

# MONITORING TURBIDITY AT DREDGING SITES

A GUIDE TO UNDERSTANDING AND ESTABLISHING TURBIDITY AS A REAL-TIME MONITORING SOLUTION



**FONDRIEST**  
ENVIRONMENTAL

## WHAT'S INSIDE

- 01 Environmental Dredging: Overview of USACE Guidelines
- 02 A Real-Time Solution
- 04 Turbidity Technology
- 06 Typical Turbidity Monitoring System
- 08 Points of Compliance
- 10 Data Management
- 12 Quality Assurance
- 14 Recommended Equipment
- 16 Purchase or Rent?
- 17 About Fondriest Environmental
- 18 System Configuration Tool

# WHY MONITORING MATTERS

Dredging is a common and economically viable solution for the removal and subsequent treatment of contaminated sediment. If executed properly, dredging can yield positive environmental results without harming water quality conditions. Dredging operations should aim to remove sediment as efficiently as possible while diminishing short-term environmental impacts, most notably the re-suspension of potentially contaminated sediments.

To minimize sediment re-suspension and contaminant release, a monitoring system should be established. Sediment can easily be dislodged by dredging and dispersed into the water column. This re-suspension may damage water quality both in the immediate vicinity as well as downstream as it travels with the current. Additionally, if the suspended sediment is contaminated, it can release toxins into the water and air. Effective monitoring of re-suspended sediments for the duration of dredging operations is crucial to maintaining acceptable water quality levels for both wildlife and humans.

For this reason, the U.S. Army Corps of Engineers (USACE) and Environmental Protection Agency (EPA) offer extensive guidelines for estimating the environmental consequences of a dredge. The guides also emphasize the need to monitor these effects as the dredging operation occurs in order to keep any re-suspension and transport under control. These monitoring efforts allow project managers to respond if re-suspended sediment levels exceed pre-established parameters by slowing down or altering the dredging.

For the complete USACE's Technical Guidelines for Environmental Dredging of Contaminated Sediments, visit:  
<http://el.erdc.usace.army.mil/elpubs/pdf/trel08-29.pdf>

For the complete EPA's Contaminated Sediment Remediation Guidance for Hazardous Waste Sites, visit:  
<http://www.epa.gov/superfund/health/conmedia/sediment/pdfs/guidance.pdf>

**FONDRIEST**  
ENVIRONMENTAL

## ENVIRONMENTAL DREDGING

### Overview of USACE Guidelines

Environmental dredging is defined as: "the removal of contaminated sediments from a water body for purposes of sediment remediation" (USACE). While there are several approaches to dealing with contaminated sediment, dredging is frequently the cleanup method of choice for projects under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as the "Superfund" program.

As no two projects are identical, the specific environmental limits set for a dredging project will vary. Several influencing factors include location, sediment composition, acting regulatory agencies and environmental laws. To assist with this effort, the U.S. Army Corps of Engineers (USACE) has generated a comprehensive set of guidelines to evaluate environmental dredging as a solution for sediment remediation projects. While the EPA's remediation guide addresses all possible steps and alternatives for dealing with contaminated sediment, the USACE's guide focuses specifically on the dredging component.

These guidelines provide detailed steps regarding the establishment of a dredging operation, from the preliminary evaluation to the process, methods and control procedures. In doing so, this guide establishes a hierarchy of objectives regarding the technical aspects of a remedial dredging operation. These objectives aim not only to minimize sediment re-suspension, release and residuals, but also to maintain a cost-effective strategy in both the short and long term.

Both of these guidelines stress the importance of implementing a monitoring strategy that provides rapid feedback, allowing dredge operators to respond to high re-suspension levels before they become problematic. Established limits for sediment re-suspension (maximum allowable levels for water quality and released contaminants), may be a part of dredging regulations established in consultation with stakeholders, or by federal acts and regulatory agencies.

The USACE recommends drafting a comprehensive monitoring plan that includes equipment and techniques to use, protocols for sampling, where to place sampling devices and details about how to interpret the monitoring data. Furthermore, the guidelines suggest creating a management plan that describes the specific actions to be taken based on the results of the monitoring. This may include increasing monitoring locations/sampling frequency to further assess impacts, implementing operational controls (i.e., stopping or slowing down dredge work), altering debris management or changing equipment. To this end, the USACE technical guidelines advise incorporating real-time feedback on re-suspension into the monitoring plan to make early identification of problems possible. The most rapid and efficient management responses are achievable with this real-time data.



# A REAL-TIME SOLUTION

Measuring total suspended solids (TSS) directly is the best method for evaluating sediment concentrations. However, it is not feasible for real-time applications such as monitoring sediment re-suspension during dredging operations. At present, TSS can only be accurately measured by collecting water samples and conducting laboratory tests, which require filtering the sediment from the water, drying and weighing it. This procedure is too time-consuming for monitoring dredge sites, considering the quick feedback required to allow timely control measures. This is particularly true in cases when the dredged sediment contains contaminants that pose an added risk to wildlife and people. To achieve this real-time monitoring, turbidity, a measure of water clarity, is substituted for TSS.

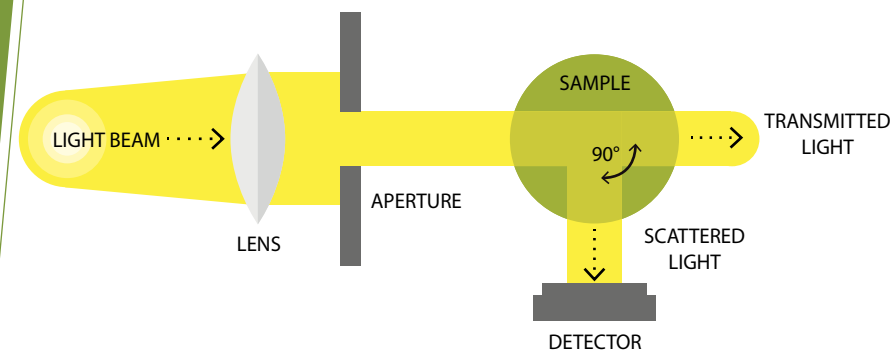
## Measuring Turbidity

Turbidity data can be substituted for total suspended solids because it is an indirect measure of the particle density in the water. When monitoring dredging operations, turbidity readings can approximate levels of re-suspension and indicate the likelihood of released contaminants in real time. As an optical measurement, turbidity monitoring requires a light source and a photodetector.

The light source in the instrument generates an incident light beam, which is scattered in all directions by particles in the water. The more particles present in the water, the more the light will scatter. A photodetector is set up to measure the amount of light scattered at a specified angle. Most turbidity instruments use nephelometry, which requires a 90-degree angle for measurement. This is considered the most accurate method and is approved by both the Environmental Protection Agency (EPA) and International Organization for Standardization (ISO) quality design standards. Other detector angles, such as backscatter, can provide useful data but they are not considered approved methods.

Real-time turbidity data are achieved with the use of a dynamic turbidity instrument, also known as a turbidity sensor. These sensors are submerged in a body of water for continuous turbidity monitoring. Turbidity meters, on the other hand, use a water sample instead of measuring in the water directly. This means they cannot be used in-situ for real-time data. While turbidity meters can be used to check data quality, they are not recommended as primary monitoring sources for dredging applications.

Most turbidity sensors are connected to a buoy-based sonde or a data logger for recording data. This is the preferred turbidity monitoring method by the U. S. Geological Survey, as in-situ measurements more accurately represent surface water conditions than sampling methods. In addition, the real-time availability of data from submersible sensors improves control measure response times when turbidity levels change.



