Florida Water Resources Monitoring Council

Best Practices Manual: Continuous Monitoring Water Quality Data

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Introduction

The principal function of this document is to identify the best management practices utilized for continuous monitoring throughout the state of Florida. This manual is intended to be a guidance document for the collection of continuous water quality data. Agencies contributing to this document include:

- Southwest Florida Water Management District (SWFWMD)
- South Florida Water Management District (SFWMD)
- St. John's River Water Management District (SJRWMD)
- Florida Department of Environmental Protection (FDEP)
- Suwannee River Water Management District (SRWMD)
- Guana Tolomato Matanzas National Estuarine Research Reserve (GTMNERR)

Equipment Overview

Sensor Types

Optical

AGENCY	SENSOR TYPE
SFWMD	• Optical probe types used include Rugged Dissolved Oxygen (RDO), Turbidity (TURB), Chlorophyll (CHL), Phycocyanin (BGA) ○ Continuous data from turbidity, chlorophyll and BGA probes are used as a screening tool with focus on trends and averages ○ turbidity, chlorophyll and BGA probes are reset to factory default calibration before deployment. Verified reading within 10% of the true value of the standard. We do not apply calibration-based qualifiers to field screening parameters but do qualify with H qualifier as this is not an approved laboratory method. ○ RDO calibrations, verifications and data validation follow FDEP guidelines

Ion-Selective Electrode

AGENCY	ION-SELECTIVE ELECTRODE
SFWMD	• Ion-selective probe types used include ammonia and nitrate ○ ammonia and nitrate probes reset to factory default calibration before deployment. Verified reading within 10% of the true value, calibration if required. We do not apply calibration-based qualifiers to field screening parameters but do qualify with H qualifier as this is not an approved laboratory method.

Single-junction electrode

AGENCY	SINGLE-JUNCTION ELECTRODE
SFWMD	• Single-junction electrode pH ○ pH calibrations, verification and data validation follow FDEP requirements

Sensors

AGENCY	SENSORS
SWFWMD	• YSI EXO series probes: temperature, specific conductance, pH, dissolved oxygen, chlorophyll, turbidity • Sea-Bird Scientific Cycle PO4: phosphate (*discontinued due to inability to get comparable readings with lab) • Sea-Bird Scientific SUNA: nitrate (*discontinued due to scaling back of continuous nutrient monitoring)
SJRWMD	• YSI EXO series probes: Temperature, Specific Conductivity, pH, Dissolved Oxygen (optical), Chlorophyll, Turbidity, fDOM • Sea-Bird Scientific Cycle PO_4: Phosphate
SRWMD	• YSI EXO series probes: Temperature (Thermistor), Specific Conductance (Electrode), pH (Electrode), Dissolved Oxygen (Optical), Turbidity (Optical), fDOM (Optical). • Sea-Bird Scientific SUNA: nitrate (UV/Optical) • EXO Nitra LED UV Nitrate sensors purchased and soon to be in testing phase. • OTT PLS-C Pressure probe and conductivity sensors deployed in coastal wells. • Continuous data are used to identify trends in impaired waters and Outstanding Florida Springs. FDOM Data are also used by MFL group in spring flow reversal studies.
NERRS SWMP	• Instrument: YSI/Xylem EXO datasondes • Required parameters: water temperature, specific conductivity, salinity, dissolved oxygen percent saturation, dissolved oxygen concentration, depth (or level), pH and turbidity. • Optional parameters: Chlorophyll and fDOM • EXO Sensors: Conductivity/Temperature Sensor (CT2 or Wiped CT), pH (Guarded or Unguarded), Optical Dissolved Oxygen, Turbidity, Total Algae (PE for saltwater, PC for freshwater), fDOM, and Central Wiper. • Chlorophyll data are quality checked and ingested into the CDMO database (nerrsdata.org) and are available through data downloads (if the Reserve collects it). fDOM are quality checked by the Reserve only and data are only available by contacting the Reserve.

Calibration and Verification

User Calibration

Acceptance Criteria

AGENCY	ACCEPTANCE CRITERIA
SWFWMD	Traditional parameters follow FDEP FT1000 guidelines, while manufacturer recommendations are utilized for parameters such as turbidity and chlorophyll.
FDEP	Parameters follow FDEP FT1000 guidelines
SFWMD	Non-traditional ammonia and nitrate probes reset to factory default calibration and then 1 point calibration as needed
SFWMD	Traditional parameters follow FDEP guidelines
SJRWMD	Temperature, Sp. Conductivity, pH, and DO follow FDEP FT1000 guidelines. Chlorophyll, turbidity, and fDOM follow manufacturer recommendations.
SRWMD	Temperature, Sp. Conductance, pH, and DO follow FDEP FT1000 guidelines. Turbidity, nitrate, and fDOM follow manufacturer recommendations.
NERRS SWMP	Temperature, Sp. Conductivity, DO, pH, depth/level, turbidity, and chlorophyll follow protocols outlined in the NERRS SWMP EXO SOP (current version is 2.2). FDOM calibration follows manufacturer recommendations. Datasondes are calibrated prior to each use. Temperature sensor is verified using a NIST traceable thermometer prior to calibrating other sensors. Temperature is also checked annually using 3 points, ice water, room temperature, and warm water ~ 35°C, Sp. Cond is checked prior to calibration. Check will verify that cleaned and dry electrodes read < 2 µS/cm with the probe dry and in air.

