Methods and Data Comparability Board — Aquatic Sensor Workgroup

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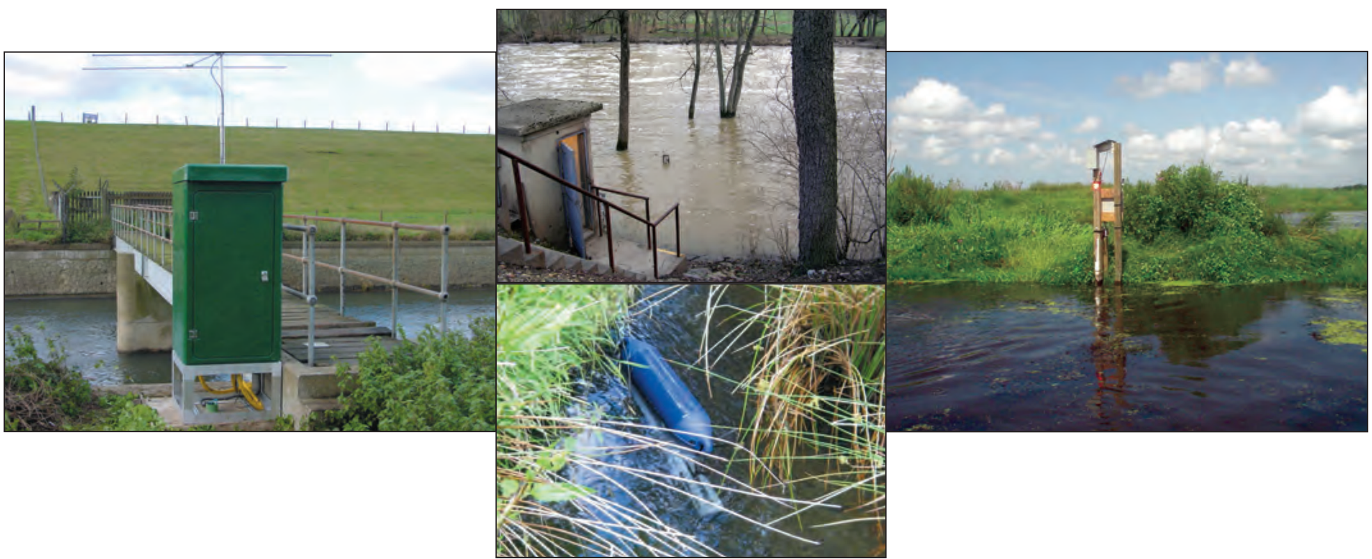
Field Deployment Guide

Checklist for Sensor Selection, Deployment, and Maintenance: **Rivers & Streams**



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How to Use the Field Deployment Guide

A basic assumption of this guide is that a monitoring location has been defined based on the project requirements; that is, you have determined that you will be sampling (for example) Black Earth Creek in the vicinity of the Highway 14 bridge near the town of Cross Plains. The next step is to visit the site and determine how and where your monitoring will take place, and if continuous data are to be collected, what are the considerations for location of structures and placement of sondes, sensors, or orifice intake lines.

The ASW Deployment Guide, therefore, is a checklist of information designed to guide both new and experienced users in the deployment of water-quality monitoring systems using sensors. System Selection guides users through the decision process for the type of monitoring system that will be needed. Site Selection covers the factors to consider in order to choose the best sampling location within your project constraints. The section on Installations provides information on platform design, safety considerations, maintenance, and requirements for power and telemetry. Documentation covers recommendations for photo and written site and installation documentation.

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1. System Selection

Measurements must accurately represent a water body based on the purpose of the monitoring and the data-quality objectives. All other factors in water-quality monitoring must be balanced against these two factors. The selection of the type of monitoring system to use is the first step.

Attended monitoring is used when relatively infrequent discrete samples are adequate for the monitoring needs. Attended monitoring requires no permanent installation at a site. In this guide, considerations for attended monitoring include all "General" comments and those marked with a **green dot**.

