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August 11, 2006

BY HAND

Magalie Roman Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Broadwater Energy LLC, Docket No. CP06-54-000
Broadwater Pipeline LLC, Docket Nos. CP06-55-000 & CP06-56-000

Dear Ms. Salas:

Enclosed on CD for filing in the referenced proceedings is a copy of correspondence from Broadwater Energy LLC and Broadwater Pipeline LLC to the New York State Department of Environmental Conservation ("NYSDEC") providing responses to NYSDEC's comments on the January 2006 *Air Quality and Visible Plume Analysis Modeling Protocol*.

Please do not hesitate to contact me with any questions regarding this submission.

Respectfully submitted,

Brett A. Snyder

*Counsel to Broadwater Energy LLC and
Broadwater Pipeline LLC*

Enclosure (1 CD)

cc: James Martin, FERC
Coordinating Agencies
ENTRIX, Inc.
Roger Stebbing and Associates

BW006719

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August 9, 2006

BY ELECTRONIC MAIL AND OVERNIGHT COURIER

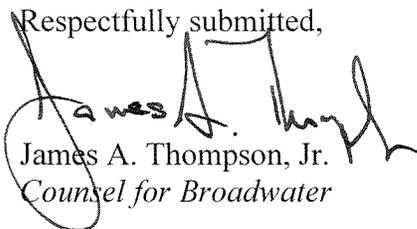
Mr. Leon Sedefian
Chief, Impact Assessment and Meteorology
Division of Air Resources, Bureau of Stationary Sources
New York State Department of Environmental Conservation
625 Broadway
Albany, NY 12233-3254

Re: Broadwater Energy Project – Response to NYSDEC Comments on January 2006 Air Quality and Visible Plume Analysis Modeling Protocol

Dear Mr. Sedefian:

I write on behalf of Broadwater Energy, LLC and Broadwater Pipelines, LLC (collectively, "Broadwater") to provide Broadwater's responses to the New York State Department of Environmental Conservation's ("NYSDEC") April 11, 2006 comments on the January 2006 *Air Quality and Visible Plume Analysis Modeling Protocol* prepared for the Broadwater Energy Project ("Project").

Please do not hesitate to contact Sandra Barnett at 403-920-7776, Bob Alessi at 518-626-9400 or Martin Booher at 860-293-3733 if you have any questions concerning the attached response.

Respectfully submitted,

James A. Thompson, Jr.
Counsel for Broadwater

Attachments

cc: Kristine Delkus (Broadwater Energy)
Sandra Barnett (Broadwater Energy)
Robert J. Alessi (LLGM)
Martin T. Booher (LLGM)
Steven C. Riva (EPA)

BW006720

NYSDEC Comment #1: In section 3.1.3, mention is made of startup and shutdown conditions for the turbines and the heaters. The pollutant emissions from these conditions which are different from normal operations emissions should be described and modeled to assure compliance with ambient standards.

Broadwater Response:

For pollutants with short-term averaging periods (1-hour to 24-hour), model runs will use the highest hourly emission rate based on evaluation of emission rates, including startup/shutdown cycles, under ambient temperatures from 0° F to 100° F and load ratings from 50% to 100%. The maximum emission rate used as model input will be developed through an evaluation of equipment emissions based on a maximum natural gas send out rate of 1.25 bcf/d.

The number of annual startup/shutdown cycles is a very conservative estimate based upon best engineering practices at this point in the design phase of the Project. The estimate is based on approximately one startup/shutdown cycle per week. Therefore, fifty (50) startup/ shutdown cycles will be incorporated into these emission rates. Each startup or shutdown cycle lasts approximately 15 minutes (a quarter of an hour).

Calculation spreadsheets used in determining startup/shutdown emissions are shown in the attached spreadsheets in Attachment A to this letter (see tables labeled ' Table 7' and 'Table 8'; please note the table numbering is such because the tables in Attachment A are the same as included in Resource Report 9, Appendix B, dated January 2006).

For pollutants with annual averaging periods, model runs will use the highest hourly emission rate that would occur during delivery of natural gas into the pipeline up to an annual maximum design limit of 7.7 million metric tons. Hourly emission rates will be calculated by dividing annual emissions by 8,760 hours. Fifty (50) startup/shutdown cycle emissions are included in the annual emission total and thus will be incorporated into the annual averaging period emission rates.

BROADWATER

NYSDEC Comment #2: Section 3.4 discusses the revised one year of meteorological data base proposed for use from the central sound buoy site. Although the data recovery appears to be substantially better than the previous data base, the origin and quality of the data is not clear. Your 2/16/06 cover letter to the Protocol indicates that more recent data have been obtained from a on-site data logger, but we need the following details on the data and the instrumentation:

- a) a description of the sampling rate and averaging times for each parameter.**
- b) a comparison of the instrument specifications and thresholds to those recommended in EPA's On-Site Metrological Program monitoring guidance document and quality assurance procedures used in collecting the data.**
- c) contact person from the University of Connecticut who provided the data.**

Furthermore, please provide computer files containing the raw data and the proposed data base for modeling and a description of how the raw data was edited to produce the latter file.

Broadwater Response:

Quality assurance methods, calibration procedures, sampling rate and data management is described in a quality assurance plan ("QAP") developed by the University Of Connecticut for the measurement program as part of the 'My Sound' project. The QAP was submitted to the EPA New England Regional Laboratory located in North Chelmsford Massachusetts. A copy of the QAP is attached to this response letter as Attachment B. Please note that the meteorological sensors listed in the QAP were replaced with the R.M. Young equipment mentioned later in this response. Data sampling rate and averaging times remained the same.

Meteorological sensors manufactured by R.M. Young, Inc., were installed on the Central Sound station (buoy 44039) and the Western Sound station (buoy 44040) during the data collection period. According to the manufacturer's sensor specification data, the sensors meet EPA Prevention of Significant Deterioration monitoring requirements. The accuracy specifications for the equipment are shown in Table A along with EPA requirements.

Parameter	Sensor Accuracy	EPA Accuracy Requirement ⁽¹⁾
Wind speed	+/- 0.2 m/sec or 1% of observed	+/- 0.2 m/s +5% of observed
Wind direction	+/- 3 degrees	+/- 5 degrees
Air temperature	+/- 0.3 C	+/- 0.5 C
Barometric pressure	+/- 0.5 mb	+/- 3mb

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Dew Point	Not used	+/- 1.5 C
Relative Humidity	+/- 2%	Not given
⁽¹⁾ Reference: Meteorological Monitoring Guidance for Regulatory Modeling Applications, EPA-454/R-99-005		

The over water surface data from the Central Sound station (buoy 44039) were obtained from the University of Connecticut "My Sound" project office. The contact person information is:

Mary M. (Kay) Howard-Strobel
Research Associate
University of Connecticut
Department of Marine Sciences
1080 Shennecossett Road
Groton, CT 06340
PH: 860.405.9172
FX: 860.405.9153
e-mail: mary.howard-strobel@uconn.edu

The raw data files and proposed data base for modeling are contained on the enclosed CD. The following discussion provides a summary of the raw data editing process for the over water surface data set used in the January 2006 *Air Quality and Visible Plume Analysis Modeling Protocol*. The overland data set (Islip) required only occasional editing of the raw data to complete a missing hour via interpolation following EPA modeling guidance for filling in missing data (see *Procedures for Substituting Values for Missing NWS Meteorological Data for Use in Regulatory Air Quality Models, USEPA, July 7, 1992*).

Much of the Central Sound station (buoy 44039) data was complete outside of the fall 2005 period. Filling in of short duration missing data during the winter, spring and summer periods was accomplished using Microsoft Excel spreadsheets; missing values were filled in either by interpolation and/or persistence for short periods following the above-referenced EPA guidance and procedures described in the Offshore and Coastal Dispersion (OCD) model User's Guide. A sensitivity study was conducted to compare the effect on modeling results from three different data substitution scenarios for the fall 2005 missing data period. A summary of initial results from this sensitivity study was included in the February 16, 2006 letter accompanying the submittal of the revised protocol.

Missing data in the Central Sound station (buoy 44039) data set during the 4th quarter of the data period was due primarily to the buoy being removed from the Sound for various equipment upgrades. The primary data substitution method used during this period was to substitute data from the: (1) Western Sound station (buoy 44040) for air and water temperature and relative humidity; and (2) Bridgeport Sikorsky Memorial Airport for

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wind direction and speed. The Western Sound station was deemed representative of meteorological conditions such as air temperature, water temperature and relative humidity because it is influenced by the Sound in a manner that is similar to the Central Sound station. The Bridgeport Sikorsky Memorial Airport meteorological station was selected as the site for obtaining representative wind direction and speed data because it is the closest available site to the Central Sound station (buoy 44039) and is located within 1 mile of the coastline on a small peninsula extending into the Sound. Wind conditions at this location exhibit a substantial influence by the Sound. Western Sound buoy wind data was not used because the data are affected by the proximity to land due to narrowing of the Sound in that location.

Other "in-Sound" sites or coastal stations, such as the Ledge Light weather station (45 miles southwest and 30 miles northeast of the Central Sound station (buoy 44039)) were not used for data substitution. Ledge Light is located just offshore from the mouth of the Thames River (near New London, Connecticut) but is further away than the Bridgeport station and was deemed to be not representative of central Sound conditions.

Water temperature data from the Western Sound station (buoy 44040) were deemed representative and the best available because of the Western Sound 'station's reasonably close location and similar water depth. When water temperature was missing in the Central Sound station (buoy 44039) data set, the air and water temperature pair from the Western Sound station (buoy 44040) were substituted into the Central Sound station (buoy 44039) data set to maintain a single site location for the air/water temperature data pair as recommended in OCD model guidance. Other coastal Sound stations that potentially could be used for substitution either: recorded water temperature in a location near shore or near the mouth of a river emptying into the Sound (which would cause the data to not reasonably represent central Sound conditions) or had missing data for the same periods as in the Central Sound station (buoy 44039) data set. Since water temperature does not vary as quickly as air temperature or other meteorological parameters, it was possible to use interpolation and/or persistence to fill in missing data for periods of short duration.

BROADWATER

NYSDEC Comment #3: With EPA's promulgation of AERMOD on 11/9/05, we agree that the "PRIME" algorithm in that model can be used to simulate structure downwash effects in the near-field zone noted in Section 3.5.2. However, we see no basis to use Islip-MacArthur airport meteorological data for this assessment, as proposed in section 3.4.2, instead of the more representative buoy data. The use of the buoy data will also avoid the classification of the land use in AERMOD as urban which is not representative of the project site.

Broadwater Response:

To address NYSDEC's comment, Broadwater will use AERMOD with PRIME using the buoy data instead of Islip for the Project to present a comparison of the methods for evaluation by NYSDEC.

It is, however, important to note that based upon discussions with EPA modelers and United States Coast Guard ("USCG") air quality contractors responsible for evaluating other proposed LNG projects, AERMOD, including PRIME, for modeling sources located over water is not the preferred air quality model for over water sources. The OCD downwash procedure, based on laboratory experiments simulating flow around offshore structures, is reliable for evaluation of over water sources. As a result, OCD has been almost exclusively used for overwater modeling; CALPUFF is being used for many Gulf of Mexico projects.

There are arguments in favor of using the OCD downwash procedure. First is consistency with other offshore LNG modeling analyses. Secondly, the Guideline on Air Quality Models (see *40 CFR Part 51, Appendix A to Appendix W*) recommends the use of OCD as the preferred refined air quality model for regulatory evaluation of over water sources, including the downwash procedure in OCD. AERMOD with PRIME are not specifically identified as a model for use with over water sources.

BROADWATER

NYSDEC Comment #4: In addition to the 2 years of data to be used for the CSVP visible plume analysis, in Section 3.4.3, we would recommend the use of the eventual data base approved for use in the OCD model.

Broadwater Response:

The Combustion Source Visible Plume (CSVP) model meteorological data requirements are slightly different from the data required for the OCD model. For the CSVP analysis included in the Coastal Zone Visual aesthetics study, temperature, relative humidity, wind speed and wind direction data from buoy 44039 were used in combination with Bridgeport, Connecticut (Sikorsky Memorial Airport) observations of visibility and present weather. These data were used to run the psychrometric portion of the analysis (i.e. to run the CSVP model). It is acceptable to run the CSVP model with one year of meteorological data that includes missing data for the portion of the analysis that is used to determine the potential for visible plume formation as long as the missing data is random and widely spaced (see *CSVP Teacher's Module 1 – Meteorological Data Processing*). Two years of data were used to maximize the evaluation of available hourly data in the 2003-2004 data set.

Upon NYSDEC's approval of the OCD model database (2005 data), Broadwater will extract the temperature, relative humidity, wind speed and wind direction data from the buoy 44039 data set and combine it with Bridgeport, Connecticut visibility observations and present weather to develop a third year of data. These data will be used in the CSVP model to complete a third year of visible plume potential analysis and, if a plume is shown to form, to complete a frequency analysis. Please note that neither present weather nor visibility is recorded at buoy 44039. Therefore, the Bridgeport, Connecticut data will be used for these parameters, as it is the best representative data for the proposed location of the Project.

BROADWATER

NYSDEC Comment #5: The receptor grid for OCD, discussed in Section 3.5.1, should include the 25m lateral interval proposed for AERMOD at the boundary of the security zone. In addition, the receptor grid around the maximum impacts in the 2km Cartesian grid should be resolved to 70m to match DEC's recommended 100m interval on the diagonal of the grids. Receptors should also be placed along the coastline at a more dense spacing (e.g. 500m) and any prominent heights of land should be simulated along or near the coastline.

Broadwater Response:

Broadwater will follow NYSDEC's receptor spacing recommendations. Broadwater also will continue to use the 500-yard radius (measured from the aft end of the Floating Storage Regasification Unit) for the safety and security zone. The USCG may recommend a different distance for the safety and security zone sometime in September 2006. We will adjust, if necessary, the radius used in the model at that time.

BROADWATER

NYSDEC Comment #6: One approach to address concerns about the representativeness of mixing heights generated from interpolated soundings at Brookhaven would be to use mixing heights generated by AERMET for the AERMOD model. The latter incorporated methods which uses onsite data such as wind speed in stable conditions and more refined calculations from the soundings during unstable layer heights.

Broadwater Response:

Broadwater appreciates NYSDEC comment and intends to coordinate with both NYSDEC and EPA to address this issue.

ATTACHMENT A

Table 7
SUMMARY OF STACK PARAMETERS FOR PROCESS HEATERS DURING STARTUP AND SHUTDOWN

Source Description	Ambient Temp & Load	Duration (min)	Exhaust Gas Temp. (F)	Actual Exhaust Gas Flowrate (acfm)	Normalized Exhaust Gas Flowrate ² (dscfm)	Stack Gas Parameters [Wet Basis] (% vol)		Stack Gas Parameters [Dry Basis] (% vol)		Air Pollutant Gas Concentrations			Air Pollutant Concentrations (ppmvd)		Air Pollutant Concentrations ⁴ (lb/dscf)		Emissions (lb)	
						O ₂	H ₂ O	O ₂	CO	NO _x	Units	CO	NO _x	CO	NO _x	CO	NO _x	
Process Heater	Startup	15	350	58,884	31,858	2.48	17	2.99	50	23.3	ppmvd @ 3% O ₂	50.0	23.3	3.63E-06	2.78E-06	1.7	1.3	
	Shutdown	15	350	58,884	31,858	2.48	17	2.99	50	23.3	ppmvd @ 3% O ₂	50.0	23.3	3.63E-06	2.78E-06	1.7	1.3	

Notes:

1. Following data from Ref. 1, Tables 3b and 4b : Fuel Flow, Exhaust Gas Temp, Actual Gas Flowrate, Stack Gas Parameters [wet], air pollutant gas concentrations (ppmvd corrected to 15%O₂ or 3%O₂).
2. Based on dry conditions with standard temperature (68° F) and pressure (29.92 in Hg).
3. VOC include total hydrocarbons except methane and ethane.
4. Based on stack pressure of 1 atm (29.92 mmHg).

Table 8
CO AND NO_x EMISSION RATES FOR TURBINES AND PROCESS HEATERS BASED ON STARTUP AND SHUTDOWN

Source Description	Ambient Temp & Load	Normal Operation Air Pollutant Rates ¹ (lb/hr)		Startup Emissions ² (lb)		Duration of Startup ³ (min)	Shutdown Emissions ² (lb)		Duration of Shutdown ³ (min)	Anticipated No. of Annual Startup / Shutdown ⁴ (#/yr)	1-Hour Average CO Rate During Startup (lb/hr)	8-Hour Average CO Rate During Startup (lb/hr)	1-Hour Average CO Rate During Shutdown (lb/hr)	8-Hour Average CO Rate During Shutdown (lb/hr)	Annual Average NO _x Rate with Startups and Shutdown (lb/hr)
		CO	NO _x	CO	NO _x		CO	NO _x							
Turbine	0 F & 100% Load	3.3	2.7	3.0	2.6	10	2.0	1.7	8	-	5.8	3.6	4.9	3.5	-
	60 F & 100% Load	3.1	2.6	3.5	2.6	10	2.23	1.96	8	50	6.1	3.5	4.9	3.3	2.6
	100 F & 100% Load	2.6	2.2	2.5	2.0	10	1.88	1.55	8	-	4.7	2.9	4.2	2.8	-
	60 F & 100% Load	2.8	1.1	1.74	1.3	15	1.7	1.3	15	50	3.8	2.9	3.8	2.9	1.2
Process Heater															

Notes:

1. Emission results from Table 4.
2. Emission data from Ref. 8.
3. Turbine data from Ref. 8; process heater data from Ref. 1, Tables 3b and 4b.
4. Number of startups and shutdowns is strictly an estimate.

ATTACHMENT B

QUALITY ASSURANCE PLAN

for

MYSound – A Realtime Partnership

Prepared for:

United States Environmental Protection Agency
New England Regional Laboratory
11 Technology Drive
North Chelmsford, Massachusetts 02173

Prepared by:

University of Connecticut
Department of Marine Sciences
1080 Shennecossett Road
Groton, Connecticut 06340

Approval:

Environmental Protection Agency

Project Manager:

Quality Assurance Manager:

Mark Tedesco

Alan Peterson

Date: _____

Date: _____

University of Connecticut, Department of Marine Sciences

Project Manager:

Quality Assurance Manager:

W.F. Bohlen

W.F. Bohlen

Date: _____

Date: _____

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A3 Distribution List

Mr. Mark Tedesco, EPA
Mr. Andy Beliveau, EPA
Ms. Carol Kilbridge, EPA CEIT
Dr. Robert Hillger, EPA ORD
Dr. W. Frank Bohlen, UConn
Ms. M.M. Howard-Strobel, UConn
Dr. Carol A. Anderson, UConn
Mr. David Cohen, UConn

A4 Project/Task Organization

The University of Connecticut's Department of Marine Sciences (UConn) has established a marine monitoring network, **MYSound (Monitoring Your Sound)**, funded initially by the U.S. Environmental Protection Agency (EPA) as part of the Environmental Monitoring for Public Access and Community Tracking (EMPACT) program. The EMPACT funding covered the period from 1999-2001 during which time protocols and procedures for deploying and maintaining stations were developed and implemented. The monitoring network is currently composed of seven stations throughout Long Island Sound (Figure 2), collecting high frequency observations of temperature, salinity and dissolved oxygen concentrations at two depths within the water column (surface and bottom), supplemented by meteorological measurements at selected stations. These data complement ongoing shipboard surveys conducted by other universities and state agencies, and are used in a variety of scientific, management and public outreach activities. Additionally, the data are posted to the web in real-time as a means to increase public understanding of water quality, its importance and governing factors.

The data from the project monitoring sites in Long Island Sound are telemetered and routed to a central computer at the University of Connecticut. Following a first-order screening, data are published in real-time as provisional charts and panels to the MYSound website (www.mysound.uconn.edu). The actual data files are not available for public dissemination until subsequent quality assurance/quality control (QA/QC) procedures have been applied. The data are then uploaded to the MYSound website where the data are available via File Transfer Protocols (FTP). The website also provides links to a variety of other ongoing sampling programs in Long Island Sound and adjoining waters (e.g., State of Connecticut Department of Environmental Protection, New York City Department of Environmental Protection, Save the Sound, Inc.) in order to broaden the database and to extend the user group.

Mr. Mark Tedesco of the Environmental Protection Agency (EPA) Long Island Sound Project Office is the EPA Project Manager for the project. Mr. Andy Beliveau from EPA Region 1 provides EPA QA/QC oversight for the project (Figure 1). Dr. W. Frank Bohlen, UConn serves as Principal Investigator and is responsible for the overall coordination of the monitoring activities, data acquisition, analysis, and dissemination, and the preparation and presentation of the instructional tutorials. Ms. M.M. Howard-Strobel, Programmer/Data Analyst, is responsible for the development of all software required for the acquisition of data by the monitoring arrays and contributed by other sampling programs, QA/QC of these data, the design and maintenance of the website, including the presentation graphics required for the dissemination of these data. Mr. David Cohen, Instrumentation Specialist, is responsible for configuring and maintaining the instrumentation arrays including the physical/chemical calibration of the sensor systems deployed on the monitoring arrays and the collection of drawn water samples required for the verification of the time series data, as well as for calibration standards. UConn's Coastal Environmental Lab (CEL), handles laboratory analysis of any drawn water samples needing a certification for the QA/QC verification of sensor accuracy and stability.

Additional project partners associated with this project include:

- **Connecticut Department of Environmental Protection**, which have contributed additional data to the WEB site.
- **Coalition to Save Hempstead Harbor**, provides and maintains a water quality monitoring site
- **Bridgeport Regional Vocational Aquaculture School**, presently serving as a receiving site for the Bridgeport monitoring station.
- **Save the Sound, Inc.**, coordinating data contributions from citizens' water quality monitoring efforts.
- **The Maritime Aquarium at Norwalk**, assisting in K-12 educational outreach and provides a water quality monitoring site.
- **The Mystic Marine Life Aquarium**, assisting in public outreach and education.
- **U.S. Coast Guard Academy**, using the data in undergraduate marine education courses.
- **CT and NY Sea Grant**, assisting in public outreach and education.