Turbidity sensors can use nephelometric (90 degree) or backscatter (>90 degree) technology to measure the amount of light scattered by particles in water. The sensor is designed with two optical windows, generally located on the same flat surface of the sensor. The light source and the photodetector are located below the optical windows, and are tilted to achieve the desired scattered-light angle. The single flat surface means that a turbidity sensor can be wiped, or cleaned remotely, during a deployment. Regularly wiping the sensor windows prevents fouling (attachment of inorganic material such as silt or biological material such as algae or barnacles). Wipers can be built into the sensor, or attached to a separate brushing mechanism. Fouling on the sensor windows can yield artificially high turbidity readings as the material can block light from entering the water or from returning to the detector.



## Turbidity Units and Reporting

Thanks to the multitude of instrument designs, turbidity reporting can quickly become confusing. There is also a large amount of misinformation regarding approved standard compliance and which turbidity units should be used in reporting. Turbidity units are only useful and accurate if they are reported correctly – with correspondence to a specific instrument design. On their own, turbidity units (including NTU and FNU) have no inherent value, physical or otherwise. They are a qualitative, rather than a quantitative, measurement.

Turbidity, and thus particle density, is a function of the amount of light that is scattered at specific angles. However, the physical properties of these particles – shape, color and distribution – can affect the measurement. This means that two water samples with the same level of suspended solids but with varying particle compositions could result in different turbidity readings. In addition, longer and shorter light wavelengths interact with and reflect off of particles in different ways. This means that two instruments with different light sources may not measure the same level of turbidity in the same water sample. Finally, the measurement angle within an instrument is only accurate within a specific turbidity range. Some angles are accurate for lower turbidity levels, while others are intended for very high measurements.

The solution to all of these variables is in the turbidity unit. The USGS and ASTM have developed a list of ten different turbidity units, each intended for use with a specific instrument design. As turbidity instrument designs vary by light source and measurement angle, these factors will determine which units should be used. If the light source or the angle changes, so will the recommended unit. Three of these units are commonly used in dredge turbidity monitoring, listed at the bottom of this page.

Each instrument design has its own designated unit, and the misappropriation of turbidity units, particularly NTU, diminishes their accuracy and usefulness. Unfortunately, most turbidity data in the U.S. have been reported in NTUs over the past two decades, regardless of their light source or detector geometry. The USGS's revised turbidity protocol (2004) is working to improve the comparability of turbidity data by requiring that reported units match the instrument design.

As mentioned earlier, the U.S. Environmental Protection Agency (USEPA) and the International Organization for Standardization (ISO) have established specific requirements for turbidity instrument designs. The quality design standards are known as EPA Method 180.1 and ISO 7027. As the EPA Method 180.1 requires a tungsten lamp light source and a 90-degree measurement angle, it falls under the nephelometric, white-light turbidimeter category. Thus, instruments in compliance with EPA Method 180.1 report in NTU: Nephelometric Turbidity Units.

ISO 7027 requires a near-infrared LED light source and a nephelometric measurement angle, so instruments in compliance with this design report in FNU: Formazin Nephelometric Units. Formazin is the recommended calibration standard for many of these instruments. The third well-known design is not compliant with any approved design standards. Instruments that follow the backscatter, near-IR turbidimeter design should report in FBU: Formazin Backscatter Units.

Most submersible turbidity sensors use a near-infrared LED light source due to the low power draw, and thus should report in FNU or FBU. Turbidity meters (used for data quality assurance) may contain a white light (400-680) instead of a near infrared light. These instruments report in NTU.

Common Turbidity Monitoring Instrument Design	Unit
Nephelometric white-light turbidimeter	NTU
Nephelometric near-IR turbidimeter	FNU
Backscatter, near-IR turbidimeter	FBU

# TURBIDITY TECHNOLOGY

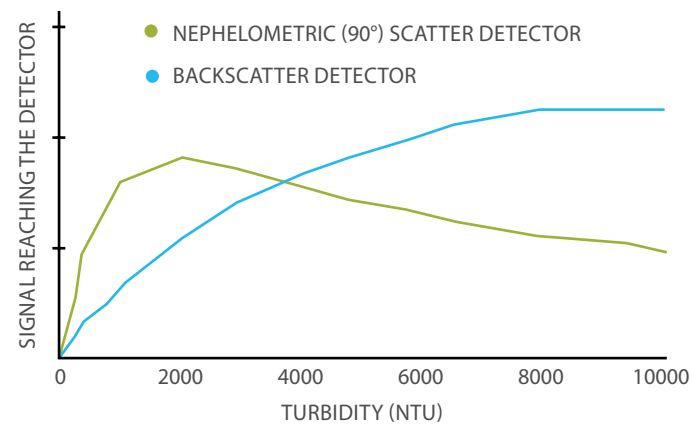
The most commonly used turbidity monitoring systems will use a submersible sensor to monitor for sediment re-suspension. These turbidity sensors can use nephelometry or backscatter technology to measure the amount of light scattered by particles in the water.

Regardless of the sensor chosen, it is important to use the same sensor model throughout a project for internally consistent data. While inter-instrument relationship models can be developed, data from different instrument designs are not directly comparable. Each sensor will read varying amounts of light scatter from suspended particles due to the differences in light source and measurement angle. In turn, the sensors will output varying results despite measuring the same water sample. In addition to cost considerations, sensor choice should be based on expected or potential turbidity readings (low, high or a wide range), and whether or not compliant and comparable data would be useful.

## Nephelometry

Nephelometry is a measurement method with a light source and a photodetector set at a 90-degree angle from each other. This is the angle that is most sensitive to light scatter as it is not affected by particle size.

Most nephelometric turbidity sensors comply with ISO 7027 guidelines. While other sensor designs exist, compliance with ISO 7027 ensures accurate and comparable turbidity readings. In addition to the high sensitivity, the relationship between nephelometric light scatter and particle density is fairly linear. However, it becomes non-linear above 40 NTU and inaccurate at higher turbidities. To account for this, some sensors offer a secondary algorithm for measurements over 1000 NTU. This yields less precise readings, but the accuracy is improved over non-adjusted nephelometric sensors.



## Backscatter

A backscatter sensor uses a photodetector centered past the 90-degree angle (90-180 degrees from the transmitted light). Backscatter sensors have several advantages: 1) a wide measurement range; 2) improved accuracy at higher turbidities (over 1000 NTU); 3) a tolerance for a varying particle sizes. Between 1000-4000 NTU, backscatter technology is nearly perfectly linear. However, during periods of low turbidity, a backscatter sensor will not be as accurate as a nephelometric instrument. Backscatter sensors are also more prone to color interference due to particle darkness value (the ability to reflect near-IR bands).

The largest disadvantage for backscatter sensors, however, is the lack of comparability. The USGS and several backscatter sensor manufacturers have attempted to define appropriate backscatter angles (e.g. 135-180 degrees

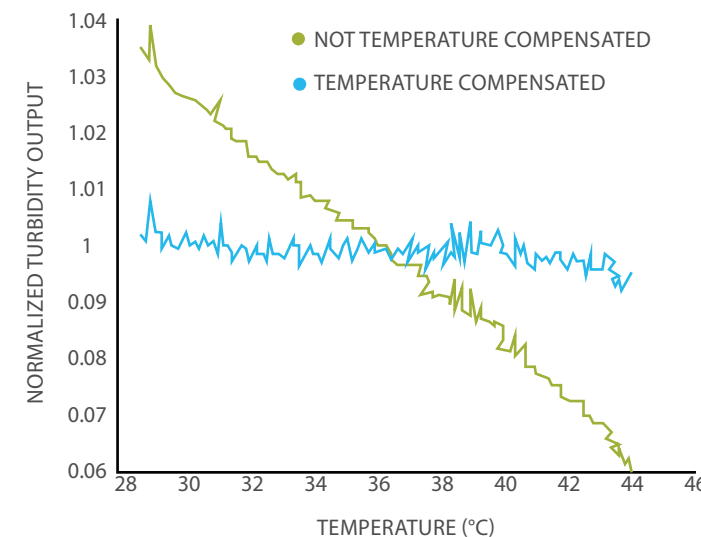
from the incident light). At this time, no current design standard has been set for these sensors. As such, any scattered light detection centered between 90-180 degrees from the transmitted light can be accepted as a backscatter sensor. Without a standardized quality guide for these instruments, any data received are not comparable to any other instrument.

