1.0 TITLE: Continuous water quality monitoring in Barnegat Bay

QUALITY ASSURANCE PROJECT PLAN

Prepared by James Vasslides, Barnegat Bay Partnership

Effective Date: March 1, 2017
Project Duration: Ongoing

Approved by: _____ 7/28/17
Donna Ringel, Quality Assurance Officer — date
U.S. EPA Region 2

Approved by: _____ 8/17/17
Barbara Spinweber, Project Officer — date
U.S. EPA Region 2

Approved by: _____ 7/25/17
Marc Ferko, Quality Assurance Officer — date
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Approved by: _____ 7-20-17
Robert Schuster, Project Officer — date
NJDEP Bureau of Marine Water Monitoring

Approved by: _____ 19 April 2017
Nicole Petersen, Principal Investigator — date
Barnegat Bay Partnership

Approved by: _____ 19 April 2017
James Vasslides, Quality Assurance Officer — date
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3.0 QAPP DISTRIBUTION LIST:

Signed copies of this Quality Assurance Project Plan (QAPP) and all subsequent revisions will be sent to the following individuals by electronic mail:

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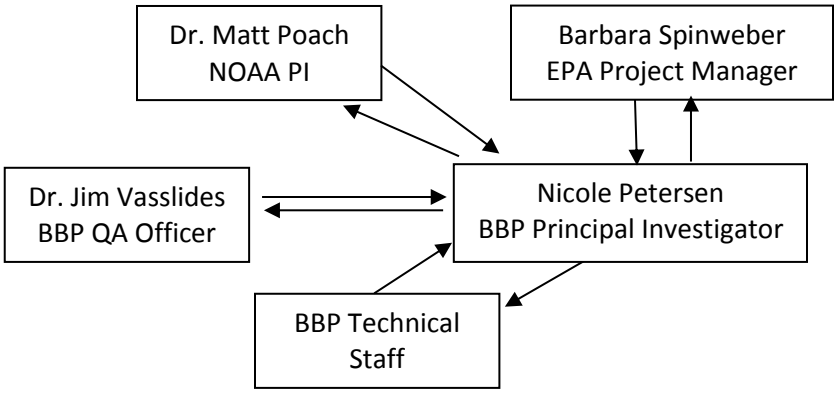
James Vasslides, Quality Assurance Officer, Barnegat Bay Partnership, jvasslides@ocean.edu
Matthew Poach, Principal Investigator, NOAA NMFS, matthew.poach@noaa.gov

4.0 PROJECT TASK ORGANIZATION:

Overall project management will be the responsibility of Ms. Nicole Petersen. Ms. Petersen will oversee the deployment and maintenance of the continuous water quality instruments and will be responsible for maintenance of the approved QA Project Plan. Dr. Jim Vasslides will provide quality assurance management, reviewing data acquisition and data analysis protocols, and ensuring compliance with all elements of the QA Project Plan. Dr. Matthew Poach will be responsible for the validation of pCO2 data.

Organizational Chart-Lines of Communication



5.0 SPECIAL TRAINING/CERTIFICATIONS:

All staff conducting maintenance and calibration activities on the long-term continuous water quality datasondes will have successfully completed the web-based Exo University training program offered by YSI. This program will ensure a base level of knowledge in critical components of maintenance and calibration activities.

6.0 PROBLEM DEFINITION/BACKGROUND:

6.1 Problem Definition:

Coastal water quality impacts many commercial and recreational activities within the Barnegat Bay, including recreational and commercial fishing and shell fishing, swimming and ecotourism. These activities depend on a healthy ecosystem for their continued success. However, New Jersey's coastal waters are adversely impacted by a variety of stressors, potentially leading to decreased water quality, including algal blooms and low dissolved oxygen. To understand the impacts of these stressors on the water quality of Barnegat Bay it is necessary to collect water quality data at appropriate temporal and spatial resolution. The availability of continuous water quality data on a near real-time basis will provide environmental managers and researchers with a valuable tool for understanding estuarine processes and the impacts described above. Simultaneous measurement of parameters such as temperature, salinity, oxygen, pH, turbidity, and water level will allow correlations to be made between these parameters and meteorological conditions, tidal conditions and diurnal conditions. Real-time data collection eliminates the need for frequent trips to monitoring sites and benefits scientists and managers by allowing them to track environmental conditions at any given moment, more readily respond to episodic events as they happen which, in turn, can facilitate more accurate planning and decision making.