Number of Calibration Points

AGENCY	NUMBER OF CALIBRATION POINTS
SWFWMD	Turbidity can be calibrated with a 2- or 3-point calibration. We produced similar results utilizing both calibration frequencies. Turbidity standard can be expensive, so a 2-point calibration might be more ideal. Chlorophyll is calibrated with a 2-point calibration of 0 and 66 µg/l solution. YSI's user manual has instructions on how to make the 66 µg/l solution.
SFWMD	Non-traditional continuous monitoring probes turbidity, CHL and BGA reset to factory default calibration before deployment. CHL and BGA probes are then verified to be reading within 10% of true value of the user made 200ug/L Rhodamine WT calibration solution based on InSitu instruction sheets 0038902 and 0038922
SFWMD	Non-traditional ammonia and nitrate probes reset to factory default calibration and then 1 point calibration as needed
SFWMD	Traditional parameters follow FDEP guidelines
SJRWMD	Temperature, Sp. Conductivity, pH, and DO follow FDEP FT1000 guidelines. Chlorophyll, Turbidity, and fDOM have 2-point calibrations with DI and an appropriate standard, according to manufacturer recommendations.
SRWMD	Temperature, Sp. Conductivity, pH, and DO follow FDEP FT1000 guidelines. Turbidity and fDOM have 2-point calibrations with DI and an appropriate standard, according to manufacturer recommendations. Nitrate has a 1-point reference update with DI.
NERRS SWMP	Sp. Cond is 1-point, pH is 2-point (7, 10 minimum) maybe 3-point (7, 10, 4) depending on water body, depth/water level is 1-point, dissolved oxygen (% Sat) is 1-point, turbidity is 2-point, chlorophyll is a 2-point, fDOM is a 2-point.

Factory Calibrations

AGENCY	FACTORY CALIBRATIONS
SWFWMD	The only meters we send back for factory calibrations are Seabird's SUNA nitrate sensor, and Hydro-cycle phosphate sensor. These are due for servicing every 2 years, and the cost is relatively high for servicing/calibration.
SFWMD	Traditional Parameters calibrated as required per FDEP guidelines. Non-traditional parameters (BGA, CHL, TURB, Ammonia, Nitrate) reset to factory default calibration via software and verified reading within 10% of true value.
SJRWMD	Cycle PO4 sent back for factory calibrations annually, as recommended by manufacturer.
SRWMD	SUNA nitrate sensors have a goal of annual factory calibration and service but may be extended if cost is prohibitive and sensors are functioning properly
NERRS SWMP	No required factory calibrations

Factory Reset

AGENCY	FACTORY RESET
SWFWMD	When troubleshooting a probe that has issues meeting calibration acceptance criteria, a factory reset of the probe, and recalibration can be applied before the decision to discard the probe is made.

Continuing Calibration Verification (CCV)

AGENCY	Continuing Calibration Verification (CCV)
SWFWMD	Traditional parameters follow FDEP FT1000 guidelines. Turbidity is checked with the lowest standard the manufacturer makes (12.4 FNU). Turbidity has issues passing with a 12.4 FNU standard at times. Chlorophyll is checked with a 66 µg/l solution. Additional staff time needed to create a lower limit standard.
SFWMD	Traditional parameters follow FDEP guidelines. Non-Traditional parameters BGA, CHL, ammonia, nitrate readings verified in standard solution after deployment. The true value and instruments verification value is recorded on deployment forms. We do not apply calibration-based qualifiers to field screening parameters, but do qualify with H qualifier (indicates that the method used to obtain the data has not been recognized as equivalent to laboratory methods, and data may not be accurate) as this is not an approved laboratory method.
SJRWMD	Temperature, Sp. Conductivity, pH, and DO follow FDEP FT1000 guidelines. Chlorophyll, Turbidity, and fDOM have 2-point calibrations with DI and an appropriate standard, according to manufacturer recommendations.
SRWMD	Traditional parameters follow FDEP guidelines (time interval is 6-8 weeks based on documented instrument stability). Turbidity and fDOM have 2-point CCVs with DI and an appropriate standard, according to manufacturer recommendations. Nitrate has a CCV check with DI.
NERRS SWMP	Calibrated sensors must have a yellow or green KOR passing score prior to deployment and passing sensor diagnostics, Sp. Cond cell constant must be within range (EXO CT2: 4.59-5.61, WPD EXO: 0.419-0.519), pH mV must be within range pH 7 (0 +/- 50 mV), pH 10 (-180 +/- 50 mV), and pH 4 (+180 +/- 50 mV)

	and 7/10 slope must be within range (165-180 mV), and optical DO gain must be within range (EXO: 0.87-1.25). Sensors are placed in standards for verifications at datasonde retrieval.

Temperature and Depth Verification

AGENCY	TEMPERATURE AND DEPTH VERIFICATION
FDEP	Field meters have temperature verified quarterly with a NIST-traceable thermometer in a warm and ice bath; temperature must read within ± 0.5°C of verified NIST thermometer. Field meter depth is verified quarterly using a weighted line or secchi disk line that has been physically measured using a measuring tape; depth must be ≤ 10% of the weighted line or secchi disk value.
SWFWMD	Temperature verified within ± 0.5°C of NIST thermometer after each deployment utilizing 2-point verification (ice, ambient). Depth calibrations and verifications are performed in air according to manufacturer specifications.
SFWMD	Ambient temperature verified within ± 0.5°C NIST thermometer after each deployment. Annually a 3 point (min, max, ambient) temperature check is complete within ± 0.5°C NIST thermometer
SJRWMD	Ambient temperature verified within ± 0.5°C of NIST thermometer before and after each deployment. Quarterly 3-point (min, max, ambient) temperature verifications are completed within ± 0.5°C of NIST thermometer. Depth calibrations and verifications are performed in air according to manufacturer specifications.
SRWMD	Ambient temperature verified within ± 0.5°C of NIST thermometer before and after each deployment. Quarterly 3-point (hot, cold, room) temperature verifications are completed within ± 0.5°C of NIST thermometer. Depth is not collected with sonde.
NERRS SWMP	Temperature sensor is verified using a NIST traceable thermometer prior to calibrating other sensors and prior to performing post deployment verifications. Temperature accuracy is determined on EXO sensor specifications plus the accuracy of the NIST device. Temperature is also checked annually using 3 points, ice water, room temperature, and warm water ~ 35°C. Depth is determined by using a barometric pressure reading and calculating an offset (depth correction). Offset information is found in Appendix B in the NERRS SWMP EXO SOP.

