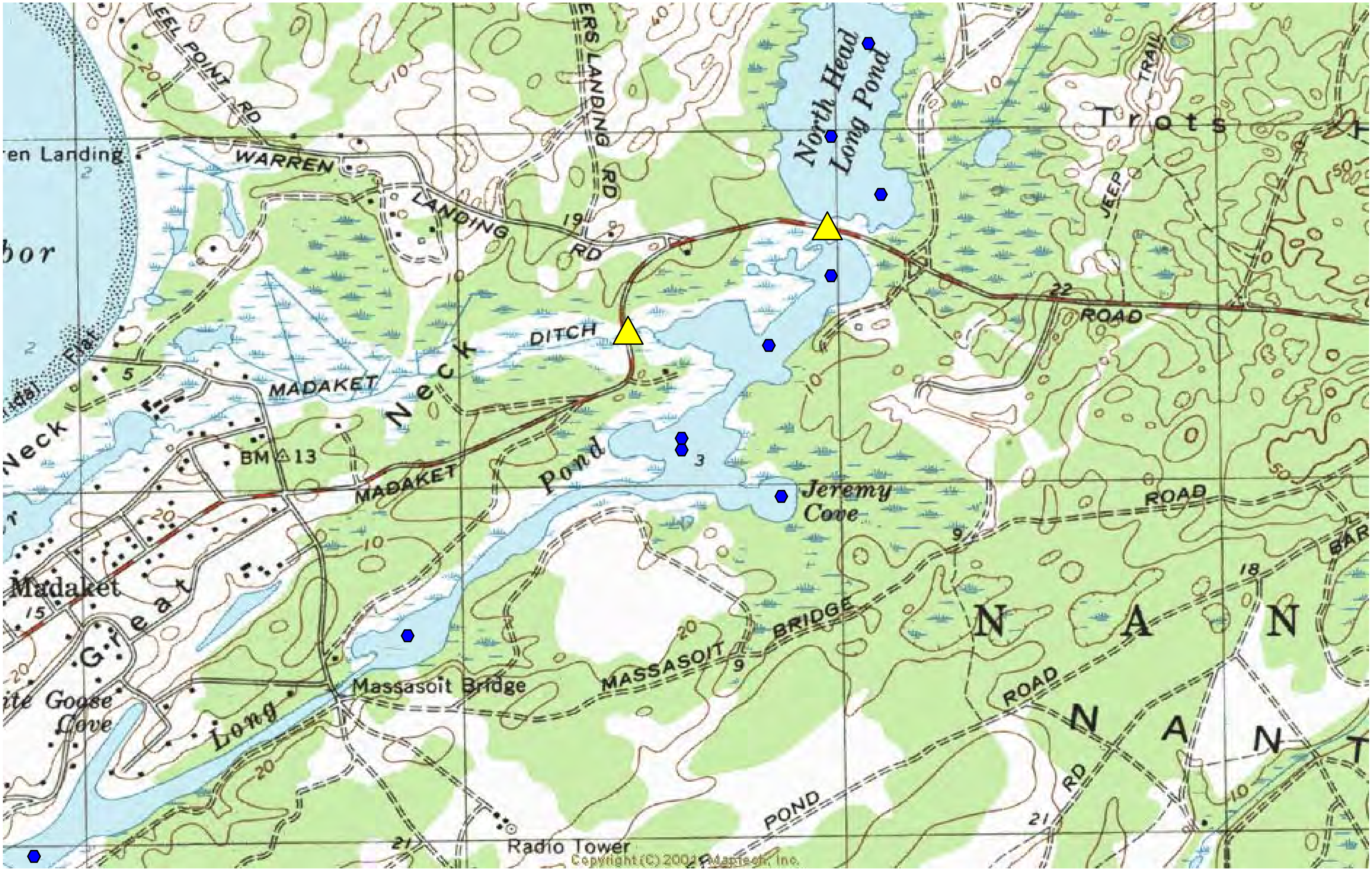

Atlantic Ocean
Plymouth
Cape Cod Bay
Atlantic Ocean
Bourne
Barnstable
Hyannis
New Bedford
Atlantic Ocean
Martha's Vineyard
Edgartown
Atlantic Ocean
Atlantic Ocean
Nantucket
Long Pond

Figure 1

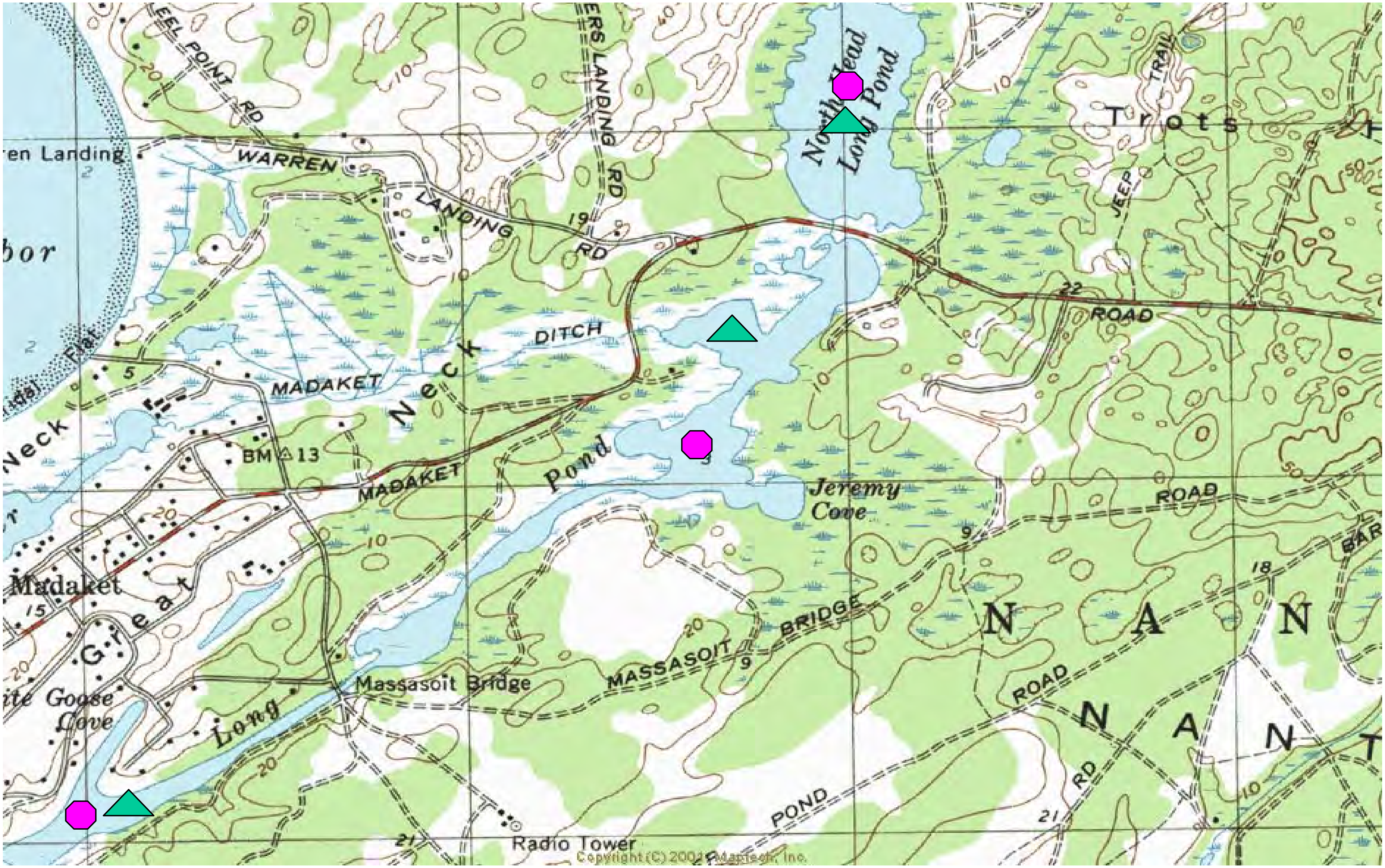


Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations Stream Gage/MEP Nutrient Sampling Figure 3



Tide Gauge Location — ADCP Transects — Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Long Pond - Nantucket (32)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g,p	Grab	2	Weekly	120	12	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	9	Once/Embayment	9	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	3**	15 minutes ****	≥ 2880	27 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	5	Once/Embayment	5	5	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXXIII Red Brook Harbor
Town of Bourne
Prioritization Rank: Round 2 - #33

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Red Brook Harbor System, Bourne*:* The Red Brook Harbor System consists of the embayment formed by Wings Neck, Scraggy Neck and Bassetts Island. This system has seen significant activity as part of the Massachusetts Military Reservation (MMR) Groundwater Remediation Program. The MMR Landfill Plume discharges to Red Brook. Data on nutrient levels and groundwater plume tracking will be incorporated into the Estuaries Project assessment.

A high quality nutrient monitoring data set is available from the Coalition for Buzzards Bay's Monitoring Program. The monitoring data has been collected and analyzed following the Coalition for Buzzards Bay Monitoring QAPP. All technical design details and analytical aspects of the monitoring program were conducted by the Coastal Systems Program at SMAST for the Coalition for Buzzards Bay Monitoring Program.

The existing key data which will be used is fully compliant with this QAPP and was collected and analyzed by present Estuaries Project Technical Team members. These data sets include: (1) limited stream nitrogen loading (from MMR); (2) tide gauges, bathimetry and a preliminary hydrodynamic model; and (3) landfill nitrogen loading measurements to support the watershed nitrogen modeling.

The main Estuaries Project efforts will be to (1) up-grade the current hydrodynamic model for the central bay which will require limited placement of tide gauges and conducting ADCP measurements; (2) update the existing land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) enhance the stream flow and nitrogen loading database to bring in to QAPP compliance; (4) conduct benthic infaunal survey; (5) collect dissolved oxygen records within each of the key tributary embayments; (6) map eelgrass distribution; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

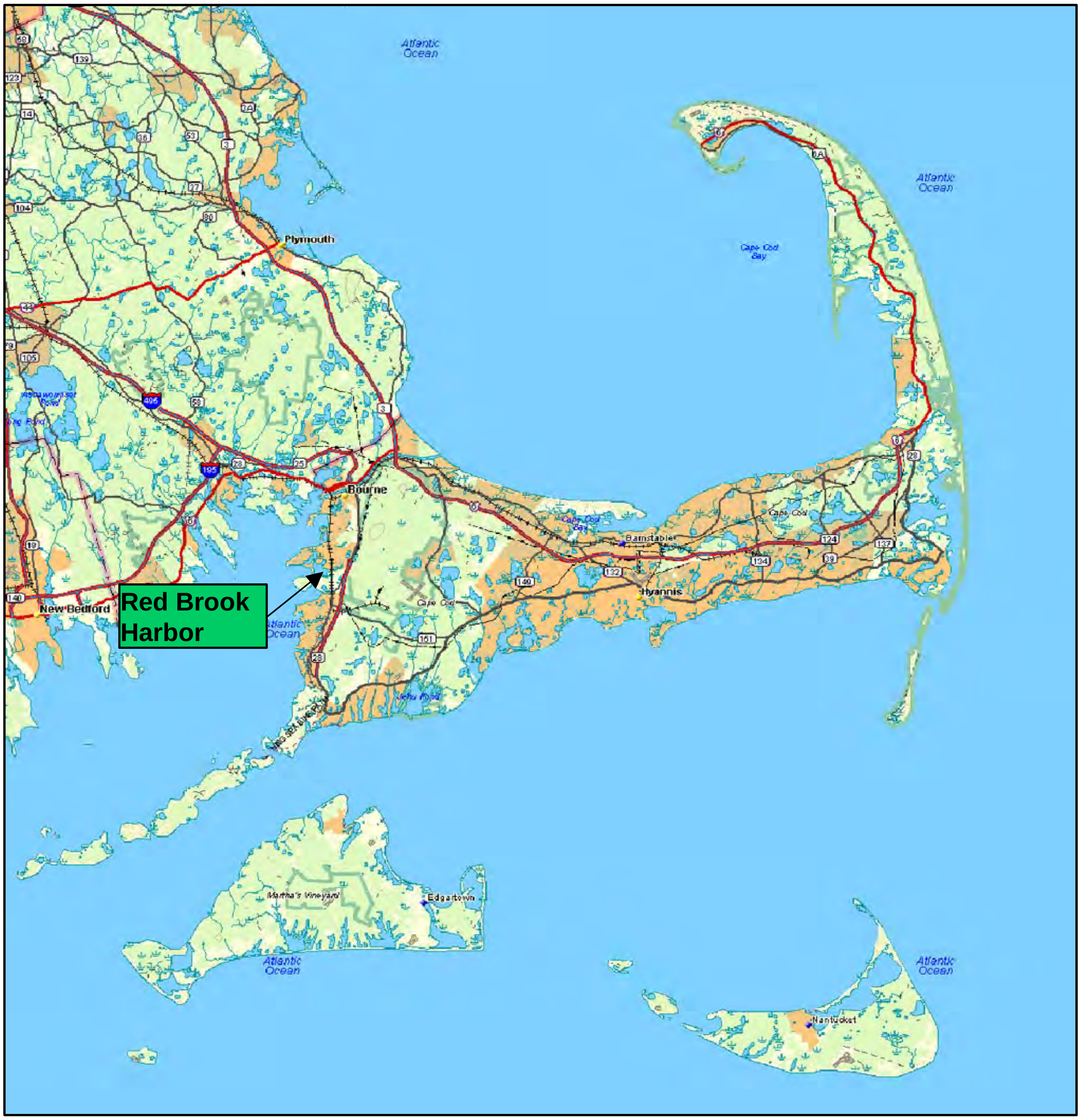
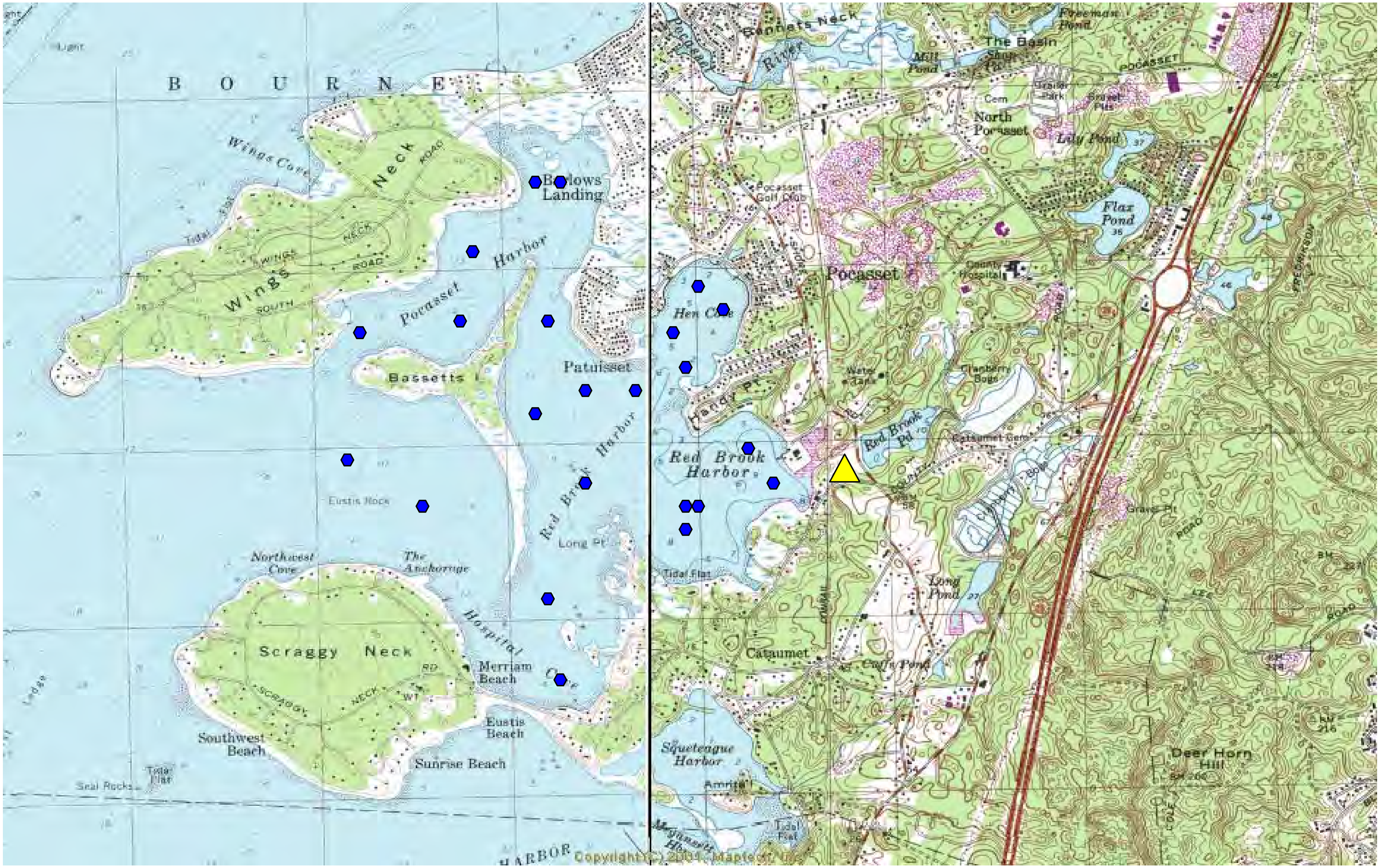