6.2 Background:

Monmouth University, with support from the Barnegat Bay Partnership (BBP) and others, has operated a suite of four continuous water quality monitoring stations in the Barnegat Bay since the mid-2000s (Bonnet Island, Barnegat Inlet, Seaside Park, Mantoloking/Point Pleasant Canal). The data generated from these stations was available through the Monmouth University website and was used by a variety of stakeholders. Monmouth University is no longer able to maintain and operate the previously deployed water quality stations. Therefore the BBP is taking over the maintenance and operation of three water quality monitoring stations.

7.0 PROJECT DESCRIPTION:

The objective of this project is to provide stakeholders (New Jersey residents, water quality managers and researchers) with timely access to measurements of coastal water quality. This will be done through the refurbishment of two existing long-term water quality monitoring stations (Seaside Park and Mantoloking) and the installation of a new station at Beach Haven (Table 1). Information to be provided at all stations will include: pH, turbidity, temperature, dissolved oxygen, salinity and water level. Additionally, the new Beach Haven station will measure pCO_2 to aid in understanding the impacts of coastal acidification. This information is expected to be useful to a wide range of users including fishermen, students, educators, researchers, and the general public. Persons interested in knowing the current conditions in "their bay" or estuary will find this valuable and should gain a better understanding of the dynamics of water quality in the waters near their home.

Table 1: Barnegat Bay Partnership's continuous water quality monitoring locations in Barnegat Bay.

Site Name	Location	Waterbody	Latitude	Longitude
Mantoloking	Mantoloking Yacht Club	Barnegat Bay	40.0374 N	74.05405 W
Seaside Park	Seaside Park Yacht Club	Barnegat Bay	39.921813 N	74.0828445 W
Beach Haven	Morrison's Marina	Little Egg Harbor	39.567079 N	74.245045 W

The YSI Exo2 multiparameter data logger system is being used in this project. The YSI Exo2 multiparameter data logger system is designed for long term *in situ* monitoring and profiling. The Exo2 series data sonde uses a fully integrated sensor setup that accurately and reliably measures the parameters chosen: water temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and water level.

To accurately measure changes in water chemistry associated with coastal acidification, the Beach Haven station will also be equipped with a Satlantic SeaFet high precision pH sensor and a Pro-Oceanus CO_2-Pro CV CO_2 sensor. In combination with the data from the YSI Exo2 sensors we will be able to measure changes in pCO_2 concentration at the appropriate scale.

Each of the monitoring stations consists of one deployment platform that will be affixed to a bulkhead, piling or other dock structure and is assigned two YSI data sondes; one data sonde is deployed in the water and a second remains ready for a maintenance and calibration swap every 3 - 4 weeks. Prior to initial deployment, each of the YSI Exo2 data logger systems will be programmed to record temperature, salinity, dissolved oxygen, pH, turbidity, and water level every 15 minutes. The Satlantic and Pro-Oceanus sensors will also record data concurrent with the YSI. Each data

sonde removed or swapped from the field will subsequently be brought back to the laboratory for cleaning and calibration for redeployment. The Satlantic and Pro-Oceanus sensors are designed for long-term deployment, and will only be brought back from the field on an as-needed basis for cleaning and calibration (see Section 13.2 for additional details). Once deployed, the monitoring stations will remain operational as long as possible, with a goal of year round at most locations, but a minimum of early spring until late fall at each location.

The data is transmitted via a cellular modem once per hour to the New Jersey Department of Environmental Protection Bureau of Marine Water Monitoring, where it is downloaded and sent to their website for data retrieval by other organizations. As stated above, it is anticipated that data will be continuously collected between March and November annually.

8.0 QUALITY OBJECTIVES AND CRITERIA FOR MEASUREMENT DATA:

Data quality objectives (DQOs) for the water quality parameters being measured can be expressed in terms of accuracy, precision, and completeness goals. These DQOs were established by obtaining estimates of the most likely data quality that is achievable by the instruments based on the instrument manufacturer's specifications.