Unattended, or in-situ, monitoring is where only the sensors are placed directly at the measuring point in the aquatic environment and communication cables are run to the data logger and power system located in a weather-resistant shelter. Power requirements for in-situ monitoring may be met by the use of batteries, perhaps supplemented by solar panels. Considerations for in-situ systems include all "General" comments and those marked with a **yellow dot**.

Flow-through monitoring system has a pump that delivers water from the measuring point to the sensor(s) or sonde housed in a shelter. Access to power is a requirement for flow-through monitoring systems. Considerations for flow-through systems include all "General" comments and those marked with a blue dot.

	Advantages	Disadvantages
🟢 **Attended Monitoring**	Calibration should be done right before data are collected, ensuring data of the highest, known quality. Vandalism not an issue. No need for expensive shelters.	Does not take full advantage of new technology. Each data point is expensive.
🟠 **Unattended: In-situ Monitoring System**	Remote locations are possible. Small shelters can be used. No power is needed to pump water, and electrical hazards are reduced. With satellite telemetry, data can be transmitted to an office location. System can be monitored remotely for problems. No pump maintenance.	Sensors are susceptible to vandalism. Sensors are more prone to fouling than in flow-through system. Servicing sensors during flooding can be difficult. In shallow bank or poorly mixed installations, properly locating intakes or sensors in the cross section is difficult. Sensors are susceptible to debris or high flow. Shifting channels may require adjustments to sensor placement. Susceptible to freezing.
🟠 **Unattended: Internal-logging Monitoring System**	Location options are flexible. No electrical hazards. Exposure to vandalism may be reduced. No pump maintenance.	Sensors are susceptible to vandalism. Sensors are more prone to fouling than in flow-through system. Servicing sensors during flooding can be difficult. In shallow bank or poorly mixed installations, properly locating intakes or sensors in the cross section is difficult. Data are available only during site visits. Sensors are susceptible to debris or high flow. Shifting channels may require adjustments to sensor placement. Status of equipment can only be checked while servicing. Site visit required to view data and assess data loss. Susceptible to freezing.
🔵 **Flow-through System**	Unit can be coupled with chlorinators to reduce membrane fouling. Expensive sensor systems can be secured in vandal-resistant shelters. Sample water from more than one measuring point can be pumped to a single set of sensors. With satellite telemetry, data can be transmitted to an office location. System can be monitored remotely for problems. Freeze protection can be provided to the sensors.	110-volt AC power source is needed. Large shelters are required, incurring higher installation costs. Pumps in streams can clog from algal fouling or high sediment loads. In shallow bank or poorly mixed installations, properly locating intakes or sensors in the cross section is difficult. Electrical shock protection is required. Pumps may be damaged by sediment or corrosive waters. Pump maintenance may be necessary. Pumping may cause changes in water quality.

Most of the information in this table is from Wagner et al, 2006.