Atlantic Ocean
Plymouth
Bourne
Red Brook Harbor
New Bedford
Barnstable
Hyannis
Cape Cod Bay
Atlantic Ocean
Edgartown
Nantucket
Atlantic Ocean
Atlantic Ocean

Figure 1

Historical Nutrient Sampling Locations

Figure 2



Benthic Coring Locations △ Stream Gage/MEP Nutrient Sampling Location

Figure 3

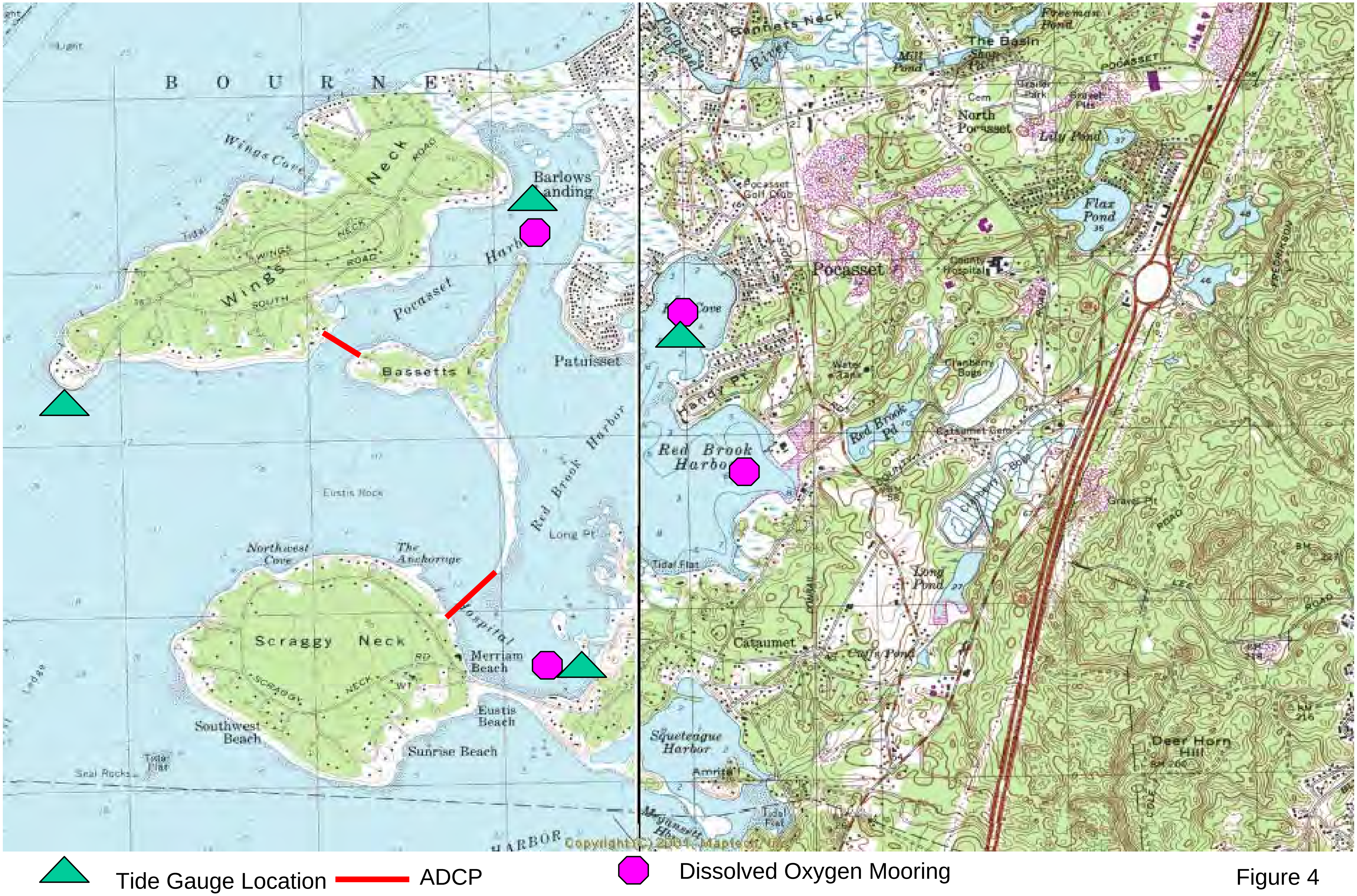

B O U R N E
Wings Cove
Neck
Wings
Barlows Landing
Pocasset
Bassetts I
Patuisset
Red Brook Harbor
Eustis Rock
Long Pt
Northwest Cove
The Anchorage
Scraggy Neck
Merriam Beach
Eustis Beach
Sunrise Beach
Southwest Beach
Seal Rocks
Gunnets Neck
The Basin
Mill Pond
North Pocasset
Lily Pond
Flax Pond
County Hospital
Pocasset Golf Club
Red Brook Pd
Cataumet
Long Pond
Squeteague Harbor
Deer Horn Hill
Tide Gauge Location
ADCP
Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Red Brook Harbor (33)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July - June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Streamflow/Nitrogen Loading	a,b,c,d,e,g	Grab	1	Weekly	60	6	14 months
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	21	Once/Embayment	21	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	4**	15 minutes ****	> 2880	36 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	10	Once/Embayment	10	15	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored Instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

MA Estuaries Project QAPP
Appendix A-XXXIV Round Cove
Town of Harwich
Prioritization Rank: Round 2 - #34

Embayment Specific Plan:
Data Collection consists of Hydrodynamic Data (field data and model), Stream gauging and nitrogen sampling, GIS based Land-use analysis, Nitrogen recycling via Benthic Regeneration, Habitat Assessment (Eelgrass, macroalgae, benthic animals, DO records). Synthesis is primarily covered in the Water Quality Modeling and Reporting components. The efforts of the Estuary Project will be to fill in data gaps to allow parameterization and full modeling and synthesis following the Linked Management Approach.

Many of the embayments currently have existing data that can be incorporated into the Linked Approach. A detailed description of previous data, its quality and how it was collected will be part of the Report. However, it is useful to indicate the existing data and our initial assessment of its quality and to present the additional field and modeling work required to fully implement the Estuaries Project Management Approach.

Round Cove, Harwich*:* The Round Cove System consists of a tributary sub-embayment to the greater Pleasant Bay embayment system.

The main Estuaries Project efforts will be to (1) incorporate Round Cove into an up-graded current hydrodynamic model for the greater Pleasant Bay system which will require limited placement of tide gauges and conducting point velocity measurements; (2) update the existing land-use and watershed nitrogen loading model based upon the new USGS watershed delineation; (3) conduct benthic infaunal survey; (5) collect dissolved oxygen records within each of the key tributary embayments; (6) map eelgrass distribution; and (7) conduct the water quality modeling, thresholds analysis and synthesis.

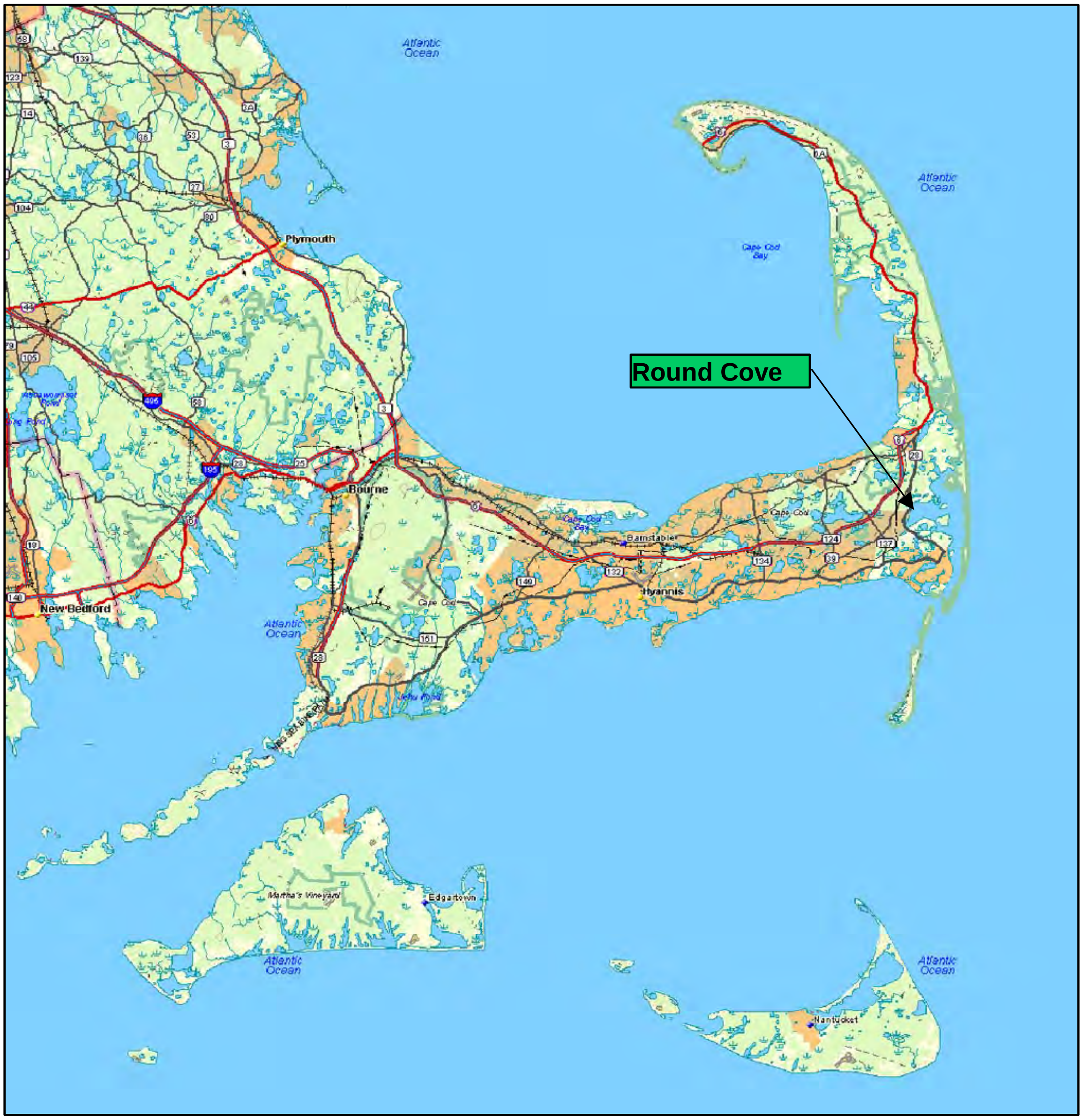
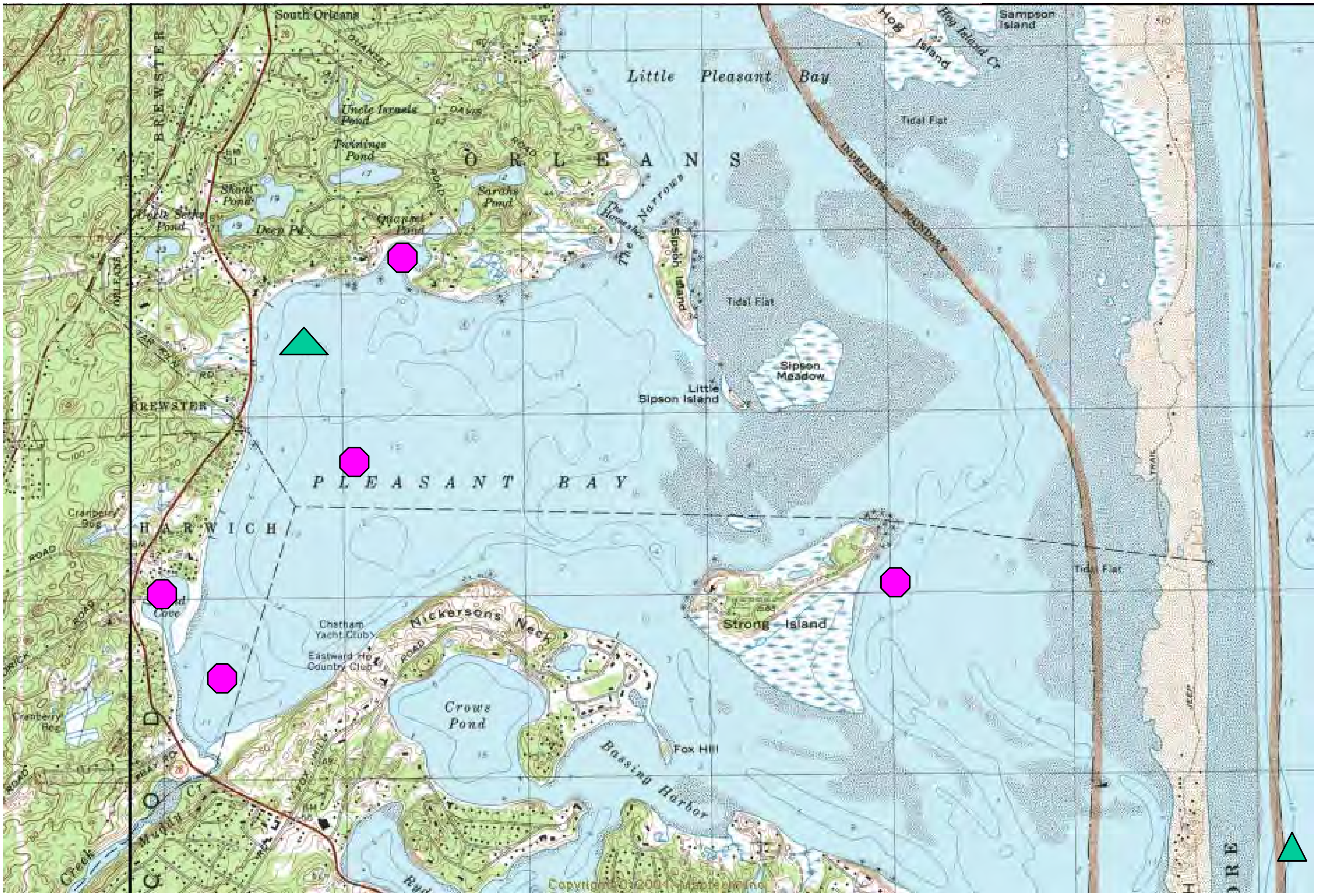