The DQOs are used as quality control criteria for field measurements to set the bounds of acceptable measurement error. Generally speaking, DQO's are usually established for the following aspects of data quality: precision and accuracy, representativeness, comparability, and completeness.

8.1 Precision and Accuracy

The term accuracy is defined as the difference between a measured value and the true or expected value, and represents an estimate of systematic error or net bias. Precision is defined as the degree of mutual agreement among individual measurements, and represents an estimate of random error. Collectively, accuracy and precision can provide an estimate of the total error or uncertainty associated with an individual measured value.

Accuracy and precision will be managed by using calibrated YSI Exo2-series datasondes to collect water quality data at each of the sites. According to the manufacturer's recommendation, individual datasondes can remain deployed for a period of 3 -4 weeks and accurately provide reliable data. At the end of this time period, the datasondes in the field will be swapped out for a newly calibrated unit.

During deployment, transmitted data will be reviewed and tracked and any anomalies will be noted and investigated to confirm that the instrument is fully operational and providing credible data. If data being collected is suspect, the data sonde will be inspected and, if necessary, a newly calibrated unit will be deployed as soon as possible. Suspect readings include consistent reporting of dissolved oxygen levels indicating hypoxic conditions or super saturation, salinities above 32 parts per thousand, and pH levels below 5.0 or above 9.5.

The data quality objectives for the water quality parameters to be measured with the YSI Exo2 data logger system in the field are expressed separately as maximum allowable accuracy, precision and completeness goals in Table 2. The data quality objectives for the water quality parameters to be measured with the Pro-Oceanus CO2-Pro CV and Satlantic SeaFet are listed in Table 3.

Table 2: Data Quality Objectives for surface water quality measurement using the YSI Exo2 multi-parameter datasonde system			
Parameter	**Accuracy Goal**	**Precision Goal**	**Completeness Goal**
Dissolved oxygen	±0.3 mg/L	10%	100%
Salinity	±0.5 psu	10%	100%
pH	±0.3 units	10%	100%
Temperature	±0.5 °C	10%	100%
Turbidity	±0.3 FNU	10%	100%
Water Level	±0.06 ft, ±0.02 m	10%	100%

Table 3: Data Quality Objectives for surface water quality measurement using the Pro-Oceanus CO_2-Pro CV and Satlantic SeaFet (pH)			
Parameter	**Accuracy Goal**	**Precision Goal**	**Completeness Goal**
CO2	+/- 20 µatm	10%	100%
pH	+/- 0.04 units	10%	100%

Pre and Post calibration checks on known standards should be within the accuracy goal for each parameter for each device, and multiple readings at that time should fall within the precision goals. During deployment, accuracy of pH and pCO_2 readings will be checked periodically against values obtained from discrete sampling.

8.2 Bias

In order to eliminate bias, which could cause errors in data obtained during the project, all equipment will be inspected and properly calibrated as described in Section 13 of this QAPP before being deployed. Calibration of the datasondes will always be performed by the same trained personnel following detailed procedures. This reduces the likelihood of human (operator) induced error.

8.3 Representativeness

The concept of representativeness refers to the ability of the project to accurately and precisely characterize the existing conditions of a water body through the measurement of selected environmental parameters. In terms of the project sampling design, the sites of deployment have been selected to be as representative as possible of conditions in the water bodies at large where they are located taking into account location, accessibility and security. Additionally, this monitoring program is part of a larger effort to deploy continuous water quality datasondes in the bay, and thus should be looked at as part of a larger program. These sites were picked based on local knowledge and in consultation with other water quality monitoring organizations (Jacques Cousteau National Estuarine Research River and NJDEP Bureau of Marine Water Monitoring).

8.4 Comparability

Comparability is defined as the confidence with which one data set can be compared to another. To ensure data comparability in this project, we utilize the same model YSI data logger systems being deployed by other organizations in the state including NJDEP, USGS, and Rutgers University. All of these data will be shared among the agencies and organizations via the internet and these data sets will undergo periodic review, comparison, and analysis by the group.

Each of the three stations is using the same hardware and are setup, operated and maintained in the same way. The only exceptions are the high precision pH and CO2 sensors at Beach Haven. The

data collected by these sensors is consistent with that of discrete sampling technology and other continuous sensors, and will be comparable to the findings in other locations.

