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Standard Operating Procedure #5: Monitoring Core Water Quality Parameters, Version SCPN_WATER_QUALITY_SOP05_20160901

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Standard Operating Procedure #5: Monitoring Core Water Quality Parameters

Version SCPN_Water_Quality_SOP05_20160901				
Revision History Log				
Previous version number	Revision date	Section and paragraph	Change(s) made	Approved by
Only changes in this specific SOP will be logged here. Record the previous version number and date of revision; identify sections and paragraphs where changes were made, who approved the revision, and the new version number. More detailed descriptions of the changes made and the reason for the changes is provided at the end of this SOP.				

This Standard Operating Procedure (SOP) describes procedures for measuring NPS core water quality parameters in SCPN parks, including temperature, pH, specific conductance, dissolved oxygen, turbidity, and discharge. It also provides instructions for documenting hydrologic conditions on the *Water Quality Datasheet* and for the calibration and use of equipment needed to take field measurements, including multi-parameter sondes, flow meters, temperature loggers, and turbidimeters.

The methods described here are based on guidance provided by the NPS Water Resources Department (2002), Rantz et al. (1982); the USGS National Field Manual for the Collection of Water-Quality Data Chapters A6.1, 6.2, 6.3, 6.4, and 6.7 (USGS variously dated); Sharrow et al. (2007); and specific equipment operating manuals.

Equipment

Please see Appendix F for a list of the equipment needed to collect field data for water quality sampling.

1 Recording site information

Fill in the identifying information on the *Water Quality Datasheet* (Figure 5-3) for each monitoring site visit.

- **Park code.** Record the park code (e.g. BAND).
- **Site name.** Record the site name (e.g. Capulin Creek at Base Camp Gaging Station).
- **Date.** Record the date in the format yyyyymmdd (e.g. 20130101).
- **Site code.** Record the site code (e.g. CAP01).
- **Observer(s).** Record the names of all crew members conducting observations.

- **Start time.** Record the beginning time of the water quality visit in the four-digit hour and minute format of military time.
- **End time.** Record the end time of the water quality visit.
- **Local time datum.** Circle the local time zone (e.g. MST for Mountain Standard Time, MDT for Mountain Daylight Time).
- **Site access notes, general observations, and other work done.** Record any pertinent information on changes to, or issues with site access (road/trail conditions, inclement weather, environmental hazards, landowner issues, etc.) Also record any changes in site conditions or other information that may be useful in interpreting water quality data, including, but not limited to:
 - Potential anthropogenic or zoogenic impacts on stream water quality
 - Possible explanations for a high flow, such as snowmelt or heavy rains elsewhere in watershed, recent water releases from upstream impoundments or diversions, etc.
 - Problems with equipment or other possible explanations of questionable data
 - Changes to gaging stations or other installed flow measurement devices (weirs, flume, etc.)
 - Organisms that haven't been seen at the site previously, or whose abundances have dramatically changed; odd smells and/or smoke in area; recent fires in watershed, etc.
 - Note if other sampling work was done and what type (i.e. aquatic macroinvertebrate, stream-reach walkthrough, groundwater wells, etc.)
- **Precipitation.** Note whether there was any precipitation and what kind. Record the following:
 - Precipitation during sampling (select one: none, rain, freezing rain, hail,

sleet, or snow)

- Precipitation within 24 hours prior to sampling (y/n)?

2 Recording site and flow conditions

2.1 Stream channel description

In the section titled “Stream Channel and Flow Conditions at the Water Quality Sampling Site”, fill in the following information:

Channel. Record the channel characteristics of the specific site where water quality measurements are made. Choices include pool, riffle, open channel, braided, or backwater. Ideally water quality measurements will be made in an open channel or a riffle.

Substrate. Record all particle size classes present in the channel substrate at the specific site where water quality measurements are made (Table 5-1). Identify the dominant size class at the site. Also record whether vegetation, wood, or other objects are present in the water at the site.

2.2 Flow description

Describe flow conditions at the water quality measurement site.

- **Stream color** (select one):
 - Clear: crystal clear, transparent water
 - Milky: not quite crystal clear; cloudy

Table 5-1. Substrate particle size classes.

Size class ¹	Definition
Clay	Grains not visible, smooth texture
Silt	Grains not visible, gritty texture
Sand	Grains visible, gritty, up to ladybug size
Gravel	Ladybug to tennis ball size
Cobble	Tennis ball to basketball size
Boulder	Basketball to car size
Bedrock	Larger than a car
Vegetation	Any size
Wood	Any size
Other	Describe in comments field

¹Kaufmann and Robison 1998

white or grey

- Foamy: natural or from pollution
- Tea-colored: clear, natural coloration from wetland
- Muddy: cloudy brown due to high sediment levels
- Green: algal coloration evident
- Scum/Odor: green or muddy plus extensive floating scum or foul odor
- Other: include a written explanation
- **Flow mixing.** This is a qualitative measure of how uniform core parameter measurements are across the stream and is an indication that sampling site is representative of other locations in the stream. See SOP #6, Section 2.1 for more information. The majority of SCPN streams will be well-mixed. Select one: Excellent, Good, Fair, Poor. Use Table 5-2 as a guide. If the measurements are outside those ranges, the site is poorly mixed.
- **Percent ice cover.** Estimate percent of the stream in the cross section where water quality measurements are being taken that is covered by ice.
- **Average ice thickness.** Measure the thickness (cm) of a piece of ice covering the stream that seems representative of the average thickness of ice cover.
- **Flow severity.** Select one: Dry, No Flow, Low, Normal, Above Normal, Flood (see Table 5-2).
- **Hydrograph limb.** Select one to describe the flow of the stream: Base flow,

Rising, Peak, Falling

2.3 Flood evidence

Record any evidence of recent flooding. In particular, place a checkmark by any of the following types of flood evidence.

- Fresh debris line in channel / above active channel (circle one)
- Grasses/shrubs laid over
- Recent flood event greater than baseflow but less than bankfull
- Recent deposition of sediments on floodplain
- Riparian vegetation scoured away
- Other (note in comments any other specific flood evidence, such as vegetation, channel, or bank scouring)

3 Measuring discharge

There are several ways to measure discharge. The specific method used will vary by monitoring site and will depend on flow conditions at the time of the site visit. Factors influencing which discharge measurement method is used include the quantity of flow, channel characteristics, and accessibility. Table 5-3 provides guidance for selecting the most appropriate discharge measurement method, describing applicable field conditions and relative accuracy (Turnipseed and Sauer 2010).

To measure discharge in wadeable streams SCPN will use one of the following devices: a Sontek FlowTracker Handheld Acoustic Doppler Velocimeter (ADV), a Price Pygmy

Table 5-2. Flow severity codes.

NPSTORET ^a Code	NPS-WRD Description
Dry	No visible water in stream (typical of dry period for an ephemeral/intermittent stream).
No Flow	Discrete pools of water with no apparent connecting flow (at surface).
Low	Base flow for a stream or flow within roughly 10% to 20% of base flow condition.
Normal	When stream flow is considered normal (greatest time that stream is characterized by this in terms of flow quantity, level, or general range of flow during a falling or rising hydroperiod, but above base flow).
Above normal	Bank full flow or approaching bank full (generally within upper 20% of bank full flow condition).
Flood	Flow extends outside normal bank full condition or spreads across floodplain.

^aThe NPS water quality database

Table 5-3. Accuracy and points to consider when selecting a discharge measurement method.

Method	Relative Accuracy	Field Considerations
Volumetric	Very high	Most easily applied where a natural pour-over exists. Can be accomplished by construction of temporary dam.
Weir, flume ^a	High to very high	Weir and flume can be difficult to carry into backcountry sites. Impacts due to repeated installations at springs are a concern.
Current meter	High	Requires wading, so will be unsafe during flood conditions. Not practical for very low discharges.
Float velocity	Low to moderate	Applicable to a single channel with a minimum of vegetation or organic debris.
Visual estimation	Low	Use only where other methods are ineffective or unsafe.