Round Cove
Atlantic Ocean
Cape Cod Bay
Plymouth
Bourne
Barnstable
Hyannis
New Bedford
Martha's Vineyard
Edgartown
Nantucket

Figure 1

Historical Nutrient Sampling Locations

Figure 2

Benthic Coring Locations   Stream Gage/MEP Nutrient Sampling Location   Figure 3



Tide Gauge Location ADCP Transects Dissolved Oxygen Mooring

Figure 4

Massachusetts Estuaries Project
Tabulations of Field Samples
Round Cove (34)

PROGRAMMATIC ELEMENTS *	SAMPLE CATEGORY	MEASURED PARAMETERS	SAMPLE TYPE	NUMBER OF SAMPLING STATIONS	SAMPLING FREQUENCY	NUMBER OF SAMPLES	NUMBER OF QC SAMPLES	COLLECTION PERIOD
HYDRODYNAMIC MODELING:								
	Bathymetric Survey	NA	NA	NA	NA	NA	NA	July – June
	Tidal Exchange ADCP	NA	NA	NA	NA	NA	NA	July - June
	Modeling/Validation	NA	NA	NA	NA	NA	NA	July - June
WATERSHED NITROGEN LOADING:								
	Freshwater Ponds	NA	NA	NA	NA	NA	NA	NA
	Watershed Delineation	NA	NA	NA	NA	NA	NA	NA
	Land Use Analysis	NA	NA	NA	NA	NA	NA	NA
	Stream flow/Nitrogen Loading	a,b,c,d,e,g	NA	NA	NA	NA	NA	NA
	Watershed N Loading Model	NA	NA	NA	NA	NA	NA	NA
NITROGEN REGENERATION:								
	Benthic Coring	a,b,c,d	Time Course Incubation	8	Once/Embayment	8	1	July - August
HABITAT ASSESSMENT:								
	Dissolved Oxygen	f,h,i,j,l,m	sensor	1**	15 minutes ****	> 2880	9 ***	July - Sept.
	Macrophyte Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Eelgrass Survey	o	Survey	NA	Once/Embayment	1	NA	July - Oct.
	Benthic Infauna	n	Grab	8	Once/Embayment	8	2	Oct. - Dec.
LINKED WATERSHED EMBAYMENT N MODEL:	NA	NA	NA	NA	NA	NA	NA	NA
SYNTHESIS OF MODELING AND HABITAT ASSESSMENT:	NA	NA	NA	NA	NA	NA	NA	NA

NOTE: * Each programmatic element of the Estuaries Project is listed regardless of whether or not it requires field data collection
** Moored instruments in the systems
*** Number of Winkler Titrations, conductivity and chlorophyll samples/assays
**** Parameters measured at 15 minute interval
NA = Not Applicable. Data collection does not involve the collection of water or sediment samples. If samples are not collected there are therefore no associated QC samples.
Measured Parameters include the following:

a = Ammonia
b = Nitrate + Nitrite
c = Phosphate
d = Dissolved Organic Nitrogen
e = Particulate Organic Nitrogen/Carbon
f = Dissolved Oxygen
g = Total Phosphorous
h = Salinity
i = Temperature
j = Secchi Depth
k = Total Depth
l = Chlorophyll / Pheophytin
m = Stage Height
n = Macro-invertabrates
o = Aquatic Plant Coverage
p = Fecal, Enterococci, E. Coli

Massachusetts Estuaries Project QAPP

Appendix B-1 Field Protocols and Data Sheets

A. Chain of Custody Record (Coastal Systems Group)

B. Bathymetric Mapping Field Data Sheet

C. Gauge Placement and Recovery Field Data Sheet

D. Field ADCP Program Data Sheet

E. Benthic Flux Field Data Sheet

F. Benthic Infauna Field Data Sheet

G. Bacteria Sampling Field Data Sheet
   Bacteria Sampling Techniques

H. Nutrients Sampling Field Data Sheet
   Nutrient Sampling Techniques

I. Stream Gaging Field Data Sheet
   Stream Gaging Techniques

J. Basic Parameter Sampling and Analytical Protocols

K. Field Instrument Calibration Protocol

L. Eel Grass Survey Protocol

COASTAL SYSTEMS GROUP
Chain of Custody Record

Personnel Contacts

COLLECTED		RECEIVED	
name		name	
date	time	date	time
RELINQUISHED		CONTACT	
name		name	
date	local	phone/address	

Sample Notes

Special notes/ Sample Handling	Total number of samples

Sample Status

Sample ID	NH4	PO4	NO3/NO2	TDN	POC/N	TSS	CHLA	TP	Salinity	pH	Alkalinity				

Relinquished by: Date: Time:
1 ______________________________
3 ______________________________

Received by: Date: Time:
2 ______________________________
4 ______________________________

Overview: Most information is recorded with instruments (DGPS/fathometer) or paper trace

Date: ________________

Notes:

Embayment: ________________

Personnel: ________________

Signature: ________________

Weather: ________________

Time on site: ________________

Time off site: ____________________

Location: ________________ Lat. _________ Lon. _______

Transect	Location Start (LAT/LON)	Location Stop (LAT/LON)	Time Start	Time Stop	Distance	Macrophytes	Transect Notes

Date: _______________

Embayment: _______________

Location: _______________

Personnel: _______________

Signature: _______________

Weather: _______________

Notes:

Time on site: _______________

Time off site: _______________________

Gauge ID.	Location Description	Latitude (degrees/min.)	Longitude (degrees/min.)	Time	Height of Water above Gauge (cm)

Date: _______________

Embayment: _______________

Location: _______________ Lat. _________ Lon. _______

Personnel: _______________

Signature: _______________

Weather: _______________

Time on site: _______________ Time off site: ___________________

Run No.	Tide Direction (ebb/flood)	Transect Start Time	Transect Stop Time	Max.Depth (meters)	Secchi Depth (meters)

Date: _______________

Embayment: _______________

Notes:

Station Location: _______________

Personnel: _______________

Signature: _______________

Weather: _______________

Time on site: _______________

Time off site: _____________________

Station: _______________

LAT: _______________ LON: ___________________

Core Collection Time:	___________
Core Collection Depth:	___________
Secchi Depth:	___________
BOD (yes/no):	___________
Temp (deg. C):	___________
Nutrient Sample (yes/no):	___________
Filter Sample Collected (yes/no):	___________
Dissolved Oxygen (DO):	___________
Sediment Type:	___________
Infauna presence:	___________
Macrophytes (type):	___________
Observations:	___________

Date: _______________

Embayment: _______________

Station Location: _______________

Personnel: _______________

Signature: _______________

Weather: _______________

Notes:

Time on site: _______________

Time off site: _____________________

Station: _______________

LAT: _______________ LON: _________________

Van Veen 25x25 (y/n)	
Other	
Screen Mesh Size 300 mm (y/n)	
Other	
Sample ID.	
Sediment Type	
Macrophytes	
Eel Grass	
Observations:	

Massachusetts Estuary Project
Field Sampling Protocol: Bacteria

Bacteria Sampling Techniques and Protocol 2001

Samples will be collected by the grab sampling technique. Depending on outfall volumes, and beach access, samples will be collected in one of two ways. If flow volumes and hazards are low, samples will be collected by hand filling a sterile 500 mL nalgene bottle placed directly into the outflow. If flow volumes are high and/or there is a potential for hazard at the site (slippery access, etc.), samples will be collected using a sampling pole. A pole that holds a sample bottle securely in place during collection. Samples will be collected according to the following procedures:

1. Fill out weather and environmental information on datasheet.
2. Using a new surgical glove pick up a sterile sample container and label it with site ID, date and time.
3. Remove the lid on the bottle taking care not to contaminate inside the lid or bottle. Hold the lid.
4. Face into the flow or current.
5. Turn the bottle upside down so that the opening is facing straight down and plunge the bottle into the water approximately 12 inches.
6. Turn the bottle horizontal with the mouth facing into the current and allow to fill as you “wiggle” the bottle mouth into the flow.
7. Raise the bottle out of the water and pour off enough water to have the water level at the shoulder of the bottle (this allows for the laboratory to shake the sample), cap the sample tightly and place the bottle on blue ice in a cooler.
8. If using a sample pole, lower the sampling pole into the flow of water at an angle, just below the water surface. Position the bottle so the opening is upstream from the pole. Water should flow directly into the bottle and should not contact the pole or base of the bottle before flowing into the mouth.
9. Fill to the fill line marked on the bottle leaving a half inch of air space.
10. Cap the bottle, remove it from the sampling pole and it on blue ice in a cooler.
11. Record sample ID, collection time, air temperature, water temperature (if thermometer is available) on the data sheet. Include tide if it is a beach sample.
12. Move to next location, use a new glove (to prevent any cross contamination) and repeat steps 1-12.Place all samples into the cooler with ice and ensure bottles are capped tightly.
13. Complete and sign data sheet (Chain of Custody form) before delivering samples to the laboratory or drop off location as soon as possible.

Submittal of Samples during Lab Hours
Iced samples will be delivered to the Project Coordinator, or directly to Barnstable County lab, Superior Courthouse, Barnstable MA.

Sample Processing

The laboratory will filter and culture samples for fecal coliform in accordance with the Membrane Filtration Technique (Standard Methods, 18^{th} Edition) using m-FC agar by DIFCO. Samples will be filtered within 6 hours of collection time.

Sampling Equipment

- cooler
- blue ice
- 500 mL sterile bottles (minimum size – 100ml)
- graduated cylinder for temperature and salinity parameters
- field thermometer
- Hydrometer or refractometer
- sampling pole
- disposable surgical gloves
- (4) large rubber bands to attach bottle to pole
- waterproof pen
- permanent markers (Sharpie)
- data sheet & Chain of Custody

Embayment: ______________________ Shore/Boat: __________
Town: ______________________ Last Rain: __________
Area Description: ______________________ Amount: __________
Personnel: ______________________
Signature: ______________________
Date of Collection: ______________________ Page ______ of _______
Low Tide: High Tide: Air Temp: Wind Dir:

Lab ID	Station ID	Location Description	Collection Time	Tide (E/F)	Grab or Composite	Pipe Flow (estimate)	Temp. (deg. C)	Salinity (ppt)	pH	Comments	Results

Relinquished by: Date: Time: Received by: Date: Time:
1 ____ 2 ____
3 ____ 4 ____

Massachusetts Estuaries Project
Field Sampling Protocol: Nutrients

Water Quality Program

Nutrient Sample Collection Overview

The goal of the Water Quality Monitoring Program is to provide needed data with which to evaluate overall water quality conditions in nearshore waters and harbors. These waters are most likely to be impacted by excessive nutrient loading originating from local land use. Because of the value of this data, it is very important that measurements are made using the protocol provided AND that collections be during the last three hours of an outgoing tide. Through training sessions, hands-on instruction and sampling tips, we will provide you with the information necessary to ensure efficiency and accuracy in the measurements. Please call (Roland Samimy 508-910-6314) if you have any questions and note any problems on the data sheet.

In addition to nutrient sample collection and filtering, the following measurements need to be taken **at each station**: **water temperature, salinity, water clarity** (secchi disk) and **total depth**. Samples collected for nutrients will be analyzed at the SMAST laboratory for:

Ammonium	Nitrate+Nitrite	Particulate Organic Nitrogen
Ortho-Phosphate	Chlorophyll a & pheophytin a	Particulate Organic Carbon
Diss. Org. Nitrogen	Total Phosphorus (as needed)	Specific Conductance

GENERAL/ WEATHER CONDITIONS Record parameters listed on data sheet:
*Time of nearest low tide from tide table and whether the tide is ebbing (approaching low) or flooding (approaching high)
*Wave conditions - see Beaufort scale
*Wind direction - the direction the wind is coming from
*Weather conditions
*Rainfall in last 24 hours.

SECCHI DEPTH/TOTAL DEPTH

Step 1. Lower Secchi disk into water slowly from shady side of a boat, dock or pier until it just disappears from view. Raise and lower slightly to insure the proper average depth of disappearance.

Step 2. Read depth on tape where it intersects the water surface, record on data sheet. *Note: Sometimes the secchi disk will hit the bottom before it disappears — in this case write "visible on bottom" or "vis/btm" on disk depth on data sheet.*

Step 3. Lower secchi disk slowly until it touches bottom, record station total depth.

NUTRIENT SAMPLE COLLECTION PROTOCOL

Each of these steps will be performed by you at each station in your embayment beginning in the inner portion and moving outward (toward the inlet). Samples are collected by Sampling Pole or Niskin Bottle. A surface sample will be collected at every station at 15 cm below the surface at pre-selected depths with the bottom sample 50 cm above sediment surface (be sure not to hit the bottom).

COLLECTION

MAKE SURE **ICE** IS IN COOLER

1. **a)** Label one 1 liter nutrient (white) bottle and one 1 liter chlorophyll (brown) bottle with station I.D., date, depth, and time of collection).
   b) Lower sampling pole with the 1 liter nutrient (white) sample bottle and oxygen bottle to 15 cm below the surface, pull oxygen stopper and then the white 1 liter bottle stopper, bring to surface, shake and dump to rinse bottle; replace stoppers then repeat, making sure to pull the oxygen bottle stopper first and let the bubbles stop before pulling the white 1 liter bottle stopper.
   c) Immediately cap nutrient (white) bottle, put in cooler, and shut cooler lid.
   d) Use the water in the oxygen bottle to determine water temperature with thermometer.
   e) Lower sampling pole again with 1 liter brown Chlorophyll bottle to 15 cm below surface, pull stopper, bring to surface, cap and put in cooler. Shut cooler.