8.5 Completeness

Completeness is defined as a measure of the amount of data collected during each field sampling event compared to the amount that was expected to be obtained under the conditions of measurement. We have established a completeness goal of 100% for the various parameters being measured. However, a loss of data collection capabilities (power supply issues) or data outside of the normal parameter range (potential biofouling or sensor drift) may not prevent the remaining data from being used, depending on the goals of the user.

8.6 Sensitivity

Sensitivity is essentially the lowest detection limit of the method or instrument for each of the parameters being measured. The sensitivity of the YSI Exo2 datasonde for the parameters being measured is summarized in Table 4, and the Pro-Oceanus and Satlantic Sensors in Table 5. Sensitivities for the analysis of dissolved inorganic carbon (DIC) and for pH of discrete samples at the NOAA laboratory at provided in Table 6.

Table 4: YSI Exo2 multi-parameter datasonde system sensitivities.

Parameter	**Range**	**Accuracy**	**Resolution**
Dissolved oxygen	0 to 50 mg/l	@ 0 – 20 mg/l; greater of 1% of reading or +/- 0.1 mg/l @ 20 – 50 mg/l; 5% of reading	0.01 mg/l
Salinity	0 to 70 ppt	Greater of +/- 2% of the reading or 0.2 ppt	0.01 ppt
pH	0 to 14 units	+/- 0.2 units	0.01 units
Temperature	-5 to 50◦C	+/- 0.2◦C	0.001◦C
Turbidity	0 to 4,000 FNU	+/- 2% or 0.3 FNU	0.01 FNU
Depth (non-vented)	0 to 33 ft., 10 m	±0.013 ft, ±0.004 m	0.001 ft, 0.001 m

Table 5: Pro-Oceanus CO_2-Pro CV and Satlantic SeaFet sensitivities

Parameter	**Range**	**Accuracy**	**Resolution**
CO_2	0-3000 ppm	+/- 0.5%	0.01ppm
pH	6.5 – 9.0 units	0.02 units	0.004 units

Table 6: Sensitivities of discrete sample analyses

Parameter	**Range**	**Accuracy**	**Resolution**
DIC	0-3000 µg C	+/- 0.3%	< 1 µg C
pH	7.0 – 8.2 units	0.005 units	0.001 units

9.0 NON-DIRECT MEASUREMENTS (SECONDARY DATA):

Non-direct measurements (secondary data) will not be used as part of this monitoring project.

10.0 FIELD MONITORING REQUIREMENTS:

10.1 Monitoring Process Design

This project involves the reestablishment of two long-term continuous water quality monitoring stations and the establishment of a third station within the Barnegat Bay-Little Egg Harbor estuary complex (Table 1). These stations are part of a broader network of automated stations independently maintained and operated by the NJDEP, US Geological Survey, and JCNERR to assess changes in water quality within the Barnegat Bay-Little Egg Harbor watershed. The reestablished station locations were determined through cooperative discussion amongst all interested parties in an effort to provide continuous water quality data at reasonable spatial scales given budgetary constraints. The new station location, which includes the capabilities to measure changes in coastal acidification, was set by consensus among the interested parties considering the current monitoring coverage, the desire to place it near to sensitive biotic receptors (particularly shellfish), and limited suitable shore-side deployment locations.

Each of the stations will contain a YSI Exo2 multiparameter datasondes that will measure temperature, salinity, pH, dissolved oxygen, turbidity, and water level every 15 minutes. The Beach Haven station will also contain a Pro-Oceanus CO_2-Pro CV and Satlantic SeaFet that will measure CO_2 and pH, respectively, concurrently. All data will be stored on a datalogger and also transmitted hourly via cellular modem to the BBP for QA/QC and to an NJDEP website for public consumption. It is our intention to deploy the sensors from March to November of each year, with removal in the winter for annual regularly scheduled maintenance and to lessen the possibility of ice damage. We will attempt to extend the deployment of the devices through the winter, weather dependent.