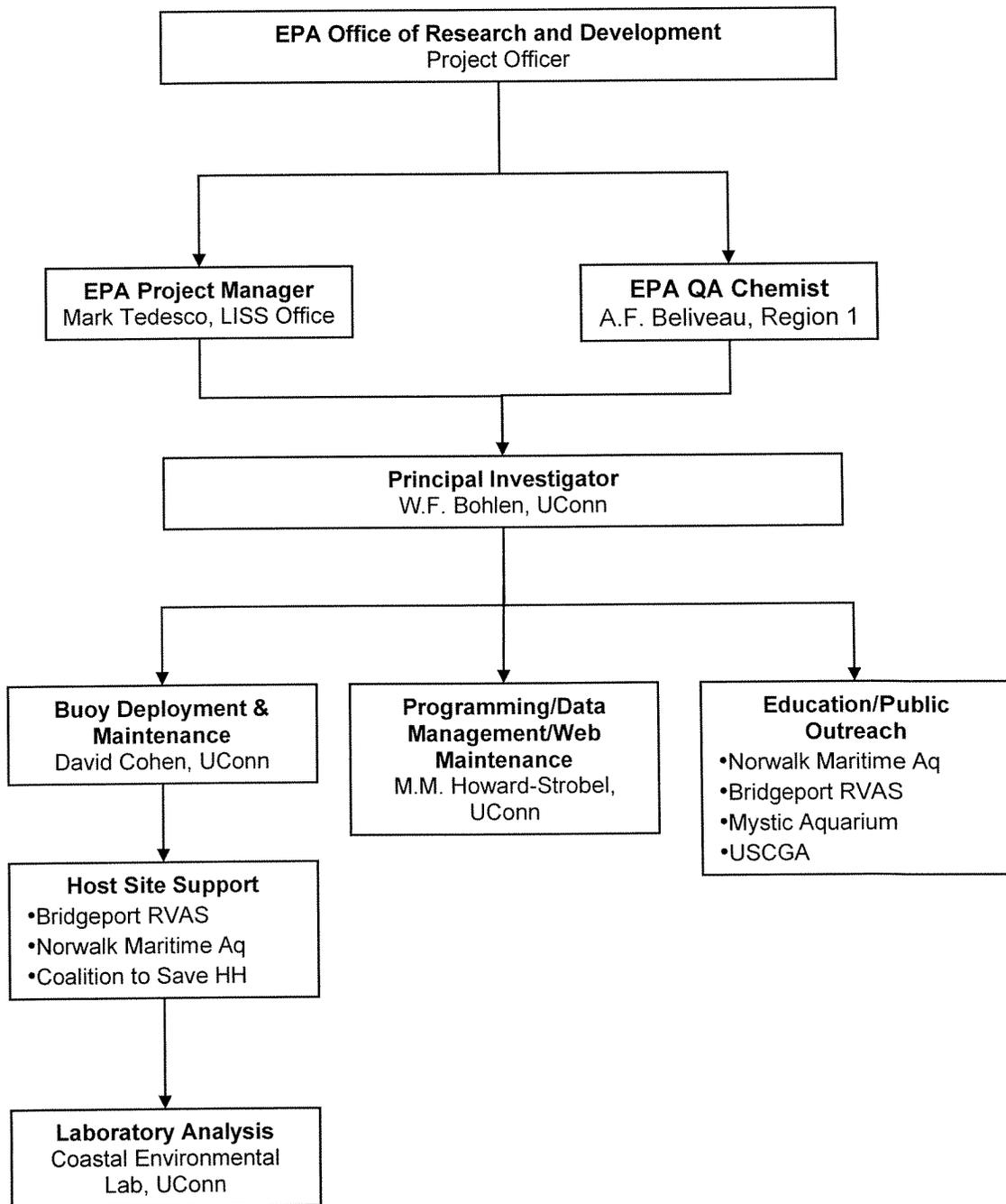


Figure 1. Project Management. RVAS (Regional Vocational Aquaculture School), Aq (Aquarium), HH (Hempstead Harbor), USCGA (United States Coast Guard Academy).

A5 Problem Definition/Background

Coastal and estuarine waterways form a dynamic boundary region between continents and the global ocean and typically support a diverse biological community and a variety of commercial and recreational uses. Positioned to affect and be affected by adjoining waters these regions have historically been the recipients of a broad spectrum of contaminants introduced by surface and groundwater drainage, atmospheric fallout, and industrial and residential discharge. This combination of loadings has in many areas produced conditions favoring progressive degradation in environmental quality sufficient to threaten resource values and in some cases, public health.

In Long Island Sound, questions concerning environmental quality were raised more than thirty years ago following an apparent increase in the incidence of toxic algal blooms, bathing beach closures, and visually evident fish kills. Many of these events appeared the result of increasing population density and associated pollutant loadings related to sewage discharge and the disposal of solid wastes including garbage, construction debris, and dredged materials. During the early 1970's these concerns resulted in one of the first studies of eutrophication in coastal waters, termination of garbage disposal in the Sound and adjacent waters, increased sewage treatment capacity including up-grading from primary to secondary treatment, and the closure of the majority of dredged material disposal areas. These closures were followed by the initiation of intense monitoring of conditions at the remaining four disposal sites.

Despite this range of activities to curtail anthropogenic impacts, water and habitat quality issues remain a concern in Long Island Sound, particularly in the western region between Bridgeport, Connecticut to the east and Throgs Neck, New York City to the west. This area has historically been subject to elevated organic loading and typically displays evident seasonality in nutrient and chlorophyll a concentrations and the associated dissolved oxygen (D.O.) levels. On occasion, conditions resulting in extremely low levels of D.O. with values approaching anoxic occurred, particularly in near bottom waters in the far western embayments along the shore of the Sound. Initial observations suggested that these events were highly aperiodic and confined to a relatively small number of areas near the western limits of the Sound. Data developed during the 1980's, however, showed the affected area to be much larger than earlier indications and suggested that both spatial extent and frequency of occurrence of these hypoxic events was increasing.

These data, in combination with recognition of the value of the resource, resulted in a 1985 Congressional Directive instructing the U.S. Environmental Protection Agency (EPA) in collaboration with the states of Connecticut and New York to sponsor a study of Long Island Sound and to develop a Comprehensive Management Plan for "... protecting and improving the health of the Sound". Low dissolved oxygen levels were specifically identified as a problem that "merits special attention". Accordingly, EPA initiated a series of field surveys intended to provide data sufficient to permit the calibration and verification of a computer based numerical model of the factors governing water quality, with particular emphasis on dissolved oxygen and the associated cause and effect relationships. These studies extended over a three-year period and provided a series of near-synoptic views of hydrography and water column chemistry under

a range of seasonal conditions. Although these surveys provided relatively limited spatial and temporal resolution, they were considered sufficient to initiate model based evaluations of the factors governing hypoxia, including consideration of remedial alternatives.

In March 1994, the Long Island Sound Management Conference issued "The Comprehensive Management Plan for the Sound". Using analyses based on the numerical water quality model, the Plan stated that "excessive discharges of nitrogen, a nutrient, are the primary cause of hypoxia" and concluded that reductions in the frequency and intensity of hypoxic events requires reductions in nitrogen loading to the Sound. Such reductions can only come from the fraction of the annual load that is anthropogenic in origin, an amount equaling slightly less than one-half of the total annual load. Of this fraction, the majority is introduced via point source discharge from sewage treatment facilities. Non-point sources, including agricultural and urban rainfall runoff represent approximately 25% of anthropogenic nitrogen loading.

A phased implementation of the recommendations of the Management Plan is currently underway. In 1990, efforts were initiated to "freeze" nitrogen loadings, both point and non-point, at 1990 levels. In 1994, selected sewage treatment facilities in Connecticut and New York were targeted for process upgrades to substantially and measurably reduce nitrogen loading. On February 5, 1998, the states of Connecticut and New York and the Environmental Protection Agency adopted a plan for *Phase III Actions for Hypoxia Management*, including nitrogen reduction targets of 58.5% for eleven "management zones" that comprise the Connecticut and New York portion of the Long Island Sound watershed. Action 3.A. under the plan is a commitment to administer and enforce the nitrogen targets through development of a Total Maximum Daily Load (TDML) analysis consistent with requirements under Section 303(d) of the Clean Water Act. The TDML was developed by CTDEP and NYSDEC and subsequently approved by EPA in April, 2001.

The success of the Comprehensive Management Plan for Long Island Sound is ultimately dependent on well informed and educated public support based on an understanding of the importance of water quality and how water quality affects their use and/or enjoyment of the Sound and its resources. An abundance of evidence suggests that this understanding is relatively limited. Despite some general interest the majority of the public typically displays little understanding of specific scientific concepts and the fundamental relationships between these concepts and their own enjoyment of the marine environment. This condition appears to be primarily the result of a combination of factors, including limited immediate effect of Sound water quality issues on daily lives, data deficiencies, and the format and presentation of available data. This range of factors stands in sharp contrast to those associated with the daily weather forecast. Here, depending on one's range of interest and available time, it has become a simple matter for nearly everyone to obtain detailed, multi-dimensional, national and international data, short and long-term forecasts, and instruction in interpretation and analysis. This availability has allowed meteorological considerations to become a routine part of every planning exercise both commercial and recreational, and serves to continuously remind the public of the role of weather in their lives. This fact suggests that public understanding of Long Island Sound water quality concepts could be significantly increased if data detailing specific characteristics were routinely available, presented in an easily assimilated format, and supplemented by instructional materials

introducing governing concepts, the basis for interpretation, and the relationships between resultant water quality and public use of the Sound. One aspect of the MYSound marine environmental monitoring network for Long Island Sound is to address this issue and complement the educational activities of the EPA Long Island Sound Office being conducted in support of the Management Plan.

The network provides the public and other users with time series data detailing dissolved oxygen concentrations at selected representative locations in the Sound and adjoining embayments, offering a basis for the evaluation of cause and effect relationships and discussions of the broader theme of water quality in Long Island Sound. To compare and contrast governing factors, monitoring stations have been established at sites displaying substantially different physical, chemical, and biological environments. The primary instrument array at each sampling site includes sensors to monitor water temperature, salinity, and dissolved oxygen concentrations at a minimum of two points on the vertical, near surface and near bottom. All data will be processed at the University of Connecticut and distributed *via* the web after editing and QA/QC. All data are to be obtained using commercially available “off-the-shelf” instruments. An indication of the accuracy required to achieve the intended purpose of this project is indicated in Table 1 for each of the currently measured parameters as well as several parameters that may be added in the future as funding becomes available.

Table 1. Needed Accuracy for Parameters Measured within the MYSound Network.

Parameter	Accuracy
Water Temperature	± 1.0 °C
Salinity	± 1.0 psu
Dissolved Oxygen	± 1.0 mg/l
Suspended Material Concentration	± 5.0 mg/l
Wind Speed/Direction	± 2.5 m/s (wind speed), 10° (wind direction)
Air Temperature	± 1.0 °C
Barometric Pressure	± 5 mb
Photosynthetically Active Radiation (PAR)*	± 50 µmol s ⁻¹ m ⁻²
Nitrate-Nitrogen *	± 1.0 µg-AT/l
Chlorophyll *	1.0 µg/l ± 20% <i>in vivo</i> measurement
Current Speed/Direction *	± 5cm/s (current speed), 5° (current direction)

* Parameters of interest, no sensors actively measuring these quantities in the MYSound network.

Beyond their educational value, the time series data provided by the network will also complement ongoing science and engineering efforts to verify the results of the numerical water quality model. Further, the data can assist in the extension of this model to more accurately simulate the response of Long Island Sound to aperiodic storm events. It is also expected that the observations permitted by this network, together with data supplied by stations currently operating in Chesapeake Bay, off the New Jersey shore, and in Massachusetts Bay, will be

included in the integrated east coast regional ocean observing system currently in the planning stages.

A6 Project/Task Description and Schedule

Locations of the water quality monitoring stations within the MYSound network are shown in Figure 2. Three stations are located along the axis of the sound WLIS (Western Long Island Sound), CLIS (Central Long Island Sound), and NLDS (New London Disposal Site) also referred to as the Eastern Sound Offshore station. LLT collects only meteorological observations just south of the Thames River on the New London Ledge Light. LTR is a water quality station located in the lower Thames River, just north of the Interstate 95 highway and Amtrak railroad bridges. BRPH is the Bridgeport Harbor station mounted to a fixed dock. The water quality station at Norwalk Maritime Aquarium (NWH) is mounted to a floating dock 300 feet south of the Aquarium's main building. The station maintained by the Coalition to Save Hempstead Harbor (HH) is fixed to a navigation structure located in the middle of Hempstead Harbor.

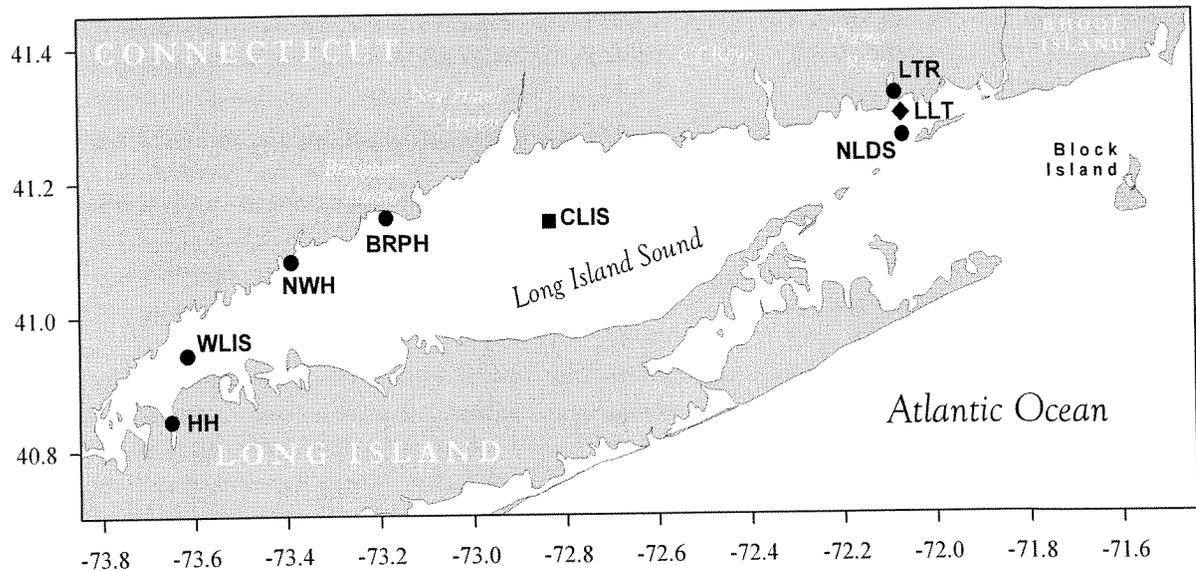


Figure 2. Locations of water quality monitoring stations in Long Island Sound. The ● indicate water quality-only stations, ◆ are meteorological-only stations and the ■ indicates that both meteorological and water quality are collected at the station. See text for station descriptions.

The key tasks required in 2003 for the MYSound Network are summarized below and in Table 2. A generalized schedule for the project is presented in Table 3.

Measurement:

1. Maintain the present status of the network via array servicings, including collection of water samples for calibrations and quality control, sensor cleanings, and buoy hardware checks.
2. Enhance the western Sound station (WLIS) with the addition of meteorological sensors and a satellite communication link.
3. Provide any necessary support for host sites which are maintaining and servicing water quality sensors (*e.g.*, Coalition to Save Hempstead Harbor and Norwalk Maritime Aquarium).

Information Management and Delivery:

1. Maintain and expand the statewide marine water quality monitoring data compilation and dissemination network initiated during the first three years of the project with data contributions from federal, state, and municipal agencies, as well as non-governmentally supported citizens' monitoring programs.
2. Enhance interpretive material supporting the data presentation targeting both K-12 education and university undergraduate and graduate programs.

Communications:

1. Convene a meeting of the project stakeholders composed of key partners, stakeholders, non-governmental organizations (NGOs), and local civic organizations representing the general public.
2. Continue publicizing the project progress and accomplishments, and increase awareness of the importance of water quality to the health of the Sound.
3. Continue presentations in coastal municipalities along the shoreline in Connecticut to make public officials, educators, non-governmental organizations, and the general public aware of the project.
4. Continue to provide orientation to citizens' water quality monitoring groups on the project.
5. Continue to survey users who routinely access the web site to obtain feedback on the overall utility of the information presented, format and supporting interpretive material.
6. Continue to establish formal linkages with other marine environmental monitoring networks in the New England region as well as around the country and worldwide.

Table 2. MYSound Monitoring Network Measurement Summary.

Stations	NLDS	LTR	LLT	BPTH	CLIS	WLIS	NWAQ	HH
Location	Eastern Sound	Thames River	New London Ledge Light	Bridgeport Harbor	Central Sound	Western Sound	Norwalk Aquarium	Hempstead Harbor
Coordinates	41° 15.8' N 72° 04.0' W	41° 21.9' N 72° 05.4' W	41° 18.3' N 72° 04.6' W	41° 09.7' N 73° 10.3' W	41° 08.25' N 72° 39.3' W	40° 57.4' N 73° 34.8' W	41° 09.0' N 73° 24.9' W	40° 49.8' N 73° 39.2' W
Water Depth	23 m	7 m	ns	7 m	27 m	18 m	0.5 m	3 m
Parameters Monitored								
Water Temperature	S/B	S/B		S/B	S/B	S/B	S	B
Salinity	S/B	S/B		S/B	S/B	S/B	S	B
Dissolved Oxygen	S/B	S/B		S/B	S/B	S/B	S	B
SMC	S/B	S/B		S/B	S/B	S/B	S	B
Met Data	ns	ns	20 m above water sfc	ns	12 m above water sfc	ns	S	B

S/B = surface and bottom, S = surface only, B = bottom only, ns = no sensors

Table 3. The MYSound Monitoring Network 2003 Project Schedule.

Activity	Year: 2003
Enhancements: Western Long Island Sound Station	June
Station Maintenance	Bi-monthly
Discrete Water Sampling for Verification	Biweekly (June-September) Monthly (Jan-May, Oct-Dec)
Data Processing and Conditioning	Continuous
Data Dissemination	Provisional - continuous Archival - monthly
Project Outreach	TBD

A7 Quality Objectives and Criteria for Measurement Data

The accuracies required in order to establish a database sufficient to complement discussions of the factors governing dissolved oxygen concentrations and to provide a basis for the evaluation of water quality trends in Long Island Sound are shown in Table 1. Beyond these primary educational objectives these accuracies are also considered sufficient for the majority of

the ongoing science and engineering activities including numerical model calibration and verification and/or modifications in model simulation schemes associated with the response of Long Island Sound to aperiodic storm events. The selected sensors and associated data sampling, telemetry, and analytical protocols will provide accuracies equal to, or better than, these criteria (Table 4).

Table 4. MYSound Monitoring Network Sensor Characteristics

Parameter	Sensor	Range	Accuracy
Water Temperature	YSI 6600	-5°C to +45°C	± 0.15°C
Salinity	YSI 6600	0 to 70 psu	± 1% or 0.1 psu
Dissolved Oxygen	YSI 6600	0 to 50 mg/L	± 2% or 0.2 mg/L
Suspended Materials	Downing OBS-3	0 to 1000 mg/L	~ 5% of full scale
Wind Speed	Climatronics WM III	0 to 55 m/s	± 0.11 m/s
Wind Direction	Climatronics WM III	0 to 360 °	± 3°
Air Temperature	Climatronics WM III	-30°C to +50°C	± 0.15°C
Barometric Pressure	Climatronics WM III	600 to 1100 mb	± 1.5 mb
<i>Photosynthetically Active Radiation (PAR)*</i>	<i>Li-COR LI-193</i>	<i>0 - 1000 μmol s⁻¹m⁻²</i>	<i>± 5%</i>
<i>Nitrate-Nitrogen*</i>	<i>YSI</i>	<i>TBD</i>	<i>TBD</i>
<i>Chlorophyll*</i>	<i>YSI 6025</i>	<i>0 to 200 μg/L</i>	<i>N/A</i>
<i>Current Velocity*</i>	<i>RDI WH-ADCP</i>	<i>0 to 10 m/s</i>	<i>0.5% of measured or ± 0.5 cm/s</i>

* Parameters of interest, no sensors actively measuring these quantities in the MYSound network.

In addition, prototype development efforts currently planned may lead to the incorporation of sensors measuring phytoplankton primary production and species composition, or nitrates/nitrogen as part of the test and evaluation of these sensors (Table 5). The actual deployment of these sensors is contingent on obtaining funding support for these projects. Quality assurance and control measures are in development and are not yet available for these sensors.

Table 5. Prototype Sensors in Development

Parameters	Instrument Manufacturer	Detection Limits
Nitrogen/Nitrate	YSI, Inc..	TBD
Phytoplankton (productivity, sp. composition)	Ciencia, Inc., EnviroTech, Inc.	TBD

The measurements obtained using the commercially available sensor suite are subject to errors caused by instruments drifting out of calibration or degradation of the sensor and/or sensor components (*e.g.*, salt water contamination of electronics, biofouling of the sensor probe). Routine data monitoring, use of other calibrated field sensors, and collection of discrete water column samples during routine inspection and servicing of the buoy can detect these errors. Table 6 lists the schedule for planned water sampling, instrument monitoring and servicing, and station overhaul.

Table 6. Quality Assurance and Maintenance Schedule for MYSound Stations.

Stations	NLDS	LTR	LLT	BPTH	CLIS	WLIS	NWAQ	HH
Location	Eastern Sound	Thames River	New London Ledge Light	Bridgeport Harbor	Central Sound	Western Sound	Norwalk Aquarium	Hempstead Harbor
Coordinates	41° 15.8' N 72° 04.0' W	41° 21.9' N 72° 05.4' W	41° 18.3' N 72° 04.6' W	41° 09.7' N 73° 10.3' W	41° 08.25' N 72° 39.3' W	40° 57.4' N 73° 34.8' W	41° 09.0' N 73° 24.9' W	40° 49.8' N 73° 39.2' W
Water Depth	23 m	7 m	ns	7 m	27 m	18 m	0.5 m	3 m
Sample Collection	2 wks	2 wks	na	2 wks	2 wks	2 wks	2 wks	2 wks
Instrument Check	monthly	monthly	monthly	monthly	monthly	monthly	monthly	monthly
Station Overhaul	bi-annual	bi-annual	na	na	bi-annual	bi-annual	na	na

na = not applicable, these stations are dock mounted

Routine Data Monitoring: Quality assurance of the data collected from the data buoys during the course of this project will be controlled by UConn, including those stations maintained by partnerships of the distributed network. As a requirement for becoming a partner, sensors are mandated to be from the same manufacturer as those used by UConn. Training is provided by the UConn technical staff on servicing and maintaining the sensors. Quality assurance and maintenance schedules follow those established by UConn (Table 6). Water samples are analyzed using methods specified by UConn (Group B). The results of partner quality assurance analysis are routinely sent to UConn staff and are archived with the data. Discrepancies between the observed data and water sample analysis require that the partner send a sample to the UConn lab for a second quality control check.