Maintenance and Prevention

Sonde and Probe Cleaning

NOTE – discuss timing of cleaning or rinsing relative to calibration or verification timing.

NOTE – maybe have a general opening section about cleaning specifics. move some of it from NERRS section?

AGENCY	SONDE AND PROBE CLEANING
SWFWMD	Monthly maintenance of all our stations has been adequate for keeping the data sondes clean and in good working order.

SJRWMD	Maintenance performed before each deployment, which lasts 3-4 weeks.
SRWMD	Sensors are calibrated and replaced every 6-8 weeks and brought back to lab for cleaning. Sondes are cleaned on-site every 6-8 weeks unless additional cleaning/maintenance is needed.
NERRS SWMP	Maintenance is performed after each deployment so datasondes and probes are not stored dirty. Maintenance is performed using guidelines outlined in the EXO User Manual. Sensors are removed from bulkhead, cleaned, and inspected. Sensors are cleaned with tap water and Dawn dish soap. Barnacle fouling is removed by soaking the sensor in white vinegar and rewashing the sensor after the soak. C/T electrodes are cleaned with the sensor's cleaning brush, sensor faces are cleaned with using a lint-free wipe (ex. KimWipes). Depth sensor is flushed. We also incorporate cleaning techniques talked about at our annual training with Xylem/YSI and use maintenance documents provided by Xylem/YSI on how to care for Wetmate connectors (EXO Repair Center Tech Bit 2018)

Frequency

Probe specific maintenance frequency differences that are common across manufactures (for example ion specific probe vs optical probe maintenance requirements).

AGENCY	FREQUENCY
SWFWMD	We budget for our optical sensors, such as the SUNA nitrate sensor and Hydro-cycle phosphate sensor to be shipped back to the manufacturer every two years for maintenance/calibration. This is sometimes impractical due to budgeting constraints and the cost associated with factory maintenance, so they are shipped on an as-needed basis. DO caps and pH modules are replaced on an as-needed basis.
SFWMD	• Ion specific and single junction probes require routine service/filling of the reference solution in the probe. These probes typically have shorter life span and require more routine maintenance. The ability to perform maintenance and service means a user can troubleshoot and fix issues with the probes. • Optical probes can only be calibrated, reset to the factory default calibration and cleaned, they are not repairable
SJRWMD	Sonde-based probes are sent for manufacturer repairs as needed; pH probes have modules changed and DO caps are replaced in-house on an approximately annually. Cycle PO_4s are sent back for maintenance annually, as recommended by the manufacturer.
SRWMD	Exo probes and sondes are sent for manufacturer repairs as needed; pH probes have modules changed and DO caps are replaced in-house on an approximately annual basis or as needed based on drift. SUNA nitrate sensors have a goal of annual maintenance but often demonstrate stability beyond 1 year.
NERRS SWMP	It is highly recommended that Reserves send in sondes and sensors for preventative maintenance annually. At the very least the central wiper should be sent in for annual maintenance so the wiper seals can be replaced.

Repair differences between multiparameter data sondes and sealed transducers/sensors

AGENCY	REPAIR DIFFERENCES BETWEEN MULTIPARAMETER DATA SONDES AND SEALED TRANSDUCERS/SENSORS
SWFWMD	Our multiparameter data sondes come with a two-year manufacturer warranty, so all repairs are covered for the first two years. The majority of repairs needed are due to failed sensor ports. This can be caused by many instances, but it doesn't render the sonde useless. If there are open available ports, they can still be utilized if data acquisition can't be placed on hold.
SFWMD	• When measuring any combination of stage, temperature or conductivity only the CTD (conductivity, temperature, depth) transducer models offer a good option as they are typically less cost, have internal battery, welded shut and pressure rated for use in wells. They are typically smaller and when measuring only Conductivity, Temperature and depth can be more versatile than larger multiparameter sondes with moving parts and Orings. The life span is 3-5 years and not repairable vs a multiparameter sonde. • Multiparameter sondes can measure more and variety of parameters (multiple probes/sensor installation) have user replaceable components (wipers, batteries, probes etc). The sonde or components can typically go in for external repair to extend life span.
SJRWMD	Multiparameter sondes and associated probes can be sent in for repairs individually without affecting each other and allows for switching out rather easily to keep a steady stream of data. Sometimes the probes cannot be repaired and instead have to be replaced, which involves additional costs of maintenance.
SRWMD	Similar to above. CTDs require less frequent calibration checks
NERRS SWMP	Program can only use YSI EXO (or in the past 6-series) datasondes. Agree with multiparameter sonde statements above.

Probe Swap vs. Sonde Swap

NOTE – maybe some narrative about data gaps during the process and how noticeable it is to observe data problems after swap. Thresholds for how different the observations are from before/after swap? External sensors to monitor during the swap.