10.2 Monitoring Methods:

Each station will include a multiparameter datasonde designed for long-term, *in-situ* monitoring. The YSI Exo2 datasondes will be equipped with sensors that measure and record the following surface water quality parameters: water temperature, salinity, dissolved oxygen, pH, turbidity, and water level. Each monitoring station will be assigned two YSI Exo2 datasondes: one datasonde is deployed in the water and a second remains ready for a maintenance and calibration swap every 3 - 4 weeks, depending on the degree of fouling. Each time a datasonde is replaced with a newly calibrated unit, the datasonde retrieved from the field is brought back to the BBP laboratory for post-deployment checks, cleaning, and maintenance. These retrieved units will subsequently be recalibrated prior to redeployment.

The Beach Haven station will also be equipped with a Pro-Oceanus CO_2-Pro CV and Satlantic SeaFet sondes. Both of these sondes are designed for long-term, *in situ* monitoring, and require annual calibration. However, during the YSI swap the housings will be examined for biofouling and cleaned as needed.

The datasondes will be located at each station in a manner that will allow for constant monitoring of surface water conditions at a depth of approximately one meter below the surface of the water. This will be achieved by hanging the data sondes inside PVC pipes affixed to the deployment platforms that have holes drilled in the lower portion of the deployment pipes along their length to allow for water exchange (see https://www.ysi.com/File%20Library/Documents/Guides/Long-Term-Deployment-Tube-Guide.pdf for an example and template). The deployment platforms will be constructed as fixed shore side locations on bulkheads/pilings at each site.

The YSI KORS software will be used to conduct the Exo2 sonde calibrations and setup. Once deployed, the Campbell CR1000 data logger and Data Management System will manage sensor sampling, data buffering and cellular telemetry to a base station. This system will be deployed shore-side adjacent to the data sonde platforms. The data sondes, water pump (Pro-Oceanus sonde only), and data loggers will be powered via an onsite 18v battery that is recharged through a solar charging system.

The Campbell CR1000 data logger systems will be programmed to record data every 15 minutes. The data telemetry system will provide data to the NJDEP web site in near real-time. The telemetry system is comprised of a field component located at each sampling site and an office component located at the NJDEP Bureau of Marine Water Monitoring. The field component consists of a housing, a data logger that stores the data collected by the sensors on the corresponding data sonde, a battery and solar panel to supply power, and a modem. Once an hour, the NJDEP computer server will connect with the data loggers located at each sampling site and will upload and update the data on the website.

Deployment and retrieval for the Exo2 data sondes will be conducted in accordance with the best management practices developed as part of the National Estuarine Research Reserve System(NERRS) System-Wide Monitoring Program (SWMP) YSI/Xylem EXO Multi-Parameter Water Quality Monitoring Standard Operating Procedure (Mensinger et al. 2016; Appendix 1). Post-deployment data downloads and processing will be conducted in a manner identical to those of the NJDEP and their approved QAPP to ensure consistency with other data collected within the bay.

10.3 Field Quality Control (QC):

Field quality control measures associated with deployment of continuous monitoring sondes can be divided into two categories; the physical environment of the sondes and the stability of the sensors.

Inspection and maintenance of the deployment platforms, data telemetry system, and associated power supply will be conducted with each site visit. Biofouling, which occurs when aquatic organisms such as algae begin to grow on the data sondes, can prevent the sensors from obtaining accurate readings. The Exo2 system is designed to operate in severe fouling environments and kept free of fouling by a universal anti-fouling sensor wiper assembly centrally installed on the sonde. In addition sensors are routinely wrapped in copper tape and the sonde guard is copper alloy. The PVC tubes holding the sondes are treated inside and out with antifouling paint every year. If biofouling is suspected of being an issue during deployments a cleaning brush will be used to clean the inside and a curved bladed long handled scrapper will be used on the outside of the tubes, which will be mounted to allow them to be rotated out of the water. These activities have been shown to be sufficient to overcome most of the problems associated with biofouling.

The sensors on the Exo2 units will be calibrated prior to deployment (section 13) and checked against known standards upon retrieval (Appendix 1, Section VI). Additionally, a YSI Pro-Plus Quatro handheld water quality meter will be used to collect discrete samples concurrent with the first and last sampling event of the continuous units as a field control.

The measurements from the Satlantic SeaFet will be checked against a discrete sample collected at initial deployment, weekly, and again at retrieval. Variance from the discrete sample will be documented in field records to be kept with the continuous data. If the variance between the discrete sample and the concurrent sensor reading exceeds the accuracy goal listed in Table 3, the sensor data will be flagged until a subsequent discrete/continuous sample pair read within the

accuracy range. This is in keeping with best practices, as is co-locating the sensor with a CO_2 and O_2 sensor (Martz, McLaughlin, and Weisberg 2015; Appendix 2).