## Method Compliance

Many turbidity monitoring projects want data to be EPA compliant. However, no true, EPA 180.1 compliant submersible turbidity sensors exist. For in-situ monitoring, the USGS instead recommends ISO 7027 compliant sensors.

The requirement of a tungsten lamp light source makes any dynamic EPA Method 180.1 instrumentation impractical. Tungsten lamps have a high power draw, require warm-up time and have an energy output that deteriorates with age. This means that instruments in compliance with this method will require frequent calibrations and bulb replacements. While this is simple enough with a handheld meter, it becomes impractical in a submersible sensor.

On the other hand, LED light sources are compact and have a smaller power draw. LEDs also have a longer lifetime than tungsten lamps, no warm-up period and they can be modulated to reject ambient light. Modulating, or rapidly pulsing, a light source reduces errors due to ambient light. This makes LED light sources ideal for long-term deployments. However, sensors with an LED light source should be compensated for temperature. While turbidity itself is not affected by temperature, the LED is. Changes in the internal temperature will affect the optical power output of the LED. As temperature increases, output intensity (brightness) will decrease, which in turn affects the measured turbidity reading. Some turbidity sensors include an



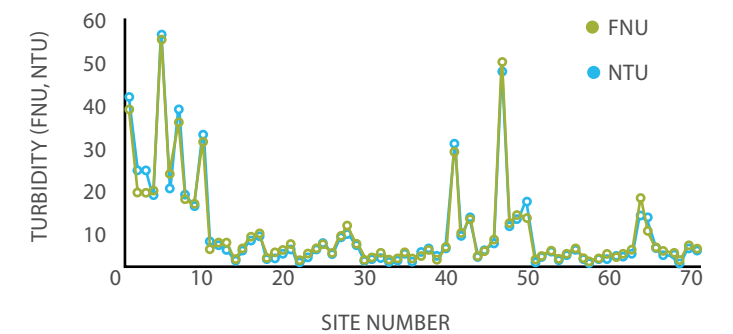
internal thermistor to compensate for these effects, while others offer the ability to make adjustments in the software. For sensors that do not compensate for temperature, a minor drift can be seen in the turbidity readings as the temperature of the LED rises.

In addition to the longevity and stability of an LED light source, near-infrared LEDs (780-900 nm) offer further advantages by reducing color interference. Near-infrared wavelengths are less likely to be absorbed by particles in the water, and thus will have a lower error value than broadband light (which can be partially absorbed). This means that colored dissolved material in the water, such as a dye or humic stain, will not affect ISO 7027 compliant sensors. White/Broadband light instruments however, (including EPA Method 180.1 turbidity meters) will be affected if color is present.

Due to the advantages of a near-infrared LED, most nephelometric turbidity sensors follow ISO 7027 guidelines. While other designs, including backscatter, also use a near-infrared LED, ISO 7027 compliance ensures accurate and comparable turbidity data.

## NTU and mg/L: Unit Conversions

For relation to an EPA-approved method (measurements in NTU), an EPA-approved turbidity meter can be used to spot sample at regular intervals for quality assurance of the sensor data. These data can then be used to establish a correlation between the sensor data and the EPA-approved data. However, a calculated model between data sets is only valid for the location where measurements were taken. At other locations, suspended particles may vary in size, material and distribution, and any constructed conversion will no longer be accurate.



Likewise, models can be created to calculate total suspended solids from turbidity. TSS samples will need to be collected and measured to establish a relationship between turbidity and suspended solids. In most situations, a relationship is derived through a single or multiple linear regression model. Once a regression model has been approved, it can be used to predict TSS concentrations.

# TYPICAL TURBIDITY MONITORING SYSTEM

When dredging, it is necessary to monitor sediment re-suspension levels to prevent damage to the local ecosystem and minimize the spread of contaminants. This is usually done with a turbidity monitoring station upstream (for background data) and two stations downstream (at locations affected by the dredging).

To be effective, measurement data should be provided in real time. The easiest and most efficient way to do this is with a buoy-based turbidity monitoring system. A data buoy can house sensors at multiple depths in the deepest part of the waterway, providing more comprehensive data than a shore-based system. This system can then securely transmit the data to the Internet in real time for access from any computer.

Buoy systems are flexible and customizable based on the dredging project requirements. They can house as many sensors as needed, and all equipment is powered via a marine battery and recharging solar panel system. With multiple telemetry options to choose from, continuous real-time data are available from any computer. This ensures that the dredging operations progress smoothly, and any control measures can be implemented immediately if parameter limits are exceeded.

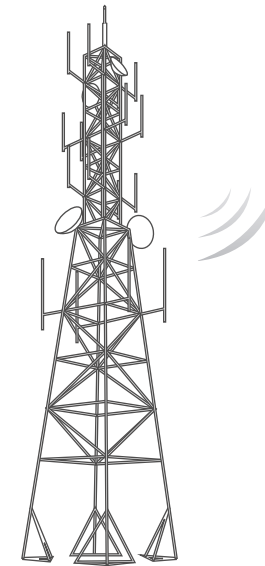


## Dredge

Dredges are excavators used to remove contaminated sediment from the water. They can be hydraulic, mechanical or a hybrid. Most are mounted on a spud barge. An additional barge may be needed for sediment disposal.

## Telemetry

Telemetry provides access to data in real time. The wireless communication can be radio-to-shore, cellular or satellite based.



## Data Buoy

A data buoy is a floating platform that supports real-time monitoring instruments such as sensors and data loggers. In addition to housing the monitoring equipment, the buoy supplies all power and can transmit sensor data in real time.

## Turbidity Sensor

Turbidity data are substituted for TSS as it can be measured instantaneously. Most turbidity sensors are compliant with ISO 7027 and have a wiper to prevent fouling. Sensors can hang at multiple levels in the water column, alone or in a multi-parameter sonde.