^aNote: Of the instruments listed, the flume is the largest and most difficult to pack into backcountry sites. It should be used under these conditions only if there is no other alternative.

current meter, a Marsh-McBirney Flo-Mate Model 2000, a Hach FH950, or a Baski flume. For sites with very low discharge, such as many of the springs in SCPN parks, a volumetric measurement provides the greatest accuracy. Temporary installation of a flume or weir is an alternative in these situations, though the impacts of repeated installations should be considered.

Most current meters used for measuring discharge, except for the Marsh-McBirney and the Baski flume, generate data files that can be downloaded to a computer. Follow the file naming conventions specified for each piece of equipment below. Equipment used for obtaining discharge measurements is listed in Appendix F.

Prior to each monitoring trip, the trip leader must ensure that all equipment is in good working order (see SOP #4). The trip leader should consult the equipment log books to see if there are any issues with the equipment that need addressing, and should record any necessary calibrations or maintenance (refer to SOP #4, Section 1).

Record the following in the “Discharge Measurement” section of the *Water Quality Datasheet*:

- **Start time**
- **End time**
- **Observer**
- **Discharge measurement method** (circle one: flow meter, flume, volumetric, or visual estimate)

- **Flow meter time zone**
- **File name**
- **Flow meter make/model/serial number** (if one is used)
- **Pygmy meter spin test time** (if one is used)
- **FlowTracker passes automatic QC test** (yes/no)?
- **Calculated discharge** (m³/s or ft³/s)
- **Discharge measurement location.** Describe in relation to permanently-located objects, e.g. “30 meters upstream from USGS gaging station”.
- **Control location (in relation to a gage), description, and condition.** This is only noted if there is a gage. The control is a feature in the stream that affects the water level behind it, such as an obstruction
- **Observer estimate of measurement accuracy** (see Section 3.3.5)
- **Estimate of total percent of flow captured by measurement**
- **Discharge measurement comments.** Note any explanations of problems or inaccuracies in flow measurement.

3.1 Volumetric measurement method

Volumetric measurements are typically used in streams and springs where there is a pour off, or other feature that allows flow to be easily captured in a container of known volume. The accuracy of the measurement is dependent on the time required to fill the

container. If a container fills in less than 5 seconds, use a larger container. If a container fills in greater than 120 seconds, use a smaller container. A suite of varying size containers should be taken to the field site. When not used for volumetric measurements, the containers can be used to help pack field gear.

The steps for a volumetric measurement are

1. Identify a location in the channel where most of the discharge flows.
2. Construct a temporary earthen dam using local soil/sediment.
3. Divert water through the temporary earthen dam with a pipe or constructed channel.
4. Allow flow to stabilize prior to measurement. Stabilization time will vary depending on flow volume.
5. Catch discharge from pipe with a container of known volume
6. Measure time to fill container with a stopwatch (tenths of seconds).
7. Repeat the measurement a minimum of 5 times.

3.2 Flume method

Typically, flumes are used to measure streams that have very low discharge and are too shallow for current meters. Flumes may be heavy and difficult to pack into backcountry sites, but they are the most accurate measurement method for some discharges. Try to minimize damage that may occur to the channel and banks when setting the flume in place. Discharge is measured by placing the flume in the channel and forcing all of the flow to pass through the device. If the following conditions are met, the result is a highly accurate (within 2-3 percent) measure of discharge:

- all the flow is flowing through the device
- all of the flow is directed downstream (i.e. there are no eddies) and lines of flow are as near parallel as possible
- the device is installed level and plumb

- there is a free fall on the downstream side of the device
- adequate time is allowed for the pond behind the device to fill and equilibrate
- water depth is measured accurately and in the correct location
- the channel is low gradient
- bed materials are fine-grained to ease placement and minimize leakage around the device

3.2.1 The portable flume procedure

SCPN will use Cutthroat-type flumes manufactured by Baski, Inc. These have adjustable throat widths from 1 to 8 inches, and can measure flows from 2.5 to 1,000 gallons per minute.

1. Select a measurement site.
2. Orient the flume with the wing walls pointed upstream in the channel and focus as much flow as possible through the regular profile of the opening of the flume.
3. Use a bubble level to make sure the flume is level.
4. Seal leaks under and on the sides of the flume using stream bed material.
5. Allow flow to stabilize prior to measurement.
6. Record water level height from the gage at half-minute intervals for about 3 minutes, then calculate the mean value
7. On some occasions, it may not be possible to capture 100% of the discharge in the flume. If less than 100% of the discharge is captured by the flume, estimate the percent of flow captured by the flume for each of the measurements and record.
8. Determine the discharge using the appropriate rating curve on the chart for the flume in use.
9. Record discharge value on the *Water Quality Datasheet*.

3.3 Current meter method

In wadeable streams SCPN will use one of the following flow meters (in conjunction with a wading rod) to measure discharge: a Sontek FlowTracker Handheld Acoustic Doppler Velocimeter (ADV), a Price Pygmy current meter, a Marsh-McBirney Flo-Mate Model 2000, or a Hach FH950. SCPN Water Resource crew members should be thoroughly familiar with all appropriate hydrologic equipment and software prior to going into the field. For guidance describing setup, use, quality control, and troubleshooting of the current meters refer to their user manuals. Table 5-4 is a list of the current meters used and the recommended ranges of depth and velocity for their use.

3.3.1 Selecting a site for measuring discharge and setting up the current meter

Site selection and setup are the same for all current meters. Be sure that the meter, wading rod, and measuring tape are in the same units.

1. Choose a cross section in a straight reach that has the following characteristics:
 - Streambed has a flat profile and is free of large rocks, plants, and protruding obstructions that create turbulence.
 - All of the flow is directed downstream and lines of flow are as near parallel to the streambanks as possible.
 - The flow is relatively uniform and free of eddies, slack water, and excessive turbulence.
2. Pull a measuring tape taut, perpendicular to the channel and secure at both ends.
3. Divide the cross section of the channel into partial sections (also known as verticals).
 - The spacing between partial sections should be adjusted so that no more than 5% of the flow is in any one partial section. This means that where water is deeper and swifter measurement points are spaced closer together, while in shallow and slow water they are spaced further apart.
 - Optimally the channel is divided into 20 to 30 partial sections. In small streams the number will be less.
 - Most SCPN meters allow technicians to ensure that each section is <5% of flow prior to saving the file. Additional measurements can be made if necessary.
4. If the stream is too narrow to measure velocity at 20 stations then measure the entire wetted channel at 5 cm intervals
5. The person making the velocity measurement should stand an arms-length downstream from the current meter so as to not disturb the flow path.
6. Measure velocity at each partial section for 40 seconds, starting at stream-left

Table 5-4. Recommended current meters for various stream depths and velocities. Ranges for the FlowTracker, Pygmy meter, and AA meter are from Turnipseed and Sauer 2010. Flo-Mate and FH950 ranges are from the manuals.

Meter	Velocity range (ft/s)	Ideal depth range (ft)	Velocity measurement ¹
FlowTracker	0.003–13	>0.25	0.6 if depth <1.5' 0.2/0.8 if depth ≥1.5'
Pygmy	0.2 – 4.0	0.3 ² – 1.5	0.6 if 0.3 < depth <1.5' 0.2/0.8 if depth ≥1.5'
Price AA	0.2 – 12	>1.25	0.6 if 1.5<depth<2.5' 0.2/0.8 if depth ≥2.5'
Marsh McBirney Flo-Mate	-0.5 – 20	none specified	none specified
Hach FH950	0 – 20	>0.1	none specified

¹At depths greater than 1.5 ft, two measurements are taken—at 20% and 80% of depth—and the meter averages them.

²Pygmy meter may be used in depths as low as 0.3 ft with 0.6-depth method; however, it should be avoided as it introduces error.

and ending at stream-right.

7. If using the Marsh-McBirney Flo-Mate, record the location of each vertical in meters from LEW in the current meter section of the *Water Quality Datasheet*, and the depth at each location.
8. For other flow meters, save the data file and write down the discharge result on the datasheet.