AGENCY	PROBE SWAP VS. SONDE SWAP
SWFWMD	Probe swapping is a cost saving practice due to the fact that probes of a single type can all be calibrated at the same time, thus saving standard. One data sonde is needed per station instead of two.
SFWMD	For multiparameter probes, replacing the probes is a good option when there is no need to disconnect for routine maintenance and risk a bad connection, a configuration issue or a non-responsive sonde after the maintenance event.
SJRWMD	Having a spare sonde and associated probes has proven very useful; it eliminates the need for calibrating and downloading data in the field. This makes time spent in the field more efficient, and allows for better troubleshooting in a lab setting. The ability to take probes off and calibrate with a smaller calibration cup saves time and standard solution.

SRWMD	Probes are swapped during each maintenance trip for more thorough cleaning and easier calibration and CCV in laboratory setting.
NERRS SWMP	Batch calibrations is allowed for SWMP, however, exchanging sensors while the sonde is deployed is not allowed. Maximum length of deployment is 45 days for EXO sondes.

Fouling Prevention

NOTE: do fouling prevention methods influence WQ observations? How do physical fouling barriers affect the data?

Maybe some intro narrative about how fouling prevention methods have improved data (animal exclusion, etc). Maybe add notes about timing of fouling prevention frequency/replacement.

Saltwater vs. Freshwater

AGENCY	SALTWATER VS. FRESHWATER
FDEP	Utilizes copper tape for the probes in marine systems. Boat bottom paint is also used on deployment housing/wells to deter barnacle growth.
SWFWMD	 In order to combat biofouling in saltwater systems, we place our data sondes in women's pantyhose. This helps prevent algae and barnacle growth. We also wrap our data sonde guards in ½" PVC mesh to keep organisms from using the sonde as a residence. The modifications to the sonde don't seem to affect the data and it makes light work of keeping the sondes clean. For freshwater systems we only use the women's pantyhose in areas of high algae growth. Ceramic CTD transducers combat fouling in saline environments, but they are more fragile than other transducers.
NWFWMD	Have used landscape fabric to wrap screened PVC; well-liner fabric can be used
SFWMD	• Titanium CTD transducers have been performing better than stainless steel in corrosive environments, however they do not have a wiper • Using Wipers on a frequent interval help to keep sensors clean of debris important for optical sensors
SJRWMD	• Saltwater: Sondes are wrapped in plastic wrap and duct tape to prevent fouling on the instruments themselves, and allows for easy removal. Probes are wrapped in copper tape, and a copper guard is used on the sonde as well. Central wiper probes are also utilized to minimize fouling on probe surfaces.

	• Freshwater: Central wiper probes are utilized to minimize fouling on probe surfaces.
SRWMD	No saltwater continuous deployments other than CTDs in somewhat saline wells. Freshwater sondes are duct taped and utilize central wipers. SUNA nitrate sensors have wipers. C-spray is sometimes used on EXO probes.
NERRS SWMP	Batch calibrations is allowed for SWMP, however, exchanging sensors while the sonde is deployed is not allowed. Maximum length of deployment is 45 days for EXO sondes.

Sonde Antifouling Measures:

1. Copper Sensor Guard – a copper alloy sensor guard offers biofouling properties and replaces the normal black plastic sensor guard
2. Duct tape – may be applied to the sonde body to both reduce biofouling and aid in ease of its removal. It works best to first wrap the sonde body in shrink-wrap sleeve (YSI) before wrapping with duct tape, to prevent the duct tape adhesive from sticking to the sonde body after removal.
3. Shrink-wrap Sleeves – specially crafted plastic sleeves designed to fit the sonde body and sold by YSI. The sleeve is applied to the sonde and hit with hot air via a blow-dryer or heat-gun to "shrink" it into a form fitting protective layer
4. C-Spray: while it does not prevent fouling, this spray material can be applied to the sonde connector region, sensors, and internal sensor guard faces to make biofouling removal easier

Probe Antifouling Measures:

1. Copper Tape – this adhesive-backed tape, sold by YSI and other vendors, reduces biofouling when applied to the body of each probe. Sensor faces should not be covered with copper tape and care must be taken to cut holes that correspond to the openings in the side of the temperature/conductivity probe
2. Temperature Conductivity Probe Screens – copper alloy screen sold by YSI that prevents critters from entering the conductivity cell region when applied to the outside of the probe
3. C-Spray - while it does not prevent fouling, this spray material can be applied to the sonde connector region, sensors, and internal sensor guard faces to make biofouling removal easier
4. Mesh screens – 0.25" mesh screens can be applied to the outer surface of the sensor guard to prevent critters from gaining access to the probes and inner sensor guard are. The mesh should be wrapped around the guard 1.25 times and secured with a zip tie to secure it
5. At GTMNERR the inside of sonde tubes are scraped clean prior to each deployment using a customized scraper called a ram rod.

Fouling Specific to Different Probes/Parameters (if there are any differences)

AGENCY	FOULING SPECIFIC TO DIFFERENT PROBES/PARAMETERS
SWFWMD	Fouling on sensor face of optical probes impacts data trends of optical measurements of CHL and BGA. Use of wiper is important. Fouling impacts traditional parameters such as conductivity. Monthly maintenance minimizes fouling impacts

Lab Sample Collection

AGENCY	LAB SAMPLE COLLECTION
SWFWMD	For estuarine stations we collect lab samples while conducting our monthly maintenance. This helps in verifying accuracy of turbidity and chlorophyll probes.
SFWMD	Yearly reporting, evaluation and summary of continuous monitoring data and associated laboratory results from water sample collection can be found in the SFWMD's South Florida Environmental Report (SFER). Non-traditional continuous monitoring data compared to associated water sample laboratory results continues to be evaluated for monitoring, sensor and protocol adjustments.
SJRWMD	Lab samples are collected during the retrieval and replacement of equipment during monthly servicing to verify field readings
SRWMD	Lab samples are collected for nitrate during service trips to compare with SUNA readings.
NERRS SWMP	Grab sampling for Orthophosphate, Ammonia, Nitrite, Nitrate, Nitrite+Nitrate and Chlorophyll are collected at four water quality stations monthly and sent to a laboratory for analysis. It is also required for the NERRS to deploy an automated sampler for diel monitoring (24-25 hours). The same analytes are required for diel monitoring as grab sampling. Reserves have the option to collect additional parameters. Laboratory sampling may or may not occur at the same time as datasonde exchanges.