11.0 ANALYTICAL REQUIREMENTS:

The analytical requirements are addressed throughout the QAPP and summarized in Tables 2 through 5. The specific methodology for each of the YSI sensors can be found in the Exo User's Manual (https://www.ysi.com/File%20Library/Documents/Manuals/EXO-User-Manual-Web.pdf). The discrete water samples will be analyzed for DIC using a coulometer (UIC Inc.) and pH using a spectrophotometer (Varian) following the methods outlined in the Guide to Best Practices for Ocean CO2 Measurements (Dickson et al., 2007). Sample analyses will be validated with certified seawater reference materials and tris buffers obtained from UC San Diego. The DIC and pH data along with in-situ sample temperature, pressure, and salinity will then be input to the CO2SYS_xls program to calculate the in-situ pH and pCO2 which will then be used to verify the continuous probe measurements (Perriot et al. 2006).

12.0 SAMPLE HANDLING AND CUSTODY REQUIREMENTS:

Sample collection and transport will be limited to discrete water samples collected to check against the SeaFet and CO_2-Pro sensors. These samples will be collected, preserved, and analyzed by NOAA personnel as part of their sampling protocol, and will be maintained within their custody throughout the process. Discrete samples will be collected following the methods in the Guide to Best Practices for Ocean CO2 Measurements (Dickson et al., 2007). Briefly, discrete samples will be collected weekly at the probe measurement depth using a water sampling bottle and transferred to 300mL borosilicate glass bottles ensuring minimal interaction with the atmosphere. Samples will immediately be preserved with 0.06mL of a saturated mercuric chloride solution and transferred to the NOAA fisheries laboratory in Sandy Hook, NJ for analysis. Samples properly collected and preserved with mercuric chloride have a holding time greater than a month for both pH and DIC (Andrew Dickson, UCSD, personal communication).

All calibration records and field notes will be initialed, time and date notated and kept as part of the permanent project record.

13.0 TESTING, INSPECTION, MAINTENANCE, AND CALIBRATION REQUIREMENTS:

The YSI sensors require routine calibration checks to verify that their performance is within acceptable quality standards. The following sections will discuss the procedures and frequency for the various instrument calibrations that are key components in the collection of accurate environmental data.

13.1 Instrument/Equipment Testing, Inspection and Maintenance:

The Pro-Oceanus $C0_2$-Pro CV and the Satlantic SeaFet require annual maintenance and calibration verification to be performed by the manufacturers' representatives or service consultants. These procedures will be documented by date and the signature of the person performing the inspection, and the documentation will be maintained as part of the QA file.

For the YSI Exo2 sondes, an equipment testing, inspection, and maintenance log will be kept for each datasonde and updated prior to, and after each deployment.

13.2 Instrument/Equipment Calibration and Frequency:

An SOP has been developed and will be followed closely while maintaining, calibrating and operating the YSI Exo2 datasondes and associated equipment (Appendix 1). The methods utilized to calibrate the probes on the Exo2 datasondes are found in Appendix 1, Section II and will be used

prior to each deployment, while the post-deployment procedure in Section VI will occur following all deployments.

The Pro-Oceanus $C0_2$-Pro CV and the Satlantic SeaFet are factory calibrated based on conditions found at our deployment site, and will be returned to the factory each winter for inspection, repair, and recalibration.

13.3 Inspection/Acceptance of Supplies and Consumables:
The Project Manager and QA/QC Project Officer will be responsible for procurement of all supplies and equipment associated with the project covered by this QAPP. It will be their responsibility to inspect and accept all supplies and consumables received to ensure their quality and acceptability. All replacement probes for YSI datasondes must be received directly from the appropriate company. Probes will only be accepted if they are not noted as damages after a visual inspection, and pass initial calibration tests (YSI). Materials that do not meet this criteria will be returned to the manufacturer and replaced.