First-order quality control of the transmitted data will consist of automated wild-point editing to ensure that the data are within preset accuracies based on sensor and known physical limits. The data are then posted to the EMPACT website as provisional - subject to change after further analysis. The provisional data are ephemeral and not archived for downloading by general users. Second-order quality checks involve statistical analysis to ascertain that the data are within two to three standard deviations of a running mean, and are also compared with the discrete water samples taken in the field at the time of servicing. Data which still do not fit this

criteria are flagged and subject to the final level of quality control in which the data are plotted and compared with other parameters (*e.g.* wind, historical, and any available third-party supplementary data) to determine the validity of the abnormality. If the data still fail this final check, a flag (*i.e.*, a numerical number) is inserted in the archived database that describes the quality level.

As described above, the data are transmitted in near-realtime to UConn and immediately plotted and posted to the internet. When data fall outside of the preset accuracies and known physical limits for a duration greater than what is considered a random spike (*i.e.*, due to wake effects, fish hits, etc.), UConn initiates corrective action. This action involves dispatch of UConn technical personnel to the site, or if the site is maintained by one of the partners, the partner is notified. The suspect sensor is replaced or serviced, and a water sample drawn for analysis. Corrective action can be delayed primarily due to poor weather. Data are then flagged in the database according to the degree of data degradation (Section B10). Further information on quality control criteria and corrective actions required is included in Section B5 and in Appendix C.

Use of Other Calibrated Field Systems: During routine buoy servicing, water quality data using other calibrated sensors (*e.g.*, thermometers for water temperature) are obtained to compare the performance of the sensor(s) in real-time. Table 7 lists the quality control checks done in the field that will provide the accuracy and functioning level of the buoy sensor data.

Quality Control Checks and Back-up Instrumentation: Water column profiles of temperature, salinity, dissolved oxygen, and turbidity will be collected using a Sea-Bird Electronics SBE 19 CTD Profiler. Backup instruments for field measurements will be available during buoy servicing. A YSI 650 MDS is available that measures conductivity/salinity, temperature, dissolved oxygen, and turbidity

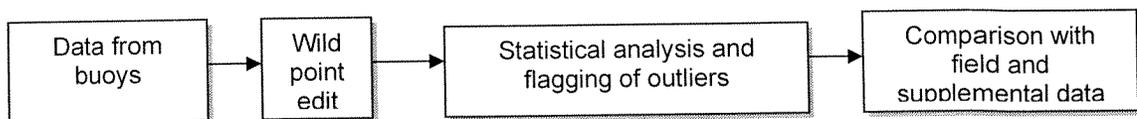


Figure 3. Quality control of data received from buoys.

Laboratory Analysis of Water Samples: UConn's Coastal Environmental Laboratories (CEL) will provide quality assurance of laboratory water samples. The analytical facility is proficient in using U.S. Environmental Protection Agency (EPA) and the U.S. National Oceanographic and Atmospheric Administration (NOAA) analysis protocols and is licensed by the State Department of Public Health (DPH). The CEL laboratory supervisory personnel are responsible for ensuring that:

1. technicians engaged in laboratory analysis have adequate education and training and are capable of performing the designated job;

2. lab facilities provide adequate equipment and resources for the analytical tasks;
3. a quality assurance program is in place and executed;
4. safety and waste disposal practices comply with the related regulations; and
5. standard operation procedure(s) (SOP) are reviewed and updated yearly or sooner if required.

Laboratory methods, precision, accuracy, completeness and minimum detection limits for analyzing the discrete water samples collected on the buoy are contained in Table 9, and detailed in Section B4 and B5. Quality control requirements for the analytical measurements are summarized in Table 10 and also detailed in Sections B4 and B5. The data consistency is applied to the entire data set, and includes comparison of replicate sample analysis, and spike sample recoveries.

Table 7. Quality Control Methods Using Supplemental Instruments

Measured Parameter	QA/QC Method	Calibration Protocol
Water Temperature	SeaBird Electronics SBE 19 CTD Profiler; ± 0.1°C thermometer	Manufacturer's calibration, lab standard thermometer
Salinity	SeaBird Electronics SBE 19 CTD Profiler; discrete sample for lab analysis	Manufacturer's calibration, Beckman RS-10 Induction Salinometer with Standard Seawater
Dissolved Oxygen	SeaBird Electronics SBE 19 CTD Profiler; discrete sample for lab analysis	Winkler titration
Suspended Material	Discrete sample for lab analysis	Vacuum filtration with 0.4µ polycarbonate filter
Current Velocity	Diver/visual observations	Manufacturer's calibration
Meteorologic Data	Comparison with adjacent DEP station	Manufacturer's calibration

A8 Special Training Requirements/Certification

The training associated with the development and deployment of the monitoring stations will be minimal as the expertise to do this currently resides at UConn. The University of Connecticut personnel involved in this project are trained to use the equipment associated with the deployment, maintenance, and periodic recalibration of the field instrument arrays. Laboratory technicians, with a minimum qualification of a college degree in science or the equivalent analytical laboratory training and experience, are responsible for analyzing samples following standard operating procedures (SOP) or other instructions.

A9 Documentation and Records

The primary point for acquisition and compilation of the water quality monitoring data will be within the Department of Marine Science on UConn's Avery Point campus. The information management system includes several Pentium-class desktop computers equipped with high-capacity storage devices. The storage devices allow for immediate backup and archiving of data for eventual end user access. The database structure in its most basic form will consist of space delimited header fields and records in ASCII format. Each record will include a time and date stamp, a numerical station identifier, sensor depth, the sensor data, and quality flags. Collection, management, and dissemination of the database will utilize in-house custom programs, as well as commercially available database management utilities.

The data will be telemetered to base stations either at UConn - Avery Point or the closest cooperative site (*i.e.*, Bridgeport Vocational School). After retrieval and QA/QC processing the data will be stored on an FTP server in ASCII files, retrievable by the user community with any FTP client software. Some data (*e.g.*, from any experimental/developmental sensors) may not be posted to the FTP site. If requested by the manufacturer/developer, that data would not be made available to the general public, preventing erroneous interpretation of experimental data. All data, including the original raw telemetered data, will be backed up and archived on a second autonomous limited-access system. The archived data on the FTP server is available to users indefinitely.

GROUP B: MEASUREMENT/DATA AQUISITION

B1 Sampling Process Design

Seven stations (Figure 2) will provide point sampling of water quality parameters with a spatial resolution of approximately 20-50 miles along the axis of Long Island Sound, and 3 to 5 miles from the offshore to onshore stations. Specific coordinates for the buoy locations are listed in Table 1. Vertical resolution for the parameters being sampled is on the order of meters. This resolution will tend to vary with time and location in response to hardware availability and user needs. The location of the axial buoys provides water quality conditions encompassing the three main bathymetric features of Long Island Sound: the urbanized western basin, the transitional central basin, and the high energy, relatively pristine waters of the eastern basin.

A generalized schematic of the buoy configuration is shown in Figure 4. Each buoy will be equipped with solar panels for power, a modem and transmitter, and a datalogger capable of accepting a wide variety of inputs (*i.e.*, analog, digital, RS232, SDI-12, etc.). Table 8 lists the frequency of measurement for the parameters of interest measured at the monitoring buoys and for the discrete sampling to be used for lab analysis and data verification. At all locations, the array of sensors will be sampled a minimum of once per hour and a maximum of four times each hour. The water quality sensors are on for one minute with sampling at a rate of 1 Hz. These data are averaged over the minute and stored as a single point in memory for future retrieval. A sampling frequency of 4 cph is sufficient to quantify any signals in the data with periodicities ranging from quarddiurnal to monthly and greater, depending only on the total length of the data set.

Table 8. Frequency of Environmental Measurements.

Environmental Parameter	Monitoring Buoy Sensors Sampling Frequency (cph)	Discrete Water Samples Sampling Frequency (weeks)
Water Temperature	4	2
Salinity	4	2
Dissolved Oxygen	4	2
Suspended Material	4	2
Meteorological Data	4/1	N/A
PAR*	TBD	TBD
Nitrogen*	TBD	TBD
Chlorophyll*	TBD	TBD
Current Speed/Direction*	TBD	TBD

** Parameters of interest, no sensors actively measuring these quantities in the MYSound network.*

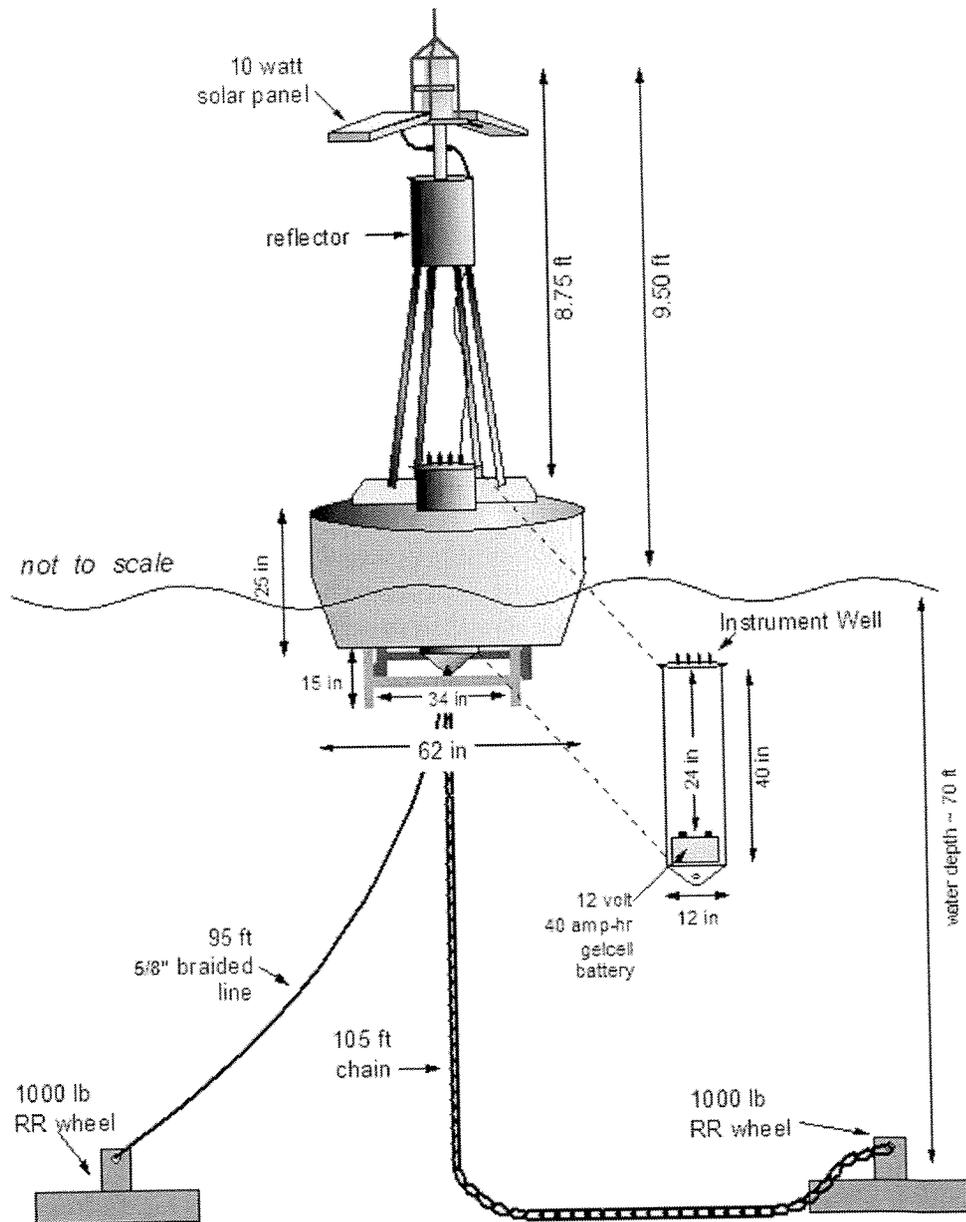


Figure 4. Schematic of buoy used at several of the water quality monitoring stations.

B2 Sampling Methods Requirements

In situ sampling for water temperature, salinity, dissolved oxygen, suspended materials, and meteorological data is performed by automated instrumentation employing electronic sensors that do not require sample capture. Chlorophyll, phytoplankton, PAR and nitrate/nitrogen sensors will be deployed as their development and availability permit. (As described in Section A7, sample capture will be used to obtain samples for laboratory verification.) Instrumentation for the buoys, listed in Table 4, includes:

Conductivity/Temperature/Dissolved Oxygen: Manufactured by Yellow Springs Instruments, Inc., the YSI 6600 incorporates probes for measuring water temperature, salinity, and dissolved oxygen. It operates in fresh or saltwater, and is equipped with internal batteries, datalogger, and memory for data storage (see Appendix B for specifications).

Suspended Material Concentration: The YSI 6136 Turbidity Probe is designed to work with the YSI 6600 Data Sonde. It is a fouling resistant, wiped sensor with built in temperature compensation, capable of measuring *in situ* turbidity concentrations in fresh, brackish and saltwater. The probe uses an LED to emit infrared radiation into the water column and a photodiode detects the amount of backscatter which is proportional to the turbidity concentration (see Appendix B for specifications).

Meteorologic Sensors: Climatronics Corporation climate sensors are collecting meteorological data including wind, temperature, and barometric pressure. The wind sensor consists of a three-cup anemometer and wind vane. The sensors are wired to a central datalogger with memory for data storage and a battery backup to an AC power supply (see Appendix B for specifications).

Photosynthetically Active Radiation (PAR): LI-COR's LI-193SA Spherical Underwater Quantum sensor measures PAR in the marine environment. The unit is 4.2 inches in height; the housing diameter is 1.25 inches (see Appendix B for specifications).

Nitrogen Concentration: Currently in development by Yellow Spring Instruments.

Chlorophyll Sensor: Yellow Spring Instrument's YSI 6025 is an *in situ* chlorophyll sensor which estimates the phytoplankton biomass by irradiating the water with blue light (470 nm) and measuring the resulting chlorophyll fluorescence. The resulting data provide a measure of the relative concentrations of phytoplankton over time, allowing the determination of trends or anomalies over a range of temporal scales (see Appendix B for specifications).

Current Profiler: The RDI Workhorse Acoustic Doppler Current Profiler is designed as a bottom-mounted, shallow-water current meter, capable of measuring velocity throughout most of the water column (see Appendix B for specifications).

Current Meter: The InterOcean S4 is a two-axis electromagnetic current meter that takes point measurements at a single depth. The unit includes internal batteries and a datalogger with memory for data storage. The 10-inch diameter sphere weighs 4 pounds in water. (see Appendix B for specifications).

B3 Sample Handling and Custody Requirements

Water samples collected for instrument verification are sent to the CEL Lab at UConn. The sample custodian receives samples and sample documentation. If there is no chain-of-custody documentation/form, a chain-of-custody form must be filled out by the sample delivery person. After acceptance of the samples and sample documentation by CEL, the sample identification number and chain of custody information are transcribed into a master logbook. Each received sample is then assigned a unique CEL sample tracking number. The sample tracking number is coded to include day, month, and year information and a sequence number indicating the order in which the laboratory received the sample.

Upon transfer of the collected sample to its container, a sequential number will be assigned for the sample that will reflect the order in which the sample was collected on that day. A sheet(s) of prepared peel-off labels (1 x 3 inch) containing the set of sequential numbers will be provided for each sampling event. After being affixed to the sample container, the label will be wrapped with clear cellophane tape. The sequential sample identification number is designed as follows:

AABBCCXXX where: AA is two-digit day of the month,
BB is two-digit month of the year,
CC is last two digits of current year, and
XXX is a number for the sample collected on that day.

The assigned sample identification number will be entered on a field log sheet that will also serve as the chain-of-custody document for the collected sample(s). An example of the field log sheet that will be used in this program is contained in Appendix C.

Collected samples for N/NO₃ and suspended material concentrations will be placed in coolers containing ice packs, as will the dissolved oxygen samples. The assigned sample custodian for that day will be responsible for assigning the sequential sample identification number and entering the appropriate data on the field sample log. All samples will be returned to the laboratory by the designated sample custodian for that deployment.

B4 Analytical Methods Requirements

Procedures used in the routine analysis of environmental samples by CEL are adopted from well-documented official methods, such as EPA approved methods, ASTM Methods, Standard Methods for the Examination of Water and Wastewater (19th ed), National Oceanic and Atmospheric Administration (NOAA) methods and Methods of Analysis of the Association of Official Analytical Chemists (AOAC). A SOP is documented and maintained by CEL for each method (Appendix B). The SOP includes the instrument and operating conditions in sufficient detail that allows for these conditions to be reproduced day to day. The SOP also includes the specifications on chemical purity, procedures for preparation of reagents, calibration standards, and samples. The SOP also includes the quality control procedure, data calculation and reporting procedure for the specific analysis. All routine laboratory sample analysis is performed with rigorous adherence to the SOP. When deviations are necessary, they will be documented and stated in the data report. The person who authorized the change will also be identified in the data report. When necessary, the required modification will be incorporated in the SOP. The general laboratory procedure for each analysis is described below and summarized in Table 9.

Dissolved Oxygen: Oxygen determinations will be made using a 0.001-mL microburet and the Standard Winkler Titration Method. Samples will be collected, preserved, and kept cool until returned to the laboratory for analysis. A quality control check will consist of the determination of the Factor *f* for oxygen calculations based on the analysis of at least three replicates and the comparison of duplicate/triplicate sample analysis.

Chlorophyll: The standard fluorometric method for chlorophyll a determinations will be used; the standard trichomatic method will be used for the determination of chlorophyll a and b as required. Quality control checks for chlorophyll a will consist of:

1. Calibration curve, five to seven points.
2. One method blank every 20 samples (where applicable).
3. Calibration curve verification every 10 samples.
4. Calibration blank verification every 10 samples.
5. Spike Recovery analysis every 20 samples.
6. Laboratory duplicate analysis every 20 samples.

Nitrogen: Automated Cadmium Reduction EPA 353.2 analysis will be performed using a Lachat QuikChem analyzer employing Lachat Method Numbers 11-107-04-1-A and/or 10-107-04-1-C. Two manifolds will be used to measure NO (nitrate + nitrite) and nitrite simultaneously. The nitrate value will then be calculated by subtracting the nitrite value from the NO_x value. A water sample is collected using appropriate sample collection apparatus. The collected sample is placed in a polyethylene container and forwarded to the CEL laboratory under ice. If sample analysis is not possible on the day the sample is received by CEL,

the sample is frozen at -20 C or below until analysis can be completed (within 28 days from arrival date at the laboratory). Samples are filtered through 0.7-m glass fiber filters prior to analysis. Samples for Nitrate + Nitrite are analyzed by an automated procedure, on a Lachat QuikChem Auto Analyzer. The Lachat QuikChem Auto Analyzer is calibrated with a six-point curve at the time of analysis. The calibration curve is then verified by an external quality control sample from Environmental Resource Associates. This second source calibration check and initial calibration blank demonstrate that the instrument is capable of acceptable performance at the beginning of the sample analysis. In order to ensure the continuing acceptable performance, a continuing calibration check and continuing calibration blank are run every tenth sample. A laboratory spike analysis and a laboratory duplicate analysis are performed after 20 samples. The frequency of blank, CCV, spiked, and repeat samples will be adjusted based on the number of samples being analyzed in order to maintain appropriate analytical data quality control and assurance. In summary the quality control check for nitrate/nitrite (NO_x) will consist of:

1. Calibration curve, five to seven points.
2. One method blank every 20 samples (where applicable).
3. Calibration curve verification every 10 samples.
4. Calibration blank verification every 10 samples.
5. Spike Recovery analysis every 20 samples.
6. Laboratory duplicate analysis every 20 samples.

Suspended Material Concentration: A 500 ml water sample will be collected and transported back to lab for immediate processing using a standard vacuum filtration system. A 0.4micron 47 mm preweighed polycarbonate filter is used to retain suspended material. The filter is then dried a minimum of 6 hrs at 60°C and reweighed.

Table 9. Precision, Accuracy, Completeness and MDL Objectives for Data Measurements.

Parameter	Lab Verification	Precision	Accuracy	Completeness	MDL
Water Temperature	Standard lab thermometer	< 20%	± 1° C	90%	0.1°C
Salinity	Beckman RD Salinometer	< 20%	± 1 ppt	90%	0.01 psu
Dissolved Oxygen	Standard Method 4500-OB (Strickland and Parsons, 1972)	< 20%	± 0.5 mg/L	90%	0.1 mg/L
Meteorologic Data	Manufacturer's calibration	< 20%	N/A	90%	N/A
SMC	EPA 160.2	<20%	± 5 mg/L	90%	2 mg/L
Nitrogen*	Lachat Quickchem Auto Analyzer EPA 353.2	< 20%	85-115% recovery	90%	0.002 mg/L
PAR*	TBD	TBD	TBD	TBD	TBD
Chlorophyll*	Fluorometer	<20%	± 10 µg/L	90%	2 µg/L
Current Velocity*	Flume calibration	< 20%	± 5 cm/s	90%	0.01 cm/s

* Parameters of interest, no sensors actively measuring these quantities in the MYSound network.

B5 Quality Control Requirements

Laboratory Quality Control:

The quality control criteria are specified by standard operation procedures or project quality assurance and quality control plans, which specify the frequency and the criteria for calibration checks, blank checks, matrix spikes, and duplicate sample analysis. The parameters used to describe the data qualities are precision, accuracy, completeness, and method detection limits.

Precision is estimated by the relative percent difference of replicated analyses for a control sample.