Station Construction

Data Buoys

AGENCY	DATA BUOYS
SFWMD	• Variety of sizes can be used from small commercial grade floats to deploy small self-logging sensors to the larger telemetry data buoys with multiparameter sondes • a fast and sometimes cheaper alternative to building platform or structure • Flexibility on where it can be deployed over long term • Data buoys are easily replaceable when needed • Depth of water and the location of the deployment require specific anchoring components, security and access logistics

Platforms

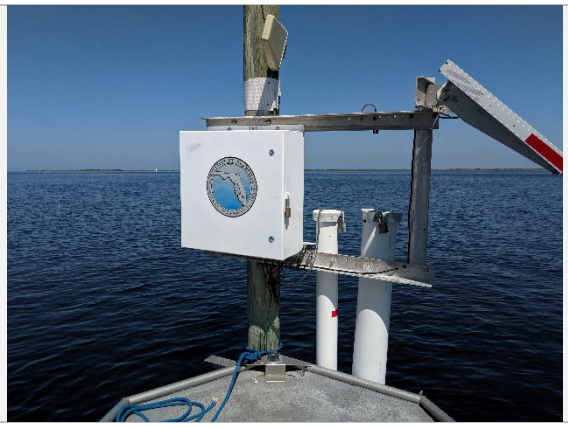
AGENCY	PLATFORMS
SFWMD	• Platforms (free standing or fixed to other structure such as riverbank, levee, bulkhead, structure) offer a fixed walkway to the deployment location of sensors for ease of routine access and attachment of telemetry equipment, sensors and wells Cost, longevity of construction and deck material, building permit, maintenance of the structure above and below the waterline are all factors

SJRWMD	• Fixed platforms are constructed out of stainless steel materials to prevent saltwater corrosion. They allow for easy access by boat, and can house all telemetry and deployment equipment with room to work for servicing. Factors affecting construction: cost, permits, maintenance/replacement (especially after hurricane events)
SRWMD	Sondes are mounted on metal/PVC sleds that can be accessed by land and pulled up by rope. Data loggers, solar panels, and batteries are mounted on elevated wooden platforms for sites that are prone to flooding.
NERRS SWMP	Reserves have the option to use platforms for station construction

Wells

LAYOUT	WELLS
SWFWMD	We use stilling wells at all of our stations. We have found that using a doorknob drill bit to drill holes in the well is adequate for flow through the well and minimizes the holes getting fouled because they are larger (FDEP – Matt borrowed this method from SWFWMD).
SFWMD	We deploy sondes in wells similar to SWFWMD however maintenance in saltwater environments becomes an issue due to fouling in and around the wells and corrosion around the attachment points of well to the platform/supporting structure. An alternative to a well that we have been using is attaching the sonde and sonde communication cable to a stainless coated cable with downrigger weight attached at bottom. During maintenance the entire stainless coated cable, downrigger weight, sonde and sonde cable is retrieved, sondes are serviced and stainless coated cable is either cleaned off and inspected or replaced.
SJRWMD	Stilling wells are attached to the fixed platforms, and the sondes are deployed within the stilling wells. They are at a length that allows for the probes to take readings below the stilling well, while the body of the sonde is still contained in the stilling well. This allows the probes to get accurate readings without interference of flow, as well as protecting the sonde from fouling and horizontal movement.
SRWMD	CTD deployments in coastal monitoring wells.

Existing Structures

AGENCY	EXISTING STRUCTURES
SWFWMD	

	We have found that attaching stations to existing FWC signs has been most practical. Getting a permit through FWC has been quick and the signs make for a sturdy platform to attach equipment.
SRWMD	One spring station with excessive water level fluctuation utilized a pump system to pump water from the spring to the second floor of a building where sondes were mounted in flow-through cells within a cabinet; pump failures along with dirt and debris accumulation within the pipes, tubing and water reservoirs were frequent issues.
NERRS SWMP	Reserves have the option to use existing structures for station construction. At GTMNERR we mostly use navigational channel markers. Permits were obtained through the Coast Guard. At each station the data sonde is contained within a 10 cm (inside diameter) PVC housing pipe mounted vertically onto a piling using customized stainless-steel hangers. Some stations are configured with the submerged portion of the pipe containing multiple 2-cm-diameter holes with the greatest hole density near the base of the pipe and a steel pin at the bottom of the pipe to hold the sonde at a position within a set distance from the bottom. Other stations use a PVC housing that has drilled holes in the tube but does not have a steel pin at the bottom. The sonde is suspended by a rope attached to the cap of the PVC pipe such that the sensor portion of the sonde extends beyond the end of the PVC housing at a set distance from the bottom.