3.3.2 Measuring discharge with the Sontek FlowTracker ADV

A Sontek FlowTracker Handheld Acoustic Doppler Velocimeter (ADV) can measure velocity and store channel geometry data, and can compute discharge based on these data. The FlowTracker records data and calculates discharge in both English and metric units to the nearest one ten thousandth. The method for measuring discharge presented here is appropriate for measuring flow in wadeable streams of all depths. Complete instructions for using the Sontek FlowTracker and related software are included in equipment manuals available on the SCPN common drive.

The main components of the Sontek FlowTracker ADV are a probe and a handheld controller (Figure 5-1). The probe attaches to a conventional top-setting wading rod through the use of an adaptor bracket designed for this purpose. The handheld controller is attached with a bracket to the

top of the wading rod. A shielded cable connects the probe and controller. All measurement configurations and necessary data entry are done using the handheld controller keypad.

The sampling volume (the volume of water in which measurements are made, Figure 5-1) is approximately 10 cm away from the acoustic transmitter/wading rod. For this reason, partial sections must be at least 10 cm apart, in order to avoid section overlap (over-sampling). Thus, in a stream with a narrow channel width, it may be impossible to obtain 20 partial sections. It is better to obtain less than 20 sections than to have overlapping sections. Also, be aware that rocks, plants, or debris may interfere with the probe's operation because it is measuring 10 cm away. In this case, a "boundary QC error" will occur and require moving the probe to another location.

Consult the FlowTracker manual for a complete list of QC messages and troubleshooting tips. This manual is stored on the SCPN server and on the field laptop. All QC messages encountered during measurement will be stored in the FlowTracker data file.

The following parameters should be checked when using the FlowTracker:

- **System clock** – make sure the clock

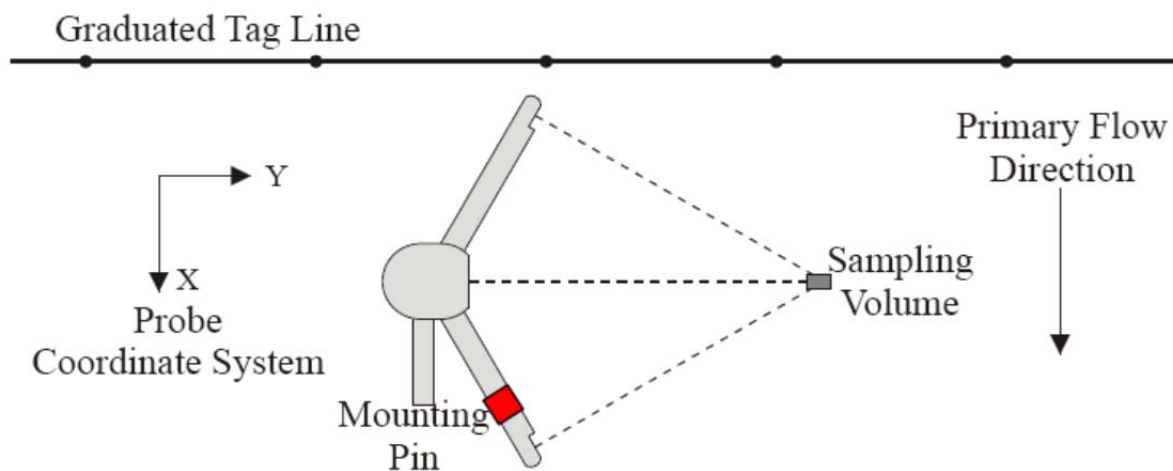


Figure 5-1. The FlowTracker probe should be oriented perpendicular to the tagline. The flow is measured at a distance of approximately 10 cm from the acoustic transmitter (and wading rod).

displays the local date/time.

- **Recorder status** – make sure there is adequate data-storage capacity for the discharge measurement or velocity data run.
- **Temperature data** – immerse the ADV probe in the stream and note the temperature. Check the temperature recorded by the ADV against a temperature reading from another thermometer. A 5-degree (Celsius) error in temperature would result in a 2-percent error in the velocity and discharge measurement. Note the temperature in the Discharge Measurement comments section the *Water Quality Datasheet*.
- **Battery data** – check the battery voltage to ensure there is adequate capacity for a discharge measurement or velocity data collection.
- **Immerse probe in flowing water and perform ‘Auto QC Test’**. Note on *Water Quality Datasheet* whether Flowtracker passes QC test.
- **Signal-to-noise ratios** – the Flowtracker signal-to-noise ratio (SNR) should be greater than or equal to 10. The SNR can be as low as 4 and adequate data still can be collected. If low SNRs appear to be causing data-quality problems, such as in very turbid water, use a different type of flow meter.
- **Ending a measurement** – once a measurement is complete, press the End Section button. You will then have the opportunity to save the file. Enter the discharge value on page 2 of the *Water Quality Datasheet*.
- **Data files** - For each discharge measurement made with the FlowTracker a data file is automatically created and stored in the handheld controller. Only file names of up to 8 characters are allowed. The file should be named with the measurement date in the format “DDMMYY.” If two or more files are created on the same date, then label each by adding an extension. Enter the SCPN site code (e.g.

“BANDRIT01”) as the site. FlowTracker files should be renamed as soon as they are downloaded to a PC, following the naming conventions in Section 4.2.1.

3.3.3 Measuring discharge with a Pygmy Current Meter and AquaCalc

Discharge measurements made with Pygmy current meters will be stored in an Aquacalc data collector. Prior to using the pygmy meter, conduct a spin test that exceeds 45 seconds. Write the spin test result on page 2 of the *Water Quality Datasheet*. Although Table 5-4 states the pygmy meter may be used in depths to a minimum of 0.3 ft, the meter is most accurate at depths above 0.75 ft.

If 25 percent of the verticals are equal to or less than 0.3 ft., try to narrow and/or deepen the section, keeping in mind the velocity and required number of sections. If this is not practical, consider using a flume or making a volumetric measurement.

The pygmy meter and Aquacalc are capable of making and recording both English and metric measurements to the nearest one hundredth. Since the Aquacalc is only capable of calculations to the nearest one hundredth metric measurements are inadvisable with this instrument in most of SCPN’s smaller streams, as most velocity and depth calculations in streams with low flow will be truncated to 0.00 and the information will be lost. For example, measurements of 0.004 will be truncated to 0.00. If metric measurements are unavoidable (for instance, if an English flow rod is unavailable):

1. Open the Aquacalc file in the Aquacalc Excel Analyzer (JBS Instruments, www.jbsenergy.com).
2. Navigate to the “summary for printing (letter)” tab, and format cell C8 to display the appropriate number of decimal places.
3. In the upper-right part of the spreadsheet, choose the “Re-Calculated Values” option. This re-calculates all the subsections of the measurement using more decimal places, adds them all up, and displays the final result in cell C8.

An instructional presentation (Microsoft Powerpoint file “Wri-4036.ppt”) for using the Pygmy meter, produced by the USGS, is available on the SCPN common drive.

3.3.4 Measuring discharge with the Flo-Mate Model 2000 and Hach FH950

Refer to the user manual for operational details and theory (an electronic version is available on the SCPN common drive). These meters are used in a similar fashion to the other flow meters. A key difference from the Flow-Tracker (which uses acoustic signals) is that the Flo-Mate and Hach FH950 produce a magnetic field and measure the voltage produced by the conductor (water) moving through the field, from which they derive the velocity of the water. These measurements take place inside the open-channel velocity sensor, which is mounted to a wading rod (Figure 5-2). Thus, the minimum distance between partial sections in a flow measurement should be slightly more than the width of the sensor body, or approximately 5 cm apart.

The Flo-Mate Model 2000 does not calculate flow; thus the section location, velocity measurement, and depth of each partial section of a flow measurement must be recorded on the *Water Quality Datasheet's* “Flow Meter” table. These section measurements will later be entered into the SCPN water quality database, which will calculate the discharge.

The Hach FH950 records and calculates discharge in both English and metric units to the nearest one hundredth (see Section 3.3.3 for further detail). Any metric measurements on smaller streams will need to be recalculated in an Excel discharge calculation spreadsheet available on the SCPN server. All measurements are saved to a .txt file which should be stored on the SCPN server after returning from fieldwork.