Accuracy is estimated by the percentage recovery of a sample spiked with a known concentration of the analyte. In the CEL laboratory, reference standards having certified values are used for this purpose.

The *completeness* of the data is the percentage of the data that meet the precision and accuracy criteria, in the total data generated for a project.

Method detection limit (MDL) is the lowest concentration that is higher than zero with 99% confidence interval. When the measured value for a given analyte is lower than its detection limit, it is reported as non-detectable (ND). A MDL is for each analytical protocol is determined by replicate sample analysis at a concentration, which is two to five times the expected MDL value. It is calculated by the standard deviation times the student-t value at 99% confidence interval and the corresponding degrees of freedom. If the sample matrix affects a MDL, a practical quantitation limit (PQL) is used to indicate the lowest concentration which can be considered as greater than zero. A PQL is determined by combining the MDL and the recoveries of the low concentration matrix spikes.

Laboratory analytical quality control is implemented at two levels. Each analyst routinely generates the quality control data along with sample analysis. The quality control data is evaluated against the quality control criteria and necessary actions will be taken immediately by the analyst. All the data are traceable to analyst, analytical date, and analytical conditions employed to generate the data. The quality control data are collected and reviewed by a quality control officer. If necessary, corrective action will be taken (Table 10).

Laboratory duplicates: Laboratory duplicates involve the independent processing and analysis of two samples poured off from the same filtrate. Laboratory duplicates are compared by relative percent difference (RPD) which is calculated as follows:

$$RPD = \left(\frac{(A - B)}{((A + B) / 2)} \right) \times 100$$

Laboratory Spikes: A known volume of standard is added to a known volume of sample. This sample is then analyzed as an independent sample. A comparison is then made of the actual value and the expected value by calculating the percent recovery.

Data Consistency Checks: The checks for data consistency are applied to the entire data set. These checks include comparison of replicate sample analysis, spike sample recoveries, comparison with historical data for that location, and if necessary determining that the Dissolved Nitrogen Series ($\text{NO}_2 + \text{NO}_3 + \text{NH}_3$) is less than the Total Dissolved Nitrogen (TDN).

Sample Collection and Processing Checks (Chlorophyll a and Nitrate/Nitrite):

1. Sample collection and trip bottle blanks
2. Filter Membrane Preparation and Acceptance
No preparation is required for the 0.7 μm 25 mm glass fiber filter pad and 0.7 μm 45 mm glass fiber filter pad used for Chlorophyll a and Nitrate/Nitrite.
3. Acceptance testing is performed on each batch of filters. Two filters per batch of 100 filters are analyzed. If the extract shows a contamination the lot is discarded and a new lot prepared and analyzed.
4. Duplicate sample collection for Nitrate/Nitrite and Chlorophyll a.
Triplicate sample collection for dissolved oxygen.

Sample Container Preparation and Sample Collection:

Polyethylene 250 ml sample bottles

1. Acid rinse the bottle with dilute Hydrochloric Acid (HCl).
2. Rinse the bottles five times with deionized water.
3. Leave bottles filled and capped with de-ionized water until used for collection.
4. Empty bottle and field rinse the bottle with sample prior to collecting sample.
5. Duplicate samples will be collected during each deployment for Nitrate/Nitrite and Chlorophyll a laboratory determinations.

Dissolved Oxygen Glass 250 mL BOD Bottle

1. Acid rinse the bottle with dilute hydrochloric acid (HCl).
2. Rinse the bottles five times with deionized water.
3. Triplicate sample will be collected during each deployment.

Table 10. Analytical Measurements Quality Control Requirements.

Analysis Method	Measured Parameter	Field/Laboratory Req.	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
EPA 353.2 Lachat Method	<i>Nitrate/ Nitrite*</i>	Field Sampling	Field Duplicate	Every Sample	N/A	N/A
11-107-04-1-A 11-107-04-1-C		Laboratory	Method Blank (where applicable)	1/20		1. Evaluate batch 2. Re-prep / analyze as necessary
Flourometer	Calibration Curve 5-7 pts		Beginning of analytical sequence	per SW-846	1. Evaluate system 2. Recalibrate when QC criterion not met	
	Calibration Blank		1/10	per SW-846	1. Clean system 2. Reanalyze affected samples	
	Continuing Calibration (where applicable)		1/10 samples	90-110% of true value	1. Evaluate system 2. Repeat calibration check 3. Recalibrate/ restandardize when QC criterion not met	
	Spike Recover		1/batch/matrix or 1/20 samples (whichever is more frequent)	RPD=15 86-115% recovery		
	Laboratory Duplicates		1/batch/matrix or 1/20 samples (whichever is more frequent)	RPD < 15	1. Evaluate system 2. Repeat calibration check 3. Recalibrate/ restandardize when QC criterion not met	
	Method Blank		1/batch/matrix or 1/20 samples (whichever is more frequent)	RPD < 15	1. Rerun 2. Evaluate batch 3. Re-prep /analyze as necessary	
	Laboratory Control Sample		1/batch/matrix	RPD < 15	1. Rerun 2. Evaluate batch 3. Re-prep /analyze as necessary	
	Performance Evaluation Sample		1/batch/matrix	per laboratory data validation functional guidelines for evaluating environmental analyses	1. Evaluate PE scores 2. Evaluate batch 3. Recommend action	

Table 10 (continued). Analytical Measurements Quality Control Requirements.

Analysis Method	Measured Parameter	Field/Laboratory Req.	Quality Control Check	Frequency	Acceptance Criteria	Corrective Action
Independent Instrument (YSI 600QS)	Dissolved Oxygen	Laboratory	100% Saturated Seawater	Each Sample	± 1.5 mg/L	Replace Sensor
Beckman Salinometer	Salinity	Laboratory	Standard Seawater	Each Sample	± 1 psu	Replace Sensor
Standard Thermometer	Temperature	Laboratory	Lab Duplicate	Each Sample	± 1 degC	Replace Sensor
EPA 160.2	SMC	Laboratory	Field Duplicate	1/10	per 160.2	Replace Sensor
Anemometer	Wind Spd/Dir	Field	Secondary Station	1/month	± 2.5 m/s	Replace/Recalibrate Sensor
<i>Flume Calibration*</i>	<i>Current Speed</i>	Laboratory	Continuous Calibration	1/year	±5 cm/s	Factory Recalibration
<i>LI-COR*</i>	<i>PAR</i>	TBD	TBD	TBD	TBD	TBD

* Parameters of interest, no sensors actively measuring these quantities in the MYSound network.

Field Quality Control and Other Quality Control Techniques:

Field QC consists of field blanks and field duplicates. Other types of QC samples include blind blanks, blind spikes, and split sample. A *field blank* is DI water that has been “run through” all the sampling equipment. The intent of a field blank is to monitor for contamination introduced by sampling personnel, although any laboratory-introduced contamination will also be present. During the course of a survey, *field duplicate* samples may be collected for analysis. These samples are collected as discrete samples, with the second sample being collected within minutes of the first. Field duplicates are compared by relative percent difference (RPD). A *blind blank* is bottled and preserved by the field group and sent as is to the laboratory. The purpose of a blind blank is to monitor for contamination introduced by the laboratory. Bottled laboratory water will be used for the blind blank. The purpose of the *blind spike* is to provide a QC sample to monitor the laboratory’s ability to reach CRDLs and/or the lab’s ability to quantitatively recover an analyte. A *split sample* is one that is divided between two laboratories. When analyzing a split sample it is important that both laboratories use the same methodology so that there is a basis for the comparison of the results.

Blanks and splits are useful as supporting evidence in the overall assessment of the survey. Blanks are samples of known composition and matrix. As such, they are useful in assessing a laboratory's performance independent of sample or method problems that may arise in a real sample. Except in the case of a gross error, blanks and splits should not be the basis of accepting or rejecting data, but rather as additional evidence in support of conclusions arrived at by a review of the total data package. Blanks, spikes, and split sample results will often point out areas the reviewer needs to look at more carefully. For the initial stages of this program split sample analysis will not be required. However, as the program and use of deployed systems increases, split sample analysis may be required and will be addressed and discussed at that time.

Table 11. Sample Preservation, Storage Requirements, and Analytical Holding Times

Parameter	Field Preservation	Field Storage	Laboratory Storage	Holding Time
Dissolved oxygen	H ₂ SO ₄ /MnSO ₄	dark @ 10-20 °C or at collection temperature	none	none, analyze as soon as possible
Nitrate/Nitrite*	none	ice	frozen	28 days
Chlorophyll*	none	ice/dark	frozen in foil	28 days

* Parameters of interest, no sensors actively measuring these quantities in the MYSound network.

Review of Analytical Data:

The chain-of-custody records and sample receipt log are reviewed for accuracy in sample descriptions, field stations and corresponding laboratory identification numbers, and the date of sampling. Although the sampling date is not addressed by contract requirements, any lag time between sampling and shipping will be noted and documented. Notable problems with matrices, insufficient sample for analysis or reanalysis, and unusual events will be noted and documented. The requirements that are checked to insure the quality of the analytical data for a given sample are as follows:

1. Sample holding times
2. Calibration
 - a. Initial calibration and calibration verification
 - b. Continuing calibration verification (CCV)
 - c. Continuing Calibration blank (CCB)

For the categories listed above the following criteria apply:

 - a. CCV and CCB are performed every 10 samples.
 - b. CCV is made by the analysis of EPA Quality Control Solutions. Where an EPA QC sample is not available, the accuracy of the calibration is conducted on an independent standard at a concentration other than that used for calibration, but within calibration range.
 - c. CCV must fall within the control limits of 80 to 120% of the true value.
3. Laboratory preparation blank and field blank

4. Specific sample results
 - a. Duplicate sample analysis (Laboratory and Field)
 - b. Spike sample analysis

B6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Sensors on all *in situ* instruments will be bench-tested according to manufacturers' specifications before deployment in the field. New sensor configurations will receive in-water, shakedown testing by deployment in seawater at Avery Point for several days. Monitoring stations will be visually inspected on a weekly basis and retrieved for servicing and overhaul according to manufacturers' recommendations (Table 12).

B7 Instrument Calibration and Frequency

Instrumentation will consist of pre-calibrated probes from YSI, Inc., (conductivity, temperature, dissolved oxygen and pressure), InterOcean S4 electromagnetic current meters, RD Instruments Acoustic Doppler Current meters, and SonTek Acoustic Doppler Velocimeters. Instruments will be returned to the manufacturer on an annual basis for calibration to predefined specifications. Calibration sheets returned with the instruments will be maintained on file in hard copy and cross-referenced with serial numbers for input to a digitally maintained database.

Sensors used in analytical methods (chlorophyll a and nitrate/nitrite) will be calibrated using known concentrations of analyte. Calibration solutions will be analyzed by listed analytical methods to determine offsets between sensor and analytical laboratory measurement. Additionally, during instrument calibrations, seawater will be spiked with a known analyte concentration, for example nitrate, to determine any effect of natural background on sensor performance.

Any offsets will be factored into data handling and reporting. At present it is not possible to determine the acceptable percent difference between offshore/onshore measurements for the identified parameters. Ideally this difference should be as low as possible. Comparison of sensor data for a given analyte will be compared with the onshore laboratory determination. If a discrepancy exist between offshore and on shore measurements that exceed a 20% difference during the initial deployment of these sensor package at a given location, appropriate studies will be undertaken to determine why. If the discrepancy is the result of natural background/matrix interference, and not the result of sensor fouling, the appropriate offset values will be determined and factored into the ongoing data sets and into the data evaluation process

B8 Inspection/Acceptance Requirements for Supplies and Consumables

Supplies required for this effort are standard chemicals and standard laboratory consumables for the study. Acceptance of material will be by certification of the specific item, e.g., for fluorescence analysis of petroleum oil sheen by ASMT Method D-3650 all solvents purchased or used will be spectroquality grade. Blanks will be recorded prior to use of the solvent to conduct the analysis.

** Parameters of interest, no sensors actively measuring these quantities in the MYSound network.*

Table 12. Sensor Servicing and Overhaul Frequency

Parameter	Sensor	Frequency of Servicing/Overhaul*
Water Temperature	YSI 6600	1/year
Salinity	YSI 6600	2 to 3/year
Dissolved Oxygen	YSI 6600	1/month
Suspended Material	YSI 6136	2/month
Meteorological Data	Climatronics sensors	1/year
<i>Nitrogen*</i>	YSI	TBD
<i>Chlorophyll*</i>	YSI 6025	TBD
<i>PAR*</i>	LI-COR LI-193	TBD
<i>Current Velocity*</i>	RDI ADCP/S4 EMCM	TBD

B9 Data Acquisition Requirements (Non-direct Measurements)

It is not anticipated that any non-direct, non-measurement data sources will be utilized in this project.

B10 Data Management

Data will be automatically transmitted, received, and stored every 15 minutes, 24 hours a day, into a primary data acquisition system and subsequently quality controlled, duplicated, and archived onto a secondary system for storage. Standard error correction protocols are inherent in the actual radio transmission of the data. First-order levels of data quality assurance include laboratory and/or *in situ* calibration of instrument probes with collected water sample data. Data received into the system are also wild-point edited and statistically analyzed for agreement with the available point measurements from the collected water samples. Data quality and missing data flags are incorporated in the database structure. For each parameter within the database, a corresponding flag is assigned. Missing data uses a value of -9999, a value outside the physical limits of the parameters measured, and is incorporated directly into the data set. Data passing the quality assurance standards are flagged with a value of one (1). Data unable to pass the initial quality assurance standards, but deemed reasonable and can be confirmed using third party

Table 13. Frequency of Sensor Calibrations.

Parameter	Sensor	Frequency of Calibration**	SOP
Water Temperature	YSI 6600	1/year	compliant with manufacturer's specifications
Salinity	YSI 6600	2/year	compliant with manufacturer's specifications
Dissolved Oxygen	YSI 6600	1/month	compliant with manufacturer's specifications
Suspended Material	YSI 6136	4/year	regression analysis with <i>in situ</i> water samples
Meteorological Data	Climatronics Sensors	1/year	compliant with manufacturer's specifications
Nitrogen*	YSI - TBD	TBD	comparison with laboratory Lachat method
Chlorophyll*	YSI 6025	TBD	compliant with manufacturer's specifications
PAR*	LI-COR 193	1/year	compliant with manufacturer's specifications
Current Velocity*	ADCP/EMCM	1/year	return for factory calibration

**Subject to change per sensor behavior.

*Parameters of interest, no sensors measuring these quantities in the MYSound network.

observations (i.e, shipboard surveys by other institutions/agencies, satellite data, etc) are flagged with a value of two (2). Data that has been changed from the original observation due to an instrument offset error, calibration error, etc., are flagged with a value of three (3). Data that cannot pass any quality assurance standards are considered missing data.

The data structure in its most basic form will consist of space delimited records in ASCII format. Data documentation is inherent within the header record of the database structure and in the time stamping of the individual parameter records. Logs and related documentation are supplemented by automatic progress recording of the incoming data.

Data access is implemented using standard TCP/IP protocols: HTTP, FTP and TELNET. End users with internet access are able to download data via any one of these protocols. Specifically, the data elements include a time and date stamp, station identifier, depth, temperature, salinity, dissolved oxygen, current speed and direction, wind speed and direction, and air temperature.

The information management system includes several Pentium-class desktop computers with access to a variety of high-capacity storage devices. The information management system resides at UConn's Avery Point campus. All data is backed-up and archived on a second autonomous limited access system and secondary storage media (i.e., CDs). Collection, management, and dissemination of the data utilize in-house custom programming as well as commercially available software packages. Security for end user data is implemented using several levels of password protections, administrative-only and domain limited access.

GROUP C: ASSESSMENT/OVERSIGHT

C1 Assessments and Response Actions

This project requires monitoring and assessing the performance and quality of deployed data acquisition systems within the environment, and the data quality generated from these deployed systems as well as the laboratory data quality of discrete sample for the verification of the deployed instruments. This project also involves the participation of private sector partners and federal, state, and local agencies acting as an internal quality assurance project team. This internal QA team will conduct periodic assessments (audits) of the deployed systems performance, the quality of field and laboratory generated data, and the field and laboratory support systems required for this project. The audit will assist the various principals involved in the determination of data quality levels and identifying and correcting deficiencies to ensure that the objectives of the project are met. The quality assurance team will report its results to the respective principals and to Dr. W.F. Bohlen, the principal investigator for this project. Dr. Bohlen will inform Mr. Tedesco and Mr. Beliveau of the findings and any necessary corrective actions that have been taken.

System/sensor calibrations are performed using acceptable certified standards when appropriate. Laboratory results are verified using traceable certified standards from two separate sources. Laboratory and field calibration of the sensors are correlated with analytical laboratory results employing the same set of standards, when appropriate. The principal investigator, Dr. W.F. Bohlen, will maintain all laboratory and field verification data. Data from the monitoring buoys will also be compared with existing historical data to determine whether any anomalies are present. Meteorological data are compared with the Groton Airport NWOS station, when necessary. Any discrepancies between these results will be investigated, and any required corrective action implemented and documented in the annual reports.

C2 Reports to Management

Project performance will be reviewed quarterly as part of regularly scheduled progress meetings between the EPA Project Manager, Principal Investigator, project staff, and collaborating (partner) organizations. Biannual (twice-yearly) meetings of the full project Steering Committee will supplement these meetings. The annual reports, submitted as part of the assessment requirement, will include the results of field and laboratory analysis, summarization of the laboratory and field QA/QC procedures for that quarter, and identify any corrective actions or modifications that were taken to improve data quality.

GROUP D: DATA VALIDATION AND USABILITY

D1 Data Review, Validation, and Verification Requirements

Data validation is performed using the quality control criteria explained in Section B5.

D2 Validation and Verification Methods

The data obtained using the baseline sensor suite will be compared with established parameter ranges (Appendix A) and correlation between data sets to determine erroneous readings and sensor malfunctions. Meteorological data will be compared with that recorded by adjacent DEP stations. Whenever possible, during routine buoy servicing, water quality data using other calibrated sensors (e.g., thermometers for water temperature) will be obtained to compare the performance of the sensor(s) in “real time”.

D3 Reconciliation with User Requirements

Routine data of a general nature (e.g., temperature, salinity, dissolved oxygen, wind speed, current velocity, and suspended materials) are processed and made available on the web page with associated educational material providing the basis for simple interpretations of the data. Other data on the environmental status of LIS (e.g., nitrates) will be gathered over time, analyzed, correlated, and interpreted by principle investigators, project staff, and the LIS Project Office. The data will then be provided in summary form to environmental managers, educators, and the public with a level of detail and explanation suitable for the user community. Interpretation of the data will be accomplished in close coordination with the EPA Long Island Sound Project and Connecticut Department of Environmental Protection to ensure that governmental standards are followed and action levels are clearly identified. Sensitive interpretations regarding public health issues will be cleared through these agencies.

EPA’s Peer Review Handbook recommends that scientific and technical work products used to support a regulatory program or policy are candidates for peer review. This project will not directly support regulatory programs or policy positions, therefore, peer review is not required. However, there are aspects of the project that would benefit from peer review, such as the quality and interpretation of data from sensor development efforts and the quality, interpretation, and presentation of continuous, real-time data of water quality conditions in Long Island Sound. As a result, peer review will be pursued for these elements of the project, relying primarily on feedback received from the variety of stake holders and members of the project’s Steering Committee (this will be an active solicitation. Attendance at workshops or training sessions intended to complement the use of the environmental data is another quantitative measure. Adjustments can be made with regard to the amount of data provided, format of the presentation, and the amount and nature of interpretive material to facilitate assimilation and use of the data by stakeholders and the public.



APPENDIX A
Sensor Specifications

SBE Model 19 SeaCat Profiler Specifications

MEASUREMENT RANGE:	Temperature	-5° to +35° C
	Conductivity	0 to 7 S/m (0 to 70 mmho/sec)
	Pressure	150 psia
ACCURACY:	Temperature	0.01° C / 6 months
	Conductivity	0.001 S/m/month
	Pressure	0.5% full scale range
RESOLUTION:	Temperature	0.001° C
	Conductivity	0.0001 S/m
	Pressure	0.05% of full scale range
SENSOR CALIBRATION:	Temperature	-1° to +31° C (measurements outside this range may have reduced accuracy due to extrapolation errors)
	Conductivity	0 to 7 S/m. Physical calibration over the range 1.4 to 6 S/m, plus 0 conductivity (air).
	Pressure	minimum of 5 values between 0 and full scale.
BATTERIES:	6 alkaline "D" cells provide at least 48 hrs continuous operation	
	PC board mounted lithium supplies at least 1 year of memory and clock/calendar backup. 10 year service life when main batteries are kept in place.	
MATERIALS:	Acetal copolymer (plastic)	
WEIGHT:	5.0 kg (11 lbs) - AIR 1.2 kg (2.6 lbs) - WATER	
SIZE:	99 mm (3.9") diameter x 475 mm (18.7") long cylinder	

Sea-Bird Electronics, Inc. 1808-136th Place Northeast Bellevue, WA 98005



Y S I Environmental



6600 EDS Extended Deployment System Measure over 10 parameters in severe fouling environments

Building upon the unprecedented accuracy and reliability of YSI's *stirring-independent* Rapid Pulse™ dissolved oxygen system, as well as on the improved and proven wiped turbidity sensor, YSI has produced the YSI 6600 EDS (Extended Deployment System).



Profile of the new 6600 EDS depicting (clockwise from bottom), temperature/conductivity, turbidity, Rapid Pulse™ dissolved oxygen sensor, chlorophyll, and pH/ORP — all of which (except conductivity) are maintained free of fouling by the patent-pending *Clean Sweep™* universal wiper assembly, as well as individual optical wipers.



Figure 1. A prototype 6600 EDS after continuous deployment for 80 days in Buzzards Bay, MA. The sensor in the foreground is the active DO sensor. The sensor at top-right was used as a non-wiped fouling reference. Note extensive fouling by plant and animal species on the non-wiped sensor.