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2. Site Selection

2.1 Location within channel/reach	2.1.1. Cross-section variation and vertical stratification -Cross-section surveys		In streams, make cross-section surveys of the desired parameters to determine the most representative location for monitor placement. Make sufficient measurements at the cross section to determine the degree of mixing under different flow conditions and to verify that cross-section variability does not exceed what is needed to meet data-quality objectives. Wagner et. al. (2006)
	2.1.2. Channel stability and uniformity -Bends, sandbars, eddies		Bends, sandbars and eddies are sources of non-uniform flow that can result in areas of erosion and/or aggradation. These areas are not ideal locations for water monitoring. Webb et. al. (2006)
	-Confluences with tributaries		Confluences are typically areas of high turbulence and non-uniform flow due to dynamic mixing of waterbodies. Due to the active mixing, monitoring in confluences is not recommended. Monitor a fair distance downstream to obtain more valid data. Distance downstream will depend on site conditions. Webb et. al. (2006)
	-Erosion and sediment transport		Avoid areas of streambank erosion for a stable, robust long-term monitoring station. Sediment transport can introduce problems related to streambed aggradation and sediment build-up on intakes or sondes. Miles (2008), Wagner (2006)
		🟢	Attended: Consider potential effects of erosion and aggradation to ensure that a monitoring site will be stable and robust throughout the monitoring period. Miles (2008)
		🟠	Unattended: Sediment buildup on the sonde may impact readings and the data produced. Miles (2008)
		🔵	Flow-through: A clean orifice line is important, therefore consider sediment transport not only for site selection but also for site maintenance. Wagner et. al. (2006)
	2.1.3. Human influences -Bridges, aprons, and other structures		Turbulence affects sensor performance and increases maintenance needs. Bridges and other structures are important souces of flow disturbance and turbulence. Also, localized heavy erosion can occur downstream of these structures and aggradation can occur upstream. Wagner et. al. (2006)
	-Outfalls, discharge points, spill-prone areas		Do not sample immediately downstream of these areas unless specifically targeting their effects. Miles (2008), Wilde, ed. (2006)
2.2 Flow and Stage	2.2.1. Range of streamflow (from low flow to flood) -Adjust sondes vertically or horizontally for extreme flows?		Typically, data collection should occur at the same point regardless of flow conditions. However, during high streamflows, the sonde (or sensors) can be displaced horizontally and vertically by high velocities. If this occurs, corrections for position may be necessary. Wilde, ed. (2006)
		🟢	Attended: May require weights and additional cable to lower the sensors into the appropriate location. Wilde (2006)
		🟠	Unattended: These systems require robust installations and may require additional cable and/or weights to properly position instrumentation. Wilde (2006)
		🔵	Flow-through: Systems need a sound installation that accounts for the range of conditions at a given site.
	2.2.2. Velocity of Streamflow		Sites must be safe and equipment installations must be robust enough to operate within the range of expected conditions while allowing sensors to perform at peak efficiency. Wagner et. al. (2006)
		🟢	Attended: Weights and additional cable may be needed during periods of increased water velocity.
		🟠	Unattended: Consider the integrity of sensor installation as well as sensor position and depth. Wilde (2006)
		🔵	Flow-through: During high velocities, cavitation may occur around the orifice. Locate orifice where it will be sufficiently submerged to collect water during all expected flow conditions. Wagner et. al. (2006)
	2.2.3. Turbulence		Turbulent streamflow aids mixing, but also creates problems in monitoring field parameters such as DO, turbidity, and water velocity. Turbulence may also increase sensor maintenance needs. Wagner et. al. (2006)

