Coastal Pollution Toolkit

Part 3

Factsheets on

Methods for Collection of In-Situ Water Quality

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Factsheets on

Methods for collection of in-situ water quality data

Table of contents

1. Methods

Manual water sampling & analysis with a water quality testing kit

Description

This technique outlines how to use a test kit for rapid water quality testing. Water testing kits can be easy to use, but usually lack the precision and range of in-laboratory testing. It is important to consider what the estimated concentration is of the parameter you are interested in , as testing kits may not be suitable for low concentrations (see **Question 6** in **Section 11** of **Guidance Document**). See **Section 2** for examples of different water quality testing kits suitable for the field. Any water quality sampling is highly dependent on the quality control around sampling, analysis, and assessment. This must include care with equipment and sampling and regularly carrying out validations and calibrations of testing kits in a trusted laboratory (see **Section 8.1** and **Question 7** in **Section 11** of **Guidance Document**). Laboratory services should be underpinned by the full range of accreditation and certifications of quality for the parameters being measured.

When & why to use

- As a screening tool to detect a parameter of interest, which can help to determine whether further laboratory analyses are required (DES, 2018).
- When logistical constraints prohibit you from being able to take water samples for laboratory analysis (see **Section 6.2** in **Guidance Document**).
- As an emergency backup in case of instrument failure.
- As additional information collected at higher frequency and used alongside laboratory based methods.
- As an environmental education tool for citizen science and a method when qualified personnel are not available.

Personnel requirements & skills needed

Testing kits are easy to use and require very little training or equipment (DENR, 2008). However, you will need trained personnel to undertake sampling and experimental design, data collection, management, analysis, evaluation, and communication.

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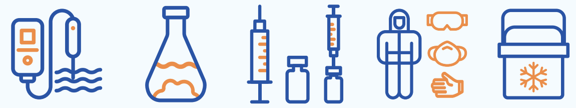
Equipment needed

- Water sampling consumables, including: reagents, sample containers, filters , and syringes.
- Water sampling equipment, including: testing kits, niskin bottles or buckets for water collection, personal protective equipment, sampling pole (if needed), a cooler, and ice.



Budget requirements

Personnel time, water sampling equipment, water sampling consumables, transportation, personnel and access to a laboratory to calibrate the testing kit.

Spatial scale of information

Spatial scale of information: In general, costs will scale linearly with the size of the area of interest and the level of effort (i.e., number of samples, number of sampling sites, and sampling frequency), so sampling is usually conducted on a small spatial scale.

Detection limits

Most portable kits do not detect low concentrations of chemicals because they are designed to monitor pollutants at relatively high concentrations, such as those present in wastewater or highly polluted water. In addition, when using kits where the results depend on color changes will be approximate measurements, with lower precision and results at no more than 1 decimal place. Kits will be very specific to different places, and it may require more than one type of kit to sample across multiple parameters. Note that technology in field kits and in field testing is progressing rapidly, and issues around precision and specificity may become less of an issue over time.

Pros

- No need to transport samples to a laboratory (unless collecting samples for calibration).
- Results can be available on-site.
- Inexpensive technique.
- They can produce accurate and reliable data if calibrated and used for appropriate concentrations in the right conditions.
- Does not require highly trained personnel.

Cons

- They only measure a limited range of parameters.
- Test kits are often very simple and can only provide general results to indicate if there is a concern.
- Generally not accurate enough to measure changes in water quality at low concentrations or to determine compliance compared to guideline values.
- Replicability can be an issue because results may depend on a color reading, and different people may perceive different colors depending on factors such as eyesight, amount of light, and interferences from chemicals present in the waters being tested.
- Needs to be calibrated regularly to ensure accuracy.
- Detection limits are usually not very sensitive, so low level concentrations would not be reported or reported inaccurately.
- Reagents required for analysis can expire and may need to be re-purchased if the testing kit has not been used in a while.

External resources with more information

Clear Water Sensors, n.d.