******PUT NUTRIENT AND CHLOROPHYLL SAMPLES IN COOLER IMMEDIATELY*****

2. Take secchi depth and total station depth.
3. If a bottom sample is required, repeat ***a*** through ***e*** at a depth of 30cm above the bottom. If water is >3 meters (depth of sampling pole) a Niskin Sampler should be used.
4. Move to next station, repeat.

Note: Surface samples can be taken by hand or with the sampling pole. If taking samples by hand you must hold the open bottle in **a** inverted vertical position while submerging to the desired depth and then tip upright to fill.

You have just collected:
White 1 liter bottle - used for two analysis, dissolved and particulate nutrients
Brown 1 liter bottle – particulate (phytoplankton) chlorophyll content and total phosphorus (on stream samples)
Water Temperature
Secchi and Total Depths

On station (preferable) or back on shore

FILTERING

- TO BE DONE AS SOON AS POSSIBLE AFTER COLLECTION,

- Filtered samples are to be shipped in the small white 60 cc plastic bottle (these bottles are acid leached),
- Write label directly on plastic bottle with provided permanent marker (date, time, station, depth, embayment name)

Procedure:

1) Remove white 1 liter sample bottle from cooler, one station bottle at a time.
2) Label a 60cc btl with identical station information:
    - Embayment name
    - Station ID
    - Sample Depth (in meters)
    - Date (mo/dy/yr)
3) Place filter (using provided forceps) in clear plastic filter holder. (white filter, not the blue paper).
4) Shake 1 liter nutrient (white) sample bottle (in case of particulate settling) and fill 60cc syringe with water from bottle by removing plunger and pouring in, replace plunger.
5) Attach filter (cup side up) to syringe (most filter holders have an arrow drawn on side indicating the direction of flow) and push through and discard the first approx. 30 cc of water through the filter.
6) Push next 20 cc - 30 cc of water through the filter into the small 60 cc sample bottle, replace cap, shake and discard water.
7) Now refill syringe, **attach to filter** (cup side up) and collect all water through the filter into the now rinsed bottle until bottle is full to shoulder, **taking care that no unfiltered water drips into sample**, Fill bottle to top leaving only a small (2-3 ml) bubble, cap and put on ice.
8) Cap 1 liter nutrient (white) sample bottle with the remaining water, check label and put on ice. The bottle must be at least ¾ full to be used for analysis.
9) Remove used white filter paper and discard.
10) Repeat steps a) through h) for each 1 liter nutrient (white) sample bottle.
    The samples must remain in the dark and cold. Keep cooler lid closed.

Samples must be returned the same day as collected to the designated shipping point and Chain of Custody forms signed. Samples can be brought directly to the SMAST Laboratory at 706 Rodney French Blvd, New Bedford, MA 02744. Questions call Roland Samimy 508-910-6314 or the Laboratory at 508-910-6352.

Embayment: ________________________

Personnel: ________________________

Signature: ________________________

Date of Collection: ________________________ Page ______ of _______

Station ID / Description	Sample Depth (m)	Collection Time	Secchi Depth (m)	Total Depth (m)	Temperature (degree C)	Salinity (ppt)	D.O

Relinquished by: Date: Time: Received by: Date: Time:

1 ______________________________________ 2 ______________________________________

3 ______________________________________ 4 ______________________________________

Massachusetts Estuaries Project
Field Measurement Protocol: Stream Gaging

The overarching mission of the Massachusetts Estuaries Project is the protection and restoration of the health of each of the each coastal embayments within Southeastern Massachusetts through integrated watershed-embayment nitrogen management planning. The proposed effort will provide technical guidance to DEP relative to policies on nitrogen sensitive embayments and will perform the data collection and modeling required for the management and restoration of southeastern Massachusetts' 89 embayment systems. This program will also provide the scientific foundation for DEP's development of nitrogen (and to a lesser extent bacterial) TMDL's on these estuaries.

The goal of the stream gaging component of the Estuaries Program is to quantify the nutrient load and freshwater inflow from major streams which discharge to each estuary. These data will be used to:

- Validate the USGS watershed discharge modeling results
- Quantify the surface water nitrogen load
- Determine site-specific nitrogen attenuation values for the surface water flows to each embayment (comparison of watershed model to stream nitrogen discharge results).

Approach
Nutrient loading to an embayment through a stream is in part dependent on quantifying surface water flows (Q, volumetric discharge) and the associated nitrogen concentration in that discharge volume. For the purpose of this stream gaging protocol, flow will be calculated from continuous measurements of water level, stream cross sectional area, and periodic measurements of velocity. Stream water levels will be measured (15 minute intervals) using a Global Waters Water Level Logger: WL-15 or equivalent. The gauges will be vented to the atmosphere. Stream cross sectional areas will be measured using a top-setting wading rod. Permanent markers will establish the cross-section location. A Marsh McBirney Flow-mate Model 2000 or equivalent current meter will be used to measure stream velocities. The summation of the products of stream subsection areas of the stream cross-section and the respective measured velocities will represent the computation of stream flow (Q). A rating curve will be developed for each gauge to transform level data to discharge rates.

Station Location
Selection of stream gaging station locations will be based on:

- Accessibility
- Lack of tidal influence
- Section of stream providing a generally straight channel
- Streambed is free of aquatic growth and relatively smooth
- Unchanging natural control
- Stream channel does not go dry during low flow periods
- Gage site is not influenced by backwater effects (culverts, dams, confluences)

- Stable channel cross section

It will not be likely that all the above listed criteria will be able to be satisfied by all sites being considered, however, attempts will be made to find gauging sites that meet as many of the listed criteria as possible.

Ingress and egress to a potential site will be field verified and ownership of the site will be investigated. Permission to access a potential site will be gained from the owner of the site prior to using the site as a stream gauging station location.

Tidal influence on stream flow will be assessed prior to selection of a gaging station location. The assessment of tidal influence will initially be based on observation of stream habitat flora. Observations will be made in the field to determine the presence of freshwater plant species. Should the site under consideration be selected, a water level indicator will be installed to record stream levels and lack of tidal influence will be confirmed via instrument measurement. Should a slight tidal influence be present, numerical filtering techniques will be applied to the data to screen the tidal influence out of the data.

All stream gauging locations will be selected in stream reaches that are not influenced by backwater effects resulting from the presence of stream confluences, drainage culverts, dams or other naturally occurring or artificial structures. The gauging location will be situated down-gradient from culverts and dams and far enough up-gradient from a confluence that water level not be effected. In the absence of stage and discharge data at a potential gauge site or concurrent stage at the stream confluence, the gauging site selected will be the one located furthest away from the known confluence.

Stream Cross Section Measurements
After having identified an acceptable stream cross section where velocity measurements will be made, the selected cross section will be waded with a top setting wading rod in order to establish the profile of the cross section. The stream channel profile will be established before each run of velocity measurements.

A measuring tape will be manually stretched across the width of the stream channel and, while facing up-stream, the left and right banks of the channel will be noted in feet using the measuring tape. The transect will be marked with permanent markers to which the tape measure will be affixed on each sampling occasion. Water depth across the width of the stream will be measured in 0.5 foot increments using the top setting wading rod. Water depth will be measured in meters. Total stream channel cross sectional area will be the summation of the total number of segment cross sectional areas.

The stream cross section location will also be described in the field record book in order to maintain a record of changes in the channel bottom or bank characteristics.

Stream Water Level Measurements
Stream water level measurements will be obtained using a Global Waters Water Level Logger (WL-15) or some equivalent instrument. The factory calibrated water level loggers will be prepared in the laboratory for deployment in selected streams by checking that the

instrument is properly sealed to prevent malfunctions resulting from moisture build up in the instrument casing. Deployments will typically be continuous for approximately one year.

The water level instrument will typically be encased in a PVC tube, open ended on the bottom so that the instrument cable can run freely and capped on the top so that moisture cannot degrade the instrument communication port. The PVC encased instrument will be mounted to a convenient and permanent natural or artificial structure and the water level probe held in the desired location in the stream reach using either a stilling well or placement on a flat weight (ca. 40 lbs) in shallow streams. The instrument cable will be run as unobtrusively as possible so as to be hidden from view and to not become an obstacle. The water level probe will be placed at the deepest point in the stream channel so as to remain submerged during low flow seasons and mean sea level will be used as the vertical datum to which the probe is referenced. The water level probe will be weighted down appropriately so as to prevent the probe from migrating down stream during increased flow rates.

Water level data will be down loaded monthly in the field via lap top computer. Water level data will be field verified each month against either an in-stream surveyed staff gage or by making a manual water level measurement of height of water over the water level probe using a tape measure. Measured height of water over the in-stream water level probe will be compared to water level data record to confirm that data record is comparable.

Stream Water Velocity Measurements
Stream water velocity measurements will be taken, at a minimum, each time the WL-15 water level logger is down loaded. Additional velocity measurements may be taken in between instrument down loads depending on weather conditions in order to capture high or low flow events. Nutrient samples for total nitrogen will be collected on each visit to the gauge site.

Field data sheet for collection of velocity data have been developed and will be used to record velocity measurements, stream depths, and distance from the right or left bank where a velocity measurement is taken. In the absence of a field sheet, the same information can be recorded in a field stream gauging book (as used by the USGS).

Field data collected for each specific stream being profiled will include:

- Name of the embayment receiving the stream discharge
- Name of the stream/river being profiled
- Name of the person doing the velocity measurements and those assisting
- Date/time
- Weather conditions (clear, fog, cloudy, drizzle, intermittent rain, rain, snow, etc.)
- Left bank distance in meters (facing upstream)
- Right bank distance in meters (facing upstream)
- Distance from bank where velocity measurement is being taken

- Velocity (m/s)
- Depth (meters)
- Height of water above water level logging probe (meters)
- Staff gage measurement (where available)
- Nutrient sample collection (sample ID)

Stream Flow Calculation

Determination of stream flow will be calculated and based on the measured values obtained for stream cross sectional area and velocity. Stream discharge will be represented by the summation of individual discharge calculations for each stream subsection for which a cross sectional area and velocity measurement were obtained. Velocity measurements across the entire stream cross section WILL NOT be averaged and then applied to the total stream cross sectional area.

The formula that will be used for calculation of stream flow (discharge) is as follows:

$$Q = \Sigma(A * V)$$

where by:

Q = Stream discharge (m^3/day)
A = Stream subsection cross sectional area (m^2)
V = Stream subsection velocity (m/s)

Thus, each stream subsection will have a calculated stream discharge value and the summation of all the sub-sectional stream discharge values will be the total calculated discharge for the stream.

Nitrogen discharge is calculated using the paired discharge and nitrogen concentration data to determine the mass flux of nitrogen through the gauging site. These data are expressed as nitrogen mass per unit time (kg/d). The mass flux over the period of interest (month, season, year) is determined by integrating the area under the appropriate interval of the daily mass flux versus date graph.

Instrument Calibration and Verification

Instrumentation deployed or utilized as part of the stream gauging program are factory calibrated. The factory calibration is checked for the Marsh McBirney Flow mate 2000 velocity meter by placing the velocity probe into a test tank containing still water. The velocity meter probe is mounted on a sled that runs the length of the test tank at a constant speed. The speed of the sled is varied in order to check the velocity meter function at low, medium, and high flow rates. Sled runs should be conducted at speeds that capture the range of flow rates that are encountered in the field program. Four sled speeds have been traditionally used in previous SMAST studies to check the calibration of the velocity meter (2.0 cm/s, 20cm/s, 40cm/s, and 80cm/s). Multiple repetitions at a selected sled speed are performed. A three to ten minute time interval is typically used between runs to allow the water in the test tank to return to still conditions. Potassium permanganate is introduced to the tank between the runs at higher speeds to check that the water in the test was sufficiently still to begin the next run.

The velocity meter calibration check is begun by running the test tank sled at the lowest check speed of interest and then increasing the speed of the calibration check runs incrementally until the highest check speed is reached. Afterwards, the lowest speed is re-run to check that instrument drift is not occurring. If a drift of more than 5% is encountered the instrument is sent back to the manufacturer for maintenance.

Water level loggers are factory calibrated prior to the start of the field season. The function of the probe is field verified each time a velocity profile is being run by measuring the height of water over the probe with a measuring tape and comparing the manual measurement with the instrument measurement. Manual measurements are subsequently plotted against instrument measurements and simple linear regression analysis is performed on the data to determine the linear relationship. The calibration is acceptable if the $r^2 > 0.98$.

Watershed / Embayment: ____________________

Stream / Creek: ____________________

Gauge ID.: ____________________

Date: ____________________

Time: ____________________

Personnel: ____________________

Signature: ____________________

Gauge Data Downloaded (y/n): ____________________

Height of Water above Transducer (cm): ____________________

Nutrient Sample (y/n): ________ Sample ID: ____________ Sample Depth: ____________

Parameters	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8	Section 9	Section 10
Velocity (cm):										
Measurement Depth (cm):										
Total Water Depth (cm):										
Total Width (cm):										
Notes:										

Massachusetts Estuaries Project
Field Sampling Protocol: Physical Parameters

Water Quality Program

BASIC PARAMETER SAMPLING AND ANALYTICAL PROTOCOLS

MONITORING OVERVIEW

1) Record weather and general observations
2) Measure secchi depth and total depth
3) Collect surface sample -analyze temperature, dissolved oxygen, salinity
4) Collect bottom sample* -analyze temperature, dissolved oxygen, salinity

GENERAL/ WEATHER CONDITIONS Record parameters listed on data sheet:

* Time of nearest low tide from tide table and whether the tide is ebbing (approaching low) or flooding (approaching high)
* Wave conditions- see Beaufort scale
* Wind direction- the direction the wind is coming from
* Weather conditions
* Rainfall in last 24 hours.

SECCHI DEPTH/TOTAL DEPTH

Step 1. Lower Secchi disk into water slowly from shady side of a boat, dock or pier until it just disappears from view. Raise and lower slightly to insure the proper average depth of disappearance.

Step 2. Read depth on tape where it intersects the water surface, record on data sheet. *Note: Sometimes the secchi disk will hit the bottom before it disappears — in this case write "visible on bottom" or " vis/btm" on disk depth on data sheet.*

Step 3. Lower secchi disk slowly until it touches bottom, record station total depth.

COLLECTING A WATER SAMPLE

Note: *For simplicity we use the sampling pole for both surface and deep water sample collection.*

Step 1. Put stopper in salinity/temperature bottle(1 liter narrow mouth) and in the oxygen bottle (0.5 liter wide mouth). Make sure the tube on the oxygen bottle is secured in the wire loop at the mouth of the bottle.