- Provides unprecedented DO accuracy and longevity in aggressive fouling environments
- Wiped fouling protection for turbidity, chlorophyll, DO, pH, and ORP sensors
- Ideal for extended, long-term deployments
- Virtually maintenance free
- Sensors are field-replaceable
- Integrates with DCPs

Initial field studies of the YSI 6600 EDS indicate that the system provides unprecedented DO accuracy and longevity in aggressive fouling environments. The 6600 EDS was inspected after 80 days of an ongoing deployment performance evaluation (see Fig. 1). The Rapid Pulse™ DO sensor performed within specifications throughout this deployment *without* the need for recalibration or cleaning. During this deployment, the instrument was removed once for battery replacement; none of the sensors were cleaned or recalibrated.

6600 EDS 80-Day DO Performance Evaluation

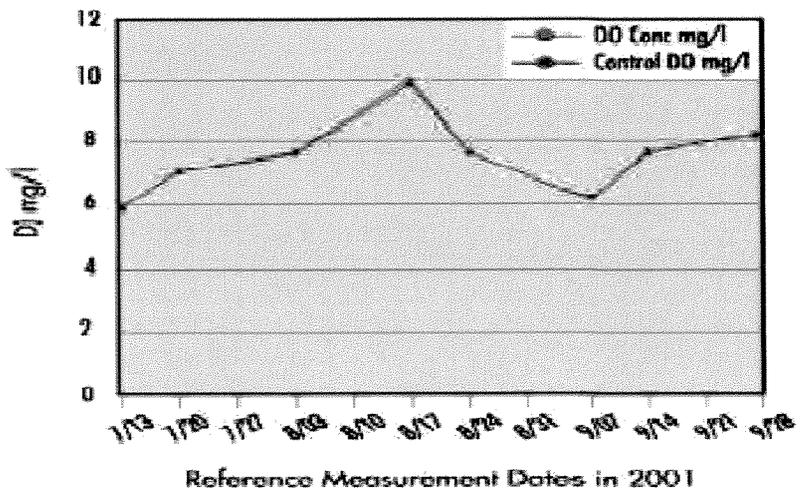


Figure 3. Remarkably close agreement (mean error 0.16mg/l) between the continuously deployed sonde and the control measurements was observed throughout an 80-day deployment.

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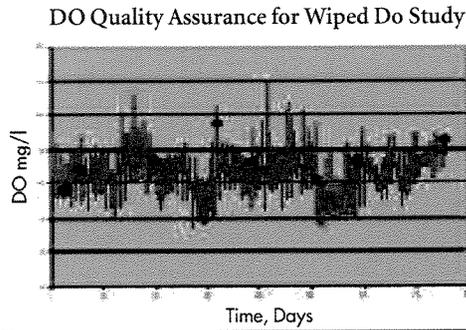


Figure 4. DO measurements made continuously at 15-minute intervals for 80 days. Eight reference measurements (blue symbols) were made during this deployment. Data depicts excellent agreement with reference measurements.

Control DO mg/l DO mg/l

YSI 6600 EDS (Extended Deployment System)

Dissolved Oxygen % Saturation	Range Resolution Accuracy	0 to 500% 0.1% 0 to 200%: ±2% of reading or 2% air saturation, whichever is greater; 200 to 500%: ±6% of reading
Dissolved Oxygen mg/L	Range Resolution Accuracy	0 to 50 mg/L 0.01 mg/L 0 to 20 mg/L: ±2% of reading or 0.2 mg/L, whichever is greater; 20 to 50 mg/L: ±6% of reading
Conductivity †	Range Resolution Accuracy	0 to 100 mS/cm 0.001 to 0.1 mS/cm (range-dependent) ±0.5% of reading + 0.001 mS/cm
Temperature	Range Resolution Accuracy	-5 to +45°C 0.01°C ±0.15°C
pH	Range Resolution Accuracy	0 to 14 units 0.01 unit ±0.2 unit
ORP	Range Resolution Accuracy	-999 to +999 mV 0.1 mV ±20 mV
Salinity	Range Resolution Accuracy	0 to 70 ppt 0.01 ppt ±1% of reading or 0.1 ppt, whichever is greater
Shallow Depth	Range Resolution Accuracy	0 to 30 feet (0 to 9 m) 0.001 feet (0.001 m) ±0.06 feet (±0.02 m)
Medium Depth	Range Resolution Accuracy	0 to 200 feet (0 to 61 m) 0.001 feet (0.001 m) ±0.4 feet (±0.12 m)
Deep Depth	Range Resolution Accuracy	0 to 656 feet (0 to 200 m) 0.001 feet (0.001 m) ±1 feet (±0.3 m)
Vented Level	Range Resolution Accuracy	0 to 30 feet (0 to 9 m) 0.001 feet (0.0003 m) ±0.01 feet (0.003 m)
Turbidity	Range Resolution Accuracy Depth	0 to 1,000 NTU 0.1 NTU ±5% of reading or 2 NTU, whichever is greater 200 feet (60.96 m)
Chlorophyll	Range Resolution Depth	0 to 400 µg/L 0.1 µg/L Chl; 0.1%FS 200 feet (60.96 m)
Rhodamine	Detection Limit Resolution Accuracy Depth	0.5 µg/L 0-200 µg/L as true dye; 1,000 µg/L as dye tracer ±1 µg/L or ±5% reading 200 feet (60.96 m)

† Report outputs of specific conductance (conductivity corrected to 25°C), resistivity, and total dissolved solids are also provided. These values are automatically calculated from conductivity according to algorithms found in *Standard Methods for the Examination of Water and Wastewater* (ed 1989).

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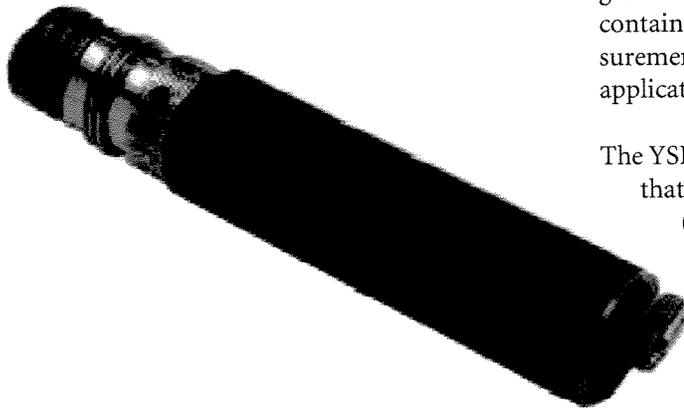


Y S I Environmental



YSI 6136 Turbidity Sensor

In the continued interest of providing the users of YSI technology with the most accurate, reliable, and easy to use water quality monitoring technology, YSI, Inc. announces the new 6136 turbidity sensor. The 6136 is a fouling-resistant, wiped sensor designed to seamlessly integrate – using no external interface hardware – with all YSI sondes that contain an optical port. The YSI 6136 provides accurate, *in situ* measurement of turbidity in fresh, brackish, and sea water, as well as other applications requiring highly accurate turbidity data.



The YSI 6136 sensor can be used in combination with those YSI sondes that have optical ports – 600 OMS, 6820, 6920, 6600, or 6600 EDS (Extended Deployment System) – and a YSI 650 MDS handheld display-logger. Make surface as well as vertical profile measurements. In addition, the YSI 6136 in combination with one of the YSI data-logging sondes can be used for unattended continuous monitoring or integrated with data collection platforms for real-time data acquisition.

Extensive empirical field and laboratory tests performed by YSI and independent agencies in Alpha and Beta studies document close agreement between *in situ* measurements made with the YSI 6136 turbidity sensor and data from the Hach™ 2100AN™, a laboratory instrument recognized as the standard for turbidity measurement (Table 1).

Pure
Data for a
Healthy
Planet.™

- Close agreement with lab analysis
- Larger sample size
- Compatible with YSI optical sondes
- No external interface hardware
- Unattended logging, connect with DCPs

Comparison of new YSI turbidity probe with Hach 2100AN
Sites number 1-71

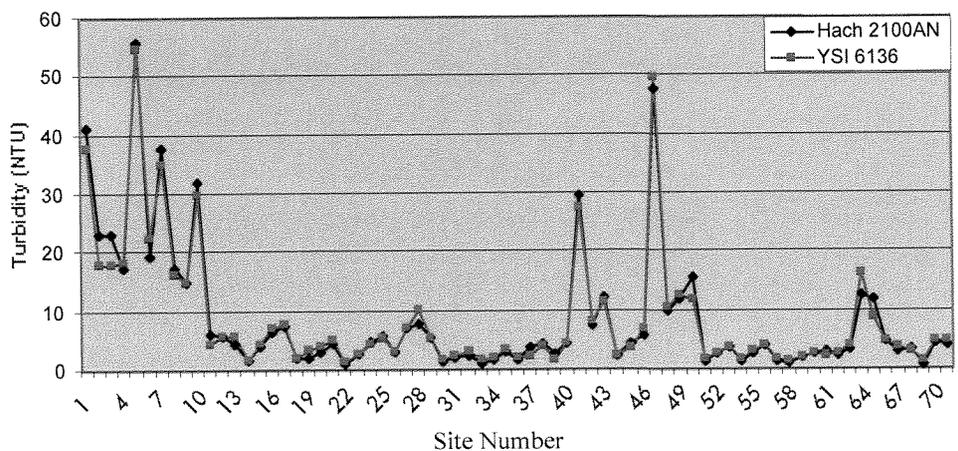


Table 1. Comparison of turbidity measurements made with the YSI 6136 Turbidity Sensor and HACH 2100 AN at 70 different riverine and lacustrine sites exhibiting widely varying (lower) turbidity ranges.

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YSI Incorporated
Who's Minding the Planet?™

Features and Benefits

- Temperature compensation provides greater accuracy
• Wiped optics: field-proven for fouling prevention
• Compatibility with all YSI optical port sondes provides system flexibility
• Handheld measurements, continuous data-logging, real-time data acquisition

Applications

- Dredging
• Stormwater
• Construction sites
• Vertical profiling
• Long-term studies
• Surface water evaluations
• Circulation: lakes, reservoirs, bays, estuaries

Table with 2 columns: Specification (Resolution, Range, Accuracy, Depth, Warranty) and Value (0.1 NTU, 0 - 1000 NTU, ±5% of reading or 2 NTU, 61 meters (200 feet), One-year)



Y S I Environmental

Multiparameter Sampling System!

YSI 600 QS (Quick Sample™)

The Easy Solution to Handheld Sampling

Packaged for convenience, the combination of the YSI 650 MDS display-datalogger and the YSI 600R sonde allows you to collect 9 parameters simultaneously in real time. Designed for reliable field use, the 650 MDS features an IP-67, impact-resistant case, and utilizes internal, non-volatile flash memory that prevents data loss and stores 150 data sets. The 600R sonde is compact, submersible to 61m (200 ft) and employs YSI's unprecedented sensor reliability and parameter measurement systems. The 600QS provides a reliable way to quickly sample fresh, brackish, sea, and polluted waters.



- Rapid-Pulse™ stirring-independent dissolved oxygen, accepted for compliance monitoring
- Collect 9 parameters simultaneously in real time
- Dissolved oxygen, dissolved oxygen % saturation, temperature, conductivity, pH, ORP¹, and depth¹ are measured simultaneously
- Specific conductance, salinity, total dissolved solids and resistivity are calculated and displayed with measured parameters at the users discretion
- Small compact sonde fits easily into 2-inch wells
- Compatible with E_{co}WATCH™ for Windows™ data analysis software²
- Menu-driven, easy-to-use interface for 650 MDS and 600R to PC
- Sonde communicates via RS-232 to 650 MDS and PC, and via SDI-12 to data collection platforms
- Easy-to-use sensor diagnostics that help insure accurate, high quality data acquisition
- 3-year warranty on the 650 MDS and 600R³

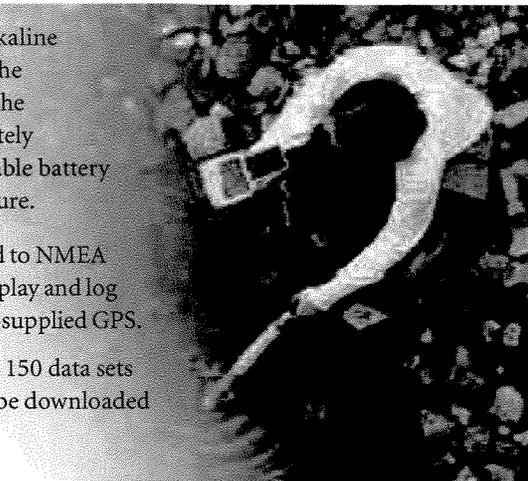
¹ optional sensor; ² EcoWatch is not necessary for operation, calibration or sensor diagnostics
³ refer to warranty statement for conditions: extended warranties are also available

Pure
Data for a
Healthy
Planet.™

*Quick Sample with a new,
cost-effective combination
of two outstanding YSI
products!*

Feature-Packed Performance

- **Battery Life** – With the standard alkaline battery configuration of 4 C-cells, the YSI 650 MDS will power itself and the sonde continuously for approximately 30 hours. Or, choose the rechargeable battery pack option with quick-charge feature.
- **Optional GPS Interface** – Designed to NMEA protocol, the YSI 650 MDS will display and log real-time GPS readings with a user-supplied GPS.
- **Memory** – Standard memory with 150 data sets with time and date stamp and can be downloaded to a PC via RS-232 interface.



www.YSI.com

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For more information on YSI's full line of products and services, as well as application notes, FAQ's, troubleshooting, and more, check our information-packed website: www.YSI.com.

Be sure to see the YSI 600 QS feature page which outlines the advantages and benefits of this new technology at: www.YSI.com/600QS.

YSI 600 QS Display-Datalogger (650 MDS)

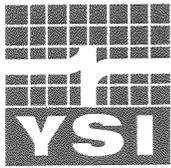
Temperature :	
Operating:	-10° to 60° C for visible display
Storage:	-20° to 70° C
Waterproof :	IP-67 for both the standard alkaline battery configuration and for the rechargeable battery pack option
Size :	11.9 cm width x 22.9 cm length (4.7 in. x 9 in.)
Weight with batteries :	2.1 lbs. (0.91 kg.)
Display :	VGA; LCD with 320 by 240 pixels with backlight
Connector :	MS-8; meets IP-67 specification
Battery :	Standard 4 alkaline C-cells with detachable battery cover Optional Ni metal hydride battery pack with attached battery cover and 110/220 volt charging system
Communications :	RS-232 to all sondes, for data transfer to PC, and for software updates and SDI-12
GPS:	Y-cable; NMEA 0183
Backlight :	4 LEDs illuminating LCD; user-selectable
Keypad :	20 keys, including instrument on/off, backlight on/off, enter, esc, 10 number/letter entry keys, 2 vertical arrow keys, 2 horizontal arrow keys, period key, and minus key

YSI 600 QS Sonde Specifications (600R)

Size:	OD: 1.65" (4.19 cm)	Length: 14" (35.6 cm)	Weight: 1.1 lbs (0.49 kg)
Depth:	Range	Resolution	Accuracy
Medium	0-200 feet (0-61 m)	0.001 feet (0.001 m)	±0.4 feet (±0.12 m)
Dissolved oxygen % air saturation:	0 to 500%	0.1%	0 to 200%: ±2% of reading or 2% air saturation, whichever is greater; 200 to 500%: 6% of reading
Dissolved oxygen mg/L:	0 to 50 mg/L	0.01 mg/L	0 to 20 mg/L: ±2% of reading or 0.2 mg/L, whichever is greater; 20 to 50 mg/L: ±6% of reading
Conductivity:	0 to 100 mS/cm	0.001 to 0.1 mS/cm (range-dependent)	±0.5% of reading +0.001 mS/cm
Temperature:	-5 to +45 C	0.01 C	±0.15 C
pH:	0 to 14 units	0.01 unit	0.2 unit
Salinity:	0 to 70 ppt	0.01 ppt	±1% of reading or 0.1 ppt, whichever is greater
ORP:	-999 to +999 mV	0.1 mV	±20 mV

How To Order

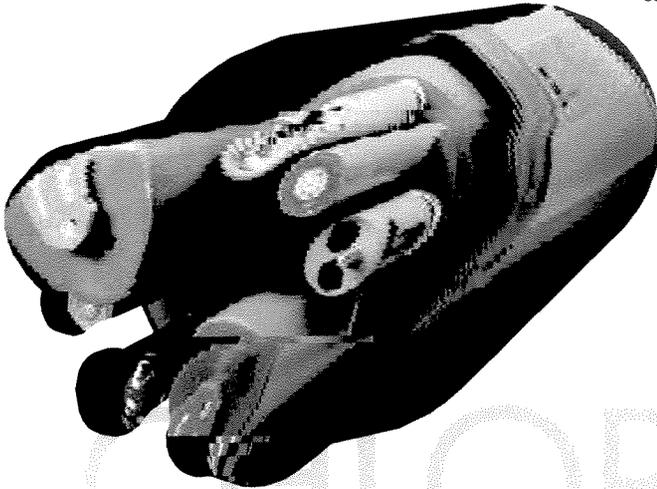
600QS-01	Temperature, Conductivity, pH, DO, 25 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-02	Temperature, Conductivity, pH, DO, Depth 0-200 ft., 25 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-03	Temperature, Conductivity, pH, DO, 50 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-04	Temperature, Conductivity, pH, DO, Depth 0-200 ft., 50 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-05	Temperature, Conductivity, pH/ORP, DO, 25 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-06	Temperature, Conductivity, pH/ORP, DO, Depth 0-200 ft., 25 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-07	Temperature, Conductivity, pH/ORP, DO, 50 ft. Detachable Cable, 650-01 MDS, 600R Sonde
600QS-08	Temperature, Conductivity, pH/ORP, DO, Depth 0-200 ft., 50 ft. Detachable Cable, 650-01 MDS, 600R Sonde



Y S I Environmental

YSI 6025 Chlorophyll Probe

The YSI 6025 Chlorophyll Probe expands YSI's suite of sensors for multiparameter, water quality monitoring applications. The new probe is designed to estimate phytoplankton concentrations by detecting the fluorescence from chlorophyll *in situ*. The data can be useful in predicting detrimental algae blooms and, indirectly, in determining nutrient loading in environmental applications. The probe features a mechanical self-wiping capability for long-term monitoring.



- *In situ* monitoring
- Fast, convenient monitoring
- Self-wiping probe for long-term measurement
- Small field-replaceable probe design

Pure
Data for a
Healthy
Planet.™

***Predict algae blooms
and determine the nutrient
loading in water!***

The YSI 6025 Chlorophyll Probe uses technology similar to that used by fluorometers, but the YSI sensor is much smaller, making it compatible with the probe ports in YSI's 6-Series instruments, including the YSI 6600 as well as the YSI 6820 and 6920. The YSI 6600 sonde allows simultaneous measurement of two optical probes (chlorophyll, turbidity, or rhodamine), along with up to fifteen other parameters. The YSI 6820 and 6920 allow measurement of one optical probe, along with up to fifteen other parameters.

Chlorophyll in various forms is bound within the living cells of algae, phytoplankton, and other plant matter found in water. Chlorophyll is a key component in the process of photosynthesis, the critical process in which energy from sunlight is used to produce life-sustaining oxygen. The amount of chlorophyll in a water sample is used as a measure of suspended phytoplankton, the magnitude of which can significantly affect the overall quality of water.

Before the new YSI sensor made *in situ* measurement convenient, the common way to measure chlorophyll was to collect samples and use extractive analysis in a laboratory, or take large equipment to the field. Extractive analysis methods, though highly accurate, are time-consuming and require an experienced analyst. The YSI optical, fluorescence probe is quick and efficient to use, and enables spot sampling in remote areas as well as continuous or interval monitoring.

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YSI Chlorophyll Probe Specifications

Sensor Type	Optical fluorescence with mechanical cleaning
Range	0 to 400µg/L
Resolution	0.1µg/L Chl; 0.1% FS
Depth	61 meters (200 ft.)

Applications for YSI's chlorophyll sensor include:

Ocean and Coastal Studies

- investigate the distribution of phytoplankton in marine systems
- check the algae in different layers and columns of water

River, Lake, Pond, and Reservoir Management

- monitor growth of phytoplankton due to high concentrations of plant nutrients
- observe the algae population and distribution in lakes and reservoirs
- sample phytoplankton at different depths to profile lakes and reservoirs
- monitor ponds where algae control is of concern (eutrophication)

Drinking Water from Rivers, Lakes, and Reservoirs

- monitor algae blooms which may be toxic
- minimize filtration system clogs through early detection of algae blooms

Aquaculture

- estimate changes in quantity of phytoplankton when used as a food source
- manage dissolved oxygen requirements based on algae blooms
- optimize amounts of phytoplankton in larval tanks

BW006777

UNDERWATER PAR MEASUREMENT

LI-COR, Inc. Toll Free: 1-800-447-3576 (U.S. & Canada) • Phone: 402-467-3576 • FAX: 402-467-2819 • E-mail: envsales@env.licor.com • Internet: http://www.licor.com

LI-192SA UNDERWATER QUANTUM SENSOR

Underwater or Atmospheric PPFD Measurement

Underwater or atmospheric *Photosynthetic Photon Flux Density* (PPFD) can be accurately measured using the LI-192SA Underwater Quantum Sensor. The LI-192SA is cosine corrected and features corrosion resistant, rugged construction for use in freshwater or saltwater and pressures up to 800 psi (5500kPa, 560 meters depth).

LI-192SA SPECIFICATIONS

Absolute Calibration: $\pm 5\%$ in air traceable to NBS.

Sensitivity: Typically $4 \mu\text{A}$ per $1000 \mu\text{mol s}^{-1} \text{m}^{-2}$ in water.

Linearity: Maximum deviation of 1% up to $10,000 \mu\text{mol s}^{-1} \text{m}^{-2}$.

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10 \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Cosine Correction: Optimized for both underwater and atmospheric use.

Azimuth: $< \pm 1\%$ error over 360° at 45° elevation.

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Corrosion resistant metal with acrylic diffuser for both saltwater and freshwater applications. Waterproof to withstand 800 psi (5500kPa) (560 meters).

Size: $3.18 \text{ Dia.} \times 4.62 \text{ cm H}$ ($1.25'' \times 1.81''$).

Weight: 227 g (0.50 lbs).

Mounting: Three $6-32$ holes are tapped into the base for use with the 2009S Lowering Frame or other mounting devices.

Cable: Requires 2222UWB Underwater Cable.