3.3.5 Hanna Combo meter

(adapted from Hanna 2005)

The Hanna Combo meter (HI98129) is a small portable water quality meter used by SCPN at remote or small sites to make single point measurements of specific conductance and pH. Before going in the field, take the following steps to check battery levels and make sure backup batteries are available.

To turn the meter on and to check battery status, press and hold the MODE button for 2-3 seconds. All the used segments on the LCD will be visible for a few seconds, followed by a percent indication of the remaining battery life (e.g. % 100 BATT).

Equipment should be calibrated for specific conductance and pH using high quality standard solutions. Complete calibration instructions, adapted from Hanna 2005, are provided below.

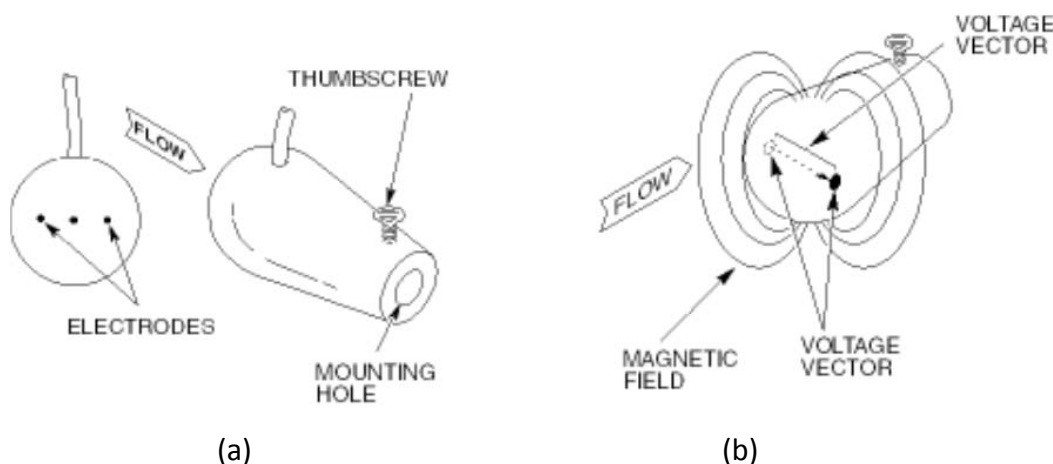


Figure 5-2. (a) Flo-mate model 2000 velocity sensor and (b) basic operational principles/design. The sensor is mounted to a wading rod via the mounting hole.

Equipment should be calibrated for specific conductance prior to calibrating for pH. This avoids contamination by the pH standards, which possess conductivities much higher than the conductivity standards.

Always use fresh calibration standard solutions for all calibrations. However, when performing a pre-calibration rinse with a standard, utilize the used standards (i.e. those used in previous calibrations) whenever possible. Follow the steps below when calibrating, both in the lab and in the field.

1. Rinse off sensors with DIW.
2. Perform a triple-rinse with used standard solution. Do the following 3 times:
 - fill the plastic calibration cup about 20% full.
 - swish the Hanna Combo meter thoroughly in the solution coat all sensor surfaces.
 - discard the liquid.
 - shake the excess liquid from the sensors.
3. Fill the calibration cup to a level sufficient to immerse all sensors with new standard solution.
4. Swish the Hanna Combo meter thoroughly to ensure that the standard is well-mixed.
5. Wait until sensor readings have stabilized before accepting a calibration value.
6. Pour the used standard into a small carry bottle (to be used for rinsing).
7. In the **Calibration Data** section of the *Premobilization datasheet* (page 1), record the name of the instrument, the calibration time, and the standard lot numbers.
8. Take pre- and post-calibration readings of standard solutions for pH and specific conductance. After all the calibrations are finished for each parameter, triple-rinse the sensors and use new calibration standards to check that the calibrations are within the ranges listed in Table 4-1 (SOP #4). Record all of these values on

the *Premobilization datasheet*.

Specific conductance

Specific conductance (SpC) measurements:

- To make specific conductance measurements, select the EC mode with the SET/HOLD button.
- Submerge the probe in the solution to be tested. Use plastic beakers to minimize any electromagnetic interference.
- Wait until the stability symbol on the top left of the LCD disappears.
- The automatically compensated temperature specific conductance value is shown on the primary LCD, while the secondary LCD shows the temperature of the sample.

Specific conductance calibration:

- When in measurement mode, press and hold the MODE button until CAL is displayed on the lower LCD.
- Release the button and immerse the probe in the proper SpC calibration solution (1413 $\mu\text{S}/\text{cm}$). The meter is designed to do a 1-point SpC calibration, but can be checked against other standards (e.g. 100 $\mu\text{S}/\text{cm}$) if desired.
- Once the calibration has been automatically performed, the LCD will display OK for 1 second and the meter will return to normal measurement mode.
- The CAL symbol should appear on the LCD, meaning that the meter is calibrated.

pH

pH measurements:

- To make pH measurements with the Hanna Combo select the pH mode with the SET/HOLD button.
- Submerge the electrode in the solution to be tested.
- Wait until the stability symbol on the top left of the LCD disappears.
- The automatically compensated temperature pH value is shown on the primary LCD while the secondary LCD shows

the temperature of the sample.

pH calibration:

Select the calibration buffer values:

- From measurement mode, press and hold MODE until TEMP and the current temperature unit are displayed on the lower LCD (e.g. TEMP °C).
- Press the MODE button again to show the current buffer set: pH 7.01 BUFF (for pH 4.01/7.01/10.01) or pH 6.86 BUFF (for NIST set, pH 4.01/6.86/9.18).
- Make sure the meter is set to pH 7.01 BUFF. Press the SET/HOLD button to change the buffer value if necessary.
- Press the /MODE button to return to the normal measuring mode.

Calibration procedure:

- From measurement mode, press and hold the MODE button until CAL is displayed on the lower LCD. Release the button. The LCD will display pH 7.01 USE. The CAL tag blinks on the LCD.
- For a two-point pH calibration, place the electrode in pH 7.01 buffer solution. The meter will recognize the buffer value and then display pH 4.01 USE.
- Rinse the electrode thoroughly to eliminate cross-contamination.
- Place the electrode in the second buffer value (pH 4.01 or 10.01, or, if using NIST, pH 4.01 or 9.18). When the second buffer is recognized, the LCD will display OK for 1 second and the meter will return to the normal measuring mode.
- The CAL symbol should appear on the LCD, meaning that the meter is calibrated.

3.3.6 Observer estimate of accuracy of discharge measurement

The accuracy of a discharge measurement is the difference between the measured flow and the true value, and is estimated on the *Water Quality Datasheet* for the discharge measurement. It is important to understand

that an estimation of accuracy does not imply a rating of the quality of the work done to obtain the measurement. Estimates of accuracy are made by the observer and are based on site conditions and methods used, not performance. The field technician should estimate accuracy of each discharge measurement based on the following criteria (Turnipseed and Sauer 2010):

- Measuring section – consider the uniformity of the depths, the smoothness of the stream bed, and the ability to accurately measure depth. Ideally, the streambed in the cross section should be uniform, free of numerous boulders and vegetation, and located in a reasonably straight reach.
- Velocity conditions – consider the uniformity of velocity across the section, as well as very slow or fast velocity, turbulence or obstructions that affect velocity. Ideally the velocity is uniform across the channel, water flow is parallel to the stream banks without eddies or turbulence.
- Equipment – consider the type of current meter used in the section and the condition of the meter.
- Spacing of observation verticals – There should be between 25 and 30 verticals, spaced so that each contains no more than 5 percent of the total discharge. This may be difficult to attain in most SCPN streams.
- Ice – presence of ice will have adverse effects on depth and velocity

Then, circle one of the following on the *Water Quality Datasheet*:

- Excellent – 2% (this is not an option for most SCPN streams)
- Good – 5%
- Fair – 8%
- Poor – over 8%

4 Measuring water temperature, pH, specific conductance and

dissolved oxygen

SCPN uses multiparameter sondes or small, combination water quality meters to collect NPS core water quality parameter data. Using multiparameter sondes is an efficient and effective way to collect NPS core water quality parameter data at most sites. A sonde can collect data for multiple parameters at the same time, can be used to collect discrete water quality field measurements, or can be deployed for long-term collection of continuous data. SCPN will use a Hydrolab Mini-Sonde 5 water quality sonde and a PDA for determining NPS core water quality parameters in the field, including temperature, pH, specific conductance (SpC), and dissolved oxygen (LDO). At remote or very small sites SCPN will use a Hanna Combo HI98129 to measure pH and SpC. Instructions for using these instruments are provided below and are based on documentation provided by equipment manufacturers.