Repairs

AGENCY	REPAIRS
SWFWMD	Routine station maintenance assists with the need for station repairs but equipment still goes down. Plan for maintenance after storms, especially hurricanes and storms with lightning. If using telemetry electronics may degrade over time, keeping spares of equipment handy is good practice
SFWMD	fixed structures and wells require maintenance especially in saltwater. Data buoys and sonde attachment to stainless coated cable and weights which are easily retrievable and serviceable are good alternatives
SRWMD	One spring station with excessive water level fluctuation utilized a pump system to pump water from the spring to the second floor of a building where sondes were mounted in flow-through cells within a cabinet; pump failures along with dirt and debris accumulation within the pipes, tubing and water reservoirs were frequent issues.
SJRWMD	Platforms themselves require minimal repairs. They are generally sturdy; occasionally bolts need to be replaced and/or tightened to maintain structural integrity. Preventative routine maintenance helps reduce the need for these kinds of repairs. Equipment malfunctions more regularly, which requires repairs. We carry spare equipment with us so we can make needed repairs more efficiently.
SRWMD	Wooden platforms have degraded under sustained flooding events and require stabilization/repair. Desiccant used to help prevent moisture impacts to electronics.
NERRS SWMP	Stations are inspected during deployments and are serviced as needed.

Other Comments

Data Management

Innovative Technology vs Traditional Parameters

(Including considerations for RFU and concentration values of fluorometers)

AGENCY	INNOVATIVE TECHNOLOGY VS TRADITIONAL PARAMETERS
SWFWMD	In comparing lab results to real-time data collected in the field for turbidity and chlorophyll, we have found that while sensor technology is a great tool, the accuracy isn't quite there.
SFWMD	fixed structures and wells require maintenance especially in saltwater. Data buoys and sonde attachment to stainless coated cable and weights which are easily retrievable and serviceable are good alternatives
SRWMD	Turbidity and FDOM values for continuous data are often negative - especially in low turbid environments (~1 NTU) and shallow environments (<1 m). FDOM calibrations generate some hazardous waste. YSI suggests calibrating to a value greater than 0 for DI water to compensate.
SJRWMD	The LED optical chlorophyll sensors are read in RFU, which is a more accurate representation of how the chlorophyll is being measured (in relation to a rhodamine dye standard), as opposed to lab-based results which are in µg/L, since they are performed with an extraction method to determine the pigments present. The absolute values of the optical in-situ probes are not as accurate as lab extractions; however, they are useful to evaluate trends in Chlorophyll. Turbidity readings track well with lab analyzed samples. fDOM values in the field aren't measured exactly with lab parameters, although field readings trend with lab-analyzed color.
NERRS SWMP	Comparing in situ chlorophyll fluorescence utilizing YSI Total Algae sensors to traditional extractive analysis highlights the need for site-by-site investigations into the relative variability in sensor data when compared to biovolumes. Sensor data occasionally agrees with monthly discrete sampling efforts, however there are instances in which the datasets do not agree. Research into the relative effect of environmental interferences has shown temperature, turbidity, and fluorescent dissolved organic matter all influence sensor data, so the need for continual paired sampling is highly recommended. Furthermore, supplementing TAL sensor data with fDOM sensor data is highly recommended for accurate data interpretation.

Telemetry

Logger Software/Programming

(tips and tricks)

AGENCY	LOGGER SOFTWARE/PROGRAMMING

SWFWMD	Consult one of the entities that are utilizing the software and inquire about already written scripts. With scripts in hand and some instruction, it is much easier than trying to learn to write in a new programming language from scratch. Data sondes may only require one command to send/receive, while equipment, such as a SUNA nitrate sensor, requires a command to be sent to tell the equipment to take a reading and another command sent to retrieve the results. Typically, this happens if the equipment reading takes longer than a minute to accomplish (SUNA's are ~90 seconds).
SFWMD	"off the shelf" type telemetry kits complete with battery, enclosure, solar panel, etc offered by variety of companies are convenient for fast installations or response monitoring. Ability for telemetry equipment to use SDI-12 to connect variety of equipment is good option to have. Having option for some user applied SDI12 programming scripts should be considered. Cellular telemetry configuration is less complex than using Satellite (GOES) which requires specific registration process with NOAA.
SJRWMD	SDI-12 capable dataloggers are compatible with most, if not all, CM instrumentation. Writing scripts to collect and send data can be difficult without prior experience, however instrument manufacturers' support can usually help with this. Telemetry via cellular modem is a relatively simple setup, and there are different antennas available to gain a stronger signal in areas where service isn't as reliable. Consider coverage of cellular networks at the station locations when determining a provider.
NERRS SWMP	NERRS are required to have at least one water quality station telemetered and transmissions are relayed using NOAA GOES satellites. Station data are available through NOAA, HADS, and CDMO. There are only two approved transmitters: SatLink 2 (phasing out) or Storm 3. KOR templates are customized for each Reserve and sent to technicians. Protocols are outlined in a telemetry SOP (Telemetry Systems for Real Time SWMP Data Delivery Standard Operating Procedure).

Metadata to Accompany Continuous Data

Standard format (ISO, FDGC, etc.)

AGENCY	STANDARD FORMAT
NERRS SWMP	Reserve metadata documents accompany data files and are submitted to the NERRS Centralized Data Management Office (CDMO) quarterly and annually. Annual SWMP metadata is much more detailed than quarterly metadata requirements and what ISO or FGDC standards require. Annual metadata is FGDC-like and would be loosely considered FGDC compliant. The CDMO submits "parent" metadata to NOAA for the entire SWMP datasets that is in the ISO format.

Data Verification Process

Qualifying Data

Various Types of Software Used

AGENCY	VARIOUS TYPES OF SOFTWARE USED
SWFWMD	WISKI (Water Information Systems by KISTERS)
FDEP	Aquarius
SFWMD	Data Analysis System (DAS), Data Depot, and Graphical Verification Analysis (GVA) time-series software
SJRWMD	Aquarius
SRWMD	Hydstra
NERRS SWMP	Microsoft Excel – Customized macro (NERRQAQC)

Assignment of Quality Codes

AGENCY	ASSIGNMENT OF QUALITY CODES
SWFWMD	Quality codes are assigned to traditional parameters based on if the probes pass CCV. All other parameters get an "Estimated" value due to there not being an acceptance criterion for the probes.
SFWMD	Data are assigned qualifiers based on pre and post deployment calibration verification checks, along with qualifiers which ensure continuity and those which denote unvalidated data.
SJRWMD	Data qualifiers are assigned as a combination of data quality ratings and indications of whether a data set has been edited or corrected, and are based on procedures established by USGS in their TM1-D3 document.
SRWMD	Data are imported as provisional. We are working on developing a QA process to review/adjust data and assign qualifiers as needed
NERRS SWMP	There are three (primary, secondary, and tertiary) stages of QAQC. During primary QAQC data are uploaded to the CDMO using the NERRS SWMP Data Upload Service. Data are automatically flagged and coded if they are missing or outside of sensor range. Flag columns are added to the data file for each QC'd parameter and the primary file is then emailed to the Reserve. During secondary QAQC a representative at each Reserve reviews the data and checks for suspect and/or anomalous data and assigns flags/codes based on their review. The last stage of QAQC (tertiary) CDMO staff review the Reserve's data files and provide feedback. Downloadable data files have columns that contain number codes defining what stage of QAQC the data file is in.

Quality Codes

AGENCY	QUALITY CODES
SWFWMD	1 (Good Quality Data) 95 (Estimated) similar to a "J" qualifier 140 (Data Unchecked) data waiting to be QA'd
FDEP	"J" - estimated value "R" - significant rain in the last 48 hours "!" - data deviate from historically established concentration ranges "?" - data are rejected and should not be used

SFWMD	('?', 'C', 'M', 'U', 'J', "H") '?' - Qualifier indicates a questionable or erratic data 'C' qualifiers are applied to passing calibration values 'M' qualifiers may be automatically applied to missing datum due to system and/or sensor malfunctions or site maintenance requiring removal of the probe. 'U' qualifiers are used for uncertified and unvalidated data 'J' qualifiers are used on calibrated sites in the following situations: BCC/CCV or ACC/ICV failure, calibration was required but not performed properly (e.g., not bracketed), or if temperature verifications were not performed. 'H' qualifier indicates that the method used to obtain the data has not been recognized as equivalent to laboratory methods, and data may not be accurate.
SJRWMD	800 Provisional 900 Working 1200 Approved
SRWMD	140 Provisional
NERRS SWMP	QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are applied automatically to indicate data that is missing and above or below sensor range. All remaining data are then flagged 0, passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected. -5 Outside High Sensor Range -4 Outside Low Sensor Range -3 Data Rejected due to QAQC -2 Missing Data -1 Optional SWMP Supported Parameter 0 Data Passed Initial QAQC Checks 1 Suspect Data 2 Open - reserved for later flag 3 Calculated data: non-vented depth/level sensor correction for changes in barometric pressure 4 Historical Data: Pre-Auto QAQC 5 Corrected Data

Data Qualifiers

AGENCY	DATA QUALIFIERS
SWFWMD	Data qualifiers are attached to field data collected at the time of station maintenance as needed.
FDEP	"J" - estimated value "R" - significant rain in the last 48 hours "!" - data deviate from historically established concentration ranges "?" - data are rejected and should not be used

SFWMD	('?', 'C', 'M', 'U', 'J', "H") '?' - Qualifier indicates a questionable or erratic data 'C' qualifiers are applied to passing calibration values 'M' qualifiers may be automatically applied to missing datum due to system and/or sensor malfunctions or site maintenance requiring removal of the probe. 'U' qualifiers are used for uncertified and unvalidated data 'J' qualifiers are used on calibrated sites in the following situations: BCC/CCV or ACC/ICV failure, calibration was required but not performed properly (e.g., not bracketed), or if temperature verifications were not performed. 'H' qualifier indicates that the method used to obtain the data has not been recognized as equivalent to laboratory methods, and data may not be accurate.
SJRWMD	0 Provisional 1 Excellent 2 Excellent Edited 3 Excellent Calculated 11 Good 12 Good Edited 13 Good Calculated 21 Fair 22 Fair Edited 23 Fair Calculated 31 Poor 32 Poor Edited 33 Poor Calculated 41 Final Nexrad 42 Historical Data 43 Final USGS 44 Reviewed Depth 51 Uncorrectable 52 Unverifiable 53 Data Gap

NERRS SWMP	QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three different code categories, general, sensor, and comment. General errors document general problems with the deployment or YSI data sonde, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an * below) can be applied to the entire record in the F_Record column. **General Errors** GIC No instrument deployed due to ice GIM Instrument malfunction GIT Instrument recording error; recovered telemetry data GMC No instrument deployed due to maintenance/calibration GNF Deployment tube clogged/ no flow GOW Out of water event GPF Power failure/low battery GQR Data rejected due to QAQC checks GSM See metadata **Corrected Depth/Level Data Codes** GCC Calculated with data that were corrected during QAQC GCM Calculated value could not be determined due to missing data GCR Calculated value could not be determined due to rejected data GCS Calculated value suspect due to questionable data GCU Calculated value could not be determined due to unavailable data **Sensor Errors** SBO Blocked optic SCF Conductivity sensor failure SCS Chlorophyll spike SDF Depth port frozen SDG Suspect due to sensor diagnostics SDO DO suspect SDP DO membrane puncture SIC Incorrect calibration / contaminated standard SNV Negative value SOW Sensor out of water SPC Post calibration out of range SQR Data rejected due to QAQC checks SSD Sensor drift SSM Sensor malfunction SSR Sensor removed / not deployed STF Catastrophic temperature sensor failure STS Turbidity spike SWM Wiper malfunction / loss **Comments** CAB* Algal bloom