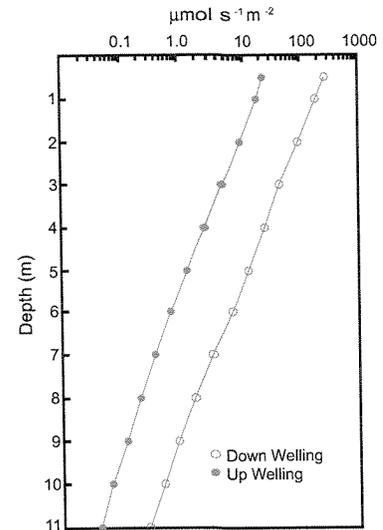
Clockwise: LI-190SA Quantum Sensor, LI-192SA Underwater Quantum Sensor, LI-193SA Spherical Quantum Sensor

UNDERWATER PAR MEASUREMENT

Accurate measurements of *Photosynthetically Active Radiation* (PAR, $400-700 \text{ nm}$) in aquatic environments is accomplished using either the LI-192SA Underwater Quantum Sensor or the LI-193SA Spherical Quantum Sensor. These sensors have been utilized extensively by limnologists, oceanographers and biologists conducting aquatic productivity studies and vertical profiling.

For extremely turbid conditions, radiation levels with resolution down to $0.01 \mu\text{mol s}^{-1} \text{m}^{-2}$ can be measured when either the LI-192SA or LI-193SA quantum sensors are used with the LI-1400 DataLogger.

Both the LI-192SA and the LI-193SA utilize computer-tailored filter glass to achieve the desired quantum response. Calibration is traceable to NIST.



Typical semi-logarithmic plot of downwelling and upwelling quantum irradiance collected with two LI-192SA Quantum Sensors.

LI-193SA SPHERICAL QUANTUM SENSOR

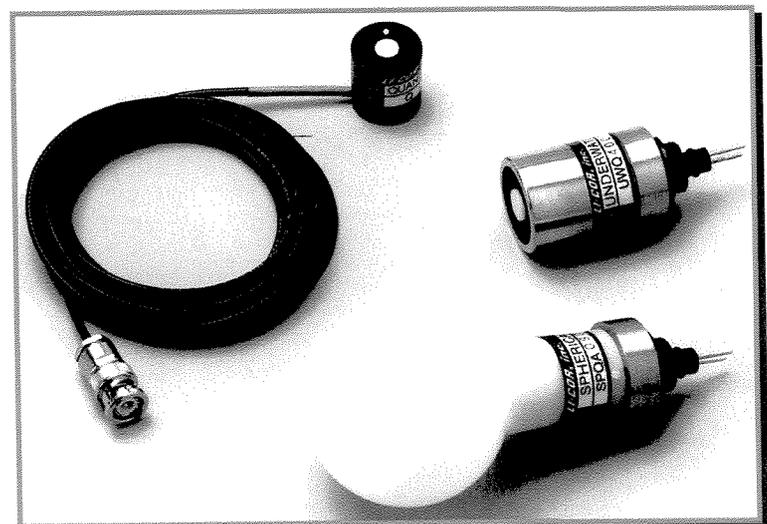
Underwater PAR From All Directions

The LI-193SA Underwater Spherical Quantum Sensor gives an added dimension to underwater PAR measurements as it measures photon flux from all directions.

This measurement is referred to as *Photosynthetic Photon Flux Fluence Rate* (PPFFR) or *Quantum Scalar Irradiance*.

This is important, for example, when studying phytoplankton which utilize radiation from all directions for photosynthesis.

The LI-193SA features a high sensitivity optical design and compact, rugged construction (3400 kPa , 350 meters depth).



LI-193SA SPECIFICATIONS

Absolute Calibration: $\pm 5\%$ in air traceable to NBS.

Sensitivity: Typically $7 \mu\text{A}$ per $1000 \mu\text{mol s}^{-1} \text{m}^{-2}$ in water.

Linearity: Maximum deviation of 1% up to $10,000 \mu\text{mol s}^{-1} \text{m}^{-2}$.

Stability: $< \pm 2\%$ change over a 1 year period.

Response Time: $10 \mu\text{s}$.

Temperature Dependence: $\pm 0.15\%$ per $^{\circ}\text{C}$ maximum.

Angular Response: $< \pm 4\%$ error up to $\pm 90^{\circ}$ from normal axis (see Figure 3).

Azimuth: $< \pm 3\%$ error over 360° at 90° from normal axis.

Detector: High stability silicon photovoltaic detector (blue enhanced).

Sensor Housing: Corrosion resistant metal for both saltwater and freshwater applications with an injection molded, impact resistant, acrylic diffuser. Units have been tested to 500 psi (3400 kPa) (350 meters) with no failures.

Size

Globe: 6.1 cm Dia. ($2.4''$).

Housing: 3.18 cm Dia. ($1.25''$).

Overall Height: 10.7 cm ($4.2''$).

Weight: 142 g (0.31 lbs.).

Mounting: Three 6-32 mounting holes are tapped into the base for use with the 2009S Lowering Frame or other mounting devices.

Cable: Requires 2222UWB Underwater Cable.

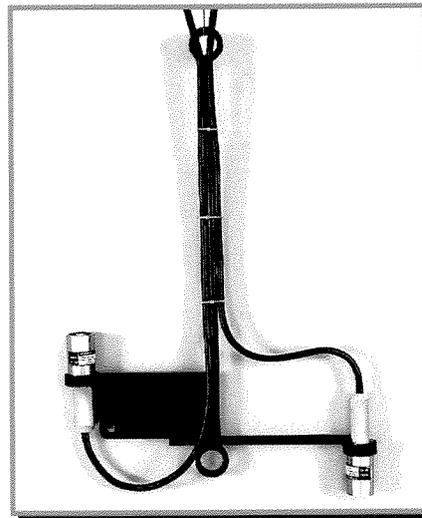
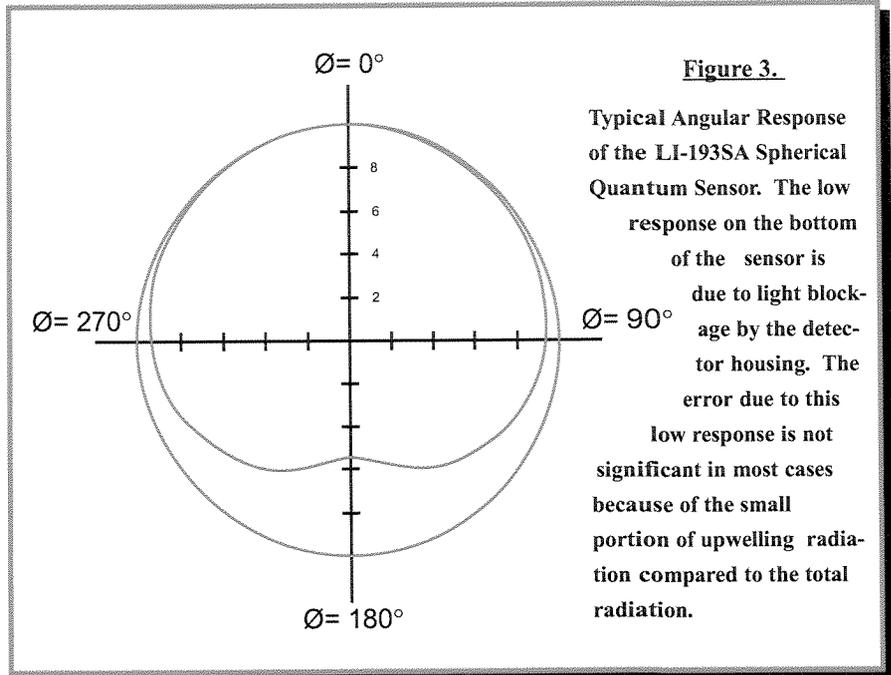
2009S LOWERING FRAME

The 2009S Lowering Frame provides for the placement of two underwater cosine sensors, one each for downwelling or upwelling radiation (shown right), or a single LI-193SA Spherical Quantum Sensor. The 2009S provides stability for proper orientation of the sensor(s), minimizes shading effects, and features a lower mounting ring for stabilizing weight attachment if necessary.

Construction: Anodized aluminum.

Size: 51.4 L ($20.3''$) \times 35.6 cm W ($14.0''$).

Weight: 327 g (0.72 lbs.).



2009S Lowering Frame

2222UWB UNDERWATER CABLE

This 2-wire shielded cable is used with underwater sensors and has a waterproof connector on the sensor end. The other end of the cable is fitted with a BNC connector for attaching the cable directly to the readout instrument for type "SA" sensors (also attaches to the calconnector of "SB" type sensors). Standard cable

lengths are 3, 10, 30, 50, 75, and 100 meters. Custom lengths over 100 meters can also be ordered.

Underwater Sensors require 2222UWB Underwater Cable.

ORDERING INFORMATION

The Underwater Sensors can be purchased with several accessories. Please see accessory sheet for more details.

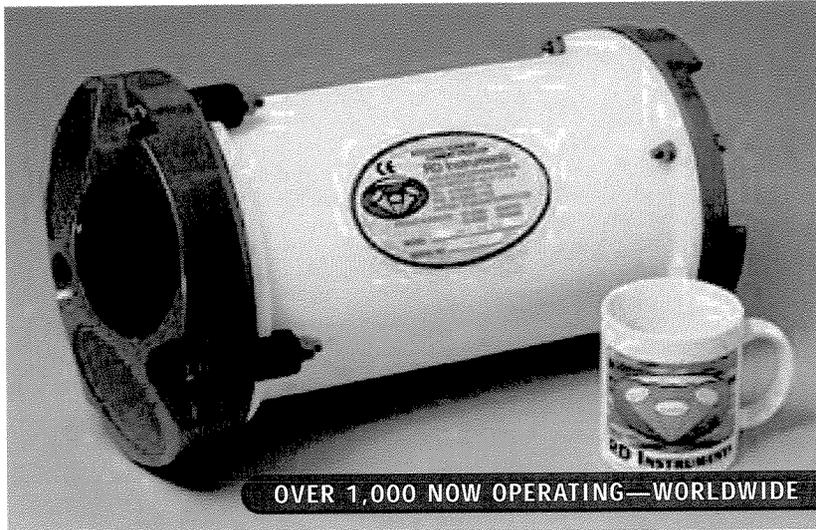
LI-192SA Underwater Quantum Sensor
LI-193SA Spherical Quantum Sensor
2009S Lowering Frame
2291 Millivolt Adapter (1210 ohm)
2222UWB-3 Underwater Cable, 3 meters
2222UWB-10 Underwater Cable, 10 meters
2222UWB-30 Underwater Cable, 30 meters
2222UWB-50 Underwater Cable, 50 meters
2222UWB-75 Underwater Cable, 75 meters
2222UWB-100 Underwater Cable, 100 meters
100L Lubricant

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Workhorse Sentinel ADCP

Self-Contained 1200, 600 or 300 kHz

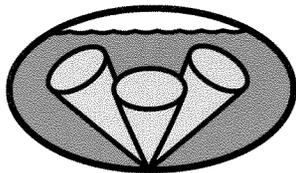


OVER 1,000 NOW OPERATING—WORLDWIDE

Our most popular instrument. Over 1000 Workhorse Sentinel ADCPs are profiling currents in 50 countries. Our customers choose it for its unbeatable precision in shallow waters, for its 175-meter profiling range and for an unmatched low power consumption that makes it ideal for year-long deployments.

Customers tell us they like it because it's light and easy to deploy on buoys, boats or on the bottom. Links to shore are by cable or modem and Sentinel is easily upgraded to measure pressure, to undertake bottom-tracking tasks or to be used as a directional wave gauge.

Frequency	Range	Long Range Mode		
		Cell Size	Range	Cell Size
1200 kHz	14m	1m	19m	2m
600 kHz	47m	2m	67m	4m
300 kHz	126m	8m	165m	8m

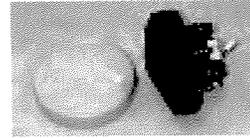


RD Instruments

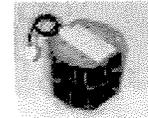
www.rdinstruments.com

RD Instruments
Tel: (858) 693-1178
sales@rdinstruments.com

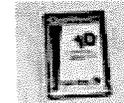
Included in a complete system:



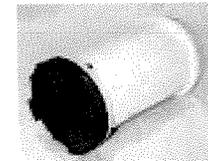
Transducer and electronics: molded composite plastic transducer head with four beams at 20° from vertical in a convex configuration, temperature sensor, electronics assemblies, fluxgate compass, pitch and roll sensors.



Batteries: one 28-D cell alkaline battery pack (factory degaussed).



Memory: 10 MB PC card internal memory (upgradeable to 440Mb).



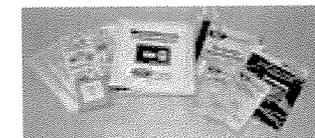
Pressure case: composite plastic, 200m rated. End cap with wet-mateable connector and dummy plug.



Power supply for laboratory testing: 110-220V AC/24V DC power converter.



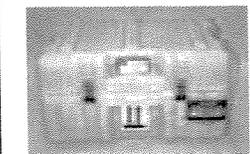
Input/output cable: 5 meter cable for communications and power.



Manuals and software: users guide; operation manual and easy-to-use Windows software package.



Spares parts and tool kit for maintenance.



Ship case: ruggedized compact case.



Workhorse Sentinel ADCP 1200, 600 or 300 kHz

Water Profiling

Depth Cell Size ^a	Typical range 12m ^b 1200kHz		Typical range 50m ^b 600kHz		Typical range 110m ^b 300kHz	
	Range (m)	Std. Dev. ^c (mm/s)	Range (m)	Std. Dev. ^c (mm/s)	Range (m)	Std. Dev. ^c (mm/s)
0.25m	11	182				
0.50m	12	66	36	182	see (a)	
1.0m	14	30	41	66	86	182
2.0m	15 ^b	18	47	30	99	66
4.0m	see (a)		52 ^b	18	112	30
8.0m					126 ^b	18

Notes: a) user's choice of depth cell size is not limited to the typical values specified, b) longer ranges available, c) BroadBand mode single-ping standard deviation (Std.Dev.)

Long Range Mode

	Range (m)	Depth Cell Size (m)	Std. Dev. (mm/s)
1200kHz	19	2	35
600kHz	67	4	38
300kHz	165	8	38

Profile Parameters

Velocity accuracy:

- 1200, 600: $\pm 0.25\%$ of the water velocity relative to the ADCP ± 2.5 mm/s
- 300: $\pm 0.5\%$ of the water velocity relative to the ADCP ± 5 mm/s

Velocity resolution: 1mm/s

Velocity range: ± 5 m/s (default):
 ± 20 m/s (maximum)

Number of depth cells: 1-128

Ping rate: 2 Hz (typical)

Echo Intensity Profile

Vertical resolution: depth cell size

Dynamic range: 80 dB

Precision: ± 1.5 dB (relative measure)

Transducer and Hardware

Beam angle: 20°

Configuration: 4 beam, convex

Internal memory: Unit comes with 10Mb card, standard. Two PCMCIA card slots available (10-220Mb each).

Communications: Serial port selectable by switch for RS-232 or RS-422. ASCII or binary output at 1200-115,400 baud.

Standard Sensors

Temperature (mounted on transducer)

- Range: -5° to 45°C
- Precision: ± 0.4 °C
- Resolution: 0.01°

Tilt

- Range: ± 15 °
- Accuracy: ± 0.5 °
- Precision: ± 0.5 °
- Resolution: 0.01°

Compass (fluxgate type, includes built-in field calibration feature)

- Accuracy: ± 2 °^e
- Precision: ± 0.5 °^e
- Resolution: 0.01°
- Maximum tilt: ± 15 °

Note: e) @ 60° magnetic dip angle, 0.5G total field

Power

DC input: 20-60V DC. Internal battery pack, external battery pack or external power supply.

Voltage: 42V DC (new)

28V DC (depleted)

Capacity: @ 0°C: 400 watt hours

Transmit

- 16W @ 35V (1200kHz)
- 37W @ 35V (600kHz)
- 115W @ 35V (300kHz)

Environmental

Standard depth rating: 200m. Optional to 6000m.

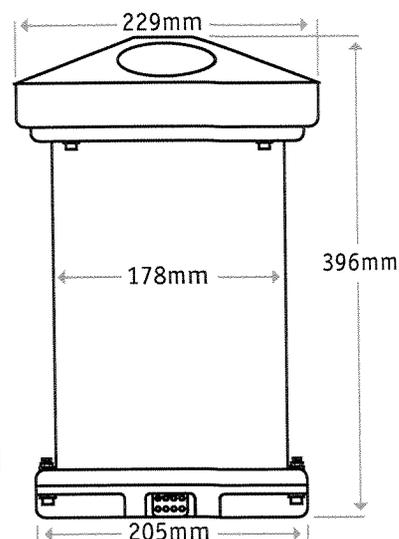
Operating temperature: -5° to 45°C

Storage temperature: -30° to 75°C

Weight in air: 13.0kg

Weight in water: 4.5kg

Dimensions



Software

Use RDI's Windows™-based software for the best results:

- WinSC — Data Acquisition
- WinADCP — Data Display and Export

Upgrades Available

- Memory - 10-220Mb PCMCIA cards
- Pressure sensor
- External battery case
- High resolution water profiling modes
- Bottom tracking
- AC/DC power converter, 48V DC output
- Pressure cases for depths up to 6000m

For More Information

Call, e-mail or visit our web page. Ask for our Primer about ADCPs.

Internet: www.rdinstruments.com

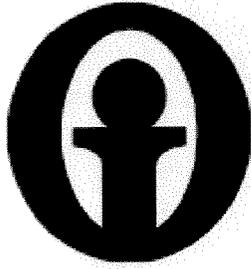
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S4 Current Meter Family

Engineering Data & Specifications

Current Speed

Range	0-350 cm/sec (standard) 0-50, 0-100, 0-600, 0-750 cm/sec
Accuracy:	2% of reading +/- 1 cm/sec
Sampling Rate:	S4/S4A 2 Hz S4AH 5 Hz
Resolution:	2 Hz 0.03 to 0.35 cm/sec depending on range 5 Hz 0.037 to 0.43 cm/sec depending on range
Noise:	Less than the resolution for averages of 1 minute or longer 0.05 cm/sec rms for 10 second averages 0.25 cm/sec rms for 2 second averages 0.75 cm/sec rms for burst sampling (0.5 second rate)
Threshold:	Equal to resolution
Vertical Response:	True cosine response (internally software corrected with Tilt option)

Direction

Type:	Flux-gate compass
Range:	0-360
Resolution:	0.5 deg
Accuracy:	+/- 2 deg within tilt angles of 5 deg

Tilt: +/- 4 deg for tilt angles between 15 and 25 deg

Memory

Type:	S4	CMOS static RAM (Non-restricted Lithium battery protected)
	S4A	Non-volatile flash memory
Battery Life:	S4	5 years
	S4A	No battery required
Capacity:	S4	64K bytes standard (128K, 256K, 512K, or 1M optional) 348,000 vector averages may be stored with 1M bytes
	S4A	5, 10, and 20 megabytes 7 million vector averages stored with 20 megabytes

Timekeeping

Type:	Temperature stable quartz oscillator
Accuracy:	+/- 12 minutes/year
Power:	Temperature stable non-restricted Lithium battery (3 years)

Power Supply

Type:	Internal batteries (6 Alkaline "D" cells), (Lithium optional)
Endurance:	Alkaline cells: 440 hours continuous logging. One year deployment with total on-time less than 440 hours. Lithium option: 1,600 hours continuous logging. Five years deployment with total on-time less than 1,200 hours.

Tilt Option

Angle Range:	+/- 45 deg
Resolution:	0.06 deg
Accuracy:	(Angle Output) +/- 0.25 deg (Speed Correction) +/- 1% of reading at 45 deg tilt

Mechanical

Size:	S4	25 cm (10 in) diameter
	S4 Deep	35.5 cm (14 in) diameter
Weight:	S4	Air: 11 kg (24 lb.), Water: 1.5 kg (4 lb.)
	S4 Deep	Air: 34.5 kg (76 lb.), Water: 10.5 kg (23 lb.)
Mooring:	In-line	
Through Load:	4,500 kg (10,000 lb.) working	
Pad Eyes:	Insulating liner, accepts 1.6 cm (5/8 in.) shackle pin	
Material:	Sphere, glass-filled cycloaliphatic epoxy. Mooring rod, Titanium 6 AL-4V	
Drag:	S4	4 kg (9 lb.) at 250 cm/sec (8 ft/sec)
	S4 Deep	0.63 kg (1.4 lb.) at 50 cm/sec 15.68 kg (34.57 lb.) at 250 cm/sec
Depth:	S4	1,000 m (3,200 ft) maximum
	S4 Deep	6,000 m (19,200 ft) maximum
Temperature:	Storage: -40 to +50 deg C Operating: -5 to +45 deg C	

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BW006784

WIND MARK III WIND SENSOR

FEATURES

- **Low Threshold**
- **Low Cost**
- **Low Power**
- **Lightweight**
- **Optional External Heaters**

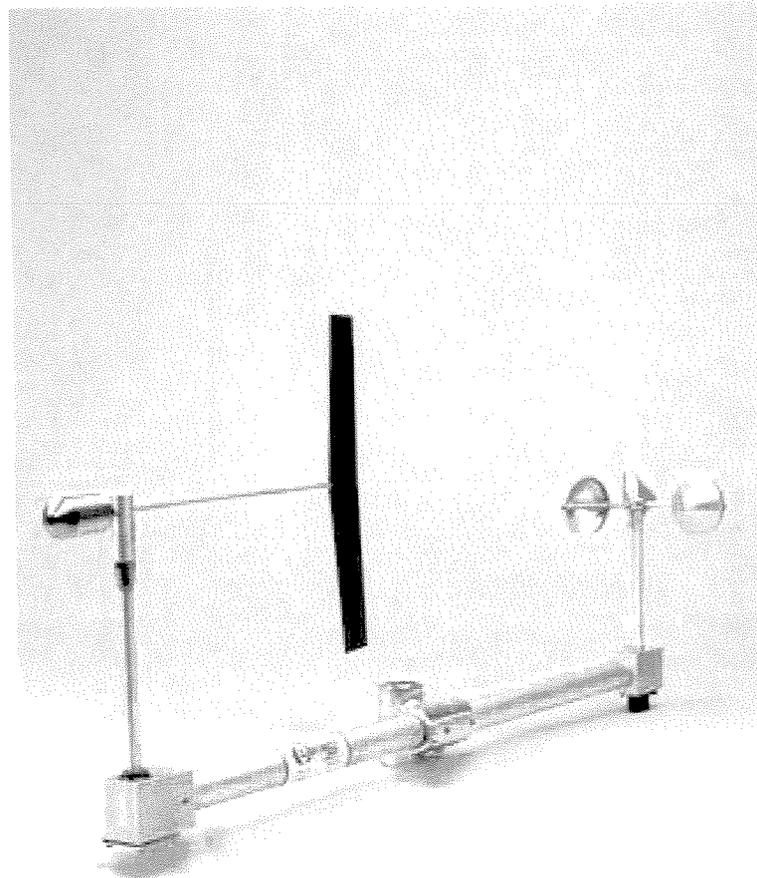
Climatronics' Wind Mark III (WM-III) Wind Sensors combine accuracy and reliability with low cost. They also meet the Environmental Protection Agency (EPA) Prevention of Significant Deterioration (PSD) requirements and are well suited for general wind monitoring applications.