Guidelines for using water quality sondes for routine field measurements are provided in Gibs et al 2007 . Guidelines for continuous water quality monitoring are provided in Wagner et al 2006.

4.1 Calibrating water quality meters in the field

Fill out the following information at the top of page 3 of the *Water Quality Datasheet*:

- Site code
- Site name
- Date (yyyymmdd)
- Observer
- Calibration date and time
- Water quality instrument make & model
- Instrument set to local time (yes or no)

Sensor calibrations should be done in an area with stable air temperatures, out of direct wind and sun. Perform a 2-point pH calibration for all meters. For the Hydrolab MS5 perform a 2-point SpC calibration as well as a 1-point LDO calibration in stream water saturated with air. For the Hanna

Combo meter perform a 1-point SpC calibration. During all calibrations, temperature sensors should be fully submerged in the standard, as the sensors require temperature compensation. When calibrating, first record the temperature of the standard in the “Temperature” column and the pre-calibration value in the “Readings” column of the **Field Calibration** section of the *Water Quality Datasheet*. The standard temperatures should be similar (within 5°C) to the stream temperature. Refer to SOP #4 for specific calibration guidelines; field calibrations are performed identically to lab calibrations, with the exception of LDO.

4.1.1 Water temperature.

Upon reaching the water quality monitoring site, equilibrate both the water quality meter (make sure the flow-through cap is attached to the Hydrolab) and the calibration standards to ambient water temperature by immersing in the stream/spring. Compare the standard temperatures to the water temperature to confirm that they are equilibrated. If a Hydrolab is not being used, then measure temperature with a NIST-certified thermometer. Record the stream water temperature at the time of calibration in °C on the Water Quality Datasheet.

4.1.2 Specific conductance

Specific conductance should be calibrated first. This is because pH buffers have much higher conductivities and can potentially contaminate the SpC buffers through solution carry over if pH is calibrated first. When using the Hydrolab select two conductivity standards that bracket the anticipated water conductivity. For most SCPN streams and springs, the 100 and 1413 µS/cm standards will be used, however some sites (such as Mancos River at low flow) may require a higher standard. Indicate this higher standard on the Water Quality Datasheet. When using the Hanna, use the 1413 µS/cm standard. Prior to each calibration, write the temperature of the calibration standard and the pre-calibration value on the *Water Quality Datasheet*. Be aware that the value of the SpC calibration standard can change by

more than 3% if the temperature is less than 6°C. If the anticipated water temperature is less than this, calibrate the SpC indoors.

4.1.3 pH

Values for pH buffers should bracket the anticipated site conditions. For most SCPN surface waters, pH 7 and pH 10 buffers will be used. Be aware that pH buffer values increase as the temperature decreases—the buffer values are 7.00 and 10.00 only at 25°C. Refer to the table provided by the manufacturer (Table 5-5) for the correct pH value for the temperature, and use this value when calibrating. Write the buffer temperature and the pre-calibration value on the *Water Quality Datasheet*.

4.1.4 Dissolved oxygen

Table 5-5. Aqua Solutions pH buffer standard values from 0 – 25°C.

Temperature, °C	pH 7	pH 10
0	7.13	10.34
5	7.10	10.26
10	7.07	10.19
15	7.05	10.12
20	7.02	10.06
25	7.00	10.00

The Hach Hydrolab uses a luminescent dissolved oxygen (LDO) sensor to determine DO concentrations in water. In the field, the Hach LDO sensor should be calibrated using air-saturated stream or spring water, but avoid using water that is likely to be supersaturated with oxygen (such as a stream with lots of algae). In this case, another water source should be selected. Because barometric pressure (BP) changes with elevation, if there is a more than 500 foot change in elevation between site visits, the LDO sensor must be re-calibrated. Changes in water temperature during LDO sensor calibration must be minimized, or the calibration will be unsuccessful. If necessary, use a damp towel (if air temperature is greater than the water temperature) or a dry towel (if air temperature is colder than water temperature) to

insulate the calibration cup.

Use a handheld barometer to obtain the local atmospheric pressure, and record this on the *Water Quality Datasheet*. Record the temperature of the air-saturated water at time of calibration. The differences between these temperatures and the temperature of the stream or spring water (measured after equilibration and immediately prior to calibration) should be similar. In case of a barometer malfunction in the field, it may be necessary to estimate the local BP. Use this equation and note that BP was estimated in the calibration notes:

BP' = barometric pressure at altitude and

A_{ft} = altitude in feet

After each calibration is complete, check the standards again to ensure that the calibration is accurate. For SpC and pH, choose the standard that is closest to the anticipated sample value, re-rinse the sensors with the standard, and measure. Write the post-calibration value and temperature on the *Water Quality Datasheet*. The post-calibration measurements must fall within the values in Table 5-6. If not, the calibration must be done again. If the sonde still doesn't meet the calibration requirements in Table 5-6, it may need to be sent to the manufacturer for repair.

4.2 Measuring water quality core parameters using the Hydrolab MS5

After the water quality sonde has been calibrated, take in-situ measurements of the water quality core parameters. The sonde should be placed in a section of the stream

Table 5-6. Acceptable post-calibration ranges for core parameter measurements with Hydrolab MS-5 (Gibs et al. 2007).

Core parameter	Post-calibration range
Temperature	± 0.2 °C
pH	± 0.2 S.U. ¹
Specific conductance	± 5 µS/cm if <100 µS/cm or ±3% if ≥100 µS/cm
Dissolved oxygen	± 0.3 mg/L, ± 3% saturation

¹If drifting persists or if measuring low conductance waters (≤75 µS/cm), allow ± 0.2 to ± 0.3 pH units

where depth is sufficient to cover the sensors completely, the water is visibly flowing, and flow is mixed sufficiently to allow for representative measurements. Be careful to avoid direct contact of probes with bottom substrates; in swift, sandy streams the sensors could become buried.

Prior to recording measurements, sonde measurements must meet the calibration requirements (Table 5-6). Allow the sonde to equilibrate to stream conditions (this should take several minutes). Determine the ranges of core parameters and compare them against the stabilization criteria (see “Method A: Discrete Measurements.”) If the range in measurements over several minutes is not within these criteria, this may indicate that the area of the stream being measured is not well-mixed. Try moving to an alternative point in the stream (near the thalweg) that appears well-mixed.

4.2.1 Short-Term (discrete measurements) vs. Long-Term (data logging) Sonde deployments

There are two alternate methods that can be used to save core parameter data with the Hydrolab MS5. If the Hydrolab will be deployed for a short period of time (less than a day), use only Method A. If it will be deployed for a day or more, or if the PDA will be needed for other purposes, use both Method A and Method B. When both methods are used, Method A should be used prior to Method B, to ensure that a set of discrete measurements is recorded in the event of data loss during Method B. Method A also ensures that the sensors have stabilized prior to the recording of measurements.

- For Method A, use the Monitoring function to observe and record data. With this method the PDA must remain attached to the sonde. Core parameter data is stored in the PDA (only after the file is manually saved).
- For Method B (long-term deployment), create and activate a log file. With this method the PDA must be detached from the sonde; otherwise, sonde will not start recording. Core parameter data

is stored in the sonde and can later be downloaded to the PDA.