Step 2. Move a couple of feet up current from where you measured total depth (to avoid disturbed sediments from the secchi). Lower the sampling pole gently to the appropriate depth (6 inches (15 cm) below the water surface for the surface sample and 1 foot (30 cm) above the bottom for bottom sample)[Use total depth minus 30cm to calculate depth for bottom sample] *Collect surface and bottom samples when there is at least 1.2 meters (4 ft) of water at your station. If there is less than 1.2 meters (4ft) collect a bottom sample 30 cm (1ft) up from the bottom sediment without disturbing bottom sediment. However, if there is less than 50 cm (1.6 ft) only collect a surface sample at* *that location (if there is sufficient depth to collect a sample without hitting the sediment with the sampling gear).*

Step 3. While holding sampling pole in place, pull the colored string oxygen bottle stopper first, let sample bottle fill.

Step 4. When all bubbles have ceased coming to the surface then pull salinity/temperature bottle stopper (1 liter), allow to fill. *NOTE: It is imperative that the oxygen bottle (colored string) is filled first to avoid oxygenating the sample from air within the salinity bottle.*

Step 5. Keeping the pole vertical, bring the samples on deck for analysis.

Step 6. Record sampling collection <u>time</u> and <u>sample depth on</u> datasheet.

<u>WATER SAMPLE ANALYSIS</u>

First: Fill glass O_2 reagent bottle from blue oxygen kit:

Step 1. Remove glass stopper.
Step 2. Lower rubber tube from oxygen bottle on pole to the <u>bottom</u> of the glass reagent bottle from the blue oxygen kit.
Step 3. Drain ¾ of the poles plastic oxygen (0.5 liter) bottle through the glass bottle, overflowing the glass bottle.
Step 4. Gently tap glass bottle to insure that no bubbles stick to sides.
Step 5. As volume reaches ¾ of the 0.5 liter plastic bottle, slowly remove the rubber tube from the glass bottle and then carefully insert glass stopper so as not to trap any bubbles. Dropping glass stopper in from above works best.
Step 6. Set sample aside in the shade for now.

Next: Put thermometer in the salinity/temperature bottle on pole, let stabilize, record this as “water temperature”. Remove thermometer and cap the salinity bottle and set it aside till after the dissolved oxygen is tested.

Now: Continue the dissolved oxygen analysis instruction below....

<u>DISSOLVED OXYGEN</u>

1. open Reagent packet #1 (use the scissors in your kit);
2. open Reagent packet #2
3. remove glass stopper from glass oxygen reagent bottle;
4. pour Reagent #1 into bottle and then add reagent packet #2 to bottle.
5. replace glass stopper, <u>careful not to trap bubbles</u>.
6. shake bottle vigorously holding bottle and stopper (some reagent may stick to bottom of bottle...this is O.K.).
7. let stand 2 minutes, shake again.

NOTE: <u>If you have a hydrometer for salinity, YOU CAN MEASURE SPECIFIC GRAVITY (Salinity) WHILE YOU WAIT, if you are sending samples to the laboratory for salinity analysis, check the bottle label and put in ice chest.</u>

8. After a total of 5 minutes (when the chemical floc has settled the second time and there is a clear division), open Reagent packet #3, remove glass stopper, add powder to bottle, replace stopper (no bubbles), shake vigorously until water in bottle becomes clear (no #3 particles). *THE SAMPLE IS FIXED NOW AND CAN BE TRANSPORTED TO THE LABORATORY IF APPROPRIATE – IN THE ICE CHEST AND DARK*. If you are titrating the samples in the field proceed to #9 below.

9. Remove glass stopper and fill small plastic tube from kit to top TWICE (two volumes) pouring each time into the square glass bottle in the kit. It helps to tip the bottle to overcome the surface tension.

10. To determine the oxygen content, shake the sodium thiosulfate solution in the brown plastic bottle in kit. Take the eyedropper and fill with sodium thiosulfate solution. Now the critical part: (be sure to hold dropper upright) add 1 drop to the square bottle and swirl. Continue to add and count drop by drop (about 10 seconds between drops) and swirl until the yellow color goes away. Record the number of drops (1 drop = 0.5 mg O_2/liter-ppm).

NOTE*: Be careful not to contaminate sodium thiosulfate solution by touching the dropper in O_2 sample.*

11. Pour waste reagent in to waste bottle and save for disposal.
12. Rinse all the oxygen kit bottles and plastic tube with tap water and shake dry before processing next sample.

<u>SALINITY = SPECIFIC GRAVITY/TEMPERATURE WITH HYDROMETER</u>

Step 1. Rinse 500 ml graduated cylinder with 100-200 ml sample from 1 L salinity bottle on pole.
Step 2. Rinse hydrometer directly from bottle with a little water (50-100 mls).
Step 3. Fill graduated cylinder with 500 ml of sample.
Step 4. <u>Gently</u> place hydrometer in cylinder (<u>do not drop</u>).
Step 5. Read number on stem of hydrometer where it intersects the water line in the cylinder, record.
Step 6. Take hydrometer out and put thermometer into cylinder and measure temperature (AGAIN); record as cylinder temperature on data sheet.
Step 7. Obtain salinity in ppt. from your table, record on data sheet.
Step 8. Rinse equipment with tap water from squirt bottle.

<u>Rinse off sampling pole and allow kit to air dry in cool dry place.</u>

Look over your data sheets to make sure everything is complete.

Mail or Deliver data to: Coastal Systems Program, SMAST-UMassD, 706 Rodney French Blvd, New Bedford, MA 02744. Questions to Roland Samimy 508-910-6314.

Field Instrument Calibration Protocol

Calibration of Field Equipment
<u>NEW EQUIPMENT CALIBRATION PROCEDURES:</u>

THERMOMETERS:

- Set up an ice bath in a large bucket. Fill the bucket close to the top with small ice cubes and water. Be sure the ice is distributed evenly throughout the entire bucket. You will want to be sure the sensors are not in a pocket of water.
- Set up a room temperature water bath. Fill another large bucket close to the top with tap water.
- Set aside an undisturbed area in which to take air temperature.
- Place all the thermometers as close as possible and record all air temperatures after allowing them to stabilize.
- Place all the thermometers in holes made in a cardboard sheet placed over the water temperature bath. Allow them to stabilize for a few minutes then record temperatures.
- Place the cardboard sheet and thermometers over the ice bath. Allow them to stabilize and record the temperatures.
- Calculate differences. Any thermometer with a difference greater than 1.0 degree should be recalibrated if possible or else discarded.

HYDROMETERS:
Take refractometer readings of each solution before and after testing hydrometers.

- Rinse all hydrometers to be calibrated with deionized water and dry.
- Fill one 500 ml graduated cylinder with fresh water.
- Fill a second 500 ml graduated cylinder with water known to be of 10 ppt salinity.
- Fill a third 500 ml graduated cylinder with water known to be of 20-25 ppt salinity.
- Place calibrating thermometer in fresh water cylinder. Read each hydrometer and record the temperature at the time of each reading.
- RINSE EACH HYDROMETER WITH DEIONIZED WATER AND DRY
- Place calibrating thermometer in the 10 ppt salinity cylinder. Read each hydrometer and record the temperature at the time of each reading.
- RINSE EACH HYDROMETER WITH DEIONIZED WATER AND DRY
- Place calibrating thermometer in the 25 ppt salinity cylinder. Read each hydrometer and record the temperature at the time of each reading.
- Calculate the salinity for each reading and compare. Discard any hydrometer with a salinity more than 1.5 ppt off standard.

OXYGEN

- Have volunteers simultaneously lower sampling poles, pull stoppers and collect sample. Have each volunteer record the temperature, process and record oxygen concentration.
- Check value with oxygen meter value. Repeat test if oxygen differs by more than 0.5 ppm.

FIELD TESTING OF EXISTING EQUIPMENT

Additionally, the Coordinator will field test and calibrate existing equipment in the field against new calibrated equipment and replicate an oxygen analysis during field visits. The Coordinator will make sure that each thermometer and hydrometer are within acceptable ranges and will record the results. If the equipment is not within range it will be replaced with pre-calibrated equipment. The equipment will then be calibrated within the new equipment procedures and if it fails to measure within the limits will be discarded. In addition, parallel samples will be sent to the laboratory for assay by specific conductivity meter (3-4 times per season) as an additional QA check. Any discrepancies in oxygen analysis will be resolved in the field through repeated sampling or correction of improper sampling techniques by the Coordinator.

Any new or additional sampling equipment (DO meters, refractometers, etc) will be maintained and calibrated under the manufactures specifications and requirements with assistance from the SMAST Lab or the manufactures maintenance program if contracted.

Eel Grass Surveying Protocol

The purpose of the Eelgrass Mapping Study is to provide critical site specific information on this key habitat quality indicator. The synthesized data takes the form of present maps of eelgrass distribution and historic trends in eelgrass coverage. This work is a continuation of the DEP mapping program (C. Costello). Data will be recorded and displayed on a digital base map which will include the accurate location of field note information and graphic representation of specific sampling points. Transects will be surveyed by differentially-corrected GPS to provide accurate coordinates for subsequent monitoring efforts. High resolution underwater digital videography (GPS stamped) will be collected and stored for the specific point and transect sites. This digital imagery will be included in the database and will be available for distribution.

<u>EQUIPMENT</u>: The following equipment is required to safely and efficiently conduct the fieldwork:

A power boat with a dependable outboard motor
A differentially corrected GPS receiver linked through
a laptop with GIS software to GPS points and fieldnote information.
An underwater color video camera system which produces high resolution digital imagery.

<u>SITE SELECTION PROCESS:</u>
All of the eelgrass beds within the selected embayment will be surveyed. In larger beds or beds where changing conditions have been pre-determined, several survey points and/or transects may be established. All known sites of Ruppia maritima, widgeon grass, will be surveyed within each embayment.

<u>TRANSECT SELECTION PROCESS</u>:
A minimum of two transects will be completed in each waterbody where an eelgrass polygon has been selected. These transects will represent several accurate "replicate sampling points" within each waterbody which can be monitored for changes over time. The transects will be conducted on a course which runs perpendicular to the shoreline unless site specific conditions (mooring lines/lobster pot lines) require another course direction.

METHODOLOGY

1. Two floating markers (buoys) will be placed to create a transect line at right angles to the shoreline. Buoy A will be placed as close as possible to the shoreline edge of the eelgrass bed as is safely possible. This inshore point will be called Point 1 and a GPS position will be recorded for this point. Buoy B will be placed outside the deeper edge of the eelgrass bed.
2. Once the transect line is established, the boat will be operated seaward from Buoy A to Buoy B with the towed underwater video camera (TOV) functioning and sending video signals to the color monitor in the boat. The boat will be operated at a speed not to exceed 3 km/hr. The monitor will be observed by the field crew and observations will be recorded into a digital database. This digital data base is geo-referenced by means of a GPS unit coordinated with the digital NOAA Coastal Chart displayed on the computer.
3. One point will be selected from each transect line as being representative (or an unusual observation within the transect). This point will be called Point 3 and a buoy will be deployed to accurately mark this point for later data capture.
4. The boat will continue on its transect to a point where the eelgrass bed terminates (where no more plants are observed). This point will be called Point 2 and a GPS position for this point (called the outer edge) will be recorded.
5. The boat will return to Point 3. The following sampling method will be completed: The boat will anchor and be allowed to come up into the wind to a relatively stable position. The TOV will be deployed in the vertical position to produce a sampling unit displayed in the monitor and viewed in the boat.

The following information will be recorded into the digital field notes for each point:

- Eelgrass polygon identifier number (referenced to embayment)
- Date/Time
- Location (lat/long)
- Tidal Stage (as referenced to Boston or Newport tide charts).
- Depth
- Presence/Absence of Eelgrass
- Percent Cover Eelgrass
- Presence/Absence Macroalgae
- Percent Cover Macroalgae
- Substrate Type (mud/sand/muddy sand)
- Secchi Depth
- Epiphytic presence
- Evidence of disease
- Other observations

Samples of the digital videography of the bottom conditions at the point will be recorded and saved to the file.

FIELDWORK GUIDELINES

The fieldwork season is limited by many factors which effect the quality of the data and also the safety of the crew.

<u>Sampling Period</u>: May thru September.

<u>Weather Conditions</u>:

Wind: Winds should be less than 12 mph and should not have exceeded that velocity during the prior 12 hours.

Waves: The seas should be relatively calm (< 2 foot) on the 12 hours prior to and during sampling. Wave action can create a hazardous situation while surveying the near shore data point (pt. 1). Wave action and swells can present a potentially damaging environment for the equipment (esp. the TOV). Wave action also tends to re-suspend sediments which reduces the quality of the underwater photography and viewing.

<u>Boat Equipment/Handling</u>:

Boat: Boat needs to be a minimum of 18 feet with a shallow draft (,12 inches).. Outboard needs to have a power tilt to maneuver in the shallow and rocky areas. Handling: The boat needs to be operated with caution when moving within the eelgrass resource area. During low tide conditions, the inner edge of the transect (pt. 1) will not able to be included in the GPS survey (data dictionary will indicate whether the inner edge is recorded).

DATA MANAGEMENT

The transect and point survey data will be collected digitally. The following is a description of the data to be collected and the final digital map/data base of the results:

1. Total collection of possible sampling sites and attribute information will be recorded in spreadsheet format.
2. Grid sampling data collected will be recorded in a digital attribute table coordinated with GPS –derived location information. This data is compatible with GIS software (ArcVew) which will be used for the development of the final digital base map.
3. Captured digital imagery will be stored on an external hard drive it will be encoded with the GPS location and will be geo-referenced to the database and will be included as part of the final project report.

Massachusetts Estuaries Project QAPP

Appendix B-2 Data Review and Acceptance Criteria

Massachusetts Estuaries Project

Data Review and Acceptance Criteria

Estuaries Project Technical Team
May 24, 2002

Overview: The Massachusetts Estuaries Project was initiated in December 2001 to provide the scientific foundation for the management and restoration of 89 estuarine systems throughout southeastern Massachusetts. Since regulatory agencies and communities have been concerned over the declining habitat quality of these systems for over a decade, there have been numerous individual data collection efforts to address specific issues, such as NPDES permits, dredging, wetland restoration, etc. It is the intent of the Estuaries Project to incorporate as much of this previously collected data as possible, both for efficiency and to provide historical perspective. However, since these previous studies are not part of the present QAPP, strict review is required before incorporating their results in order to ensure data quality and comparability.

SMAST will be responsible for review of existing monitoring data and estuarine process data to determine suitability for inclusion into the water quality modeling, synthesis and development of site specific thresholds. Decisions regarding data incorporation will be made by the Estuaries Project Technical Team (which includes DEP Project Manager). There will be 4 classes of data and process for inclusion:

- gathered with a QAPP, with limits meeting the requirements of the Estuaries Project QAPP – data accepted;
- gathered with a QAPP, with limits <u>not</u> meeting the requirements of the Estuaries Project QAPP – data unacceptable unless further review by Technical Team deems any special considerations to allow use;
- gathered without a QAPP, but with traceable and documentable sampling and analysis which indicates data limits that meet the requirements of the Estuaries Project QAPP -- data likely acceptable after review by Technical Team;
- gathered without a QAPP and without traceable and documentable sampling and analysis related to the requirements of the Estuaries Project QAPP -- data almost certainly will be unacceptable after review by Technical Team. These data will be treated as anecdotal information.