DENR, 2008

DES, 2018

Manual water sampling for laboratory analysis

Description

Manual water sampling is the direct collection of water samples by a person for its analysis in laboratories. There are also portable labs that can conduct analyses in the field (see below).

When & why to use

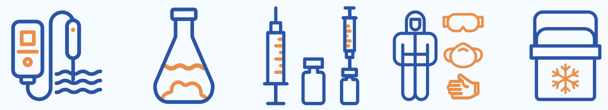
- Can be used to measure any water quality parameter.
- Manual water quality sampling is appropriate for long term trends of chemical parameters present at lower concentrations, which are difficult to measure with kits in the field.

Personnel requirements & skills needed

- Trained personnel to undertake sampling and experimental design and sample collection, preservation, and transport.
- Trained personnel to undertake data management, analysis, evaluation, and communication.
- Specialized trained staff to perform laboratory analyses.
- Personnel should also have ongoing access to training to keep up with latest methods and technologies.

Equipment needed

- Water sampling consumables, including: sample containers, preservatives, reagents, filters, and syringes.
- Water sampling equipment, such as: niskin bottles or buckets for water collection, personal protective equipment, sampling pole, a cooler or freezer, and ice.



Budget requirements

Personnel time, water sampling equipment, water sampling consumables, field and sample transportation, and per sample laboratory costs.

Spatial scale of information

In general, costs will scale linearly with the size of the area of interest , the level of effort (i.e., number of samples, number of sampling sites, and sampling frequency) ,and the type of parameter being tested. Due to budget constraints, manual sampling is often limited to a smaller area or a limited amount of time.

Detection limits

Dependent on the equipment used to process samples in the laboratory.

© Cefas

Pros

- More sensitive and accurate than other methods, such as in-situ sampling with a water quality testing kit.
- Samples can be collected from any type of water body with appropriate type of sampling equipment.
- There are some portable laboratories that can conduct analyses in the field.
- Can be used to accurately measure a wide range of pollutants.

Cons

- Can be very costly and time-consuming for long-term or large-scale sampling programs.
- Logistical constraints such as the requirement to keep samples cold or frozen and to process them within a specified period of time (i.e., sample holding time) (see **Section 6.2** in **Guidance Document**).
- There are additional quality controls that need to be conducted to ensure the integrity of the water sample remains intact from collection to sample processing (see **Section 8.1** in **Guidance Document**).
- More difficult logistics for locations that are difficult to access.
- Results for water samples collected in the field are not available immediately.

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External resources with more information

- Bartram & Ballance, 1996
- DENR, 2008
- DES, 2018
- Núñez-Vallecillo et al., 2023
- The ASEAN Secretariat, 2008
- U.S. EPA, 2024
- U.S. EPA, 2024b

Automated water sampling for laboratory analysis

Description

Automated samplers use a trigger or pre-determined time to collect samples and pump water into clean bottles for preservation. These instruments must be installed at a fixed point where there is a potential source of pollution (DENR, 2008) and they can be programmed to take samples according to sampling needs, such as using rainfall as a trigger to sample. This approach usually works best for sampling streams during events, e.g., flooding events. Samples are collected by the automatic sampler, and retrieved later for their analysis in a laboratory. As with the water quality sampling method, it is critical to ensure you have a trusted laboratory with appropriate qualifications, consistent methodology around sampling and analysis, and regular calibration checks.

When & why to use

When it is not possible to collect samples manually, such as:

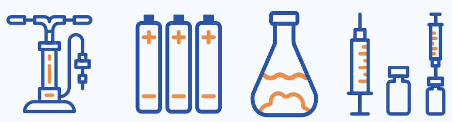
- When it is unsafe (e.g. high river levels and high flows, flashy unpredictable flows).
- When there is a requirement to sample at regular intervals throughout a 24-hour (or longer) period (e.g., to capture the rise or fall of a hydrograph for calculating pollution loads).
- Information on small scale variability is required, such as for model validation or understanding complex coastal processes.