The WM-III sensor is also available as a wind speed only (P/N 100108-1) or wind direction only (P/N 100108-2) instrument.

Wind speed is sensed by a three-cup anemometer and converted to an electrical signal by a solid-state photo chopper. A counter balanced wind vane coupled to a precision, low torque potentiometer senses wind direction. The sensors use stainless steel precision ball bearings for maximum life and low threshold. Traceability to NIST is available as an option for each anemometer cup assembly by comparison testing against an NIST transfer standard in our wind tunnel test facility. The sensors and their crossarm are an integral unit. The crossarm mounts on a 3/4-inch IPS vertical pipe stub (1.05 inch O.D.). Orientation of the crossarm is along an East-West plane.

The LEXAN cup (P/N 102138) and magnesium vane (P/N 101944) combination are standard. The Heavy-duty aluminum cups (P/N 101286), and heavy-duty magnesium vane (P/N 101292) are optional. A sensor transit case (P/N 100255) is available. Climatronics Universal Interface Module (UIM), IMP-800 series of digital data acquisition units, or almost any data loggers / data acquisition system currently available on the market are easily interfaced with the Wind Mark III sensor.

The Wind Mark III sensor can be provided with a 4 - 20 mA current loop output. In this configuration, the part number is 101908. Please consult the Current Loop Wind Sensor data sheet for additional details.



SPECIFICATIONS

PERFORMANCE

	WM-III Wind Speed	WM-III Wind Direction
Accuracy	0.25 mph (± 0.11 m/s) or $\pm 1.5\%$ of true air speed (whichever is greater)	± 3 degrees
Threshold	<1.00 mph (0.45 m/s)	< 1.0 mph (0.45 m/s)
Distance Constant	102138 LEXAN <2.4 m (8.0 ft) 101286 HD Aluminum <4.6 m (<15.0 ft)	101944 Standard <2.4 m (8.0 ft) 101292 Heavy Duty <4.5 m (<15.0 ft)
Damping Ratio	N/A	>0.4 to 0.6 at 10° initial angle of attack
Operating Range	0 to 125 mph (0 to 55 m/s)	0 to 360 degrees - mechanical

ELECTRICAL

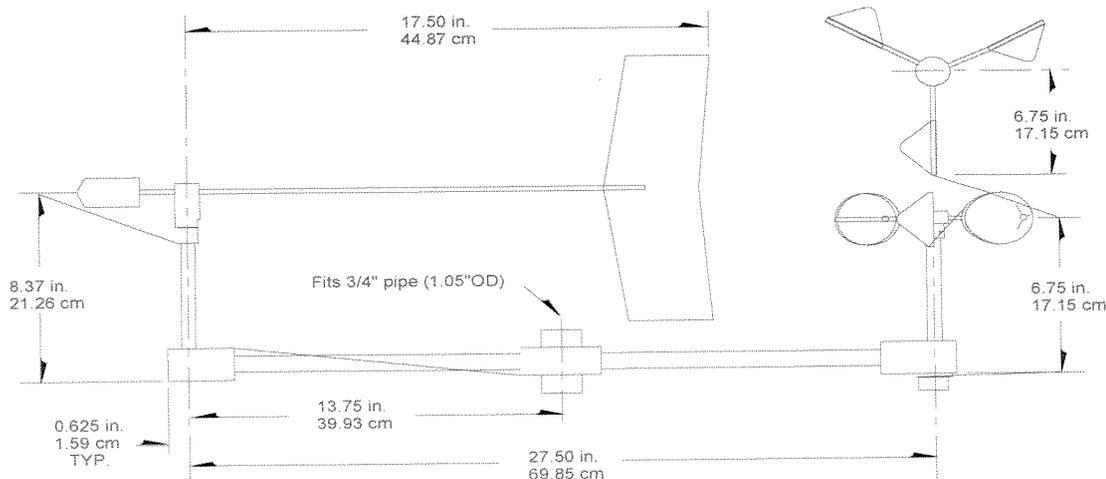
Signal Output	Nominal 2.0 Vpp into 4.7 Kohm, frequency proportional to wind speed, amplitude dependant on supply voltage	Variable DC voltage, magnitude proportional to wind direction
Power Requirements	5 to 15 Vdc @ 1 mA nominal	Max. 5 mA through 2 Kohms

PHYSICAL

Weight	Less than 2 lbs (0.9 kg)	
Turning Radius	3.75 in (9.5 cm)	17.5 in (44.4 cm)
Operating Temperature	-40° to 140°F (-40° to 60°C)	

SENSOR HEATER SPECIFICATIONS

External 20 Watts per sensor thermostatically controlled
110/60 VAC/Hz, P/N 101234-G0 or 220/50 VAC/Hz, P/N 101234-G1



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Rev. 24 Jan 2002

TEMPERATURE SENSORS

FEATURES

- **Maintenance Free**
- **Versatile**
- **Highly Accurate**
- **Durable**

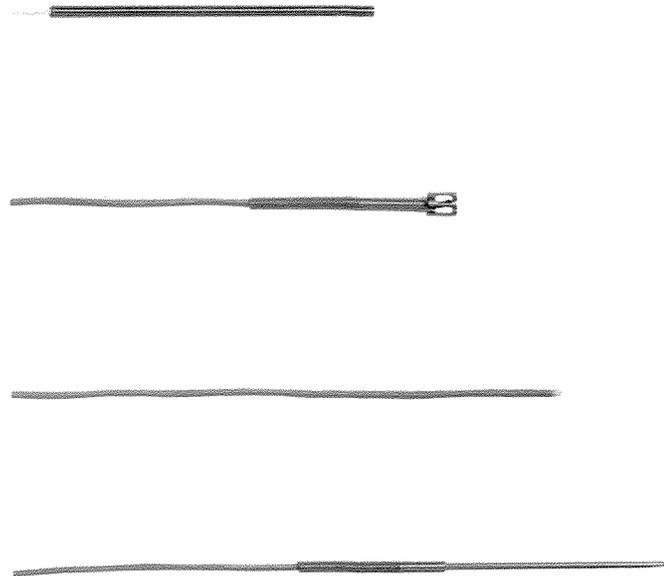
Capable of meeting virtually any ambient measurement need, Climatronics' temperature sensors are accurate, durable, and linear over a wide range, can be provided with NIST traceable calibration, and are well matched for high accuracy delta temperature applications.

The Air, Water/Soil, and Expanded Range Sensors encase a thermistor bead in a stainless steel or vinyl sheath. This casing, combined with Climatronics' temperature shield, gives the thermistor bead protection from solar radiation, precipitation, and corrosive, airborne particles. Such configurations transfer heat as rapidly as possible, yielding a typical time constant of 3.6 seconds. When direct exposure of the thermistor to the media being measured is permissible, our Fast Response Sensor reduces the time constant to a minimal 0.6 seconds.

A second type of sensor, Platinum 4-Wire, operates on the principle that electrical resistance of a pure metal increases with temperature. Platinum's superior linearity, stability, sensitivity and resistance to corrosion, make it an ideal practical choice. The unit's four-wire design automatically compensates for possible lead resistance errors, and it is supplied with certified NIST traceability.

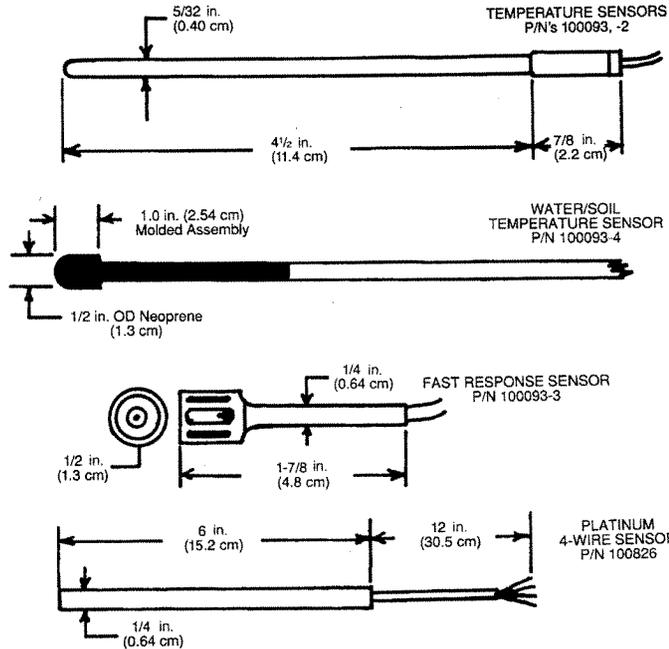
Sensors install easily in Climatronics' temperature shields. The TS-10 Motor Aspirated Shield, P/N 100325, provides a constant airflow past the sensor (as discussed in the TS-10 data sheet), while the Naturally Aspirated Shields (P/N 100552 or P/N 102080), rely on ambient air flow or convection for sensor aspiration.

Please consult Climatronics for assistance with the proper combination of sensor, shield, cable, and data acquisition electronics to meet your specific monitoring requirements.



SPECIFICATIONS

	Air, Water/Soil P/N's 100093 (102090*) 100093-4	Expanded Range P/N 100093-2 (102096*)	Fast Response P/N 100093-3	Platinum 4-Wire P/N100826 (102092*)
Accuracy	±0.27°F (±0.15°C) over full range	±0.18°F** (±0.10°C) over full range	±0.27°F (±0.15°C) over full range	±0.18°F (±0.1°C)
Range	-22.0° to 122.0°F (-30.0° to 50.0°C)	-58.0 to 122°F (-50.0° to 50.0°C)	-22.0° to 122.0°F (-30.0° to 50.0°C)	-58.0° to 122.0°F (-50.0 to 50.0°C)
Time Constant	3.6s	3.6s	0.6s	5.5s
Interchangeability	±0.27°F (±0.15°C)	±0.18°F (±0.10°C)	±0.27°F (±0.15°C)	±0.45°F(±.25°C) can be compensated
Linearity	±0.29°F (±0.16°C)	±0.25°F (±0.16°C)	±0.29°F (±0.16°C)	±0.09°F (±0.05°C) included in accuracy
Leads	3	4	3	4
Dimensions				
Diameter	5/32 in (0.40 cm) 0.5 in (1.3 cm)	5/32 in (0.40 cm)	½ in (0.64 cm)	¼ in (0.64 cm)
Length	4.5 in (11.4 cm) 1.0 in (2.54 cm)	4.5 in. (11.4 cm)	1-7/8 in (4.8 cm)	6.0 in (15.2 cm)



** Can be improved to ± 0.08°C with 0.02% accuracy composite resistors.
* Includes MS Connectors



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RELATIVE HUMIDITY SENSORS

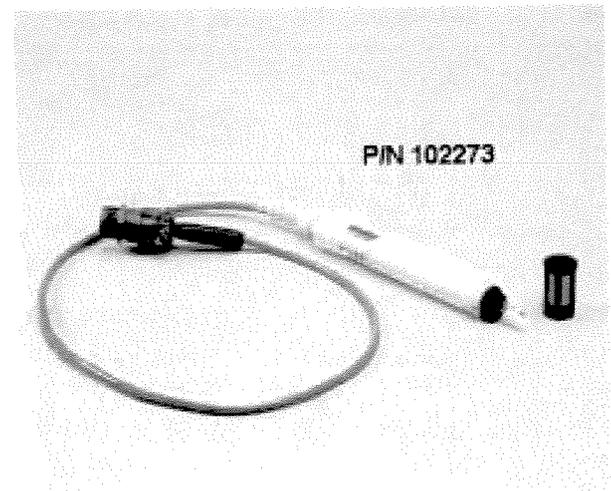
FEATURES

- **Inexpensive**
- **Excellent Long-Term Stability**
- **Wide Operating Temperature Range**
- **Contamination Resistant**
- **Optional Temperature Sensor**
- **Linear Voltage Output**
- **Compact Size**

Climatronics' capacitive relative humidity sensors, P/N 102273 and 102425 are specifically designed for meteorological monitoring systems. Very low power consumption makes these relative humidity sensors ideal for integration with data acquisition systems operating at remote locations. Both sensors provides a linear 0 to 1 VDC output signal corresponding to 0 to 100% relative humidity.

The sensors require a minimum of maintenance or calibration and features exceptional resistance to contaminants. Repeatability is also excellent, even after complete sensor saturation. The P/N 102273 sensor maintains its accuracy over the full range of humidity, even in conditions close to condensation. This is accomplished by electronic temperature compensation of the humidity element. The moderately priced P/N 102425 sensor does not have the high overall accuracy of the P/N 102273 and an increase in error at the upper and lower 10% of its range.

Both sensors include provision for adding a temperature measurement. The temperature option for the P/N 102273 is a dual bead thermistor with electrical and performance characteristics identical to that of Climatronics P/N 100093 temperature sensor. The temperature option of the P/N 102425 sensor is a PT100 platinum transducer, which produces a 0 to 1 VDC linear output of the specified temperature range. Dimensions and weight of the sensors remain the same with or without the temperature option.



SPECIFICATIONS

PERFORMANCE

P/N 102273

P/N 102425

Relative Humidity

Accuracy	<+/- 1% RH from 0 to 100%	<+/- 3% RH from 10 to 90 %
Repeatability	+/-0.3% RH	
Operating Range	0 to 100 %	0 to 100 %
Operating Temperature Range	-40° to 60°C	-10° to 60°C
Long Term Stability	+/-1% over 12 months	+/- 5% RH over 24 months
Response Time (without filter)	10 seconds	10 seconds

Temperature

Type	Dual bead thermistor	PT1000 DIN 43760B
Accuracy	+/- 0.15°C	+/- 0.6°C
Range	-30° to 50°C	-10° to 60°C

ELECTRICAL

Relative Humidity

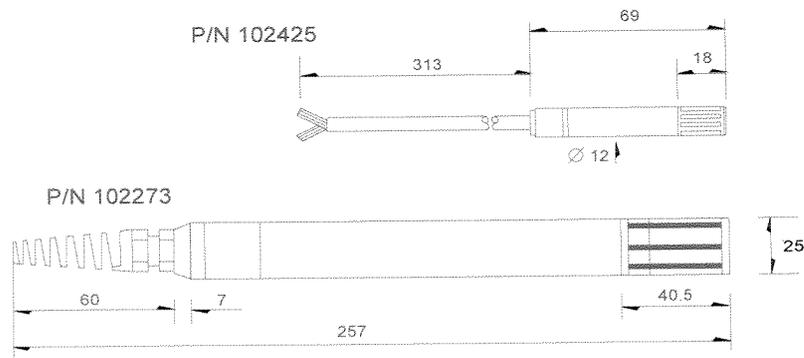
Excitation Power	4.8 to 30 VDC; 2.5 mA @ 12 VDC	7 to 28 VDC; 2 mA @ 12 VDC
Signal Output	0 to 1 VDC = 0 to 100%	0 to 1 VDC = 0 to 100%
Output Impedance	1000 Ohms	

Temperature

Excitation Power	Precision DC voltage supplied by Climatronics data logger or signal conditioner	7 to 28 VDC; 2 mA @ 12 VDC
Signal output	Variable, low level DC voltage for input to data logger or signal conditioner	0 to 1 VDC = -40° to 60°C

PHYSICAL

Length	10.12 in (257 mm)	2.7 in (69 mm)
Transducer Diameter	0.98 in (25 mm)	0.47 in (12 mm)
Weight	0.15 lb (70 g)	0.15 lb (70 g)



Dimensions in mm / Modifications reserved



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Rev. 10 Jan 2002

BW006790

NATURALLY ASPIRATED SHIELDS

FEATURES

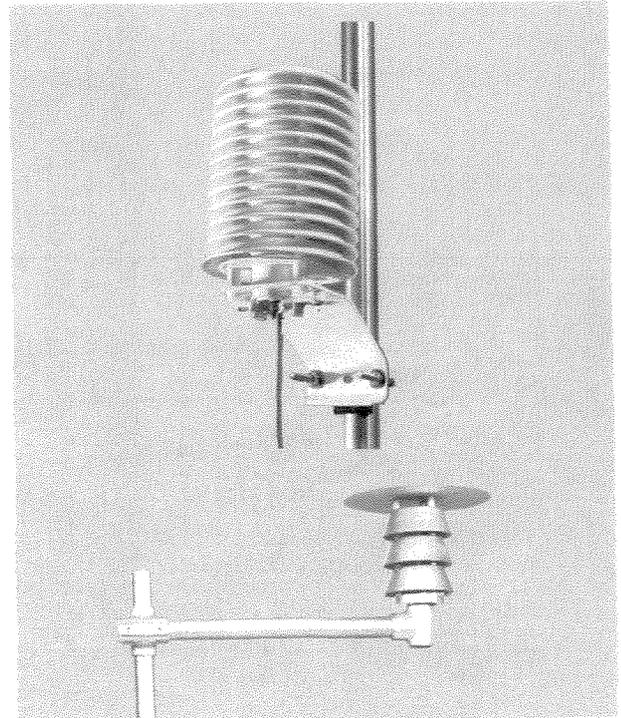
- **Low Cost**
- **Compact, Lightweight**
- **Maximized Radiation Protection**

Climatronics offers three types of naturally aspirated shields. All are field proven, varying principally in price, materials, and mounting configuration. They are naturally ventilated and designed to our ambient temperature, relative humidity, and dew point temperature sensors in applications where AC power is unavailable or maximum sensor accuracy is not required. The shields may be mounted on a tower or boom with pipe size varying from $\frac{3}{4}$ " to 2". All feature easy access for sensor installation and servicing.

The Multi-Plate Radiation Shield, P/N 101956 and 102080, consists of twelve, white opaque molded, thermoplastic discs permitting easy air passage through the shield. This material provides high reflectivity, low thermal conductivity, and low heat retention. The unique disc profile provides positive blockage of direct and reflected solar radiation. Wind tunnel tests with maximum artificial radiation indicate that under conditions of low air movement (1m/s) the temperature sensor is maintained within 2.7 °F (1.5 °C) of ambient. This improves to 0.7 °F (0.4 °C) or less at wind speed greater than 3 m/s.

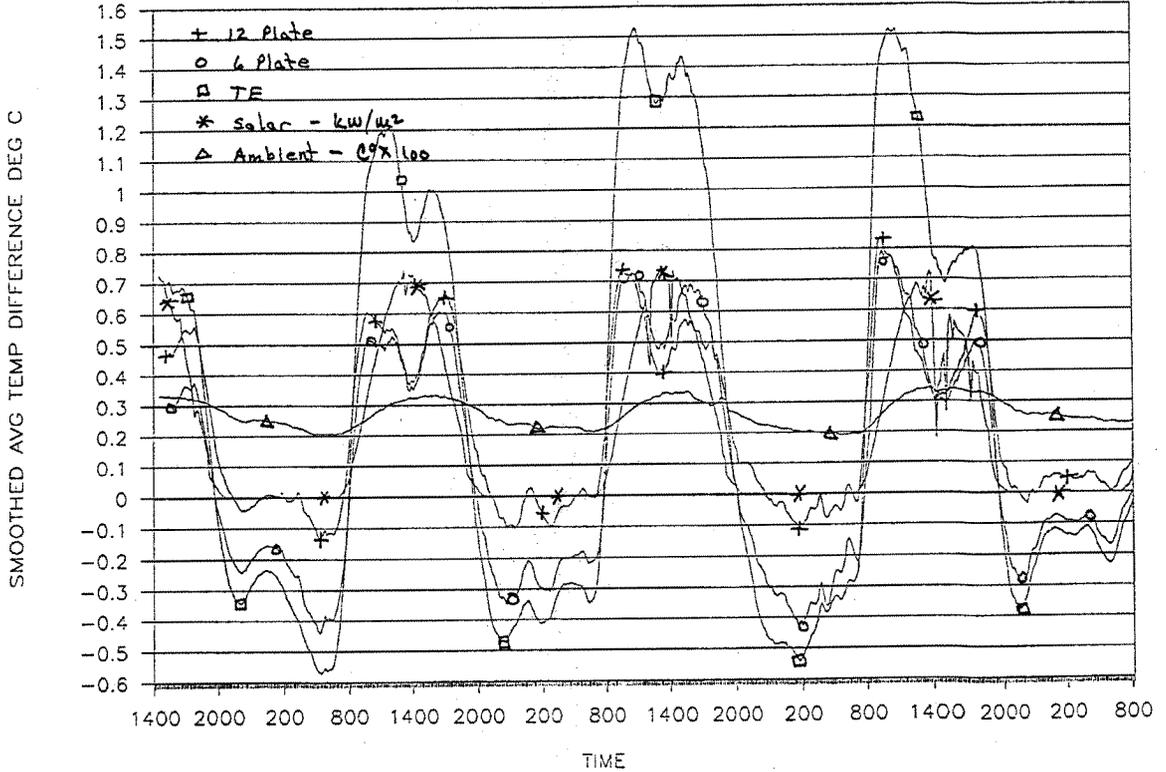
The Anodized Aluminum Shield, P/N 100552, is our most cost-effective shield designed to house Temperature Sensor, P/N 100093, and/or Relative Humidity Sensor, P/N 100098. These sensors are held inside the shield via a mount made of Delrin. The cover plate of this shield provides a convenient location for mounting any of Climatronics solar radiation sensors.