When saving data files on the PDA, use the following naming convention: YYYYMMDD_SITECODE. For example, “20100913_BANDRIT01”. If there is more than one data file with the same date and site code, order the files chronologically by adding an extension, i.e. “20100913_BANDRIT01_1”, “20100913_BANDRIT01_2”, etc. The location where the files will be saved can be user-specified and later viewed on the PDA by navigating to the specified location.

Data files stored on the PDA should be downloaded to the SCPN server as soon as possible after each field trip.

4.2.2 Method A: Data monitoring

Follow these steps to ensure that valid data is collected and record the values in the “Water Quality Field Measurements” section of the datasheet:

1. Place the sonde in the water with the flow-through cap installed and allow it to equilibrate to the stream water temperature (this usually takes several minutes). Meanwhile, make sure the clock in the display and the sonde are synchronized to local date/time.
2. Start a monitoring file to collect data at 5 second intervals. View the graph to make sure the measurement curves are stable (see the user manual for instructions)
3. If the measurement curves are not already stable, it may be necessary to wait until they stabilize and re-start the monitoring file so that all saved data are valid.
4. As soon as 7 samples have been taken, click the “Statistics” button, and verify that the ranges (maxima minus minima) of each parameter meet the stabilization criteria in Table 5-6.
5. If the stabilization criteria are met, keep the Hydrolab in monitoring mode for the duration of the visit, occasionally writing down core parameter values on the datasheet in case the monitoring file is lost before being downloaded to the

SCPN server.

6. Before exiting Monitoring mode, save the data file.

4.2.3 Method B: Data Logging

Follow these steps to ensure that valid data is collected during long-term deployment of a day or longer. With a log file, the data are stored in the Hydrolab and the PDA must be detached in order for data logging to occur. Care should be taken to ensure that the sonde is deployed in a stream section that is hidden from passersby, and locked in place where theft is a possibility, so it will not be disturbed or stolen. It should be installed very securely to a permanent structure, so that there is no danger of it being carried downstream by flash floods.

1. Create a log file and name it according to this convention:
20100913_BANDRIT01_log.
2. Select a start and end time. Set the start time to approximately 10 minutes later than the current time displayed in the upper-right corner of the PDA (to allow ample time to setup and activate the log file). Be very careful, the software defaults to a 1-hour log file. Always set an end time if a >1-hour log file is desired. Record the start and end time and date in the *Water Quality Datasheet*.
3. Set the interval to one that is appropriate for the length of time that the data is to be recorded. The logging interval, sensor warm-up time, and water temperature all affect the battery life. A typical log interval is 15 minutes, synchronized to the nearest quarter hour, such as 12:00, 12:15, 12:30, etc. For the longest possible battery life, set the Hydrolab to a 1-hour recording interval and a 30-second sensor warm-up time. Otherwise, the sensor warm-up time default (02:00) is okay. SCPN does not use Hydrolab MS5s with circulators installed, so this can be left as the default as well.
4. Uncheck the Audio box.
5. Select the following parameters to be

logged: date-time (seconds), internal-battery (% left), temperature (°C), SpC (µS/cm), pH (Units), LDO% (Sat), LDO (mg/l), and LDO_BP (mmHg).

6. Be sure to enable the log file by clicking the button that says “enable”. If the log file is not enabled, data will not be collected.
7. Disconnect the Hydrolab from the PDA. If the PDA is not disconnected, data will not be collected.
8. When retrieving the sonde after long-term deployment, disable the log file and download it to the PDA, using the naming convention listed above.
9. Check the sonde against two SpC standards, pH 7 and 10 standards, and air-saturated water for DO to determine if there was calibration drift. Write these values in a field notebook and enter these in the database.
10. Consult SOP #4 for instructions for maintenance of the sonde after deployment.

5 Collecting continuous temperature data

If possible, use the same model of temperature logger at all monitoring sites throughout the network. SCPN uses Onset HOBO® Pendants to collect continuous water and air temperature data at the network’s aquatic macroinvertebrate monitoring sites, many of which are co-located with water quality sites.

5.1 Temperature logger tracking and pre-installation setup

Communication between pendants and a PC is accomplished using an Onset Optic USB Base Station or a Onset HOBO® Waterproof Shuttle and HOBOWare® software. Complete instructions for this equipment and software are available in electronic format on the SCPN common drive or at www.onset.com.

Each SCPN temperature logger should be thoroughly documented. The following information should be entered on the *Water*

Quality datasheet: manufacturer, model, serial number, start date and time, end date and time, downloaded file name, and comments.

Following are basic steps to remember when deploying Hobo[®] Pendant loggers.

- Time cannot be configured—the pendant will automatically sync its time to the PC time (Mountain Standard Time) when the HOBO program is started.
- Enter the site code (e.g. BANDRIT01). This will later be included in the file name that is automatically generated when a log file is downloaded and saved.
- Configure the sensors (see user manual). Log both temperature and battery level.
- Program the loggers to record data at 15-minute intervals (1200, 1215, 1230,...). to capture temperatures representative of fluctuations over 24 hour periods and through the course of a year. If sites are to be visited only once per year, use a 30-minute interval.
- Ideally, the logger should be launched on-site immediately before it is deployed. Pendants may be launched in advance of deployment (e.g. if a laptop will not be available in the field). In either case, make sure to record the actual time the logger is placed in the water (deployment) on the datasheet.

Always bring Optic Base Station or Waterproof Shuttle, USB cable, spare Pendant, small Phillips screwdriver, spare batteries, spare desiccant packets, and cord to be used for securely attaching Pendant in field. Also bring a scrub pad for cleaning grime/biofilm from water temperature pendants.

5.2 Installing and relocating temperature loggers

1. Place the water temperature pendants at a location in the stream channel that is adequately mixed and not influenced by localized warm or cool water sources, such as ground water, point sources, lake outlets, or direct sunlight. Shaded sites with moderately turbulent flows tend

to make good pendant placement spots. Avoid backwater pools and standing water. It may be necessary to check water temperatures to ensure that the site is representative of the stream or spring. Select a site where the pendant is likely to be submerged throughout the year and will be protected from high flows. Make sure it is completely submerged and not in contact with the bottom or other mass that could serve as a heat sink/source.

2. Attach the water temperature pendants to a stable, permanent object, such as a tree root. If there are no natural anchoring objects, you may need to install a permanent marker, such as a piece of rebar, and attach the pendant to it.
3. Place air temperature pendants at a location near the stream channel where the air is not influenced by localized warm or cool sources, such as by bedrock or direct sunlight. If possible, place the pendant about 2 meters above ground surface and 5 to 10 meters away from the stream. Suspending pendants from the branch of a tree with dense foliage is often the best choice.
4. Attach pendants to their anchors using a piece of thin, strong, weather-resistant cord, such as Kevlar. Use cord that is a natural, drab color, as it will be less noticeable to passersby. Tie a knot that will not come undone, even if it means that it may need to be cut to remove it. The cord and pendant should be tied to the anchor in such a way as to minimize change in pendant position over time as the result of high winds or stream velocities.
5. Record thorough descriptions of the locations where each logger is deployed in the notes section. This is very important to help ensure the pendant can be relocated and to account for factors that may influence temperatures. The description should include a site map, photographs (see SOP #8 for photodocumentation instructions) of the pendant and direc-

tions to the site from relatively permanent landmarks.

Occasionally loggers must be removed or relocated, for example, when high-flow events bury aquatic loggers in sediment and alter the channel characteristics, rendering the old location undesirable. Whenever a temperature logger is removed from a site or moved from one location to another within a site, the following must be documented on the datasheet: The reason(s) for moving/removing the logger, and—if relocated—a full description of the logger's new location should be indicated in the notes section. Upon returning from the field, this documentation should be included in all of the following files on the SCPN common drive: the trip report, the database, and the site folder.