Personnel requirements & skills needed

Automated samplers require time and effort to maintain, and it is important that a skilled technician check the battery life, sampling frequency, and trigger.

Equipment needed

- Refrigerated or non-refrigerated automatic pump samplers (auto-samplers) and rising stage samplers.
- Batteries or solar panels are needed to provide power to pumps.
- Water sampling consumables, including: sample containers, preservatives, filters, and syringes.



Budget requirements

Personnel time, water sampling equipment, water sampling consumables, field and sample transportation, and per sample laboratory costs.

Spatial scale of information

Small spatial scale–whilst this technique can sample at high frequency, fixed positioning of equipment will collect a large number of samples from only one location, over a set period of time.

Detection limits

Dependent on the equipment used to process samples in the laboratory.

© Cefas

Pros

- Automatic sample collection (e.g., during storm events) when people may not be able to access a site.
- Provide consistent, regular sampling with low level oversight (field trips still required to deploy and retrieve instrumentation).
- Eliminate human error inherent in manual sampling (Clesceri et al., 1999).
- Mechanical sampling can reduce any issues of human contamination. However if there is high sedimentation, as is often the case during flooding events, data for other parameters may be skewed.

Cons

- Considerable cost and maintenance (DENR, 2008).
- Requires regular checks for early detection of problems or to prevent malfunctions.
- Results are not available immediately.
- A range of parameters can be measured, but options are limited based on preservation and storage requirements, as well as access to a laboratory to analyze the samples.
- The accuracy of a water sample is affected by how long it takes a technician to retrieve a sample and get it to the laboratory for analysis.

© Zoom Fiji

External resources with more information

- DENR, 2008
- DES, 2018

Manual measurements with a handheld analog instrument

Description

Analog instruments can measure basic physical parameters. These include refractometers for measuring salinity, thermometers for temperatures, and Secchi disks for turbidity. Secchi disks are a simple but extremely effective method for measuring turbidity, and has been successfully used in many long term monitoring programs.

When & why to use

While the values of these instruments may not be as precise as digital tools, they offer the advantage of not needing power or lots of training, so they can be good diagnostic tools for some locations. As costs of implementation are low, they provide a useful, accessible, and widely used method for simple water quality metrics. These simple measurements can be very useful for collecting higher frequency water quality information at low cost, which can complement other types of more accurate, but more costly methods.

Personnel requirements & skills needed

Minimal, though careful use and reporting is essential.

Equipment needed

Analog instrument.

Budget requirements

Equipment costs, personnel and field time, transportation.

Pros

- Very low cost.
- Does not require any sampling consumables.
- Can measure trends over time of water clarity (turbidity), temperature, and salinity at a specific location.
- Equipment is not likely to break.
- Good as an education or scoping tool or for citizen/community science programs.
- Can take a lot of a measurements at low costs.
- Transferable between different programs.

Cons

- The data is not as precise as other methods, and other parameters (nutrients, dissolved oxygen) are not possible when only using analog instruments.
- Secchi disk measurements are subjective, making it hard to compare data from different users, though careful training and quality control can minimize user error.
- Record keeping is by hand and subject to error, and again minimized by careful quality control.

Passive sampling

Description

Passive sampling involves deploying an accumulating material (chemical-absorbing or -adsorbing material, sometimes called a passive membrane) in the water column or sediments to capture time-integrated measurements. Once the exposure period has finished, the material can be retrieved and the accumulated chemicals analyzed. These membrane samplers can measure parameters that are present at very low concentrations including organic compounds, pharmaceuticals, and personal care products. Typically, passive samplers are used after initial analyses are conducted so that hotspots can be identified.

When & why to use

- To detect contaminants that may be present in concentrations below detection limits of laboratory equipment.
- To obtain a time-weighted average concentration over a deployment period.