Process: The Massachusetts Estuaries Project Technical Team will review all project data prior to its use in water quality modeling, system synthesis or thresholds development. The team will render an opinion and judgement regarding data acceptability, generally using the criteria in the 4 data classes given above. Data will be deemed to be:

- Fully useable, to be fully incorporated into the Project database;
- Useable only as supporting data, requiring Project data collection;
- Useable only as qualitative supporting information (anecdotal);
- Not useable in any fashion for this Project.

Data used in the Massachusetts Estuaries Project must, at a minimum, be traceable back to its source. The source of the data may be a specific person who was responsible for the actual data collection or it may be an organization. If a source can not be determined for any given data set, the data set under consideration will be brought to the attention of the technical team and a recommendation will be made to not accept the data for inclusion into the program. If the source of a data set can be identified with certainty, than the data set will be considered for verification of the data quality.

Verification of a data set can occur in several different ways. Ideally, the data set being considered for inclusion into the Massachusetts Estuaries Project will have been collected under an approved Quality Assurance Project Plan (QAPP), with limits meeting the requirements of the Estuaries Project QAPP. Approval of QAPPs would typically be rendered by the Massachusetts Department of Environmental Protection (DEP) or the U.S. Environmental Protection Agency (EPA). Attempts will be made by the Estuaries Project to collect QAPPs for each data set which could provide useable data to the Project. These QAPPs will be kept in the Estuaries Project library for future reference should the need arise. Should this scenario be the case, it will be recommended to the Technical Team that the data set be included into the Estuaries Project. If it is determined that the data was collected with an approved QAPP but detection limits do <u>not</u> meet the requirements of the Estuaries Project QAPP, data will be considered unacceptable unless further review by Technical Team deems any special considerations to allow use.

In the absence of a DEP or EPA approved QAPP, the person or organization responsible for collecting the data and the lab that was responsible for analysis of samples will be sought out for specific information regarding data collection practice and analysis. Collection of samples or measurement data, in addition to the analysis of samples by a lab, at a minimum must have been performed in accordance to a set of standard operating procedures specific to the parameter measurement or sample type being collected.

Should a data set under consideration be collected in the absence of a DEP or EPA approved QAPP and the data is not traceable back to the person or organization responsible for the collection of the data, data almost certainly will be unacceptable after review by Technical Team. These data will be treated as anecdotal information.

Verification of the quality of a data set can also be achieved should the data have been peer reviewed or published in a scientific journal. In these cases, the protocols are available in the “Methods” section of the paper. However, the data collection and analysis still needs to be reviewed by the Technical Team to determine if it satisfies the criteria detailed in the Project QAPP. Data presented in the context of “grey” literature (e.g. an organization newsletter, reports proceedings etc.) will be considered in a similar manner to journal articles, except without the imprimatur of the peer review. Should a data set be presented in a technical report and be deemed appropriate for consideration for the Estuaries Project, the Technical Team will be convened for review of the evidence for data inclusion. If the source can be identified and the data was collected according to an established SOP, the technical team may judge the data to be acceptable to the project. In all cases, the criteria used for data inclusion will be that the data meets the requirements of the Estuaries Project QAPP.

Verification of data to be included in the Massachusetts Estuaries Project will help determine that the data set is either of insufficient quality based on above mentioned criteria and therefore should not be included in the Estuaries Project or satisfactory for use by the project. Having determined that the data set under consideration is of sufficient quality, the Technical Team will evaluate whether or not the data set is comparable to the needs of the Estuaries Project. For example, dissolved oxygen measurements may have been collected appropriately and with proper QA under an approved QAPP, but the measurements were made outside of the needed July-August window or may have been collected at the wrong depths.

In addition to satisfying an Estuaries Project need/objective, it will be necessary that the data set be sufficient in quantity in order for it to be worth considering for the project. A primary consideration is that data meet the Data Quality Objectives detailed in the Estuaries Project QAPP. The technical team will determine the degree of sufficiency based on the parameter being considered. Both temporal and spatial criteria will be applied to the determination of sufficiency.

Depending on the parameter being considered for inclusion into the project, consideration will be given as to whether or not the parameter of interest needs to be supported by additional Project data collection in order to be of value to the Project. In the absence of appropriate supporting data, the parameter under consideration may be of little value and therefore a Technical Team recommendation would be made to not include the specific data set into the project.

Ultimately, all data being considered for use in the Massachusetts Estuaries Project will be judged worthy relative to quality control criteria set forth in the overall umbrella QAPP for the project. Criteria for acceptance of data in each of the Estuaries Project elements (hydrodynamic modeling, watershed nitrogen loading, nitrogen regeneration, linked watershed embayment nitrogen model, habitat assessment, synthesis of modeling and habitat assessments) are presented in respective sections of the overall project QAPP. Additionally, data being considered for inclusion in the estuaries project must meet the criteria for precision, accuracy, and sensitivity (including instrument detection limits) as defined in the overall project QAPP.

Massachusetts Estuaries Project QAPP

Appendix B-3 Embayment Specific Bacterial Assessments

A) Bacterial Sampling Approach

B) Technical Memorandum: Analysis of Yr 1 Priority Estuaries for inclusion on 303(d) List for Bacterial Contamination

C) Top 20 vs. DRAFT Cape Cod Watershed Water Quality Assessment Report Estuary Segments Evaluation Matrix

Bacterial Assessments:
Massachusetts Estuaries Project Priority Embayments 1-20.

PART A:

Embayments for Bacterial Assessment:

Based upon the review of existing data relative to bacterial contamination within the Yr. 1 Priority Embayments, 1-20 (Howes and Samimy 2002, see Part B this Appendix), 7 estuaries were selected for further evaluation of contamination and field data collection. The 7 embayments are:

- Muddy Creek, Chatham (Appendix III)
- Frost Fish Creek in Bassing Harbor System, Chatham (Appendix IV)
- Acushnet River Estuary, New Bedford/Fairhaven/Acushnet (Appendix IX)
- Nantucket Harbor, Nantucket (Appendix XIII)
- Three Bays, Barnstable (Appendix XV)
- Oyster Pond, Falmouth (Appendix XVII)
- Sesechacha Pond, Nantucket (Appendix XVIII)

Assessment of Bacterial Contamination:
Assessment of bacterial contamination by the Estuaries Project within each of the 7 target embayments will consist of:

- Review of existing bacterial data within and in freshwater discharges to each embayment;
- Field sampling of bacterial contaminants (Fecal coliforms, *E. coli* and *Enterococcus*) in freshwater inflows under wet and dry weather conditions[1];
- Field sampling of distribution of bacterial contaminants (Fecal coliforms, *Enterococcus*) within the estuarine waters under wet and dry weather conditions.
- Synthesis of all bacterial information with circulation information to target embayment regions requiring source identification for remediation.

[1] Dry Weather = <0.1” of rain in previous 72 hrs; Wet Weather = >0.30” rain in previous 48 hrs.

The review of existing bacterial contamination data will focus primarily upon data from the Division of Marine Fisheries shellfish monitoring program and secondarily upon data collected by water quality monitoring programs and beach monitoring programs (DPH) and any site specific survey data which might be available. Although information on Fecal coliforms, *E. coli* and *Enterococcus* are desired, the bulk of the existing information relates only to Fecal coliform sampling.

The surface freshwater input and estuarine survey samplings will be conducted under both wet and dry weather conditions. The purpose of these paired surveys is to identify major regions of each estuary that need further investigation for remediation and to determine the role of stormwater versus chronic inputs (septic systems, fauna, etc.) in the levels of contamination.

The embayment sampling program is to determine the distribution of bacterial contaminants within each of the 7 estuaries and to determine changes from dry to wet weather conditions. Coupling the freshwater inflow data to the estuarine response surveys will be used to identify the focus studies required for implementation of bacterial remediation alternatives. However, as the focus of the Estuaries Project is not on the management of bacteria in the coastal zone, sampling efforts will not be designed to pin point individual sources of bacteria within a watershed. For the purpose of the Estuaries Project, bacterial assessment in an embayment will stop at the tributary level of the aquatic system. The output of the hydrodynamic model showing the circulation of the embayment under study will be used in the synthesis and interpretation of the historic and sampling data.

Findings on bacterial counts in an embayment will be presented in each embayment report. Suggestions will be made based on the data generated that can help steer a town's efforts (e.g. sanitary sewer / septic tank surveys) towards identifying and managing sources of bacteria in a watershed.

Stream Sampling: In addition to stream nutrient sampling, SMAST will conduct bacterial sampling in each of the major surface water inflows to each of the 7 embayments where bacterial contamination is an identified issue. Sampling will consist of routine collection of stream water samples for (Fecal coliforms, *E. coli* and *Enterococcus*) following the field protocol in B-I. Additional stormwater pipes/discharge points may be assayed during wet weather sampling, to the extent that these flows can be identified by site survey or Town records. These freshwater samples will be assayed by the Barnstable County Department of Health and the Environment Laboratory. Focus will be placed on fecal coliform as the majority of currently available bacterial data is for that organism. Bacterial assays will be performed by a DEP certified laboratory (generally Barnstable County Health Laboratory (Dr. Tom Bourne, director, 508-375-6608). In the event that historic data or field sampling shows a high fecal coliform count for a specific stream (>50 CFU/100 mL), additional assays will be routinely performed to determine counts for *Enterococcus* and *E. coli*. The analytical methods are discussed in Section B.3 in the Estuaries Project QAPP.

Bacterial samples will be obtained at the same time that the stream is being sampled for nutrients, gauged, and measured for flow velocity. The identified major freshwater inflow sampling sites are shown in Figure 3 within the 7 specific embayment Appendices I - XX. Based on the bacteria data generated for each stream discharging to an embayment, determinations can be made as to possible regions of an embayment watershed that are most likely bacterial contributors to the aquatic system.

Estuarine Sampling: Sampling of surface water within each of the 7 priority embayments determined to have bacterial contamination issues (see Part B this B-III) will be conducted as an "independent event (i.e. will be a focused sampling for bacterial contaminants). Sampling will be conducted from a boat with all of the samples collected within an embayment within an interval of 2 hours, but more likely within a 1 hour interval.

Sampling will be at each of the sites used for the Benthic Regeneration and Stream sampling (see Figure 3 within the 7 specific embayment Appendices). These sites are distributed throughout the each estuary and will be geographically referenced (Garmin GPS) prior to the first bacterial surveys. The high density of survey sites is needed for resolution of the distribution of bacterial contaminants.

Samples will be collected directly into the 250 mL sterile bottle provided by the analytical laboratory at a depth of 0.15 m, following the protocol in B-I. Estuarine survey samples will be assayed for fecal coliform and *Enterococcus* by the Barnstable County Health Laboratory (Dr. Tom Bourne, director, 508-375-6608). Samples will be transported to the laboratory within 6 hours of collection. Analysis and transport procedures are detailed in Section B.3 and B-I of this QAPP.

The Estuarine Survey samplings will focus on collected paired dry and wet samples at the same tidal stage (generally mid-ebb). The rainfall determinations will be based upon the closest meteorological station (see Section B.3). However, the Estuary Project may establish rain gauges within the watersheds of some of the 7 estuaries for confirmation purposes. At present Project gauges are proposed for 2 sites: the Chatham Water Quality Laboratory, Three Bays on Grand Island. These gauges will be graduated cylinder models with an accuracy of 0.01". They will be sited based upon manufacturers recommendations. These gauges will be read daily by scientists collaborating with the Estuaries Project. They will be fully trained as to the operation and maintenance of the gauges. The gauges may be upgraded to tipping bucket rain gauges which have a digital readout and 0.01" accuracy (Forestry Suppliers).

Dry weather sampling will be conducted when a rain event is anticipated within the next several days. The paired wet weather sampling will be launched only after 0.3" of rain have fallen within the previous 48 hours. Ideally, the wet weather sampling will be conducted on the first mid-ebb tide following the 0.3" of rain (i.e. within 12 hrs). For very large rain events (>1" in 24 hours) a second estuarine survey may be conducted (if feasible) on the first mid-ebb tide following the end of the rainfall.

Part B:

****************************** **MEP Technical Memorandum** *****************************

To: Massachusetts DEP
From: SMAST-UMD, Massachusetts Estuaries Project (Howes/Samimy)
RE: Analysis of Yr 1 Priority Estuaries for inclusion on 303(d) List for Bacterial Contamination
Date: June 26, 2002

The Estuaries Project Technical Team has analyzed available bacteriological data for the Year 1 Priority Estuaries to support an evaluation relative to their inclusion on the revised 303(d) list for Pathogens. We will soon be forwarding to you a comprehensive Technical Report further detailing this issue. We await a transfer of maps from vacationing DMF personnel. We consider all other aspects of this research and analysis exercise to be complete for the 20 estuaries in question.

The analysis required the following sub-tasks:

- Review of the DEP Cape Cod Watershed Water Quality Assessment Report
- Review of the DMF Shellfish Area Classification Report, Appendix E in the above DEP Cape Cod Watershed Water Quality Assessment Report
- Review of the DMF – Designated Shellfish Growing Area Maps for the 1-20 embayments not in the DEP Cape Cod Watershed Water Quality Assessment Report
- Analysis of the DMF bacterial data, assembled by DEP.

Please note that this memo is in response to DEP's request that we review the DEP Watershed Water Quality Assessment Report for Cape Cod embayments and compare their listed segments with the Massachusetts Estuaries Project (MEP) list of Top 20 Priority Embayments. This review and comparison process has prompted us to make an integrated assessment of the spectrum of bacterial data available using all of the data sources above. The attached summary table will be revised with additional information but we feel it is important to provide a summary at this time.

It should be noted that the approach used in both the DEP Cape Cod Watershed Water Quality Assessment Report and in the DMF data assembled by DEP, generally had multiple sub-regions within an embayment "rolled-up" into their larger block designations. In many cases where the DMF breakdowns were independently obtained, it was clear that only a small area within the total block was Provisionally Closed or Prohibited. Sometimes the closure of this small area resulted from harbor or marina activities only. In one case an area was referred to as being open, despite a bacterial contamination problem within large sections of the embayment. These issues will be discussed in the more comprehensive Technical Memorandum.

Based upon information from the above sources, the following analysis evolved as we proceeded:

(1) Review of the DEP Assessment Report determined that the DMF source data was also required. The reworked data in the Assessment Report was not sufficient for the Projects needs. One problem is that no maps of the DMF collection sites were available which is important if a whole embayment is to be considered for 303(d) listing. In addition, only 5 of the 20 MEP estuaries were in the report.

(2) DMF has been contacted and have been very helpful in providing information on area classifications for the initial 20 MEP embayments. This data will be provided in the full technical document.