3. Installations: Platform Design, Installation, & Maintenance

3.1 Access and Safety	3.1.1. Safety		Safety should always be the first priority! Always use personal flotation devices (PFDs) when in contact or near a water body. Plan trips with frequent check-ins via cell phone. All field work personnel should have first-aid kits and emergency training. During inclement weather or at complicated sites, crews should should include more than one person with all the appropriate safety equipment. In extreme conditions, when safety cannot be guaranteed despite taking all precautions, it is better to have missing data than to risk personal safety. Wagner et al (2006)
	3.1.2. Vehicle Access		Ensure that your field vehicle can handle the likely range of conditions at your site(s). Consider worst-case scenarios such as ice, snow, shallow flowing water, mud, and steep inclines with loose gravel. Extreme conditions may require a 4-wheel-drive field vehicle. Wagner et al (2006)
	3.1.3. Reliable access in varying conditions		Reliable access to the monitoring site and instrumentation: historical flood levels, removal of vegetation, and the appropriate vehicle that allows for site access in all conditions. Wagner et al (2006)
		🟢	Attended: Have access to the site and instrumentats during all conditions. Miles (2008)
		🟠	Unattended: Have access to the site and instruments during all conditions. Miles (2008)
		🔵	Flow-through: Same as attended and unattended systems plus access to, and maintenance of, the orifice line. Wagner et al (2006)
	3.1.4. Vandalism		Aside from attended monitoring, always consider vandalism. Always make the site as inconspicuous as possible. Keep site locked and ensure that structures are sturdy enough to prevent or discourage vandalism. Miles (2008), Wagner et al (2006)
3.2 Equipment location	3.2.1. Shelters, sondes, and pump intakes -Flood damage		Place structures at an elevation above the expected high-water mark. Where possible, shield sondes and intakes in partially sheltered flow to minimize damage from high flow, and attach securely to bridge piers or other sturdy locations. Wagner et al (2006)
	-Debris damage		Structures must be sufficiently robust to handle the impact of large, fast-moving debris flowing with the water. Wagner et al (2006), Miles (2008)
3.3 Available Infrastructure	3.3.1. Power Sources	🟠	Unattended: Can be powered by batteries and/or solar panel, reducing electrical hazards. Give attention to the power demands of your system.Wagner et al (2006)
		🔵	Flow-through: 110-volt AC power is required. Wagner et al (2006)
	3.3.2 Data Transmission -Telephone lines, Internet access, satellite access		Requirements depend on data needs. If the study requires real-time transmittal, consider how data will be transmitted. Miles (2008), Wagner et al (2006)
3.4 Extreme Conditions	3.4.1 Drying		During extreme drought conditions or events that cause channels to shift, probes can be exposed to air and susceptible to dessication.
	3.4.2 Freezing		Freezing temperatures and ice formation are major issues: ice formation causes problems for unattended, flow-through and profiling systems. In addition, sites that rely on battery power may need more frequent charging. Miles (2008), Wagner et al (2006)
		🟠	Unattended: Protect lines and sondes from the effects of freezing and thawing; ice formation can permanently damage instruments. Wagner et al (2006)
		🔵	Flow-through: Consider ice formation at the orifice intake, as well as freezing inside the pipes that deliver the water to the monitoring equipment. In extreme climates, operators may need to shut down flow-through systems during the coldest months. Wagner et al, 2006.
3.5 Service Intervals	3.5.1 In-stream aquatic plants		All monitoring locations should be free of vegetation in order to maintain consistent and high-quality data. Areas around sensors and orifice intakes should be inspected during growing season and vegetation removed as needed. Miles (2008)
	3.5.2 Terrestrial vegetation		Terrestrial vegetation can inhibit site access and damage intake and communication lines; trim and remove overgrowth as necessary.
		🟠	Unattended: A thick canopy of overhanging trees can inhibit telemetry; consider shelter location relative to large trees and other vegetation, or trim if necessary.
	3.5.3 Fouling Rate		Fouling rate is highly site dependent and should be taken into consideration when developing maintenance plans. Typically warm salt water is the most productive, requiring a higher frequency of visits to collect quality data.
	-Use wipers when available		Biofouling effects can be supressed with various anti-fouling hardware. Wipers keep optical sensors clean and free of debris,and brushes clean pH and temperature sensors while removing debris and fouling from wipers. Copper tape and copper alloys also successfully discourage biological growth on sensor bodies and sonde guards.
	3.5.4 Power requirements -Check and maintain appropriate battery voltage for duty cycle/ site visit interval.		If on-site DC current is available, duty-cycle determination can be disregarded. However, maintain regular maintenance intervals based on biofouling and sensor calibration recommendations. For sites powered by AC current (batteries and/or battery + solar power), determine a duty cycle/site visit interval and compare it to maintenance intervals for biofouling and sensor calibration to determine the most effective interval. Use the most frequent interval to maintain the site.

4. Documentation

4.1 Installation Documentation	4.1.1 Written documentation	In site file, keep records of installation including receipts, owners' manuals, etc. Keep notes on modifications made, etc. Wilde ed. (2006)
	4.1.2 Photo documentation	A complete photographic documentation of the site and installation are assets that are difficult to overvalue. Photos of the site including upstream and downstream, cross-section photos at the sampling site, photos of installations, etc.
4.2 Ongoing Site Visit Documentation	4.2.1 Written documentation	Keep record of site visits, maintenance performed, problems encountered and their solutions, etc.
	4.2.2 Photo documentation	Photos should be taken at a variety of site conditions. Keep in site file.