Personnel requirements & skills needed

The passive samplers are easy to deploy, but require partnering with a laboratory that can supply the membranes, analyze the membranes, and interpret the results.

Equipment needed

- The appropriate passive sampler for the pollutants you are trying to detect.
- Deployment equipment.
- Personal protective equipment.

Budget requirements

- Personnel and field time.
- Field consumables.
- Transportation.
- Laboratory analysis costs.

Parameters that can be measured with this technique

Organic pollutants that are absorbed by lipids and fatty tissues, such organohalide and organometallic compounds.

Spatial scale of information

Although they can be deployed across a variety of environments, they are expensive to analyze, making them more suitable for a few key sites that need to be assessed.

Detection limits

Very good at detecting pollutants at low concentrations that would otherwise be below the detection limits for other methods.

© Cefas

Pros

- Works well for identifying the presence of hard to measure organic pollutants that are absorbed by lipids and fatty tissues, such as pesticides present at low concentrations.
- No energy required to operate.
- Provides an average concentration over a deployment period that can go from hours to weeks, denominated Time Weighted Average concentrations.
- Can be deployed in a wide range of environments.
- Cost-effective for heavy metals and pesticide sampling.

Cons

- Requires sites with minimal human interference, and the ability to leave equipment out for long periods of time.
- Not suitable for heavy use areas, such as ports or tourism areas, where pollution issues may also be occurring.
- Does not work for nutrients, turbidity, or other biological parameters (bacteria, chlorophyll *a*).
- Biofouling can be a serious issue, and timing of the deployment and retrieval needs to consider how much biofouling will happen in the sampling time.
- Concentrations are only time weighted concentrations and high episodic concentrations will be missed.
- Data interpretation requires complex knowledge of chemical behavior and environmental context. This can be carried out by a laboratory but requires expertise in this field.

External resources with more information

- DES, 2018
- Madrid & Zayas, 2007

© Zoom Fiji

Manual measurements with a handheld digital instrument

Description

A common technique for water quality measurement is with a sensor attached to an instrument or meter (known as a logger). This can be a portable instrument including the main meter and data logger, and a number of sensors, each of which measures different individual parameters and displays the measurements on a digital monitor. Some instruments can be submerged into a waterbody to obtain a digital water quality reading at either the surface or at depth.

When & why to use

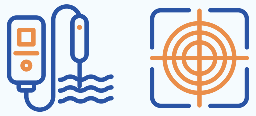
- To measure parameters that are likely to change during transport to the laboratory or storage (for instance, pH, temperature, or dissolved oxygen).
- Provides high sampling frequency.
- To understand the physical composition of water as related to nutrient or other chemical parameters (for instance, low salinity waters generally have higher nutrient concentrations compared to marine waters).
- To measure at different depths to record information on the water profile. This type of information is useful for understanding water column conditions such as stratification and changes in water quality parameters over depth. For example, parameters such as dissolved oxygen need to be measured close to the bottom of the water column to understand impacts on the benthic system.

Personnel requirements & skills needed

Personnel require training and experience using the instruments, and they must be comfortable with digital technology. Instruments are designed to be relatively easy to use. A separate technician may be in charge of calibrating the instrument on a regular schedule. Data collected through sensors is complex, high frequency data requiring additional processing, either through calibration or aggregation of the data. Expertise in data processing can be required,especially when working with data simultaneously collected on multiple parameters.

Equipment needed

Digital instrument, calibration solutions.



Budget requirements

- Personnel and field time, transportation.
- Instrument costs can vary significantly, ranging from \$100 to \$30,000 depending on the quality and the parameters measured.

Parameters that can be measured with this technique

The most common type of instrument is a CTD, which measures electrical conductivity, temperature, and depth. Turbidity, dissolved oxygen, fluorescence (as a measure of chlorophyll *a*), light, colored organic dissolved matter, and even dissolved nutrients can all be measured through sensors, although nutrient sensors are still in testing phase. Total suspended solids can be measured with prior lab calibration.