The Aluminum Dew Point Shield, P/N 100859, is designed specifically to protect the Lithium Chloride Dew Point Sensor, P/N 101197, from solar radiation and atmospheric contamination. The shield consists of a heater board assembly along with two cylindrical tubes and a baffle network. Natural aspiration of the sensor is controlled by the internal baffle network designed to avoid measurement oscillations, which may develop if the sensor is over aspirated.



SMOOTHED AVG DIFFERENCE FROM REF

T083091 / 8-26-91 TO 8-30-91



SPECIFICATIONS

PERFORMANCE

Radiation Error

P/N 102080
P/N 101956

P/N 100552

P/N 100859

0.7 °F RMS @ 6.7 mph
(0.4 °C RMS @ 3 m/s)

Not Available

Not Available

With 1080 W/m²
intensity
Dependent upon
wind speed
(ventilation rate).

1.3°F RMS @ 4.5 mph
(0.7°C RMS @ 2 m/s)

2.7 °F RMS @ 2.2 mph
(1.5 °C RMS @ 1 m/s)

PHYSICAL

Dimensions

Overall

4.7 in diameter, 10.6 in
high
(12 cm diameter, 27 cm
high)

4 in diameter, 8.75 in high
(10 cm diameter, 22 cm
high)

4.75 in diameter, 14.5 in
high
(12 cm diameter, 37 cm
high)

Weight Net
Shipping
Volume

1.5 lbs (0.7 kg)
3 lbs (1.4 kg) approx.
0.1 ft³

2.3 lbs (1.0 kg)
4.5 lbs (2.0 kg) approx.
0.06 ft³

1.6 lbs (0.7 kg)
3.5 lbs (1.6 kg) approx.
0.15 ft³



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Rev. 8 Jan 2002



RECYCLED

APPENDIX B

Standard Operating Procedures (SOPs)

Dissolved Oxygen

Determination of Dissolved Oxygen Content

The method described here is a modification of the classical Winkler Method. A divalent manganese solution, followed by a strong alkali is added to the water sample. The resulting precipitated manganous hydroxide is dispersed evenly through-out the seawater sample which completely fills a stoppered glass bottle. Any dissolved oxygen rapidly oxidizes an equivalent amount of divalent manganese to basic hydroxides of higher valency states. When solution is acidified in the presence of iodine, the oxidized manganese again reverts to the divalent-state and iodine, equivalent to the original dissolved oxygen content of the water, is liberated. This iodine is titrated with standard thiosulfate solution (Strickland and Parsons, 1972).

If you want more information on this method and variations thereof, consult Strickland Parsons (1972, on reserve).

I. Sampling Procedure

A. Carefully fill a siphon bucket by turning the bucket on its side and gently lowering it into the water so as not-to-disturb the surface of the water. Once the bucket is beneath the water, swirl it back and forth a couple of times and lift it out of the water, again being careful not disturb the surface.

B. Using the siphon tube attached to the bucket,

1. Fill 300 mL BOD bottles from-the-bottom, being careful to minimize turbulence and agitation of the sample. Let the bottle overflow for 5 or more seconds and stopper the bottle. Fill all the bottles at once.
2. Remove the stopper and add 1 mL MnSO_4 from the automatic pipette. Place the tip of the pipette just below the surface of the water, then add 1 mL alkaline iodide solution (AI).
3. Restopper and shake until the precipitate is evenly dispersed. Make sure there are no air bubbles in the bottle.
4. After the precipitate has settled, re-shake the bottle to ensure complete reaction.
5. Put a little water on top of the stopper and place a plastic cap on top of the bottle. The sample can now stand indefinitely at this stage if the temperature remains fairly constant.

II. Analytic Procedure

Automatic filling burettes and magnetic stirrers are available of the titration procedure.

50 mL sample

A. Add 2 mL conc H_2SO_4 to the sample, stopper and shake until precipitate dissolves.

Titrate within one hour. (You may add acid to 4-6 bottles at a time.)

1. Using a 50 mL volumetric pipette or cylinder, transfer 50 mL of sample into a flask or beaker.
2. Titrate with standard 0.1 N sodium thiosulfate while stirring moderately until the solution is almost colorless (pale yellow).
3. Add a little starch indicator (solution turns blue) and complete titration. Note "V", volume titrated in mLs (read burette carefully to 0.001 mL).
4. Perform at least 2 replicates per bottle. Values should agree within 0.003 mL.

C. Calculate Oxygen Content

$$\begin{aligned} \text{mg-at. } O_2 / L &= 0.1006 (f) (V) \\ \text{mL } O_2 / L &= 11.2 \times \text{mg-at. } O_2 / L \\ \text{mg } O_2 / L &= 16.0 \times \text{mg-at. } O_2 / L \end{aligned}$$

D. Determination of factor "f"

1. Fill a 300 mL BOD bottle with water.
2. Add 1 mL conc. H_2SO_4 and 1 mL AI solution and mix thoroughly. Add 1 mL H_2SO_4 and mix again.
3. Withdraw 50 mL aliquots. Add 1.0 mL of 0.1 N iodate. Allow the iodine liberation to proceed for exactly 2.5 minutes. Keep the solution out of direct sunlight.
4. Titrate the iodine with thiosulfate.
5. Calculate "f"

$$f = 1.0 / V \quad V = \text{vol. titrated, in mL}$$

The determination of "f" must be done each time you do a series of samples. It is extremely important that this be done accurately, so be sure to get good replicate titrations here.

**NITRATE/NITRITE:
NITRATE IS CALCULATED BY SUBTRACTING THE
NITRITE VALUE FROM THE COMBINED
NITRATE/NITRITE VALUE**

4.0 Nitrate + Nitrite (Lachat QuikChem)

4.1 Scope and Application

EPA Method 353.2 is the reference method for measuring Nitrate + Nitrite in brackish surface waters by automated colorimetric determination. This section provides a stepwise procedure for bench use by laboratory personnel.

- 4.1.1 This method (Lachat QuikChem nitrate method number 11-107-04-1-A) was developed for the quantitative analysis of nitrates in surface waters. The applicable range is 0.002 to 0.100 mg/L as nitrogen. Brackish samples higher in range may be analyzed using Lachat Quikchem nitrate method number 10-107-04-1-C.
- 4.1.2 This method is based on automated colorimetric determination and is restricted to the use by or under the supervision of analysts experienced in the use of autoanalyzers as a quantitative tool.

4.2 Summary of Method

The whole water sample is filtered through a 0.7 μm GF/F filter in the field. The filtrate is frozen at -20°C or below until analysis can be completed (samples must not be preserved with mercuric chloride or thiosulfate, as these degrade the copper-cadmium column used in this analysis). Analysis is completed within 28 days from arrival date at the laboratory. Samples for Nitrate + Nitrite are analyzed using flow injection on a Lachat QuikChem Auto Analyzer. Nitrate is reduced to Nitrite at pH 7.5 in a copperized cadmium column. The Nitrate reduced to Nitrite, plus any free Nitrite present, reacts under acidic conditions with Sulfanilamide to form a diazo compound that couples with N-1-Naphthylethylenediamine Dihydrochloride to form a reddish-purple azo dye that is measured at 520 nm.

The Lachat QuikChem Auto Analyzer is calibrated with a six point curve at the time of analysis. The calibration curve is then verified by an external quality control sample from either the EPA or ERA (Environmental Resource Associates, an independant supplier). Both the EPA and ERA supply guidelines for making up the quality control solutions, as well as information on the true value and acceptable value range for the analytes being measured in each quality control sample. This initial calibration check, along with an initial calibration blank, demonstrate that the instrument is capable of acceptable performance at the beginning of the sample analysis. In order to ensure continuing acceptable performance a continuing calibration check and continuing calibration blank are run every tenth sample. For every Sample Delivery Group (SDG \leq 20 samples) a laboratory spike analysis and a laboratory duplicate analysis are performed. Percent recovery for the spike is determined using the following formula:

$$\%R = 100(X_s - X_u)/K$$

Where

X_s = measured value for the spike

X_u = measured value for the original sample, adjusted to allow for the dilution caused by the spike

K = known value of the spike in the sample.

Relative percent difference for the duplicate is calculated by:

$$\frac{A-B}{A+B/2}$$

$$A+B/2$$

Where

A = the value determined for the first run of the sample

B = the value determined for the second run of the sample.

4.3 Apparatus

The instrument used is the Lachat Quikchem Automated Ion Analyzer. For a detailed description, see section 3.0.

4.4 Interferences

- 4.4.1 Build up of suspended matter in the cadmium column will restrict flow. Look for a "jerking" action in one or several of the pump tube lines as evidence of such a blockage. Nitrate nitrogen is, however, found in a soluble state, so pre-filtering of samples should be sufficient to keep lines clear.
- 4.4.2 Low results are possible for samples high in metals concentrations such as iron or copper. 1.0 g per liter $\text{Na}_2\text{EDTA}\cdot 2\text{H}_2\text{O}$ can be added to the buffer to reduce this interference.
- 4.4.3 Samples that contain large concentrations of oil and grease will coat the surface of the cadmium. This interference is eliminated by pre-extracting the sample with an organic solvent.

4.5 Manifold: Nitrate + Nitrite

This manifold is complete and kept in place on the system unit. It functions as described in section 3.0.

4.6 Reagent Preparation

Unless otherwise specified, all chemicals should be ACS grade or equivalent (make note especially of the first reagent recipe). DI water refers to high quality reagent water, TYPE I or TYPE II as defined in ASTM Standards, Part 31, D1193-75.

Some of the following reagents can be made by weight. If so, both a volumetric and a weight method will be given. When making reagents, it is advisable to date the container in which the reagent is stored.

Reagents and all other solutions except standards should be degassed with helium to prevent bubble formation (which interferes with signal processing). Bubble helium through the solution vigorously (at about 10 psi) for two to three minutes. The solutions should be degassed just prior to use.

Many of the following solutions are stable indefinitely. Otherwise, shelf-life is noted.

4.6.1 64% Artificial Seawater (ASW)

This particular reagent should be made with the highest quality chemicals available, in order to minimize contamination through trace impurities of nitrogen often present. Currently, Fisher Ultrapure Bioreagent Sodium Chloride (<5ppm nitrogen compounds as N per lot, catalog no. 4058-05), Fisher Biotech Sodium Bicarbonate (maximum 5ppm NH₄ impurity per lot, catalog no. BP328-1000), and Fisher Biotech Magnesium Sulfate (<0.002% of both NH₄ and NO₃ per lot, catalog no. BP213-1) are being used. New batches of these chemicals should be ordered well before the old batches run out, so that ASW made with the new chemicals can be analyzed against the old to check for contamination.

Sodium chloride	37.4 g
Magnesium sulfate	12.0 g
Sodium bicarbonate	0.26 g
DI water, q.s.	2000 ml

Dissolve 37.4 g of sodium chloride, 12.0 g of magnesium sulfate, and 0.26 g of sodium bicarbonate in about 1800 ml of DI water in a 2L volumetric flask. Dilute to two liters with DI water and mix thoroughly. Transfer to plastic containers if the ASW is also to be used for silica or phosphorus determinations, as the glass volumetric flask will contaminate the ASW with silica (an interferent in both phosphorus and silica analyses).

4.6.2 Stock Imidazole Buffer, 0.1 M

This recipe was taken from Technicon Traacs 800 Industrial Method no. 824-87T, Bran + Luebbe Analyzing Technologies, Inc. The original buffer recipe suggested by Lachat Instruments contains ammonium chloride, which could contaminate ammonia analyses when run concurrently with nitrates. We are presently using Aldrich Imidazole (catalog no. I-20-2) and Baker Hydrochloric Acid (catalog no. 9535-33).

Imidazole	6.81 g	
Hydrochloric acid		As required
DI water, q.s.		1000 ml

Dissolve 6.81 g of imidazole in about 900 ml of DI water. Adjust pH to 7.5 ± 0.05 with hydrochloric acid. Dilute to one liter with DI water and mix thoroughly.

4.6.3 Working Imidazole, 0.05 M

Stock imidazole buffer, 0.1 M		50 ml
DI water, q.s.	100 ml	

Dilute 50 ml of stock imidazole buffer, 0.1 M, to 100 ml with DI water, and mix thoroughly. Keep any leftover solution refrigerated. Prepare fresh weekly.

4.6.4 Sulfanilamide Color Reagent

We are currently using Fisher Sulfanilamide (catalog no. O4525-100), Kodak NED (catalog no. 1465-25-4), and Aldrich Phosphoric acid (catalog no. 21,510-4).

Phosphoric acid (85% soln. by wt.)		100
Sulfanilamide	40.0 g	
NED (N-(1-naphthyl)ethylene-diamine dihydrochloride)		1.0 g
DI water, q.s.	1000 ml	

By Volume: To a 1L volumetric flask add 600 ml of water. Then add 100 ml of 85% phosphoric acid, 40.0 g sulfanilamide, and 1.0 g NED. Shake to wet, and stir to dissolve for 20 min. Dilute to the mark, and invert three times. Store in a dark bottle. This solution is stable for one month.

By Weight: To a tared, dark 1L container add 876 g water, 170 g (100 ml) 85% phosphoric acid, 40.0 g sulfanilamide, and 1.0 g NED. Shake until wetted and stir to dissolve for 20 min. This solution is stable for one month.

4.6.5 Cadmium-Copper Reduction Column

Pre-packed cadmium columns for use with the Lachat nitrate/nitrite manifold are available from Lachat (Lachat part/order no. 50237). Lachat will also repack spent cadmium columns (Lachat order no. 50237R). The following instructions are for persons wishing to pack or repack their own columns.

4.6.5.1 Cadmium Preparation

CAUTION: cadmium is very toxic and a known carcinogen! Work under a vent hood, wear gloves, and collect all cadmium waste (including rinse materials) for proper disposal.

Place 10-20 g of coarse cadmium granules (40-60 mesh, or about 0.3 to 1.5 mm in diameter--available from Lachat as part no. 50231) in a 250 ml flask or beaker. Wash, in turn, with 50 ml acetone, water, and two 50 ml portions of 1M HCl (one part conc. HCl to eleven parts water). The cadmium should take on a silver appearance. Rinse again several times with water.

4.6.5.2

Copperization

Make up a 2% solution of copper sulfate (20 g $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$; q.s. to 1 liter with DI) and add a 100 ml portion to the cadmium. Swirl for about five minutes or until the blue color partially fades. Decant and repeat the process with fresh copper sulfate until the blue aqueous copper color persists. At this point there should be a brown colloidal precipitate. Decant and wash with distilled water at least ten times, to remove the precipitated copper. The copperized cadmium may now be stored immersed in imidazole solution in a stoppered bottle.

4.6.5.3

Packing the Column

Again, be aware that cadmium is very toxic. Wear gloves, work under a hood, and catch excess cadmium in a tray dedicated to this purpose.

Empty cadmium columns are available from Lachat (part no. 50230). It is helpful to clamp the column upright using a small burette clamp, so that both hands may be free. Unscrew one of the colored fittings on the end of the column (be careful, as the column threads are glass and chip easily). Pull out and save the foam plug for later. Keeping the unscrewed fitting higher in level than the open end of the column, fill the column and attached tubing with imidazole buffer. Using a spatula, scoop up some copperized cadmium granules and pour them into the column. Let the granules sink to the bottom, tapping the column in the meantime to dislodge air bubbles and to settle the cadmium more evenly. Once the cadmium is about 5 mm from the top of the column, replace the foam plug and screw on the colored fitting. Rinse the outside of the column thoroughly with water.

4.7 Standard Preparation

Final working standards can be made by either weight or volume. The weight method is preferred as it is more accurate.

4.7.1 Stock Standard A, 100.0 mg/L N

Potassium nitrate	0.7218 g
DI water, q.s.	1000
	ml

In a 1L volumetric flask containing about 800 ml of water add 0.7218 g of potassium nitrate (KNO₃, Aldrich catalog no. 22,129-5) and swirl to dissolve. Dilute to one liter and mix thoroughly.

4.7.2 Stock Standard B, 1.0 mg/L N

Stock standard A	1
	ml
64% ASW, q.s.	100
	ml

In a 100 ml volumetric flask containing about 80 ml of 64% ASW add 1 ml of stock standard A. Dilute to 100 ml with 64% ASW and mix thoroughly.

4.7.3 Working Standard Solutions

<u>ml(g) Stock B</u>		<u>mg/L N</u>
10.0	0.100	
5.0	0.050	
2.0	0.020	
1.0	0.010	
0.5	0.005	
0.2	0.002	

4.7.4 Preparation of working standards:

By Volume: Transfer aliquots of stock standard B as noted above to individual 100 ml volumetric flasks. Dilute to volume with 64% ASW and mix thoroughly. Prepare fresh daily.

By Weight: Tare out five clean, dry 125 ml containers. To each, add about 10.0, 5.0, 2.0, 1.0, 0.5, and 0.2 g, respectively, of stock standard B (as noted above). For each in turn, measure the exact weight of solution added and multiply this weight, respectively, by 10, 20, 50, 100, 200, and 500. The answers obtained indicate the total weight of the diluted solution to be made. Make up each of the solutions to this weight with 64% ASW. A wash bottle is helpful in adding the last 10 grams of ASW to the precise weight desired. Cap and mix thoroughly. Prepare fresh daily.

4.8 Sample Preparation

Sample turbidity is removed by filtration through a 0.7 μm GF/F filter in the field. Turbidity absorbing in the range of 520 nanometers (nm) will present a positive bias. Preserve the sample by freezing at -10°C or below until the time of analysis (again, do not use mercuric chloride or thiosulfate for preservation. See section 4.2 above). Samples with pH below 5 or above 9 should be adjusted to between 5 and 9 with either conc. NaOH or conc. HCl before running. Sample containers are rinsed with 1:1 hydrochloric acid, followed by DI water and finally by an aliquot of the sample itself. Disposable plastic sample tubes are used to avoid contamination from improper washing of glass tubes.

4.9 Instrumental Analysis

It is assumed that the user is basically familiar with the appearance and location of the various parts of the Lachat. For a physical description of the instrument, see section 3.0.

It is also assumed that a method for running nitrate analyses has already been created, and that the user is familiar with basic system operations. For more information on the creation of Lachat methods and on basic operations, see sections 3.1 and 3.2.

4.9.1 Method Timing and Calibration Curve Segmentation

This refers to parameters set during the creation of the method. Again, see the section on creation of methods.

Pump speed: 35
Cycle period: 60 s
Load period: 30 s
Inject period: 30 s
Inject to start of peak: 24 s
Inject to end of peak: 78 s
Segmentation: two segments of four and three standards each (100 to 10, 10 to 2).

4.9.2 Other System Notes

Light interference filter: 520 nm
Sample loop: 50 cm
Pump tube changes: None.
Special instructions: Once the system is flushed with reagent (see section 3.2.1.6 above), stop the pump and put the cadmium reduction column "on line" in the reaction module. Restart the pump. Before shutting down the system (see section 3.2.3 above), stop the pump and remove the cadmium column, connecting the ends with a union. Avoid introducing air or excessive amounts of water into the column. If this occurs, reconnect the cadmium column to the manifold and pump buffer solution for several minutes, tapping the column with a screwdriver handle to dislodge any air bubbles that may be trapped.

CHLOROPHYLL A METHOD

(Fluorometric method)

The fluorometric method for determining chlorophyll a is more sensitive than the spectrophotometric method but is applicable only for marine work since it depends on the absence of chlorophyll b, which is undetectable in the open ocean. The fluorometer is calibrated with chlorophyll a standard of known value which is also run by spectrophotometric method.

A known volume of water is filtered through a 0.7 μm 47 mm GF/F filter and the resulting pigments are extracted with an aqueous Acetone Magnesium Carbonate solution. The fluorescence of the extract is determined with a fluorometer and the chlorophyll a concentration is calculated.

Turner model 450 Fluorometer or equivalent with a 1 cm light path length.

Unless otherwise specified, all chemicals should be ACS grade or equivalent. DI water refers to high quality reagent water, Type I or Type II as defined in ASTM Standards, Part 31, D1193-75.

16.4.1 Saturated Magnesium Carbonate Solution

There are several manufacturers of magnesium carbonate. Fisher (catalog no. M29-100) is a good source.

Magnesium carbonate		1 g
DI water	100 ml	

Preparation:

Add 1.0 gram of magnesium carbonate to 100 ml of water and mix thoroughly. The magnesium carbonate will not dissolve completely.

16.4.2 Aqueous Acetone

We are currently using Baker Acetone (catalog no. 9006-03).

Acetone	90 ml
Saturated magnesium carbonate	10 ml

Preparation:

Combine 90 ml of acetone with 10 ml of magnesium carbonate solution and mix thoroughly.

A known volume of water is passed through a 47 mm 0.7 μ m GF/F filter pad in the field. The pad is then folded in half and stored in aluminum foil, labeled, and frozen until analysis can take place.

16.6.1 Before analysis the filter pad is thawed and then placed in a 15 ml glass screw top centrifuge.

16.6.2 10 ml of 90% acetone is added.

16.6.3 The tube is then shaken and the samples are allowed to extract for 24 hours in the dark at 4° C.

16.7.1 The tubes are removed from the refrigerator and allowed to warm to room temperature under dark conditions.

16.7.2 The samples are clarified by centrifuging closed tubes for 20 minutes at 500 rpm. They are then decanted into clean glass screw top vials.

16.7.4 Stock standard A for chlorophyll is Sigma catalog no. C-6114, 1000 mg chlorophyll a/L in acetone.

16.7.5 Prepare serial dilutions of the extract using 90% Acetone to provide concentrations of approximately 40, 100, 200, and 400 ug/l chlorophyll a.

F_S = Calibration factor for sensitivity setting S.

R_S = Fluorometer reading for setting S.

16.7.6 Measure sample fluorescence at fluorometer sensitivity setting that provides a mid-scale reading. Convert fluorescence readings into chlorophyll a concentrations by multiplying the reading by the calibration factor of a known standard.

Determine the "corrected" chlorophyll a and pheophytin a in the sample extracts with the following equation.

$$\text{ug chlorophyll a/L: } \frac{F_d \times R \times \text{vol extract (liters)}}{\text{volume filtered (liters)}}$$

where:

R = Fluorometric reading, ug chlorophyll a/L

F_d = door factor = C_a/R_d

R_d = reading of C_a on fluorometer door, ug chlorophyll a/L