(3) Bringing together the available data into Table 1 provides an overview of the relationship of the existing 303(d) listed embayments and those with significant closures. The information presented in the Table supports recommendations for revised 303d listings for pathogens.

Evaluation for 303(d) List:

Based upon the data in Table 1, there are 7 embayments sufficiently contaminated for potential inclusion on the 303d List. The sole criterion for this statement is the exceedance of fecal coliform levels of the shellfish standard of 14 colony forming units per 100ml as collected and assayed (by MPN) by the Massachusetts Division of Marine Fisheries. Evaluation of these systems follows:

1) *Muddy Creek, Town of Chatham:* DMF has designated the 2 sections of this system (SC58.1, SC58.2) Conditionally Approved and Prohibited. There seems to be a clear bacterial problem in this system. *Evaluation - 303d Listing Appropriate.*

2) *Bassing Harbor System, Town of Chatham:* This system includes Bassing Harbor, Crows Pond, Ryders Cove and Frost Fish Creek. Bassing Harbor, Crows Pond and Ryders Cove are real embayments. Frost Fish Creek is a salt marsh with a tidal basin and is a tidally restricted wetland. Only Frost Fish Creek has a bacterial problem. It is almost certain that this problem stems from its wetland status. In addition, it is tidally restricted and a relatively isolated sub-component of Ryders Cove. Therefore, while there is support for adding Frost Fish Creek to the 303d List, it should not bring all of the Bassing Harbor System to the 303d List. *Evaluation – Uncertain, but at most only Frost Fish Creek should be considered.*

3) *Nantucket Harbor, Town of Nantucket:* This system is already on the 303d List. It appears that there are 2 Prohibited areas. Polpis Harbor and in the boat basin in Nantucket Harbor. The boat basin is the primary marina area and where the Steamship Authority docks are located. It should be confirmed as whether this area may be closed as a result of harbor activities. It would seem reasonable to restrict the 303(d) assessment to Polpis Harbor, rather than the full extent of Nantucket Harbor. Polpis Harbor functions as a major sub-embayment to Nantucket Harbor and only a

small fraction of one of its two lobes shows bacterial contamination. This latter lobe supports the major stream input to the entire Nantucket Harbor System and drains a major wetland and cranberry bog area. *Evaluation – Focus 303d Listing efforts on Polpis Harbor.*

4) *Three Bays, Town of Barnstable:* Princes Cove, the relatively small sub-embayment to upper Three Bays, is currently on the 303d List. DMF data indicates that Princes Cove and associated North Bay are Conditionally Approved. There are other sources of fecal bacterial data for the Three Bays System so perhaps a modest system-wide analysis with a more detailed upper system analysis would be in order. *Evaluation – Continue 303d Listing.*

5) *Oyster Pond, Town of Falmouth:* This system is currently classified as Prohibited by DMF. There is an extensive set of fecal coliform data available for this system. It should be noted however that this system has been reconfigured as a brackish water system with a salinity range of 2-4 ppt. It is unclear whether there is a shellfish resource to protect. *Evaluation – Uncertain.*

6) *Sesechacha Pond, Town of Nantucket:* This system is currently on the 303d List. In addition, DMF has this system classified as Prohibited. *Evaluation – Continue 303d Listing.*

7) *New Bedford Inner Harbor (Acushnet River Estuary), Towns of Acushnet and Fairhaven and the City of New Bedford:* This system is currently on the 303d List. In addition, DMF has this system classified as Prohibited. Major issues within this system stem from the fact that it is fully enclosed and (a) has a significant river input, (b) has a number of operational CSO's, (c) contains the outfall from Fairhaven's WWTF, and (d) is the primary commercial harbor in southeastern Massachusetts. *Evaluation – Continue 303d Listing, but many of the TMDL implementation options are already clear.*

Habitat Quality: In addition to considering bacterial contamination the review of the DEP Cape Cod Watershed Water Quality Assessment Report included nutrient related assessments. The Report does consider habitat under an "Aquatic Life" category. From the description provided, we interpreted this category as being analogous to habitat health, which in these embayments can be a good indictor of "nutrient related habitat quality" or trophic status. Unfortunately, and without explanation, none of the Estuaries Project (1-20) embayment segments listed in the Assessment Report had been assessed for "Aquatic Life".

We are finalizing the comprehensive fecal coliform review that includes issues presented in this Technical Memorandum. The full report will have the source data and graphical representation of the DMF field data and will be used as a reference document for the MEP. This reference document will be upgraded to include all 89 embayments of southeastern Massachusetts when we obtain the tabular data for MEP embayments 21-89 from DEP/DMF and from the DMF field sampling program.

MASSACHUSETTS ESTUARIES PROJECT
Shellfish Classification Areas and Classification Types in Top 20

TOP 20 vs. DRAFT Cape Cod Watershed Water Quality Assessment Report Estuary Segments

MEP RANKING Top 20 (mep)	**MEP** TOWN (mep)	**MEP** EMBAYMENT SYSTEM (mep)	**DEP** ESTUARY SEGMENT CAPE COD WATERSHED	**DEP** SEGMENT NUMBER	**DEP** AQUATIC LIFE	**DMF** EMBAYMENT CLASSIFICATION AREA CODE	**DMF** EMBAYMENT CLASSIFICATION TYPE	**EPA** 303(d) LIST
1	Mashpee/Barnstable	Popponesset Bay	Mashpee River Shoestring Bay	MA96-24 MA96-08	NA	Popponesset Bay(SC19)	A	
2	Chatham	Sulfur Springs Bucks Creek	NOT APPLICABLE			Sulfur Springs (SC46) Bucks Creek (SC46)	CA CA	
3	Chatham	Muddy Creek	NOT APPLICABLE			SC58.1 SC58.2	CA **P**	ADD
4	Chatham	Bassing Harbor Ryders Cove Frost Fish Creek	Chatham Harbor *	MA96-10	NA	Bassing Harbor (SC54) Frost Fish Creek (SC57)	A **P**	ADD
5	Chatham	Stage Harbor	Stage Harbor	MA96-11	NA	SC48.0 SC48.4	A CA	
6	Chatham	Taylors Pond	NOT APPLICABLE			SC45	CA	
7	Falmouth	Bournes Pond	NOT APPLICABLE			SC13.0 SC13.1 SC13.2	A CA A	
8	Falmouth/Mashpee	Hamblin Pond Jehu Pond Quashnet River	Waquoit Bay Quashnet River Red Brook	MA96-21 MA96-20 MA96-25	NA	Hamblin / Jehu (SC16)	A	
9	Falmouth	Great/Perch Ponds	NOT APPLICABLE			SC11.0 SC11.20 SC11.21 SC11.22	 CA A A CA	
10	Falmouth	Green Pond	NOT APPLICABLE			SC12	CA	
11	Wareham	Agawam Wareham Broad Marsh Rivers	NOT APPLICABLE			BB36	Not in DMF Report	
12	Falmouth	Little Pond	NOT APPLICABLE			SC10	MC	
13	**Nantucket**	**Nantucket Harbor**	**NOT APPLICABLE**			**NT2.1 NT2.2 NT3 NT4.0 NT4.1 NT5**	**A P A A P A**	**ON**
14	Falmouth	West Falmouth Harbor	NOT APPLICABLE			BB54.0 BB54.1 BB54.2 BB54.20	CA P R A	
15	**Barnstable**	**Three Bays**	**Prince Cove**	**MA96-07**	**NA**	**(North) SC23 Prince SC23.1,2,3 (West) SC22 (Cotuit) SC21**	**CA CA A CA/A**	**ON**
16	Marthas Vineyard	Edgartown Great Pond	NOT APPLICABLE			V26	CA	
17	Falmouth	Oyster Pond	NOT APPLICABLE			SC6	P	
18	**Nantucket**	**Sesachacha Pond**	**NOT APPLICABLE**			**NT9**	**P**	**ON**
19	**New Bedford**	**Acushnet River, New Bedford Inner Harbor**	**NOT APPLICABLE**			**BB15**	**P**	**ON**
20	Bourne	Eel Pond, Back River	NOT APPLICABLE			BB47.1 BB47.2 BB47.3	CA CA CA	

MEP = Massachusetts Estuaries Project
DEP = Massachusetts Department of Environmental Protection
DMF = Massachusetts Department of Marine Fisheries

* Chatham Harbor, though listed as in the Top 20 is really source water to the Bassing Harbor System
Not Applicable = Cape Cod Watershed Water Quality Assessment Report Estuary Segment not present in Top 20

NA = Not Assessed
A = Approved for shellfishing
CA = Conditionally Approved for shellfishing

SMAST University of Massachusetts Dartmouth
The School for Marine Science and Technology

Massachusetts Department of Environmental Protection

Massachusetts Estuaries Project QAPP

Appendix B-4 Response to Comments on Final QAPP (7/24/2002)

A. Laboratory QA Plans
   SMAST and Barnstable County Health Department Laboratory
   Previously submitted to DEP under separate cover (January 2003)
   Not for general distribution

B. SOP for Bathymetry

C. Role of Volunteer Monitors in Coastal Water Quality Programs

D. Applicability of Blue Ice Packs for Cooling Bacteriological Samples

E. Revised Table B.1-1 found in Section B.1.1 of the MEP QAPP

F. Addendum to Section B.3.3 (Phosphorous Loading)

G. Tabulations of samples collected in 2002

MASSACHUSETTS ESTUARIES PROJECT
Bathymetric Standard Operating Procedure

Introduction:

Accurate hydrodynamic modeling requires accurate mapping of water depths throughout the tidal reach of the embayment. This requires simultaneous location and depth data gathering. In addition, since the systems are tidal, a correction for tidal elevation is also required.

Equipment:

Leica DGPS and Leica Beacon
Odum Single beam transducer and fathometer
Lap Top computer with HYPAK Oceanographic Software
Meter stick
Tide Gauge
Field data sheets
Batteries (2 – 12V Batteries)

Instrument Calibration:

1. DGPS

Check instrument against local USGS benchmark before and after survey.

2. Transducer/Fathometer

After mounting transducer on the side of the boat, measure depth below surface with meter stick and record.

3. Tide Gauges

Use gauges that have been pre-calibrated in SMAST seawater tank at multiple depths. In field, after mounting gauge on piling (or other fixed structure), record depth of water over gauge with meter stick.. Note: in complex embayments multiple gauges may have to be placed for a survey.

Field Procedure:

1. Connect transducer to the bottom of the swivel mount.
2. The DGPS beacon is fixed to the top of the swivel mount directly above the transducer.
3. Turn on instruments and allow 30 minutes for warm up before pre-survey calibration is performed.
4. Connect Fathometer and DGPS to laptop computer.

5. Check accuracy of transducer read out on computer by comparing read out to actual measured depth. Record on data sheet.
6. Follow transects set up prior to arrival at the field site on aerial photo. Transect lines are established perpendicular to the long axis of the embayment starting from the head of the embayment to the mouth. Transects are established to allow for 250-500 feet between transect lines.
7. Record start and stop times of each transect on data sheet

Post Survey:

Repeat calibration checks for transducer, tide gauge and DGPS.
Disconnect DGPS from swivel mount.
Disconnect transducer from swivel mount.
Disconnect Batteries.

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Massachusetts Estuaries Project
Bathymetric Survey Data Sheet

[Telephone: (508) 910-6352]

Embayment: ______________________ Date: ____________

Personnel: ___________________________________

Weather: ______________________

Time on site: ________ Time off site: _____________

	Pre-Calibration		Post-Calibration	
Measured Depth of Transducer				
Transducer Read Out				
DGPS Benchmark (Lat/Lon)				
DGPS Measurement (Lat/Lon)				

Run No.	Transect Start Time	Transect Stop Time	Run No.	Transect Start Time	Transect Stop Time
1			27		
2			28		
3			29		
4			30		
5			31		
6			32		
7			33		
8			34		
9			35		
10			36		
11			37		
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24			50		
25			51		
26			52		

MASSACHUSETTS ESTUARIES PROJECT
Role of Volunteer Monitors in Coastal Water Quality Programs

Regarding USEPA Memorandum dated August 19, 2002, Section C, Item number 1 **(*Training and Assessments [Sec.B.1.2 and C.1])***

Overview:
The Estuaries Project requires three years of baseline nutrient related water quality data on an embayment prior to the implementation of its full field data collection, modeling and thresholds development program. These data are needed both to guide field sampling and to validate the water quality model.

At present, the SMAST Team has reviewed coastal monitoring programs throughout southeastern Massachusetts as to applicability of data to the Estuaries Project. Programs typically consist of trained volunteer monitors, although some are fully conducted by professional staff. Almost all of the present programs are associated with the SMAST Coastal Systems Program for technical guidance and sample analysis. In almost all cases nutrient analyses have been conducted within the Coastal Systems Analytical Facility at SMAST and all potentially acceptable bacterial analyses have been conducted in DEP certified laboratories (primarily the Barnstable County Health Laboratory).

In almost all programs, SMAST has been responsible for training guidance, development of sampling methodologies, preparation of field sampling gear, and database preparation. In many of the programs, SMAST also conducts the assessments and prepares the monitoring reports. This existing association will facilitate the evaluation and incorporation of monitoring data by the Estuaries Project Technical Team.

The review and evaluation criteria for monitoring data (and all other data) is detailed in B-II of the Massachusetts Estuaries Project Quality Assurance Project Plan (QAPP).

Background:
Long-term population growth and associated increases in nitrogen loads has resulted in the increased eutrophication of estuaries, not only along the Southeastern Massachusetts shoreline, but along many of the world's coastlines. To address the ecological problems associated with this increase in nutrient loads, new TMDL methodologies have been developed to provide the quantitative approaches needed to model current and future nitrogen loads and their environmental impacts. Fundamental to these models is the availability of long-term high quality monitoring data that takes into account year to year variations in key environmental variables, and on a time scale suitable to identify any trends that may follow changes in land use and/or discharge along the coastline. This baseline data is therefore essential to the development of appropriate nitrogen management and land use strategies for coastal ecosystems.

One of the numerous tasks that must be undertaken in the execution of the Estuaries Project is the assemblage and review of all available long-term water quality monitoring data suitable for incorporation into the Estuaries Project. In many cases, this data has become available in recent years through the use of citizen-based water quality monitoring programs operating in Southeastern Massachusetts under the technical guidance of the Coastal Systems Program at SMAST. These water quality monitoring programs are staffed with trained volunteers, given both technical hands-on training of equipment use and sample collection, as well as fundamental information on ecological processes upon which sampling techniques were based. The goal of these programs is to collect research quality data using techniques appropriate for use by trained citizens; the techniques were developed to answer basic research questions and have been tested against more sophisticated (and expensive) approaches utilizing the tools of basic ecological research (Taylor, C.T. and B.L. Howes, 1994).