Spatial scale of information

Depending on staff capacity, the spatial scale can be large. Sensors can be attached to vessels such as boats, kayaks, or other floating rigs. High quality, high frequency information at depth can be collected over short periods of time.

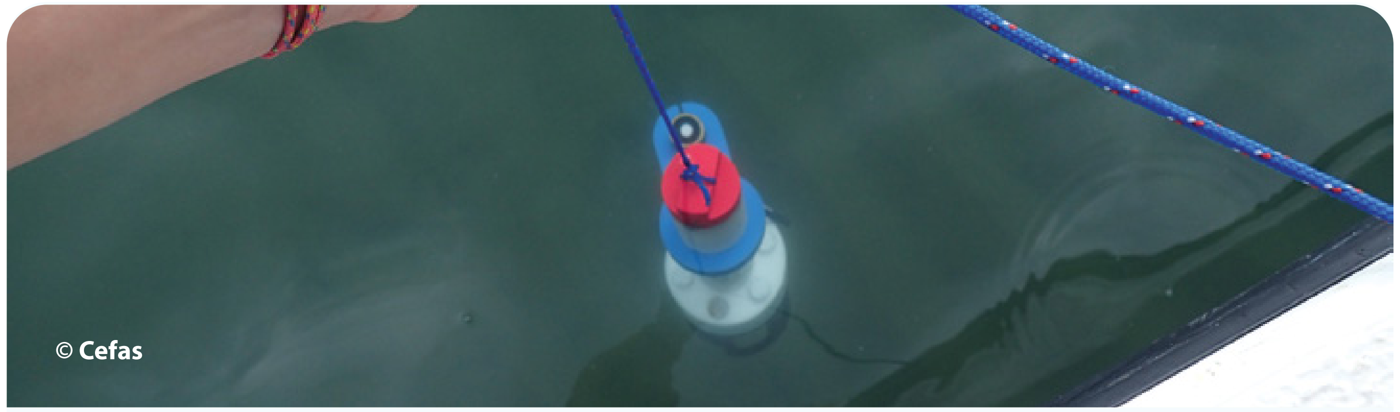
RBR Products | World Leading Oceanographic Instruments (rbr-global.com)

Pros

- No equipment needs to remain in the field.
- No sampling consumables required.
- High quality instruments can be expensive but if used for multiple measurements over large spatial scales or long time periods, cost per sample can decrease significatively.
- Results are accurate if the instruments are frequently calibrated with appropriate standard solutions (DENR, 2008).
- As the instruments are used directly in water bodies, errors caused when handling samples are reduced or avoided.
- Results are available immediately and are not subject to sample processing errors, but do require regular calibration to ensure accuracy and precision are high.
- Most probes allow for the digital registration of data, which reduces human error.
- Can be immediately deployed during emergencies.

Cons

- Personnel need to be sent to sites to take measurements.
- Traditionally, only measure a limited range of parameters, though technology on new water quality sensors is progressing rapidly.
- A specific sensor is required for each pollutant being measured, though multiple sensor can be attached to a single logger.
- Instruments can only hold a certain number of sensors at one time, though recent loggers have been able to take over 10 different sensors.
- Chemical pollutants are difficult to measure accurately with sensors.
- Sensors need to be calibrated, maintained, and changed on a regular basis. Most pH probes only last 3-6 months, while dissolved oxygen and temperature can last years if well looked after. Calibration of turbidity probes requires expensive reagents that need to be stored at specific temperatures.


© Cefas

Automated measurements with a data logger/sensor

Description

Data loggers and sensors that can be deployed in water to take automated measures semi-continuously over a longer period of time. These are instruments widely used to monitor various water quality parameters. The data can be transferred by cabled or wireless connection to a computer. It is important for optical sensors to include a wiper if deployed for a longer (sometimes even more than 24 hours) period and to be managed at least monthly for biofouling.