14.0 DATA MANAGEMENT:
As previously described, data collected at each of the monitoring sites will be transmitted via cellular modem to the NJDEP and BBP. Once an hour, the NJDEP computer server will connect with the data loggers located at each sampling site and will upload and update the data to the Bureau of Marine Monitoring website. The BBP system will also download the data hourly, but it will be stored for biweekly QA/QC checks to make a final archive for public use. This archived data will undergo a data review and validation process (see Section 16) prior to being made available to the public.

Transmitted data will be reviewed daily (excluding weekends) by the BBP via remote access to look for any anomalies, which will be noted and investigated to confirm that the instrument is fully operational and providing credible data. If data being collected is suspect, the datasondewill be inspected and, if necessary, a newly calibrated unit will be deployed as soon as possible. Suspect readings would include consistent reporting of dissolved oxygen levels indicating hypoxic conditions or super saturation, salinities above 32 parts per thousand, turbidity below 0.1 NTU or above 250 NTU, and pH levels below 5.0 or above 9.5.

YSI sensor calibrations are conducted using the YSI:KOR software. Station programming is accomplished through the Campbell datalogger software. Data QA/QC will be done using Microsoft Excel.

The hard copies of the datasonde calibration sheets and deployment logs will be held at the BBP office to enable QA/QC of the downloaded data, after which they will be stored by the BBP indefinitely.

15.0 ASSESSMENTS AND OVERSIGHT:
The BBP's QA/QC Project Officer will ensure that all data from the project are generated in accordance with procedures outlined in this Quality Assurance Project Plan. Other project participants will immediately report any problems or QA/QC issues to the QA/QC Project Officer. The QA/QC Project Officer will recommend appropriate corrective action and determine the acceptability of affected data. The BBP QA/QC Project Officer will conduct an audit of the calibration procedures, field deployment, data retrieval, and data verification within the first three months of the start of each sampling season.

The QA/QC officer will be present during the initial calibration and datasonde deployment each year to ensure consistency with previous years' efforts. They will also be tasked with ensuring that no unacceptable data (i.e., data that has previously been deemed suspect) is released or included in evaluations and analysis of results.

The QA/QC Project Officer shall keep a written record of any deviations from the approved QAPP. Results of all corrective actions will also be documented for the record.

16.0 DATA REVIEW, VERIFICATION, VALIDATION AND USABILITY:

16.1 Date Review, Verification, and Validation

Transmitted data will be reviewed daily and any anomalies will be noted and investigated to confirm that the instrument is fully operational and providing credible data. If data being collected is suspect, the data sonde will be inspected and, if necessary, a newly calibrated unit will be deployed as soon as possible.

Discrete sample analyses will be validated with certified seawater reference materials and tris buffers obtained from UC San Diego. Samples will only be analyzed when the reference materials produce results that meet the data quality objectives in Table 6.

Raw data is currently directly disseminated via the web. No flagging of suspect data is currently being provided in real time. The following disclaimer is posted on the web site:

Warning: You have chosen to graph Real-time Data. This data is preliminary and has yet to be QA'd. Use at your own risk.

Post processed data is examined for outliers, effects of drift, miss-calibration, and or sensor failure.

Manual Validation

Manual validation will take place twice, once before, and once after, the automated validation.

Data Screening: This process involves screening of the individual stations' real-time data files for each parameter measured for erroneous or unusual data. All suspect data is reviewed against environmental factors that may explain the values before being excluded from the dataset. All probe diagnostic values collected during the deployment will be evaluated to ensure the sensors were within the acceptable range and functioning properly; all data found to be collected with a malfunctioning probe will be deleted. All pre-deployment and post-deployment calibration and diagnostic values are evaluated to ensure proper function of sensors and to monitor for sensor drift during the deployment.

All data is compared to handheld field meter data collected at the time of deployment and at retrieval. The field meter data will be used to evaluate sensor accuracy and drift. This data will allow for the calculation for drift correction, if necessary.

All changes are made to a file copy representing the valid data. Original data before validation is stored in the data logger program file folder, unedited.

Pre and Post Deployment Sensor diagnostic Operating Range

Parameter	Range
Dissolved Oxygen Sensor (gain)	0.87-1.25
pH sensor Buffer 7 (mv)	0 +/- 50

pH sensor Buffer 4 (mv)	+180 +/-50
pH sensor Buffer 10 (mv)	-180 +/-50
Conductivity (cell constant)	0.469 +/- 0.05
Millivolt span between pH 4 and pH 7 Buffers	165 to 180
Millivolt span between pH 7 and pH 10 Buffers	165 to 180

Automated Validation
After the manual validation, the data files are run through an automated process to flag suspect data based on set threshold values.