	CAF Acceptable calibration/accuracy error of sensor CAP Depth sensor in water, affected by atmospheric pressure CBF Biofouling CCU Cause unknown CDA* DO hypoxia (<3 mg/L) CDB* Disturbed bottom CDF Data appear to fit conditions CFK* Fish kill CIP* Surface ice present at sample station CLT* Low tide CMC* In field maintenance/cleaning CMD* Mud in probe guard CND New deployment begins CRE* Significant rain event CSM* See metadata CTS Turbidity spike CVT* Possible vandalism/tampering CWD* Data collected at wrong depth CWE* Significant weather event -5 Outside High Sensor Range -4 Outside Low Sensor Range -3 Data Rejected due to QAQC -2 Missing Data -1 Optional SWMP Supported Parameter 0 Data Passed Initial QAQC Checks 1 Suspect Data 2 Open - reserved for later flag 3 Calculated data: non-vented depth/level sensor correction for changes in barometric pressure 4 Historical Data: Pre-Auto QAQC 5 Corrected Data

Parameter Codes and Units of Measure

AGENCY	PARAMETER CODES AND UNITS OF MEASURE
SWFWMD	629 – Depth (m) WQ_250 – Specific Conductance (µS/cm) WQ_333 – Salinity (PSU) WQ_360 – Temperature (°C) WQ_192 – Dissolved Oxygen (mg/l) WQ_310 – pH (SU) 893 – Turbidity (FNU) 894 – Chlorophyll (µg/l) 895 – fDOM (QSE) 892 – NO3 (mg/l)

FDEP	Current DEP DEAR data qualifier use: • Apply a "J" qualifier for the following examples: o Calibrations or calibration verifications did not meet calibration acceptance criteria, including quantitative or chronological bracketing requirements for field testing data. o Other quality control items associated with the reported value(s) failed to meet the established QC criteria (identify the specific failure in the Note). For example, apply "J" if calibration standards were expired. o Instances when data are questionable because of improper field protocols (e.g., guard not attached correctly to meter, improper installation or deployment such as meter rested on waterbody bottom where sedimentation is likely to occur and affect accuracy of readings instead of the water column, etc.). o For all parameters for the YSI 6000 and for all parameters except turbidity for the YSI EXO, instances where the temperature sensor failed verification (i.e., apply a "J" qualifier to temperature *and* to all parameters except turbidity). o Instances when the sample matrix interfered with the ability to make an accurate determination (e.g., turbidity interference). o Sensor fouling is observed. o Sensor drift is suspected. o Sensor diagnostics are yellow/warning. o Vandalism/tampering is suspected. • Data may need to be qualified as rejected for many reasons. Apply a "?" for the following examples: o Reject data if a sensor is registering values even if there was no sensor installed on the data logger. o Reject data for all parameters when the readings are known to have occurred when the meter is out of the water (such as when there are tidal or tampering issues). Include a Note explaining what interruption occurred in the data. o Reject data for values outside the listed range specifications of the instrument. o Reject data if the sensor is damaged, if the data are erratic (e.g., from water intrusion, even if the sensor passes the CCV), or if the sensor diagnostics are red/indicate failure. o Reject data for a power failure/low battery. o Consistent with the National Estuarine Research Reserve SOP, reject ALL data on YSI 6600 when the temperature sensor malfunctions, and reject all data except turbidity when the temperature sensor malfunctions on the YSI EXO. o Vandalism/tampering of the sonde was confirmed.

SFWMD Parameter Codes and Units of Measure

H2OT Temperature, Water Degrees Celsius

DO DISSOLVED OXYGEN mg/L
DS DISSOLVED OXYGEN SATURAT Percent PH PH, FIELD None
SALIN SALINITY PSU
SCOND SP CONDUCTIVITY, FIELD uS/cm
TURB TURBIDITY JTU
PF PHYCOCYANIN RFU - FIELD RFU
PU PHYCOCYANIN ug/L - FIELD ug/L
CF CHLOROPHYLL-A RFU - FIELD RFU
CU CHLOROPHYLL-A ug/L -FIELD ug/L
NH4F Ammonia as Nitrogen, Field (mg/L)
NO3F Nitrate as Nitrogen, Field (mg/L)

NERRS SWMP Units of Measure

- Water Temp - °C
- SpCond – mS/cm
- Sal - psu
- DO_pct - %
- DO_mgl – mg/L
- Depth - m
- CDepth - m
- pH
- Turb - FNU
- ChlFluor – µg/L

Annotations Attached to Data Qualifiers

Data Interpretation

Trend Analysis

AGENCY	TREND ANALYSIS
SWFWMD	• Daily averages vs breakpoint data depending on parameter type • Non-traditional parameters should focus on trends and averages rather than breakpoint data
NERRS SWMP	SWMP status reports are standardized templates that summarize SWMP key findings and trends. Reports can be produced annually or cover multiple years. Also, through a NERRS science collaborative grant NERRs in the southeastern US are working on developing a Storm Stories report similar to the status reports but will focus on using SWMP data to communicate hurricane impacts.