When & why to use

They can be used to collect data at a high temporal resolution (on the order of seconds or minutes), or for long time periods (weeks to months). For these types of instruments, biofouling is a major concern.

Personnel requirements & skills needed

Personnel to deploy and maintain the data logger; Trained personnel to undertake data management, analysis, evaluation, and communication.

Equipment needed

- Data loggers and sensors.
- Deployment equipment.
- Data loggers require either battery changes or solar panels for power.

Budget requirements

- Personnel and field time; transportation.
- Data loggers are often very expensive (>\$10k), though some budget models (Eureka, Seametrics) can be closer to \$5,000.
- Deployment equipment.

Parameters that can be measured with this technique

The most common type of instrument is a CTD, which measures electrical conductivity, temperature, and depth. Turbidity, dissolved oxygen, fluorescence (as a measure of chlorophyll *a*), light, colored organic dissolved matter, and even dissolved nutrients can all be measured through sensors, although nutrient sensors are still in testing phase. Total suspended solids can be measured with prior lab calibration.

Spatial scale of information

The spatial scale is very small as this technique is really best for collecting several data points from one location, over a set period of time.

Pros

- High frequency data can be collected across weather events, waves, tidal cycles, and microalgae blooms, which provides high temporal resolution on natural variability of parameters.
- Once the equipment has been installed, the results can be available remotely for very advanced systems.
- They can be used to measure some parameters, such as temperature and dissolved oxygen, that would otherwise change during storage or transport of samples for laboratory analyses.
- Can be placed in remote locations where manual sampling is impractical.

Cons

- A technician needs to periodically calibrate and provide maintenance to the equipment.
- Relatively large setup costs in both expertise, personnel, and budget.
- Each pollutant to be measured requires a different probe. However, there are in-situ bundles that include several common sensors.
- Equipment could be damaged in the field or stolen.
- The large volume of data means that data analysis requires additional expertise beyond analysis of discrete data points.

© Cefas

2. Information on sampling equipment

Common brands for water quality testing kits & portable laboratories for manual water sampling

Water kits that measure basic physical environmental parameters

Parameters measured

Alkalinity, carbon dioxide, dissolved oxygen, hardness, pH, salinity.

Examples

https://lamotte.com/products/environmental-science-education/water-monitoring-kits/water-monitoring/marine-science-outfit-5903-03

https://www.haines.com.au/test-kits-marine-science-550-tests.html

https://www.acornnaturalists.com/marine-science-water-quality-test-kit.html


© haines.com

Water kits that measure limited water quality parameters

Parameters measured

Limited nutrient measurements and some basic environmental parameters.

Examples

https://lamotte.com/new-products-at-lamotte/waterlink-reg-spin-touch-reg-ff

https://au.hach.com/saltwater-aquaculture-test-kit-model-ff-3/product-parameter-reagent?id=14533673867&callback=pf

https://us.vwr.com/store/product/23264176/sl1000-ppa-portable-parallel-analyzer-portable-colorimeter-with-usb-hach


© vwr.com

Water kits that measure a wider range of water quality parameters

Parameters measured

A wider range of organic matter, nutrient, sediment, and heavy metal parameters as well as indicators of urbanization and domestic and industrial wastewater.

Examples

https://au.hach.com/dr900-multiparameter-portable-colorimeter/product-parameter-reagent?id=15684103252

https://www.thermofisher.com/order/catalog/product/AQ4000

https://www.thermofisher.com/order/catalog/product/AQ3700?SID=srch-srp-AQ3700

https://www.lovibond.com/usa-en/PW/Water-Testing/Products/Lab-Portable-Instruments/ColorimetersPhotometers/MD-600-Photometer-Series/MD-600

https://www.lovibond.com/usa-en/PW/Water-Testing/Products/Lab-Portable-Instruments/ColorimetersPhotometers/MD-600-Photometer-Series/MD-610

https://www.lovibond.com/usa-en/PW/Water-Testing/Products/Lab-Portable-Instruments/ColorimetersPhotometers/MD-600-Photometer-Series/MD-640