Each individual monitoring program within southeastern Massachusetts generally maintains the same goals of providing reliable water quality data to assist environmental managers to:

- Establish baseline water quality,
- Evaluate nitrogen loading inputs,
- Characterize and identifying sources of pollution,
- Document long-term environmental trends in water quality,
- Evaluate the relative success of clean-up efforts,
- Facilitate implementation of management recommendations

Data Sought from Water Quality Monitoring Programs:
This focus is also driven by the Regulatory Agencies, including EOEA's Watershed Initiative, as well as the Public's concern relating to nutrient issues. Regulation of nutrients is changing relative to watershed-based water quality management and the public interest in clean water. As well, management of nutrients continues to be at the top of the US EPA's Agenda.

In addition to nutrient measurements some of the monitoring programs collect parallel measurements of fecal coliform levels. Almost all of this bacterial data has been collected by Division of Marine Fisheries (DMF) and will be assembled with their help for use by the Estuaries Project. Limited additional bacterial data has been collected by water quality monitoring programs. Bacterial contamination is the primary cause of embayment closures to shell fishing and swimming. Review of existing coliform data from state and local programs as well as ongoing monitoring programs will determine the need for additional measurements of fecal bacteria within specific estuaries within the Estuary Project study area. As available (and appropriate) this information will be evaluated for incorporation into Estuaries Project database.

The goals of the monitoring programs are to provide data needed to evaluate overall water quality conditions throughout the sub-embayments and to determine changes over the long-term. Through the use of trained volunteers, we can effectively collect the substantial amount of spatial and temporal water quality data. The number and locations of sample stations is specific to each embayment and depends in part upon the embayment's size and shape, access, and navigational passages. Sampling is to be conducted throughout each estuary from its headwaters to its mouth under the same conditions of tide and weather. This is possible due to the coordinated efforts of a large number of volunteers. The data collected by the volunteers is of sufficient quality to represent environmental conditions since (1) volunteers are trained each year and are constantly checked by the Coordinator, (2) volunteers collect physical data and D.O. which are performed in the field and (3) all nutrient assays are conducted at the SMAST laboratory.

Training of Volunteer Monitors:
Volunteer monitors will not be directly involved in collecting samples for MEP-related activities. Previous data collected by volunteer monitoring programs will be reviewed and evaluated for acceptance for use by MEP or rejection according to the criteria outlined in B-II of the QAPP. Data reviewed in this manner will be classified as:

1. Fully useable
2. Useable only as supporting data
3. Useable only as qualitative or anecdotal information
4. Not useable

The criteria detailed in B-II will ensure that the only data accepted for MEP use are collected using QAPPs previously approved by the DEP or EPA.

Monitoring Program coordinators for past sample collection efforts are volunteers who have been fully trained and evaluated by SMAST personnel before field sampling begins. They need to provide the Technical Team with sampling techniques and training materials. Volunteers should be taught the monitoring program's objectives and their role and responsibilities. The seriousness of the enterprise and the need for completeness of sample collection should be emphasized. Volunteers need to have received a formal hands-on training session prior to each field season. Specifically, volunteers need to be instructed in the importance of taking accurate and timely measurements and following the written field protocols provided. They should have been given a demonstration of the protocol and been observed collecting the samples and performing the tests. Retraining sessions should be held at the beginning of each sampling season. Ideally coordinators conduct individual follow up with field checks on new volunteers and seasoned volunteers are teamed with newly trained volunteers to assure consistent sampling technique. Volunteer assessment should be checked by evaluation of data against previous sample data from earlier assessments. The program coordinators should have a contact database for all volunteers. In reviewing data from water quality monitoring programs, the Estuaries Project will ascertain that field and laboratory approaches are related to a formal QAPP or sampling plan.

Applicability of Blue Ice Packs for Cooling Bacteriological Samples Collected by the Massachusetts Estuaries Project

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Background:
During technical discussions between EPA and DEP QAPP reviewers and Estuaries Project Technical Team members, concerns were raised relating to the use of blue ice packs for cooling bacteriological samples. The major concern related to the ability of these re-usable ice packs to cool water samples sufficiently quickly and to the appropriate temperature. Based upon the importance of proper sampling handling for these "live" biological samples, it was prudent to conduct tests of the performance of blue ice relative to bacteriological sampling.

Approach:
Duplicate bacteriological sample containers (150 ml), provided by Barnstable County Department of Health and Environment. A 8 liter container was filled with freshwater. Two temperature loggers (Onset Computer Hobo Loggers) were placed into the container for sufficient time to reach temperature equilibration (~5 min). Duplicate sample bottles were then filled and a logger placed in each (logger vol. ~10 ml). The sample bottle temperature was determined using a thermocouple digital temperature probe/meter (Omega). The bottles were immediately placed into a standard 13 liter Igloo "Playmate" Cooler held at 22^{o}C. In the cooler were blue ice packs which had been frozen in the SMAST walk-in sample freezer (-30^{o}C). The temperature of each bottle was recorded every 3 minutes throughout the holding period. The loggers were calibrated in a stirred ice bath prior to use and the temperature of each bottle was checked by thermocouple temperature probe/meter at the end of each experiment. Three experiments were conducted in which the volume of blue ice was varied, combinations of large (7.5"x 5.8"x 1.5") and small (6.8"x 4"x 1.5") packs were used.

Results:
In all cases the blue ice appeared to rapidly (<0.65 hr) cool the samples to the required sample temperature, <10^{o}C (Standard Methods, 19th Edition, Section 9060B). This cooling rate is considered acceptable given that (a) the sample initial temperatures were between 26^{o}C and 28.6^{o}C and (b) the cooler was held at 22^{o}C during the incubation. In experiment 1, where a maximum number of ice packs (5) were employed, the sample temperature in one of the bottles was brought too low (-0.1^{o}C). The standard field sampling cooler has between 3 and 4 ice packs. In experiments 2 and 3 the samples reached proper temperatures and excessive cooling was not evident. In all cases the blue ice packs gave sustained cooling for 16 hours, much longer than the Estuaries Project holding time of 6 hours (Table 1).

The time-course of cooling for the most rigorous experiment is shown in Figure 1. In this text, only 1 large and 2 small ice packs were used compared to a minimum field cooler of 2 large and 1 small. In addition, the initial sample temperature was high, 28.6^{o}C. However, the data indicates that the appropriate holding temperature was reached in an acceptable period of time, within approximately 30 minutes (0.50 hours).

Table 1
Summary of tests of cooling capacity of blue ice packs for bacteriological samples. All experiments were conducted in a standard 13 liter cooler held at 22^{o}C.

	Rep Btl	# Blue Ice Packs	Start Temp (C)	Time to 10^{o}C (hr)	Time to 4^{o}C (hr)	Temp C @ 6 hr	Temp C @ 16 hr
Expt. 1	A	5 (2 l + 3 s, 4.1L)*	26.0	0.62	1.27	--	-0.1
	B		26.0	0.62	1.52	0.5	0.9
Expt. 2	A	4 (2 l + 2 s, 3.5L)	26.6	--	--	--	0.9
	B		26.6	--	--	--	0.0
Expt. 3	A	3 (1 l + 2 s, 2.4 L)	28.6	0.40	0.65	1.6	--
	B		28.6	0.35	0.55	1.5	--

* The number, type (l=large, s=small) and total volume (liters) of blue ice is presented.

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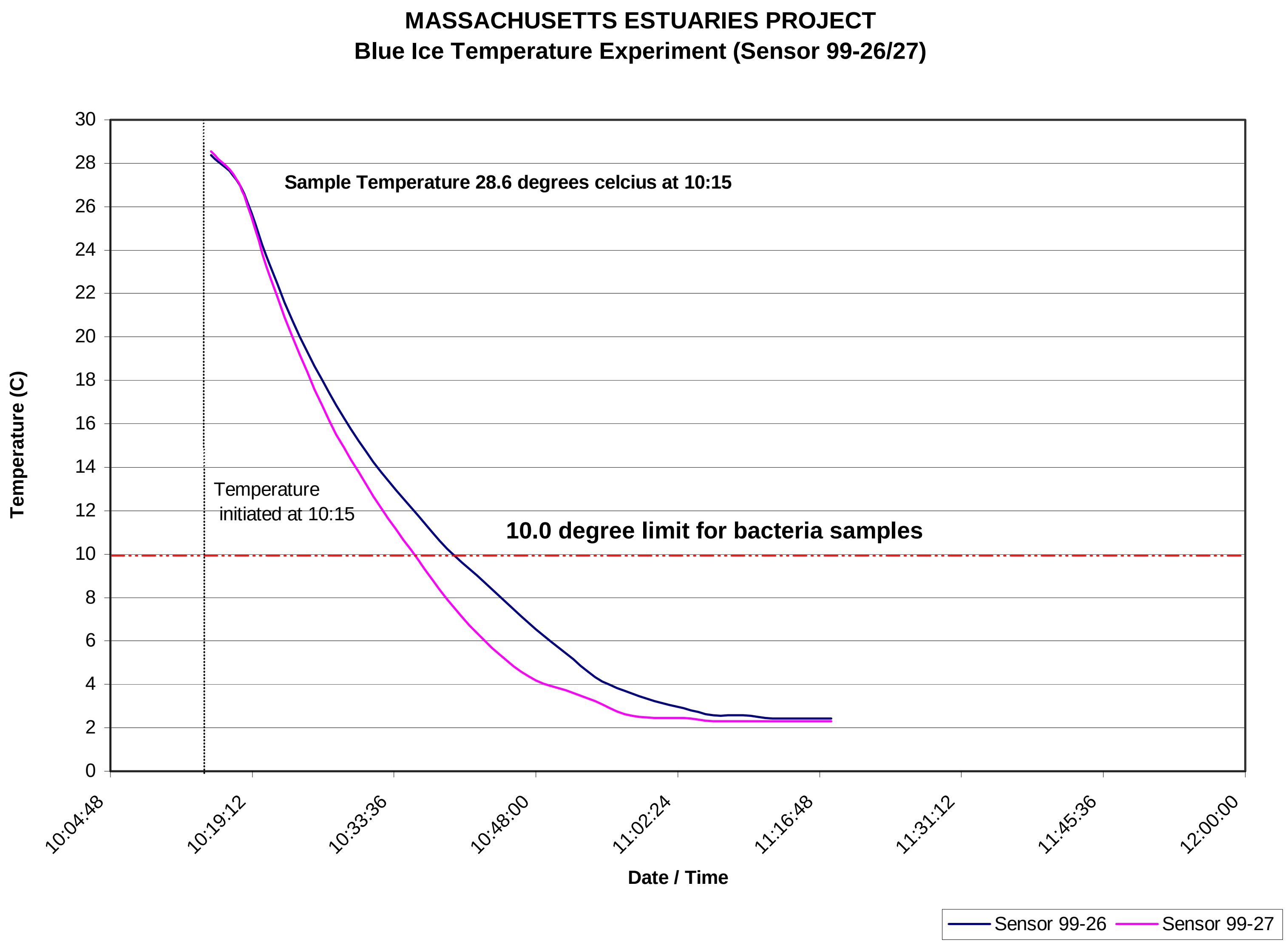

Figure 1 - Time-course of Sample Cooling

MASSACHUSETTS ESTUARIES PROJECT
Revised Table B.1-1 from Section B.1.1 of MEP QAPP

B.1.1 Data Quality Objectives

Data quality objectives have been selected as criteria for the **Review of Nitrogen Related Water Quality Monitoring Data Task** in order to fit with the goals of the Water Quality Monitoring Task and the concentrations and natural variability found within the tidal estuarine environments throughout southeastern Massachusetts. The methods and approaches which render data acceptable for inclusion of data into the Estuaries Project must meet the required levels of precision, accuracy, field blank cleanliness (analyte free), and detection limits. Although site-specific exceptions may be made after review by the Technical Team (B-II), the minimum performance criteria for the basic physical sampling is given in **Table B.1-1 revised below to include footnotes.**

Table B.1-1 Water Quality Program, field parameters measured & data objectives

Parameter	Method	Range	Sensitivity	Precision	Accuracy	Calibration
Temperature[a]	*Thermometer*	*-5°C to +40°C*	*0.5°C*	*±0.5°C*	*1°C*	*Certified thermometer over temperature range*[b]
Temperature	*Thermister*	*-5°C to +40°C*	*0.1°C*	*±0.1°C*	*0.2°C*	*Factory calibration & Certified Thermometer*
Salinity	*Conductivity Meter*	*0-35 ppt*	*0.1 ppt*	*±0.1 ppt*	*0.2 ppt*	*Certified Conductivity Standards*
Salinity[c]	*Hydrometer*	*1.000 to 1.050/ Specific Gravity*	*0.5 ppt*	*±1 ppt*	*1-2 ppt*	*Conductivity Meter & Certified Standards*
Dissolved Oxygen	*Modified Winkler Titration Hach OX2P*	*0-16 ppm*	*0.5 ppm*	*±0.5 ppm*	*1 ppm*	*Dissolved gas standards*
Dissolved Oxygen	*Oxygen Meter*	*0-16 ppm*	*0.1 ppm*	*±0.1 ppm*	*0.2 ppm*	*Dissolved gas standards*
Water Clarity	*Secchi Disk disappearance/ meters*	*0-15 m*	*1 cm*	*±10 cm*	*20 cm*	*NA*

[a] Not preferred method for measuring temperature (Thermister Method is preferred). However, this method is acceptable if it is only used for calculating oxygen saturation for monitoring purposes.

[b] Calibration uses regression of field thermometer vs. certified thermometer with 5 temperature points and an $R^2 > 0.99$ and no pair of temperature points should exhibit a difference greater than ±1.0 degree.

[c] Not preferred method for measuring salinity (Specific Conductivity Method preferred). This method should not be used to determine stratification unless differences > 2 ppt.

MASSACHUSETTS ESTUARIES PROJECT
Addendum to Section B.3.3 (Phosphorous Loading)

Phosphorous loading to freshwater systems (ponds/streams) will not be determined as it is not the focus of the Estuaries Project in and of itself. The Estuaries Project focuses primarily upon the sources, sinks, and transfers of nitrogen within the watershed-embayment complex. Nitrogen is the nutrient for managing eutrophication in Massachusetts coastal embayments, while phosphorus is the primary nutrient for management of eutrophication of freshwater systems. In specific cases where it is necessary to determine phosphorous loading in support of other analyses or evaluations, loading may be determined. Some examples of cases where support may be requested:

- NPDES Permiting
- Nitrogen source reduction for embayment restoration, where P load to eutrophic freshwaters will also be effected. Source reduction may be by relocation of discharges or reduction in discharged load.
- Cases where a regulatory agency has a priority

In the event that phosphorus loading determinations are undertaken, a project specific plan will be developed to meet site specific needs. However, the analysis will follow the format of the nitrogen loading analysis for the embayments. This site specific project plan will be appended to the relevant embayment specific Appendix QAPP under this umbrella QAPP for the Estuaries Project.

MASSACHUSETTS ESTUARIES PROJECT
Tabulations of Field Samples

Embayment specific tabulation of field samples to be collected in each of the systems under investigation by the Massachusetts Estuaries Project have been developed and are included in each of the embayment specific appendices.