Range Test: This process compares the value to a range expected set for each parameter. The range is based on historical data for estuarine waters.

Parameter	Validation Range
Chlorophyll a (ug/l)	0.1 to 365
Dissolved Oxygen (mg/l)	3 to 13
Dissolved Oxygen % saturation	50 to 300
pH	7 to 9
Salinity (ppt)	5 to 35
Specific Conductance (mS/cm)	10 to 52
Temperature (°C)	4.5 to 32
Turbidity (NTU)	0.1 to 250

Spiking test: This process compares the values to a unlikely interval difference, for each parameter for 15 minute intervals.

Parameter	Unlikely Interval Difference (15 minute interval)
Chlorophyll a (ug/l)	5
Dissolved Oxygen (mg/l)	2
Dissolved Oxygen % saturation	15
pH	0.25
Salinity (ppt)	2
Specific Conductance (mS/cm)	5
Temperature (°C)	1
Turbidity (NTU)	15

If a data record fails either Range or Spiking test, that record receives a comment that indicates the result seems to be "Low", "High" or a "Big Jump". These represent flagged markers and none of the data is deleted at this point in time.

The file containing all the data after the automated scan, including the flagged records marked for one of the above reasons, is carefully evaluated on whether the result is actually valid. This is done by comparing various ecological variables to determine whether natural events (excessive rainfall, droughts, etc.) have led to these flagged results. If it is determined that the data is valid, the flagged comment is removed and data is considered valid, otherwise, data will be removed permanently.

The post-processed data will eventually be to upload the data to the Rutgers University Continuous Monitoring Website.

16.2 Reconciliation with user requirements:
Users of the data collected will include collaborating agencies and organizations including the Barnegat Bay Partnership, NJDEP Bureau of Marine Water Monitoring, Stevens Institute, Monmouth County Board of Health, etc. In addition the data will be available to other interested scientists, agencies, and the public via the NJDEP Bureau of Marine Water Monitoring web site. However, it should be noted that in any use, the end user must evaluate the data using quality criteria appropriate for their intended use or decision-making process.

17.0 REPORTING, DOCUMENTS AND RECORDS:
All QAPP related data and all associated raw data records (including records of calibrations and calibration checks, deployment log books and other pertinent project related documents) will be maintained in electronic and hard copy at the Barnegat Bay Partnership's offices at Ocean County College and shall reside indefinitely from date of collection. If Barnegat Bay Partnership can no longer provide the required storage, the data shall be transferred for archival storage to the NJDEP.

18.0 CORRECTIVE ACTIONS:
During deployment of the data sondes, transmitted data will be reviewed and tracked and any anomalies will be noted and investigated to confirm that the instrument is fully operational and providing credible data. If data being collected is suspect, the data sonde will be inspected and, if necessary, a newly calibrated unit will be deployed as soon as possible.
The post-deployment probe diagnostic values will be evaluated to ensure the sensors were within the acceptable range and functioning properly; all data found to be collected with a malfunctioning probe will be deleted from the corrected dataset. If a data record fails either Range or Spiking automated test, that record receives a comment that indicates the result seems to be "Low", "High" or a "Big Jump". These represent flagged markers and none of the data is deleted at this point in time.

The file containing all the data after the automated scan, including the flagged records marked for one of the above reasons, is carefully evaluated on whether the result is actually valid. This is done by comparing various ecological variables to determine whether natural events (excessive rainfall, droughts, etc.) have led to these flagged results. If it is determined that the data is valid, the flagged comment is removed and data is considered valid, otherwise, data will be removed permanently from the corrected file.

This QAPP will be reviewed every year for updates or changes. If updates or changes are necessary, all signatories will be requested to review and approve.

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APPENDICES:

Appendix 1. BBP EXO Multi-parameter Water Quality Monitoring Standard Operating Procedures

Appendix 2. Best Practices for autonomous measurement of seawater pH with the Honeywell Durafet pH sensor

Appendix 3. BBP Water Quality Calibration Log and Field Log