© thermofisher.com

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Water kits that measure non-standard water quality parameters

Parameters measured

Algal toxins, pesticides, bacterial toxins, industrial chemicals, hormones, surfactants.

https://www.goldstandarddiagnostics.us/home/products/rapid-test-kits

© Philippe Delavie

Portable laboratories that measure a range of water quality parameters

Parameters measured

Algal toxins, pesticides, bacteria, bacterial toxins, industrial chemicals, hormones, surfactants.

https://www.idexx.com/en/water/water-products-services/enterolert/

https://www.micrologylabs.com/product/coliscan-water-monitoring-kit/

https://www.goldstandarddiagnostics.us/home/products/rapid-test-kits

© idexx.com

Common brands for handheld instruments & continuous data loggers & factors to consider when selecting one

Things to consider when buying handheld instruments & continuous data loggers

- Do you want to use the same instrument to work as both a handheld instrument and as a data logger that can be deployed in situ to take semi-continuous measurements?
- Do you want to use the same instrument to work as both a handheld instrument and as a benchtop instrument in a laboratory?
- Is it valuable to have bluetooth communications or other more complicated data logging and transmission methods on an external device?
- Is it important to know tidal state or river height? If so, a pressure sensor can be helpful to include in the sensor package.

Xylem (YSI) - US based

Industry standard instruments offered for varying degrees of in situ and continuous measurement. The ProDSS is a handheld that is appropriate for grab samples and can hold up to 4 probes. Probes are interchangeable between different instruments. The EXO1, EXO3 and EXO2 are meant for deployment in the field, and use bluetooth to transfer data to a computer or iPad.

https://www.ysi.com/prodss

https://www.ysi.com/products/sampling-handhelds

© ysi.com

Hach

Quality instruments that are designed mostly for benchtop but can be field deployable as well if careful. Need calibration standards and a schedule to replace probes.

Hach 2100Q - Turbidimeter, easily portable.

Hach 40d - Multiprobe system for pH, conductivity, dissolved oxygen - lab bench and field deployable.

© hach.com

Hanna

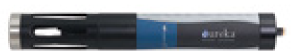
Budget grade handhelds for some parameters. Sensors may be less accurate than other brands. Usually one meter per parameter. Data needs to be recorded manually.

© hanna.com

Eureka

The Manta is the flagship deployable probe, similar to YSI but much cheaper. Be sure to note if a depth sensor or wiper are included, or as these are not standard.

https://www.waterprobes.com/sensor-parameters-water-quality-monitoring



© waterprobes.com

AquaTrOLL

There are multiple models of this probe, which can also be used as a handheld if hooked up to a computer or ipad. May be more difficult to use than the YSI brand.

https://in-situ.com/us/aqua-troll-600-multiparameter-sonde

© in-situ.com

Seametrics

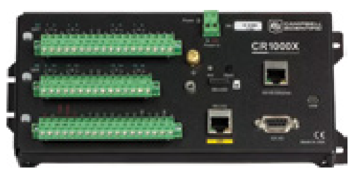
Good for integrating into other data logger systems (see Campbell Scientific below). Can be operated standalone, and may be cheaper than YSI.

https://www.seametrics.com/product/multi-parameter/

© seametrics.com

Campbell Scientific (high quality instruments with a bigger investment in equipment and learning)

Considered the gold standard by the United States Geological Survey for stream monitoring, Campbell Scientific makes sensors that fit into standalone (external) data loggers for turbidity, salinity, pH, and more. There is a big learning curve to programming and setting up these systems, and talking with a product engineer is recommended. Good for quality data at sites where access to land is possible and long term monitoring with less maintenance is the goal.



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Other companies for consideration

Seabird
(known for its conductivity, temperature, and depth probes for depth profiling)

NKE

OTT Hydromet

Imbros

3. References

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