5.3 Recording temperature logger information and routine maintenance

Download the data from pendants during each site visit to reduce the risk of losing significant amounts of data. This is particularly important at sites where high stream flow conditions may occur. Each time data is retrieved from a Pendant, its batteries and LED lights (indicating operational status) should be checked, and its exterior cleaned, if necessary. The desiccant pack should be inspected about every 6 months and replaced if it is no longer bright blue. The following information should be recorded on the *Water Quality Datasheet*:

- Existing logger stop / download time (local time)
- Existing logger serial number
- New logger placement time. This will be left blank unless a new logger is deployed at the site.
- New logger serial number
- Temperature at time of download. Hold thermometer as close to the logger as possible.
- Battery status (% remaining; see below)
- Notes on sensor condition or actions taken

- Data logger file name, in YYYYMMDD_SITECODE_air format

5.4 Downloading data from the temperature logger

There are two methods for downloading data from pendants:

1. Pendant data is downloaded directly to a laptop using either a Waterproof Shuttle with a USB cable attached, or an Optic USB Base Station. The data in the pendant is transferred to the laptop, but also remains on the pendant. Choose the option to stop the pendant, and then re-launch it after downloading and saving the data file. Check the battery status during this step; if <80% is remaining, replace the battery. Re-launching the pendant will reset its memory. This is important to do, because pendants have no “wraparound” memory capability; that is, if the memory becomes full while logging, it will stop logging, rather than continuing with data collection and overwriting the oldest data.
2. Pendant data is downloaded to a Waterproof Shuttle, which must be launched using the HOBO program. The data in the Pendant is transferred to the shuttle and the Pendant's memory is reset. The Pendant will automatically begin recording data, using the same settings (time interval, channels, etc.) that were set in the last manual launch. The data file must later be transferred from the shuttle to a PC (see below).

Use method (1) when possible, because this is the only way the Pendant battery can also be checked (it also reduces the number of downloading steps). In determining whether or not to replace a battery, consider the percentage of remaining power, the duration of deployment, and the anticipated date of next site visit. It is best to err on the side of premature battery replacement, particularly in winter when very low temperatures reduce battery voltage.

6 Measuring turbidity

Turbidity is a water quality core parameter and is measured using the Hach 2100P portable turbidity meter and reported in nephelometric turbidity units (NTU). A description of the method for calibration is included in the Portable Turbidimeter Model 2100P Instrument and Procedure Manual, as well as in SOP #4. Turbidimeter calibration should be checked every time it is used. Record calibration standard values and meter readings on the “Turbidity” section of the *Water Quality Datasheet*.

6.1 Collecting samples for measuring turbidity

A turbidity sample is a grab-sample taken at the centroid of flow with a brown, 100mL plastic bottle. Before collecting a grab sample, triple-rinse the bottle with stream water first, then fill it by lowering slowly into the stream at the centroid of flow.

Turbidity is time-sensitive and samples are subject to fouling by biological growth, degradation, and sorption and settling of particulates. Changes in pH may also result in precipitation of minerals and humic acids into the sample. Thus, turbidity samples must be processed within 24 hours of collection, kept away from sunlight, and kept at or below 4°C during this time (ASTM International 2003).

1. Turbidity measurements should be made as soon as possible after the sample has been collected, after which the samples can be discarded.
2. Label the sample bottle with sample site, date, and time using an indelible marker.

6.2 Checking the calibration of the Hach 2100p Turbidimeter

The turbidimeter should be calibrated in the lab, but the calibration of the Hach 2100P Turbidimeter should be checked before each use in the field using the three Gelex secondary standards. Record values of all three Gelex standards on the *Water Quality Datasheet*, and verify that the readings are within

the acceptable range ($\pm 5\%$ of the assigned value). If the readings are not within the acceptable range, the turbidimeter will have to be recalibrated in the lab.

6.3 Measuring turbidity with a turbidimeter

1. Select a location with low light.
2. Place the turbidimeter on a level surface to help prevent stray light from entering the measurement chamber.
3. Remove dust and condensation from the cell with a clean, soft lint-free cloth or tissue. Turbidity readings can be affected by unmatched cell orientation, condensation, gas bubbles, fingerprints, scratches, or dirt on the surfaces of the sample cell or turbidity probe.
4. Apply a thin coat of silicon oil on the outside of the cell about every third time the cell is wiped free of moisture. The oil will reduce condensation and mask minor imperfections and scratches. However, too much oil will attract dirt and could foul the cell compartment.
5. If condensation is an issue, it may be necessary to allow the sample to equilibrate with ambient temperature. However, this may change particle associations in the water matrix.
6. Fill the sample cell from the sample bottle. Invert the sample cell 25 times to disperse and suspend solids. Ensure that no air bubbles are present in the cell. Air bubbles can cause a significant positive bias on turbidity readings. Do not touch the cell walls with fingers.
7. Insert the sample cell so that the arrow on the cell faces the notch on the turbidimeter sample cell chamber.
8. Close the turbidimeter lid. Ensure that “signal average” and “auto range” are turned on. Press the “read” button to obtain a turbidity reading. Samples containing readings above the turbidimeter’s limit of 1,000 NTU will need to be diluted (see below).
9. Particle settling can affect turbidity read-

ings. This can be indicated by readings which fluctuate widely during a measurement, or by the obvious presence of coarser sands and silts which settle to the bottom within 3-5 seconds. If this is occurring, then turbidity cannot be accurately measured and readings should be qualified as estimated.

10. If measurements were obtained from a diluted sample, then it should be indicated that readings were obtained by performing serial dilutions.
11. Repeat measurements with at least two other samples from the same sample bottle, for a minimum of three measurements. When measurements have been completed, triple-rinse the vials with de-ionized water and carefully store in such a way that the vials do not become scratched.

6.4 Serial dilutions

The Hach 2100P Turbidimeter can measure turbidities within a range of 0-1,000 NTUs. If the turbidimeter cannot obtain a reading from a turbid sample, it will need to be diluted. Dilutions will introduce errors if there are coarse sediments present in the sample, which will settle to the bottom within 3-5 seconds. These sediments may settle before an aliquot is taken, resulting in a lower turbidity measurement than actually exists. Because of this, it is important to ensure the sample is well-mixed and that the aliquot is taken immediately after mixing. Additionally, it is important to denote on the *hydrology datasheet* that the turbidity value is derived from a dilution. If coarse sediments were present, then indicate that the written value is an estimate of the actual value. Record turbidity serial dilution data in an excel spreadsheet.

The following are directions for conducting serial dilutions:

1. Invert sample 25 times, ensuring that particles are not stuck to bottom of vial.
2. Start with a 20% dilution: Before particles settle, immediately take 3mL of sample using a pipette. Dispense sample either into a glass beaker or glass graduated cylinder. Use a pipette to add 12mL of de-ionized water to the sample.
3. Cover beaker or graduated cylinder with parafilm and invert 25 times to mix sample. Avoid shaking, as gas bubbles may appear in the sample.
4. Immediately pour enough diluted sample into cuvette, then record the turbidity, ensuring that signal averaging is on.
5. Repeat this process at least two more times with fresh sample until three or more sequential values read within 10% of one another. Record the median of these values.
6. Repeat steps 1-5 with 50% and 80% dilutions, if possible. The object is to encompass a wide range of dilutions in order to derive a line of best fit. If 80% is too turbid, try a higher dilution. At least three dilutions are required; however, more are better.
7. Graph the median turbidities against their dilution values and obtain a regression equation. Ensure that the turbidity values are linear.
8. Use the regression equation to solve for the estimated turbidity of the undiluted sample.
9. Save the excel spreadsheet on the SCPN server.

7 Decontaminating water quality monitoring equipment

Although nonindigenous aquatic species (NAS) are not a particularly serious concern in many of the streams and springs at which SCPN works, several species are known to exist in the larger water bodies of the Colorado Plateau. Therefore, SCPN takes the potential for spread of NAS among its sites seriously, and will be vigilant in following the procedures detailed in Appendix C: Decontamination Considerations and Procedures. Following is a summary of the decontamination procedures in that appendix. These

steps should be followed whenever personnel or equipment make contact with ambient (stream, spring, lake, etc.) water, and are moving between sites on a water body or to a different water body.