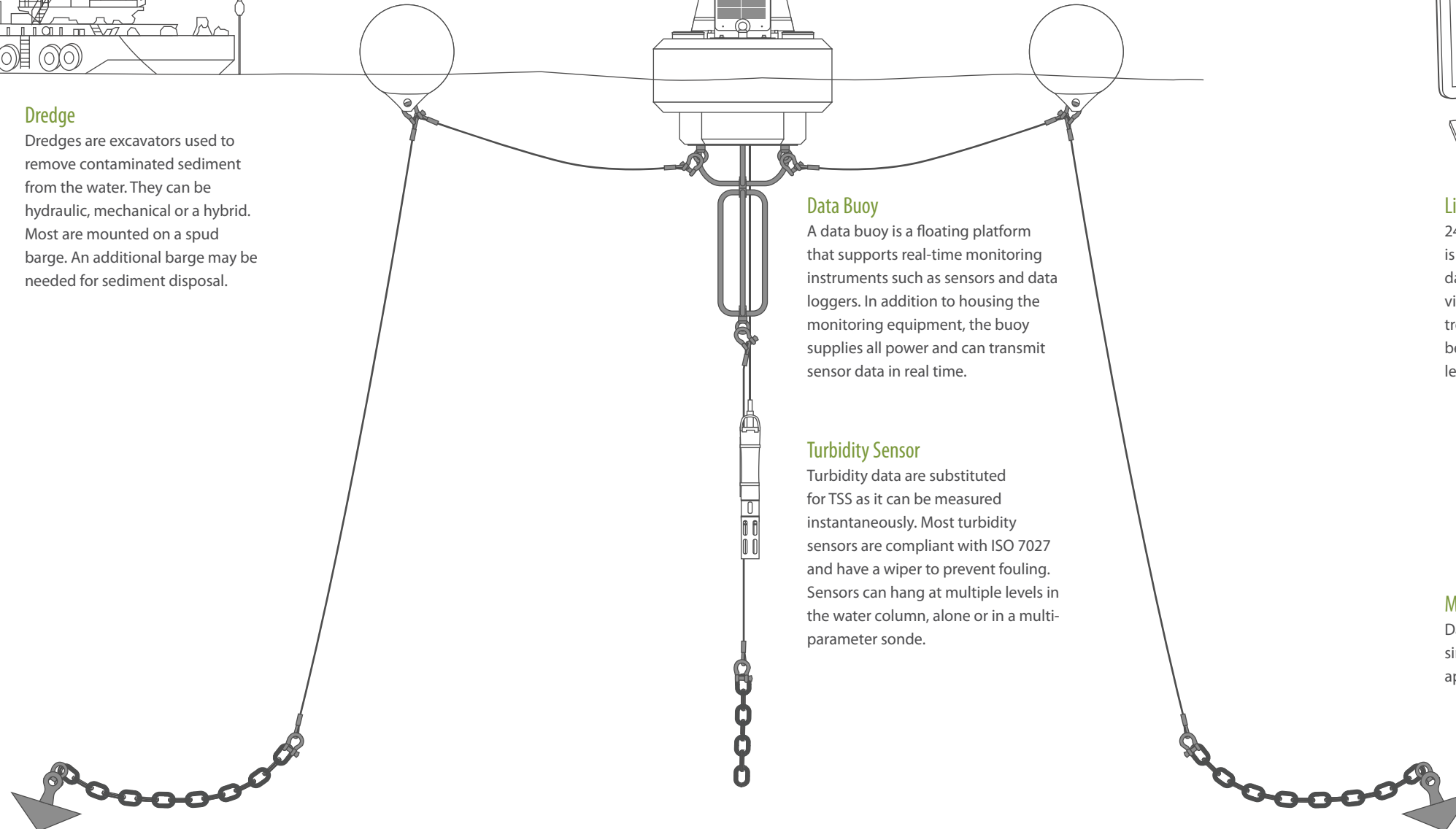


## Live Data

24/7 instant access to project data is available through a cloud-based datacenter. Monitoring data can be viewed in real time, or as a graph to see trends. Real-time automated alerts can be sent via text or email when turbidity levels exceed pre-defined limits.

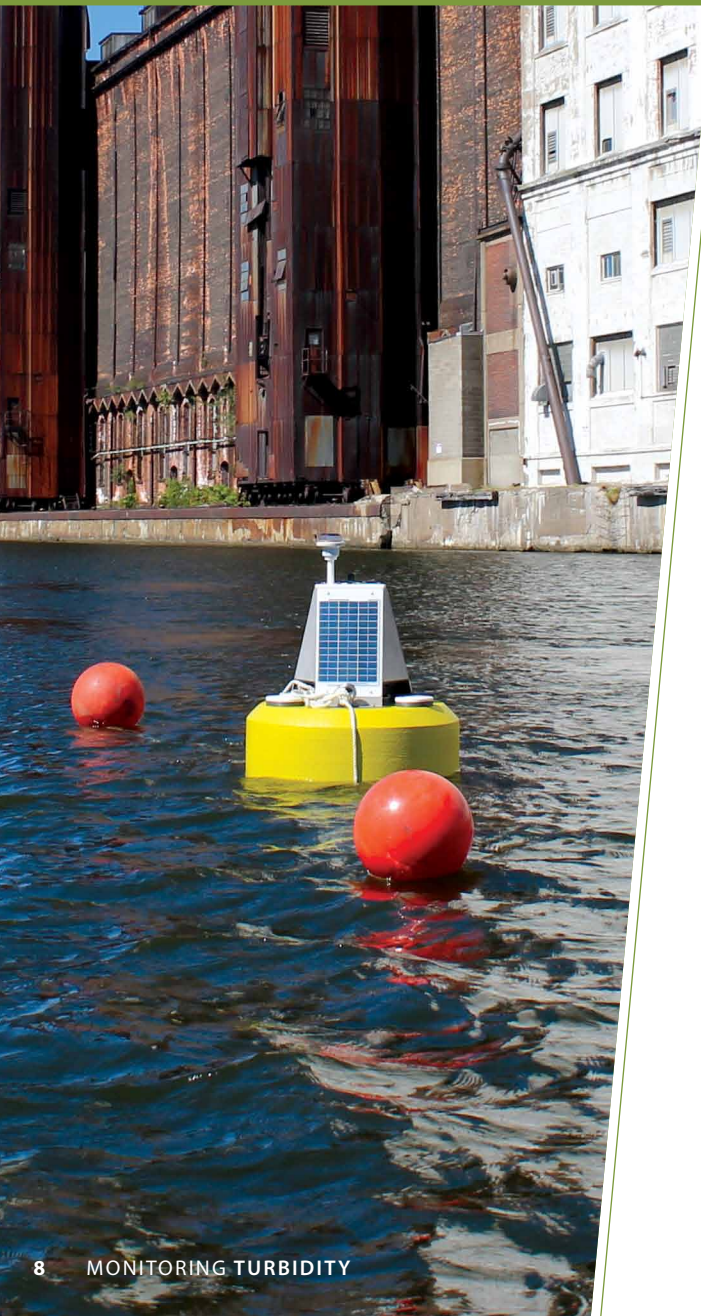
## Mooring Hardware

Data buoys can be anchored with a single or two-point mooring based on application requirements.



# POINTS OF COMPLIANCE

Where turbidity monitoring systems should be located will depend largely on the site conditions of the dredging project. The number of monitoring locations required for a dredging operation can vary, but a common monitoring setup relies on three measurement locations. The chosen measurement locations are known as points of compliance. At these points, the USACE suggests using stationary or towed turbidity sensors in conjunction with water column sampling.



## Selecting the Location

As suggested by the name, stationary systems are set at fixed locations. These systems can be placed on structure or on an anchored buoy in the water. Seawalls are a common example of a structure that can be used, as turbidity monitoring sensors can be mounted in a perforated PVC pipe along the seawall. However, site conditions often make it difficult or impractical to mount the monitoring equipment along the shore. In addition, relying solely on shoreline solutions may not accurately represent re-suspension levels and sediment transport due to the nature of water currents. For these reasons, buoy-based systems offer the most comprehensive and cost-effective solution. Data buoys provide a stable platform for turbidity monitoring, with the ability to house multiple sensors at different depths in the water column. In addition, they can carry a data logger, solar-powered battery pack, and telemetry (wireless communications) systems for extended deployments.

Anchored buoys are usually located both up and downstream of the dredging operation. The downstream buoy(s) measure re-suspended sediment and sediment transport in areas at risk, while the upstream (and off-site) buoy serves as a control for suitable turbidity levels. These buoys can come in different sizes based on the environmental conditions and the number of sensors suspended from the buoy. Data buoys with 150- to 450-lb. net buoyancy are generally adequate for monitoring projects on rivers, inland lakes and protected waters. Larger platforms may be required in coastal and Great Lakes deployments that are subject to more extreme conditions and wave action.

Towed sensors are known as “floating” points of compliance, as they move with the dredging operation. While these can be attached directly to the dredging equipment, they can also be deployed on a buoy system a set distance away from the dredge location. The buoy systems then move with the dredge as the project progresses, remaining the same distance away from the active dredging site.

## Pre-Deployment

For accurate data, all sensors should be calibrated shortly before the project begins. If using a buoy-based system, the platforms should be fully assembled on shore prior to deployment. This includes attaching any sensors, towers, solar panels and additional ballast weights if needed. Furthermore, the complete turbidity monitoring system (sensors, data logger, telemetry, software) should be tested before the buoy is put in the water. While this process ensures that all equipment is functioning within specifications, it also gives everyone the chance to familiarize themselves with the system prior to deployment. Issues are always easier to deal with before the buoy platform is deployed in the water.

## Buoy Mooring

A buoy-based system must be moored to ensure that it remains stationary. The buoy is usually moored via a stainless steel mooring line, bottom chain and anchor. It is recommended to moor the buoy in the deepest part of the waterway to ensure the most inclusive measurements. This allows for multiple measurement depths and will best reflect the characteristics of the water body as a whole.

Buoy-based systems are typically moored as either a single-point or two-point mooring, based on environmental and application-specific factors.

## Single-Point Mooring

Single-point moorings are not common, but they require the least amount of mooring equipment. This setup can be deployed in very calm waters with minimal instruments. A single-point mooring should only be used when all sensors and equipment are housed within an instrument cage or deployment pipe. Hanging sensors risk getting damaged or entangled with the anchor line. A cage or pipe protects the instruments from entanglement, subsurface debris and currents without affecting sensor readings.

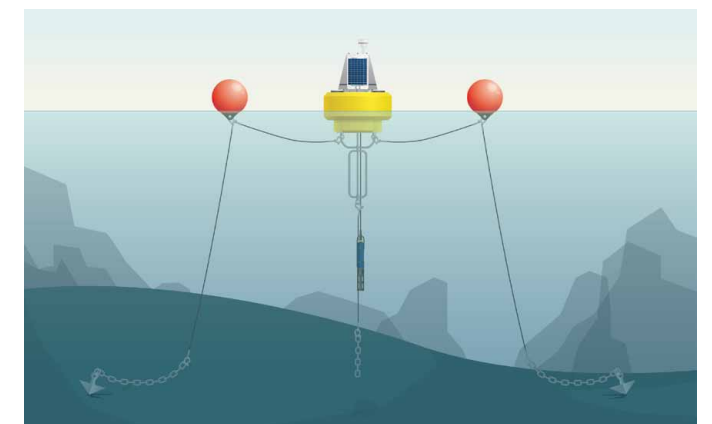
In a single-point configuration, a mooring line connects the buoy directly to a bottom chain and anchor. The sensors are typically housed within a central deployment pipe or attached to a rigid instrument cage. The anchor, bottom chain and mooring line are assembled and attached to the buoy prior to deploying the system.



## Two-Point Mooring

Two-point moorings are the most common deployment configuration. This is the recommended setup if sensors will be hanging at multiple depths in the water column. In a two-point setup, the mooring lines are pulled away from the data buoy by two smaller marker buoys. This configuration leaves the water column below the buoy available for sensors, without risk of entanglement with anchor lines. It also offers greater stability if there are currents or wave action at the location.

A two-point mooring requires a larger deployment area than a single-point mooring, as the marker buoys are typically set about ten feet away from the data buoy. Additional mooring lines run from the marker buoys to bottom chains and anchors at the seafloor. The increased system stability from the two anchor setup is well worth the extra equipment, as is the expanded area for hanging sensors. If there is significant subsurface debris or other risks present, deployment pipes or instrument cages can still be used.



# DATA MANAGEMENT

A major part of any monitoring project is collecting and accessing the data. While it is possible to simply record measurements onsite, the ability to log, send and view monitoring data in real time is far more efficient.



## Data Logger

As the name implies, a data logger is an instrument that stores data. In environmental monitoring applications, data loggers can be used not only to collect data from sensors and sondes, but to control sampling rates and transmit data to a central location in real time.

While sondes often have the ability to log their own data, a separate, dedicated data logger can gather data from any and all attached sensors, while ensuring that no data are lost. If telemetry (wireless communication) is available, the logger can remotely control sensor sampling rates and transmit collected data to a central project computer. Data loggers with telemetry technology can provide real-time turbidity data and remote access via a cellular modem, radio transmission or satellite modem.

When housed in a data buoy, a data logger is charged by the buoy's solar power system. If a solar panel system or external battery is not available, the logger can be self-powered using alkaline batteries. Data loggers can be configured with a number of sensor ports for connection to industry-standard digital and analog interfaces, including RS-485, SDI-12 or 0-2.5 VDC. Turbidity sensors can connect to a logger directly or through a multi-parameter sonde. A data logger can also handle additional water quality sensors, temperature strings or Doppler velocity meters if they are required for the dredging application.

## Telemetry

Telemetry, or wireless communication, is a useful tool for monitoring turbidity in real time. Common telemetry options are cellular and radio, though satellite telemetry can be used in more remote locations. The deciding factor when determining the most cost-effective telemetry option should be the local site conditions and proximity to a project computer. All three of these options permit real-time updates regarding water quality during a dredging operation.

Radio telemetry is recommended when all equipment is in close proximity. If equipped with a license-free spread-spectrum radio, a data logger can communicate with a shore-side radio base station. This range may vary depending on the logger and base station used. Spread-spectrum radio technology may allow a range as far as five miles (line-of-sight) or a few hundred feet (non-line-of-sight). The radio base station serves as a central hub for any buoy-based data logger in range, with the ability to send the collected data to a project computer.

Cellular telemetry offers more geographic flexibility than radio, though it does require a cellular data plan. This small, additional cost permits data transmissions from anywhere that receives a cellular signal. With cellular

telemetry, monitoring stations do not need to be in close proximity, nor is a shore-side base station required. Instead, all the data can be accessed wirelessly via the Internet. Data loggers may be equipped with cellular modems from different providers, including AT&T, Verizon and Sprint.

For remote applications where radio and cellular telemetry are not feasible, satellite telemetry can be used. The Iridium communications network maintains a dynamic, cross-linked constellation of Low Earth Orbiting (LEO) satellites, providing coverage all over the world. This means that data loggers with an Iridium satellite modem can transmit data in real time from anywhere on Earth. As with cellular networks, the data are sent to a central gateway, which then transfers the data over the Internet to any project computer or cell phone.

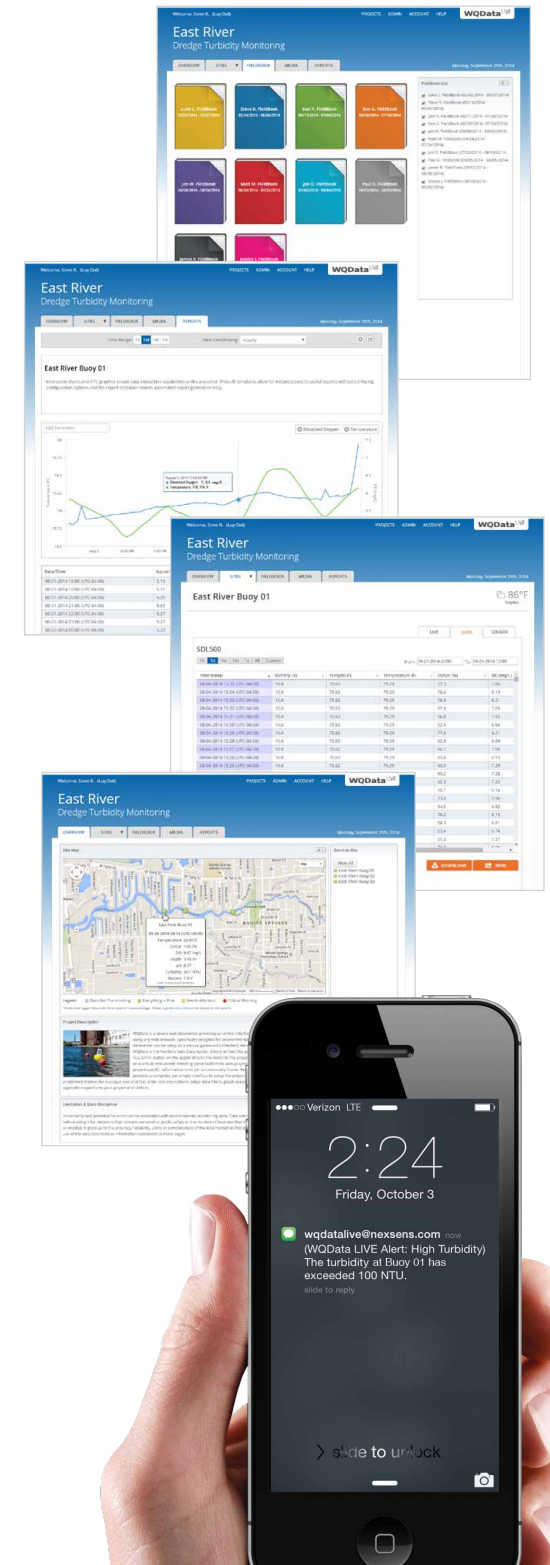
## Real-Time Online Datacenter

The easiest way to share and view turbidity monitoring data is through a web-based datacenter. An online datacenter offers 24/7 instant access to project data via any web browser. Turbidity monitoring and other data can be exported into the datacenter directly from the data logger, or through the project software.

This project management service can be password protected or public, and allows users access to the collected data in real time. In addition to any dredging-specific information, the online interface can provide dynamic area maps, overlaid with weather information, recent and historical data, time series graphs and statistical summaries. Visitors can interact with the project maps and view real-time monitoring data or turbidity level trends over time.

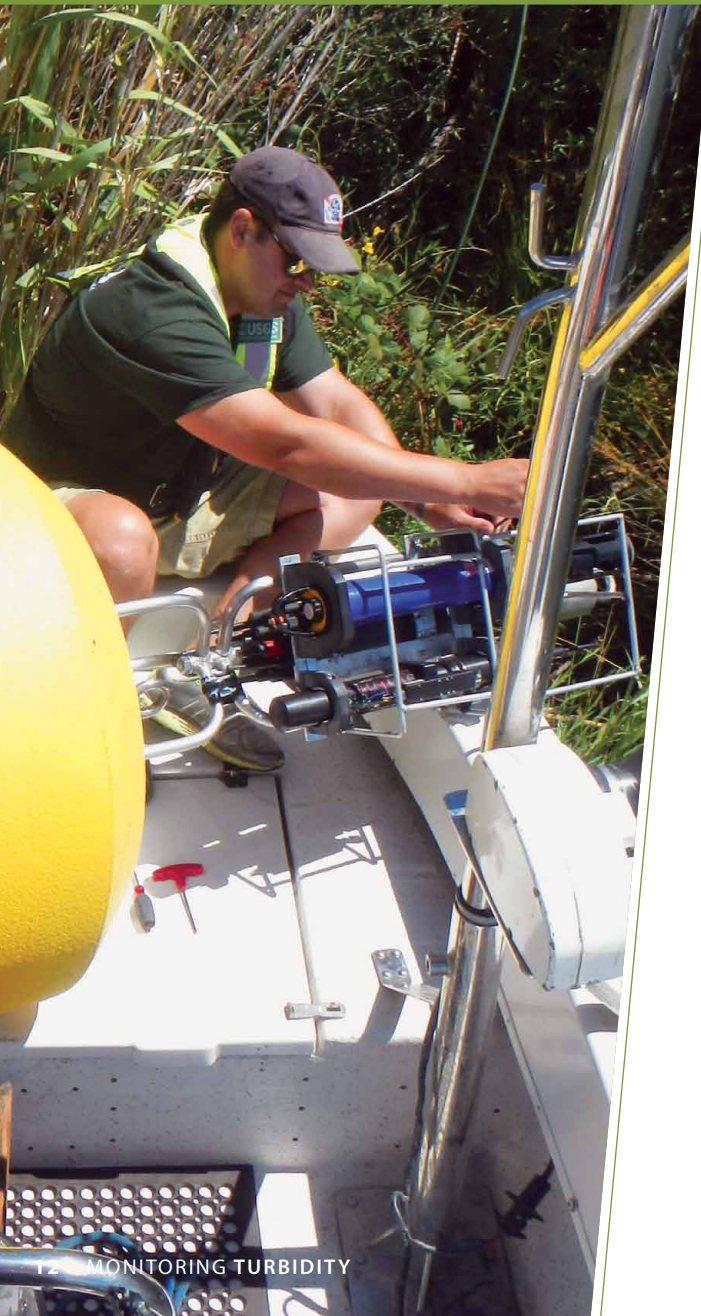
But these cloud-based datacenters are more than just a pretty face. Many can be programmed to send out automated alarm notifications when turbidity levels exceed pre-defined limits. These limits are determined by collecting background data prior to dredging using spot-sampling equipment. Once an allowable turbidity range has been set, the data are entered into the online database. If turbidity levels exceed this recommended range during dredging operations, the datacenter will immediately issue an alert (text and/or email) to the appropriate project manager or operator.

With the availability of real-time data and the datacenter's auto-alert system, dredge operators can be notified immediately when turbidity levels rise. This means that timely control procedures can be implemented to slow down, alter or stop the dredging operation until levels fall below the maximum allowable limit. The online datacenter can also transmit this alert back to the data logger in order to respond to the exceeded turbidity range. Automated responses may include taking more frequent readings during high turbidity periods, then resuming regular log intervals when levels return to normal.



# QUALITY ASSURANCE

Accurate data ensure that dredging operations remain in compliance with set regulations. To maintain that accuracy and keep equipment functioning within specifications, best practice recommends cleaning and calibrating the instruments at regular intervals. It is also recommended to cross-check sensor accuracy against a separate instrument. This cross-checked data can then be used to show compliance against an EPA approved method, if needed.



## System Maintenance

Regardless of the turbidity equipment chosen to monitor a dredging site, periodic maintenance and calibration is required. Instrument maintenance includes cleaning the instruments (especially if a sensor is not self-wiping), and replacing any deteriorating o-rings to prevent water ingress. If using additional parameter sensors (such as conductivity), further field servicing may be required. Maintenance intervals are largely dependent on site conditions and other variables, such as the potential for biofouling. Common calibration and maintenance intervals are on a weekly or bi-weekly basis.

Turbidity sensors usually require a two-point calibration — one at 0 NTU/FNU and another at a higher turbidity value (often 126 NTU/124 FNU). The 0 NTU value can be obtained using de-ionized water, though 0 NTU/FNU standard solutions do exist. The high range calibration should use an approved standard such as a commercial or prepared Formazin, or commercial AMCO-AEPA standards. For greater accuracy and a wider range, turbidity sensors can follow a three-point calibration (e.g. 0 NTU, 100 NTU and 1000 NTU). Regardless of the number of points used, it is important to always include 0 NTU/FNU as the first point. For best results, use only freshly prepared or purchased turbidity standard, as they degrade over time. Any diluted standard should only be used on the day it is made.

In case of sensor failure or damage, it is useful to have spare sensors or sondes on hand. These can be field swapped during calibration or routine maintenance checks. Having a spare turbidity sensor available will reduce downtime due to unforeseen sensor failure, which could cause critical and costly interruptions to safe dredging operations.

For greater details regarding maintenance requirements and sensor calibration, the manufacturer's user manual should be referenced.

## Performance Verification

In addition to keeping turbidity equipment calibrated, it's important to periodically verify that the sensors are providing accurate turbidity data. The best way to achieve this is by checking turbidity in the same area using a separate, portable monitoring system. This is also known as spot sampling.

There are two portable turbidity measurement methods available for spot sampling. The first method uses a sensor (much like the one used in the buoy-based monitoring system) and a handheld display. The turbidity sensor can be attached directly to a handheld display or through a sonde to the display to show real-time data. Sondes are useful instruments if other parameters, such as pH, dissolved oxygen or conductivity should be recorded as well. The sonde or sensor can be lowered into the water column to a depth that matches the in-place sensors. While it is at that depth, a turbidity measurement can be taken. The data from this portable system can then be compared to the in-place monitoring system and checked for discrepancies. As with the buoy-based system, this method reports in FNU or FBU based on the sensor used. While FNU readings are approved by ISO 7027, neither option is approved by the EPA.

The second method uses a handheld turbidity meter. This method requires taking a water sample, and then inserting it into the meter for a reading. As this method uses a sample instead of an in-situ measurement, it is often not representative of the surface water as a whole. This is especially a hindrance



when quality checking monitoring systems that measure turbidity at multiple depths along the water column. While handheld meters are not submersible, many styles are compliant with EPA method 180.1. This means that the long-term data can be cross-checked against an EPA-approved method. However, while correlations can be made between data sets, care should be taken when comparing data between the meter and the buoy-based monitoring system. Turbidity instruments are inherently not comparable, and comparative models are only accurate for the specific sample location.





# RECOMMENDED EQUIPMENT

While there are plenty of turbidity monitoring instruments on the market, some stand out above the rest. Fondriest Environmental has selected these products as the best in their field for their quality, reliability and value. Together, they provide an advanced and powerful real-time turbidity monitoring system. For a sensor or sonde, accuracy is of utmost importance and the YSI EXO2 does not disappoint. The rugged NexSens CB-450 offers long-term durability with 30 W of solar power, 450 pounds of buoyancy and a choice of instrument mounts for multiple sensors. Alone, real-time data are good, but with remote data collection, 24/7 access from any computer, instant alarm notifications and trend tracking, the intuitive WQData Live takes real-time data to the next level.



## YSI EXO2 Multi-Parameter Sonde

The YSI EXO represents the next generation of water quality instruments from YSI. The advanced sonde platform offers a wide range of capabilities to those dedicated to monitoring natural aquatic environments such as oceans, estuaries, rivers, lakes and groundwater. With a highly efficient power management platform, robust construction and chemistry free anti-fouling system, EXO allows accurate data collection for up to 90 days between service intervals.

The EXO2 sonde includes six sensor ports and a central anti-fouling wiper option. Sensor parameters include temperature, conductivity, depth, dissolved oxygen, pH, ORP, total algae (phycocyanin and chlorophyll), turbidity and fluorescent dissolved organic matter (fDOM). The sonde can also output 4 calculated parameters including salinity, specific conductance, total dissolved solids (TDS) and total suspended solids (TSS).

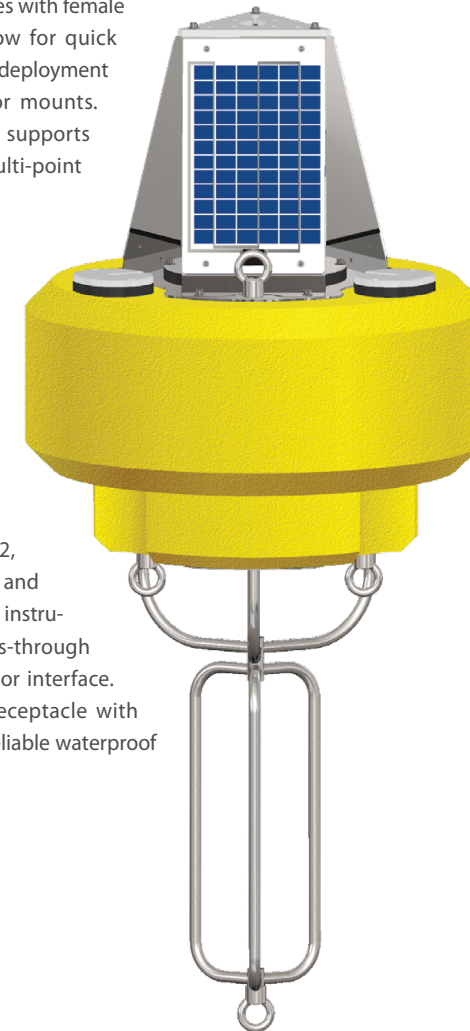
All EXO sensors are digital sensors with onboard signal processing and memory. Built-in sensor diagnostic and calibration data allow users to calibrate multiple sensors in one sonde and distribute to various other sondes in the field. Wet-mateable connectors allow for swaps in wet conditions, while active port monitoring automatically detects each sensor and verifies operation.

## NexSens CB-450 Data Buoy

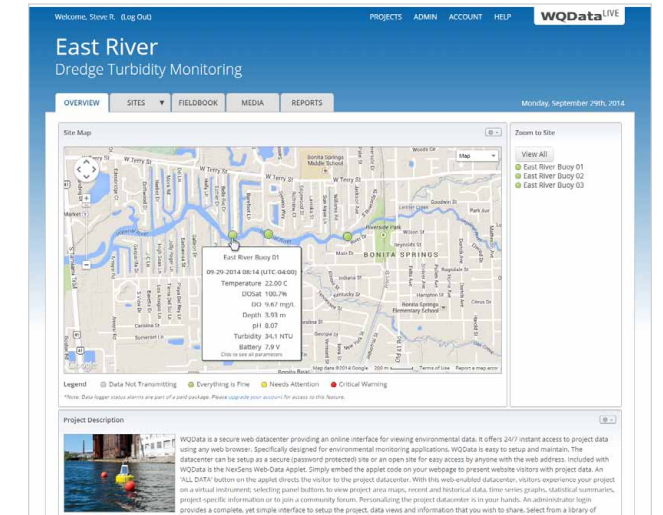
The NexSens CB-450 Data Buoy is designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments. The floating platform supports both topside and subsurface environmental monitoring sensors including weather stations, wave sensors, thermistor strings, multi-parameter sondes, Doppler current profilers and other monitoring instruments.

The buoy is constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A topside 20" tall stainless steel tower includes three 10-watt 12VDC unbreakable solar panels, and a center 10" ID x 18" tall instrument well accommodates batteries, data loggers, sensors and more. Three 4" pass-through holes with female NPT bottom threads allow for quick connection of instrument deployment pipes and custom sensor mounts. The stainless steel frame supports both single-point and multi-point moorings.

The CB-450 Data Buoy is optimized for use with NexSens data loggers. Wireless telemetry options include Wi-Fi, spread spectrum radio, cellular and Iridium satellite. Compatible digital and analog sensor interfaces include RS-232, RS-485, SDI-12, VDC, mA and pulse count. The top of the instrument well includes 8 pass-through ports for power and sensor interface. Each port offers a UW receptacle with double O-ring seal for a reliable waterproof connection.



## NexSens WQData LIVE Web Datacenter



WQData LIVE is a web-based project management service that allows users 24/7 instant access to data collected from NexSens remote environmental data logging & telemetry systems. More than just an online database, WQData LIVE offers the ability to generate automated reports, configure alarms to notify project personnel when data values exceed threshold limits, create FieldBooks to store calibration forms, notes and media and much more. Projects are password protected with the ability to configure a public portal or presentation view to share data with the general public. Project Administrators have the ability to edit project descriptions and information, while users given Collaborator access are limited to data viewing and form entry.

The Google Maps view shows all project sites on a map with zoom, scroll and drag capability. Mousing over a site on the map displays the most recent data values, and clicking on the site navigates to a display showing the last reading or tabular data that can be downloaded to Excel and sent via email or FTP. FieldBooks can be created to store notes recorded during field visits, including forms to store calibration data, which can be submitted from the WQData LIVE mobile app. This eliminates the need for conventional fieldbooks while keeping critical project information in a single, easy-to-access location. Site photos can even be placed onto FieldBook pages or uploaded into the project's Media page.

The WQData LIVE report feature allows data to be shown both graphically and in a tabular format. Report templates can be saved so that specific information can quickly be referenced. Project alarms send email or text messages to project staff for immediate notification of critical conditions. With this unique set of features, WQData LIVE provides everything needed to effectively manage an environmental monitoring application.

# PURCHASE OR RENT?

When managing a large or long-term dredging project, purchasing several turbidity monitoring systems is often the most economical option. However, for short-term dredging projects on a tight budget, it may not be practical to purchase the necessary turbidity monitoring equipment. In these situations, it is much more prudent to rent real-time monitoring systems. With several lease duration and extension options available, the flexibility of renting turbidity monitoring systems may still be cost-effective for the larger dredging applications as well.

Turbidity monitoring equipment can be rented instrument by instrument, or as an entire system, calibrated and ready to deploy on arrival. Rental equipment can include sensors, sondes, handheld displays, data buoys and web-based datacenter access. Real-time telemetry via radio-to-shore, cellular and satellite can also be incorporated. A large rental pool also means that most turbidity monitoring equipment can be shipped same-day for quick deployment and emergency situations.

Just as with Fondriest purchases, rental projects have access to a knowledgeable support staff who will provide personalized service before, during and after the project.

Fondriest Environmental, Inc.  
2091 Exchange Court  
Fairborn, OH 45324

tel: 888.426.2151  
fax: 937.426.1125  
customer@fondriest.com

# ABOUT FONDRIEST

## Company

Located in the Lower Great Lakes and Ohio River Valley region, Fondriest Environmental is a leading distributor and integrator of equipment for natural resource professionals and outdoor enthusiasts. Our team of specialists can help customers understand the products they are buying and make the correct decisions out in the field. We seek to understand project needs, devise a comprehensive solution, provide the equipment and know-how to implement it and then offer long-term project support for whatever needs arise.

## Capabilities

We work closely with NexSens Technology, a company that specializes in the design and manufacture of real-time environmental measurement systems. A variety of sensor, platform and telemetry options are available to fit the unique needs of each project. We can provide complete integrated solutions and support projects from conception to completion. An extensive fleet of rental equipment is also available for short-term project needs.

## Certifications

Fondriest Environmental is a Certified Repair Center for YSI, NexSens & FishSens, offering quick turnaround, affordable labor rates and personalized service. Our knowledgeable technicians are available for phone, email and onsite support when the need arises.

## Publications

We cover many customer projects in our Environmental Monitor magazine, which is updated daily online and printed quarterly. We also produce Lake Scientist, an interactive online resource providing research articles and news on lake ecology. Informational pages on environmental parameters and applications are available in the Measurement Sciences section of our website. And FishSens Magazine, available online, provides anglers, boaters and fisheries professionals with the latest fish science news.

## Commitment

A commitment to integrity and longstanding customer relations are the standard, rather than the exception, at Fondriest Environmental. We support professionals, educators and researchers who continuously work to monitor and protect our global resources by providing them with the products and services needed to face today's environmental challenges. Our team of solution-driven experts has years of field experience and a keen eye for finding the best equipment for each application.

## Contact Information

To reach an application specialist, please call (888) 426.2151 or email [customer@fondriest.com](mailto:customer@fondriest.com)



## SYSTEM CONFIGURATION TOOL

Fondriest application specialists will assist with tailoring buoy configuration and equipment choices on a site-by-site basis to ensure reliability and proper data management. The questionnaire below can help you get started. Once completed, this form can be faxed to (937) 426.1125 or, if completed digitally, emailed to [customercare@fondriest.com](mailto:customercare@fondriest.com).

### Contact Information

Name: \_\_\_\_\_

Organization: \_\_\_\_\_

Telephone: \_\_\_\_\_

Email: \_\_\_\_\_

### Site Conditions

Describe the site conditions in a paragraph or two. Please include details regarding levels of wind, waves and boat traffic experienced in the area.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### Site Location

The location of a monitoring system can affect what buoy configuration best suits the conditions. Please select in what type of water body the system will reside.

Lake     River     Coastal     Other    Please Specify \_\_\_\_\_

### Approximate Depth

The mooring hardware and cable lengths used for a deployment depends on the distance to the sea floor. An application specialist can develop the best mooring plan to accommodate the approximate water depth.

< 5 ft.     Between 5 and 25 ft.     Between 25 and 50 ft.     Between 50 and 100 ft.     > 100 ft.

### Water Column Measurements

Measuring turbidity at a single mid-level depth is often sufficient for dredge monitoring. In some cases, however, regulatory agencies may require readings at multiple depths.

Single Depth     Multiple Depths    Please Specify \_\_\_\_\_

### Telemetry

License-free spread-spectrum radio telemetry allows communication with a shore-side NexSens radio base station as far as five miles line-of-sight from the monitoring site. Cellular telemetry allows greater geographic flexibility and is able to transmit from almost anywhere in the U.S., but it includes the cost of a cellular data plan. Satellite telemetry can be used nearly anywhere in the world, but it tends to have the highest data cost compared with cellular telemetry.

Cellular     Radio     Satellite     None

### Quality Assurance

A multi-parameter sonde with turbidity sensor connected to a handheld display is an ideal way to verify the accuracy of a turbidity monitoring system and uses the ISO 7027 method. Alternatively, there are portable turbidimeters that can measure using the EPA-approved 180.1 method.

Multi-parameter sonde & handheld display (ISO 7027 Method)     Portable turbidimeter (EPA 180.1 Method)

### Project Length (Rental vs. Purchase)

Although it often makes sense to purchase systems outright, many short-term dredging projects make it cost-prohibitive. Fondriest Environmental offers real-time turbidity monitoring systems with weekly and monthly rental rates to accommodate these operations. An application specialist can make recommendations on what choice is most cost-effective.

1-3 Months     3-6 Months     6-12 Months     >1 Year    Please Specify \_\_\_\_\_

# FONDRIEST ENVIRONMENTAL

Fondriest Environmental, Inc.  
2091 Exchange Court  
Fairborn, OH 45324

**P** 888.426.2151

**F** 937.426.1125

**E** [customercare@fondriest.com](mailto:customercare@fondriest.com)



when your  
**research**  
demands  
**quality data**

PRSR STD  
US POSTAGE  
**PAID**  
DAYTON, OH  
PERMIT# 860

**TAKE YOUR PROJECT TO THE NEXT LEVEL.**  
CONTACT A FONDRIEST APPLICATION SPECIALIST  
888.426.2151