Before leaving a site, remove all organic matter and sediment of aquatic origin from all equipment and clothing using a scrub brush. This is important to do at or near the site, because sediments and organic matter are the typical “vectors” of NAS propagation. A garden type sprayer containing a 5% cleaning solution of a quaternary ammonium compound should be kept in the field vehicle. For other decontamination methods, see Appendix C, Section 2. All equipment and clothing that made contact with stream water should be decontaminated as soon as practical. First remove all soil or organic materials from the objects using a scrub brush, and then spray liberally with the cleaning solution. After letting the objects sit for at least 15 minutes, rinse them thoroughly with tap water.

Water Quality Datasheet

Park code: _____ Site name: _____ Date: (yyyymmdd): _____

Site code: _____ Observer(s): _____

Start time: _____ End time: _____ MST or MDT (circle one)

Site access notes, general observations, and other work done:

Precipitation during sampling (circle one): None Rain Freezing rain Hail Sleet Snow

Precipitation 24 hours prior to sampling (circle one): Yes No

Stream channel and flow conditions at the water quality sampling site												
Stream Channel	Channel (check one)	☐ Pool ☐ Riffle ☐ Open channel ☐ Braided ☐ Backwater										
	Substrate	☐ Clay grains not visible, smooth texture	☐ Silt grains not visible, gritty texture	☐ Sand Grains visible, gritty, to ladybug size	☐ Gravel Ladybug to tennis ball size	☐ Cobble Tennis ball to basketball size	☐ Boulder Basketball to car size	☐ Bedrock Larger than a car	☐ Vegetation	☐ Wood	☐ Other	
Flow (check one in each category)	Stream color	Clear	Milky	Foamy	Tea	Muddy	Green	Scum/odor	Other: _____			
	Flow mixing	Excellent	Good	Fair	Poor	% Ice cover: _____		Average ice thickness (cm): _____				
	Flow severity	Dry	No flow	Low	Normal	Above normal	Flood	Comments:				
	Hydro-graph limb	Base	Rising	Peak	Falling							
Flood evidence (Check all that apply)	None											
	Fresh debris line in channel / above active channel (circle one)											
	Grasses/shrubs laid over											
	Recent flood event greater than baseflow, but less than bankfull											
	Recent deposition of sediments on floodplain											
	Riparian vegetation scoured away											
	Other (note in comments)											

Aquatic and air temperature loggers			
Existing logger stop/DL time:	Serial number:	Existing logger stop/DL time:	Serial number:
New logger placement time:	Serial number:	New logger placement time:	Serial number:
Notes on sensor condition, battery %, and actions taken:		Notes on sensor condition, battery %, and actions taken:	
Data file name:		Data file name:	
NIST-Traceable thermometer model and serial number:			
NIST thermometer temp at time of download (°C):		Temperature at time of download (°C):	

Figure 5-3a. Water Quality Datasheet, page 1

Site code: _____ Site name: _____ Date: (yyyymmdd): _____ Observer: _____

Discharge measurement							
Start time:			End time:			Observer:	
Discharge measurement method (circle one)		Flow meter	Flume	Volumetric	Visual estimate		
Flow meter time zone: MST MDT		File name:					
Flow Meter Make/Model/SN#:					Pygmy meter spin test (45 seconds ok):		
FlowTracker passes quality control test (circle): yes no					Discharge (m³/s): ft³/s:		
Discharge measurement location (e.g. distance upstream from gage):							
Control location, description, and condition:							
Observer's estimate of measurement accuracy (circle one): Excellent (<2%) Good (<5%) Fair (<8%) Poor (>8%)							
Estimate total percent of flow captured by measurement:							
Discharge measurement comments:							
Flow meter						Volumetric measurement	
Point	Velocity measurement depth (circle one)	Location (m)	Depth (m)	Velocity 1 (m/s)	Velocity 2 (m/s)	Container description	Container size
LEW						Try	Time to fill (seconds)
1						1	
2						2	
3						3	
4						4	
5						5	
6						Mean value	
7							
8							
9							
10							
11							
12							
13							
14							
15						Stage height	
16						Time	Height
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

Figure 5-3b. Water Quality Datasheet, page 2

Site code: _____ Site name: _____ Date: (yyyymmdd): _____ Observer: _____

Field calibration of water quality instrument						
Calibration date:		Water quality instrument make and model:				
Calibration time:		Water quality instrument SCPN name:				
Instrument set to local time (circle one)?		Yes	No	Stream water temperature (°C) at time of calibration:		
Parameter	Standard value	Lot number	Pre-calibration		Post-calibration	
			Reading	Temperature (°C)	Reading	Temperature (°C)
Specific conductance	100 µS/cm					
	1413 µS/cm					
	Other: _____ µS/cm					
pH						
Dissolved oxygen	100% saturation (water saturated w/ air)					
	Barometric pressure (mmHg):					
Calibration notes:						
Water quality field measurements						
Water quality meter (attended)						Multi-parameter sonde (long-term deployment)
Time	Battery (%)	Water temperature (°C)	pH	Specific conductance (µS/cm)	Dissolved oxygen (mg O ₂ /L)	Dissolved oxygen (%Sat)
File name(s):						pH 7 value used: 7.____ temperature:____ reading:____ pH 10 value used: 10.____ temperature:____ reading:____ SpC 100 temperature:____ reading:____ SpC 1413 temperature:____ reading:____
Comments on water quality data collection						
Turbidity						
Turbidimeter Make/Model: Hach 2100P		Serial number: 06110C019647		Observer:		
Be sure to turn on signal average and auto range !			Date of last calibration:			
Calibration check with Secondary Gelex Standards						
Calibration check:	Date:	Time:	Sample readings			
Assigned value	Acceptable range	Reading	Sample #	Readings (NTU)		
cfs = m ³ /s * 35.31	P _{mmHg} = 25.4 * PinHg	BP' = 760-2.5(Aft/100), where BP' = barometric pressure at altitude, Aft = altitude in feet				
deg F = 1.8 (°C + 32)	m x 3.28 = ft					
Acceptable post-calibration ranges for core parameter measurements with Hydrolab MS-5 (Gibs et al. 2007): Temperature - ±0.2 °C; pH - ± 0.2 S.U.; specific conductance - ± 5 µS/cm if ≤100 µS/cm or ±3% if ≥100 µS/cm; dissolved oxygen - ± 0.3 mg/L, ± 3% saturation						

Figure 5-3c. Water Quality Datasheet, page 3

Site code: _____ Site name: _____ Date: (yyyymmdd): _____ Observer: _____

Bacteria sample processing			
Processed by:		Tray(s) read by:	
Incubation start time:		Incubation end date:	
Incubator Make/Model:		End time:	
		Item name	Lot number
Temperature logged during incubation: yes no		Idexx 120 mL Vessel	Expiration date
Temperature logger Make/Model:		Idexx Quanti-Tray 2000	
Logger serial number:		Idexx Colilert 18 / 24 (circle)	
Logger data file name:			
Incubator temperature			
Event occurred and/or action taken	Date	Time	Temperature

Bacteria tray readings		
	Positive large wells	Positive small wells
Tray 1: Total Coliform (yellow wells)		
<i>E. coli</i> (yellow & fluorescent wells)		
Tray 2 (circle): Blank Duplicate		
Total Coliform		
<i>E. coli</i>		
Comments on bacteria samples:		

Sample collection, processing and shipment			All bottles collected by:	
Sample collection time:			MWQL samples processed by:	
Processing time:				
Filter Make/Model	Quantity used	Lot number	Samples chilled? yes no	
			Filtration location: On-site At car Indoors Chamber	
			Pump Make/serial number: Geopump C08001443	
Bottle or acid type	Quantity used	Lot number / treatment/ schedule number	Lab name	
			Shipping method	
			Drop date & time	
			Tracking#	
			Lab name	
			Shipping method	
			Drop date & time	
			Tracking #	
			Lab name	
			Shipping method	
			Drop date & time	
Inorganic blank water			Tracking #	
Comments on sample collection, processing and shipment:				

Figure 5-3d. Water Quality Datasheet, page 4

8 Revision history

Provide the following information for each revision made to SOP #5.

New version:

SCPN_WATER_QUALITY_SOP05_YYYYMMDD

Date:

Author:

Sections affected:

Changes & reasons:

